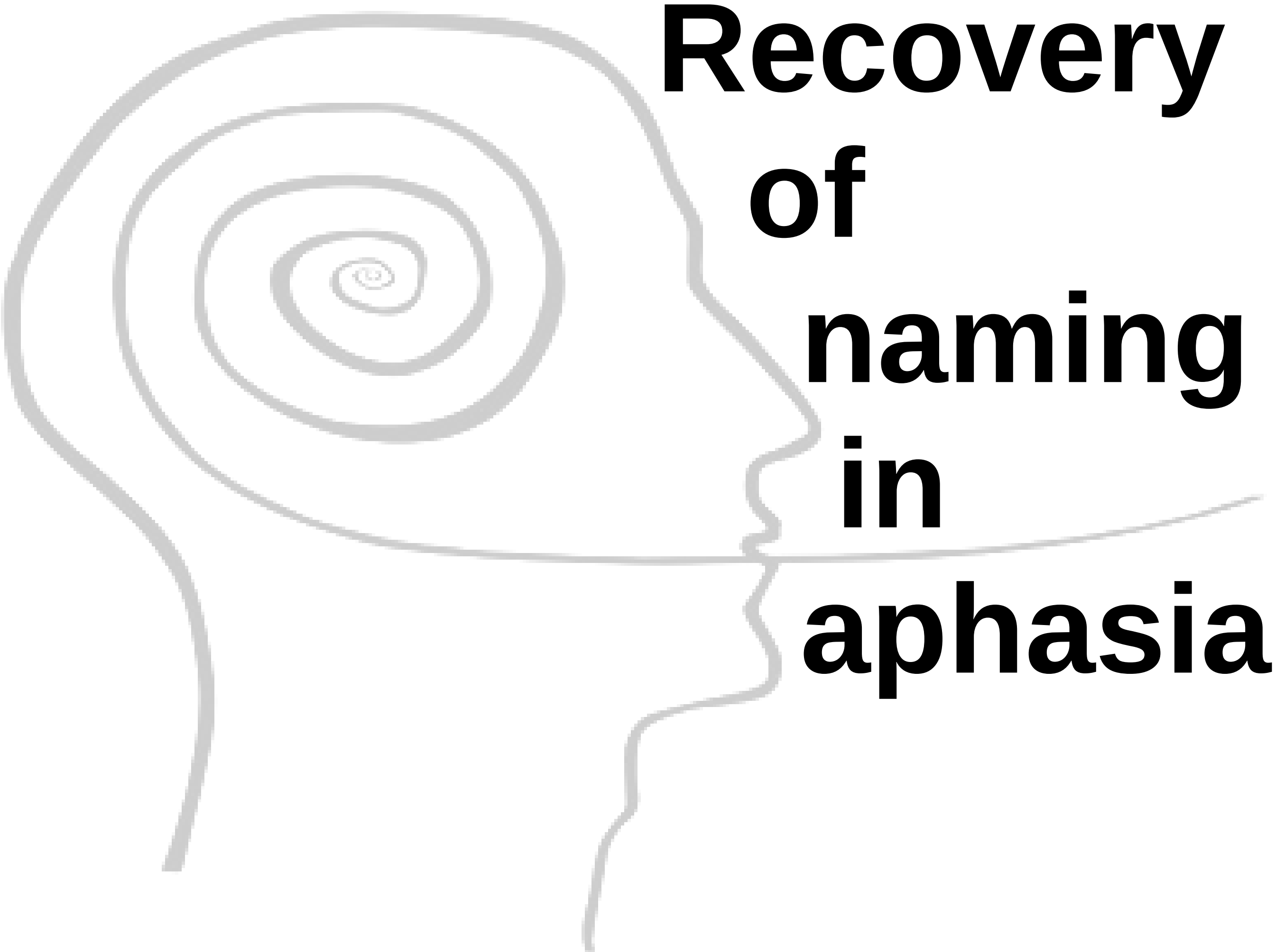

Recovery of naming in aphasia

Master thesis

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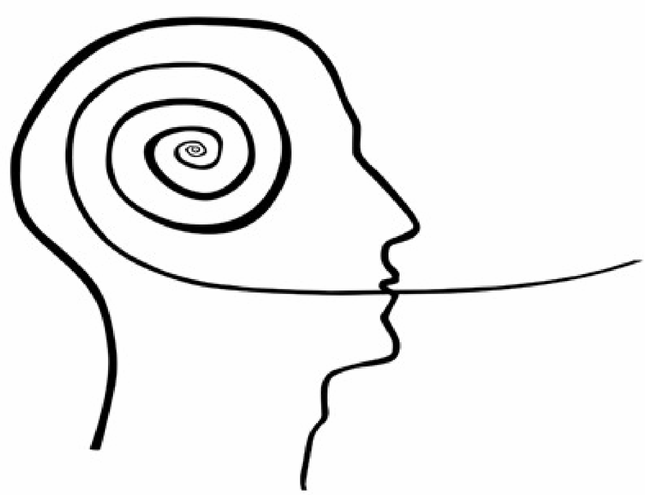
Date	18 August 2008

"Luck is when preparation meets opportunity"

Seneca

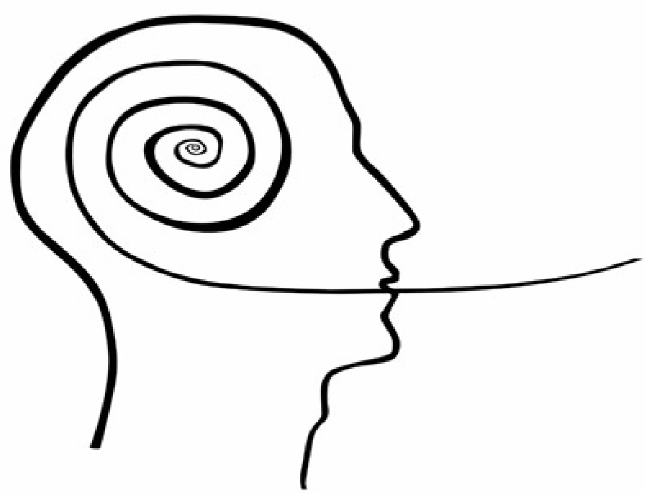
Roman dramatist, philosopher, & politician (5 BC - 65 AD)



Preface

During my master period, I've always thought of my thesis as my "piece de resistance". Six months of hard labour, dedication and a lot of meetings were needed to finish this last assignment for my master Taal en Spraak: verwerking en stoornissen.
First of all I would like to thank my supervisors from Erasmus MC Rotterdam: Drs. M. de Jong-Hagelstein and especially Dr. E. Visch-Brink who have guided me through this thesis with welcome feedback and thoughts. Also thank you for giving me the chance to work with such interesting data.
Second, I would like to thank my supervisors from Utrecht University: Dr. N. Vasic and especially Dr. S. Avrutin. Thanks to you I got a thesis which is linguistic, but still very into my own beliefs and interests.
Third, I would like the people who gave me insights in to the statistic part of this thesis: Mr. N. Prins, Mr. H. Quené, Mr. F. Duits and Mrs. H. El. Hachoui.
Fourth, I would like to thank Ray, Frank and Karen who were there for me to check my (mis)use of the English language in this thesis.
Of course a lot of other people must be thanked!
My family and the BF1-Girls: How to keep some one motivated? Tell her you believe in her and love her, just for trying to do the right thing in her life. Thanks for the distraction, food and drinks. Linda: thank you for the art work in my thesis.
My SLT-stars: Especially Annika & Sandra, Marleen, for spending another two years full of exiting actions and moments together.
Nicole, Nicole, how can I thank you enough? Your everlasting friendship keeps me going on: you're my inspiration and always have been.
Coert: No words can explain how much you mean to me and how much you've helped during these last two years and especially during my thesis period. Trust in my beliefs and hard work; you were there for putting things in perspective, advice, discussion and relaxation. Thank you for always being there for me, even at 3 a.m.

P.P.H. Cox
Sevenum, August 2008



Summary

In this study the recovery of naming errors has been investigated in twenty patients with fluent aphasia and naming problems who participated in RATS-2 (Rotterdam Aphasia Therapy Study – 2, Visch-Brink (2006)) and received six months of cognitive linguistic therapy within 0 – 6 months post onset. All patients were tested on three test moments with the Boston Naming Test (within 3 weeks, 3 months and 6 months post onset.

This study is divided into two parts with each its very own research question.
In Part I an in-depth view in recovery of naming errors is given by performing a micro analysis which focused on correct answers, semantic relatedness and Phonological Overlap Index. This analysis was carried out to investigate which recovery patterns can be found in semantic and phonological paraphasias in aphasic patients in 0 – 6 months post onset. The data in this study suggest that the proportion of correct answers and semantic relatedness increases significantly in time on the Boston Naming Test. The Phonological Overlap Index does in this study not increase significantly in time.

In Part II of this study, predictions were tested about recovery of semantic and phonological paraphasias derived from linguistic models that explain lexical-semantic retrieval. For this study, predictions were created based on two of these models: The discrete account by Levelt and colleagues (1999) and the Restricted Interaction Account (RIA) by Rapp & Goldrick (2000). For each participant a case summary was described about the individual recovery pattern in 0 -6 months post onset on the Boston Naming Test. A prediction from each model was assigned to each participant and tested for predictability.
The discrete model by Levelt and colleagues was found unable to predict recovery in aphasic naming based on the created predictions derived from the model. One prediction based on The Restricted Interaction Account by Rapp & Goldrick could be assigned and confirmed in seven patients. The Restricted Interaction Account by Rapp & Goldrick seems more useful to derive predictions for recovery of semantic and phonological paraphasias from. More research should be conducted to make more fine-grained hypotheses about recovery in aphasic naming.

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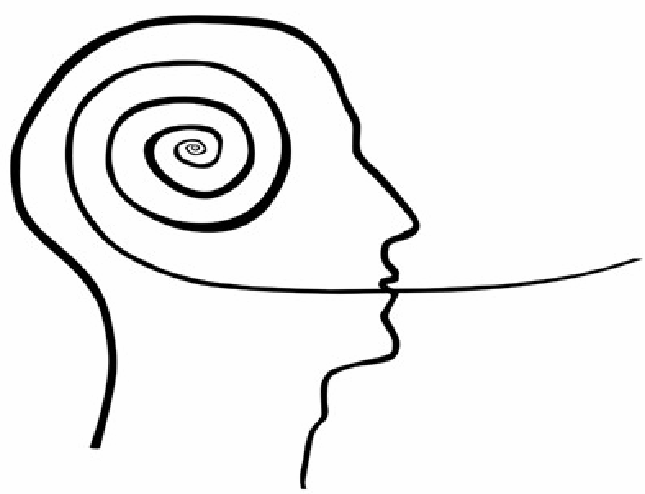
Preface

Summary



Chapter 1. Introduction

1. Background and motivation

Aphasia is capable of impairing the naming process in various ways. Differences in the functional locus of the deficit yield distinct error patterns. A well accepted fact is that two patients can achieve comparable levels of correctness on a picture-naming test but may generate quite different error profiles depending on the origin of the processing deficit.

Researchers have investigated data from impaired naming in aphasic patients to learn more about normal naming and speech errors. Numerous researchers have examined recovery of naming in patients with aphasia when provided with treatment (Kiran & Thompson, 2003). The authors state that several studies have used semantically based treatment by means of auditory and written words to picture matching tasks, answering yes/no questions about the target, spoken word categorization, and relatedness judgement tasks, and that other studies have compared the effects of semantic and phonological treatment on naming and, in general, have found that a combination of both treatments is to be most effective.
A study by Houthuizen et al. (unpublished) showed that patients who only received semantic therapy had on a naming task a decrease in semantic disorders and patients who only received phonological therapy had a decrease in phonological disorders. This effect was for the semantic therapy larger than for the phonological therapy. These two studies already show us, that there is a lot of discussion about the type of therapy that should be used and the effect of these therapies on naming. These studies also show that we are retrieving more knowledge about the type of therapy that should be used in aphasia rehabilitation. Even fewer researchers have examined error patterns resulting from treatment (Kiran & Thompson, 2003).

Paraphasias in aphasic patients can be analysed using linguistic models that explain lexical-semantic retrieval (Garrett, 1980; Levelt, et al., 1999; Dell, et al., 1997; Rapp & Goldrick, 2000). Every model explains normal lexical-semantic retrieval and then some explain word retrieval problems of aphasic patients by the model, for example the restricted interaction account by Rapp & Goldrick (2000).

A highly interactive model, such as the one by Dell and co-workers (Dell, et al., 1997) expects a lot of mixed errors (a semantic and / or phonological disorder), whereas the highly discrete model of Levelt and co-workers cannot reconcile these errors (Levelt, 2001). Another model is somewhere between these two former accounts: the restricted interaction account (RIA) by Rapp & Goldrick (Goldrick & Rapp, 2002).

In this study I have investigated the naming recovery after six months cognitive linguistic therapy (semantic and phonological therapy), which started directly after a patient had a stroke. In this thesis I present an experimental design for a group study which can be divided into two parts:

- Part I: I provide an in-depth view in recovery of naming errors, by performing a microanalysis which focused on correct answers, degree of semantic relatedness and degree of phonological overlap in patients who received six months of cognitive linguistic therapy.
- Part II: I present and test predictions about the recovery of semantic and phonological errors derived from the model by Goldrick & Rapp (2002) and the model by Levelt and colleagues (1999).

2. Research questions and hypotheses

First, I present my research questions and second, I present the hypotheses for both parts of this study.

The research questions can be divided into main questions and sub questions and are related to the two parts in this thesis that were mentioned above.

1. What is the recovery pattern of semantic and phonological paraphasias in aphasic naming in aphasic patients who received six months of cognitive linguistic therapy?
2. Can predictions be made about recovery of aphasic naming, based on the model of lexical access by Levelt & colleagues and by Rapp & Goldrick?

Based on the information gathered in Chapter 2 “Background”, hypotheses were made for several research questions.

For the following topics, hypotheses are found in paragraph 4.4 in chapter 2 “Background”. These hypotheses are related to Part I of this thesis.

- The predicted recovery of semantic and phonological paraphasias in aphasic naming and *type of aphasia*.
- The predicted recovery of semantic and phonological paraphasias in aphasic naming and *type of linguistic disorder at inclusion*.

For the following topic, hypotheses are found in paragraph 5.1.3 in chapter 2 “Background”. These hypotheses are related to Part II of this thesis.

- The predicted recovery pattern of semantic and phonological paraphasias in aphasic naming in *the model by Levelt and colleagues*.

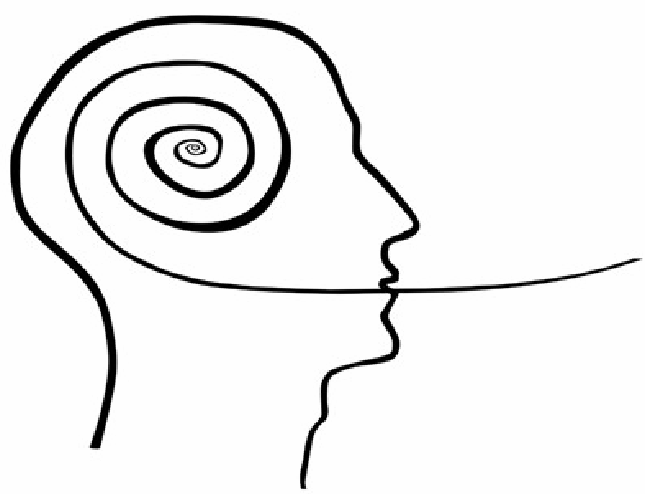
For the following topic, hypotheses are found in paragraph 5.2.3 in chapter 2 “Background”. These hypotheses are also related to Part II of this thesis.

- The predicted recovery pattern of semantic and phonological paraphasias in aphasic naming in *the model by Rapp & Goldrick*.

Continuing, several broad clarifications are in order. Since this thesis concerns speech production, interactions from other perceptual domains (e.g. object recognition) will not be discussed.
Second, this thesis focuses on lexical access of single morphologically simple words. Since full discussion of the influence of syntactic information would require broadening the discussion to include sentence production and other connected speech tasks, the role of syntactic features is also omitted.
Main effects of frequency, length, age of acquisition, concreteness and phonological neighbourhood density on naming are also not discussed in this thesis, even though word frequency and age of acquisition are important variables that have been identified to affect ease of lexical access (Bormann, et al., 2008).

3. Short guide through this thesis

The contents of this thesis are: In Chapter 2 you can find background information and the hypotheses that were used to investigate recovery in aphasic naming. In Chapter 3 the methodology of this present study is described. The results of this study can be found in Chapter 4, which are discussed in Chapter 5 along with some limitations of this study. Finally in Chapter 6 you can find the general conclusions and suggestions for further research.



Chapter 2. Background

In this chapter the following topics will be described for Part I: varieties of paraphasias in naming tasks; paraphasias and aphasia syndromes; paraphasias and linguistic disorders; and recovery in aphasic naming.
For Part II the following topics are described: linguistic theories about normal naming and naming deficits.

1. Varieties of paraphasias in naming tasks

One of the most common signs associated with left hemisphere injury and aphasia is anomia or word-finding difficulty: the inability to retrieve intended words during conversation or in structured language task, such as naming pictures to confrontation. Many investigations of word retrieval have focused on nouns; including several that indicate that left posterior (especially temporal) lesions are associated with noun-retrieval impairments (Raymer, et al., 2006). Unsuccessful attempts for retrieval generally resemble the target, either in sound (phonological level) or in meaning (lexical-semantic level).

I have described the varieties of paraphasias in naming tasks in six categories: formal paraphasic error, semantic paraphasic error, mixed paraphasic error, unrelated error, phonological error, non-word and other errors (Boles, 1997; Dell, et al., 1997).

1.1 Formal paraphasic error

A formal paraphasic error is a *real existing word* that meets the criterion of phonological similarity. This means that the answer shares either the initial phoneme or at least 1/3 or more phonemes with the target, for example, ‘dog’ becomes ‘desk’ or ‘pan’ becomes ‘pen’ (Nicholas, et al., 1996).
A characteristic of the formal paraphasic error is that it meets the grammatical category constraint: The error belongs to the same grammatical category as the target (Schwartz, et al., 2006). The difference with a phonological error is that the formal error is an existing word.

1.2 Semantic paraphasic error

A semantic paraphasic error is a *real word* response that is semantically related to the target: it's a synonym, a semantic category co-ordinate, a subordinate, a superordinate or a strong associate of the target.

- Semantic paraphasia: a response in the same semantic category (e.g., substituting the target word "penguin" with the word "seagull").
- Remote paraphasia: a response belonging to a different semantic category but sharing some semantic characteristic or trait with the target stimulus (e.g., substituting the target word "hose" with the word "snake" [both are thin, long, and bend]).
- Superordinates (e.g., substituting the target word "squirrel" with the word "mammal").
- Verbs or adjectives describing the target word (e.g., substituting the target word "mountain" with the word "rocky").
 (Boles, 1997; Dell, et al., 1997; Fargo, et al., 2005)

1.3 Mixed paraphasic error.

A mixed paraphasic error is a *real word* response that is related both phonemically and semantically to the target word. For example, the following target–response pairs share the same initial phoneme and also belong to the same semantic category or share some characteristic: "lemon"–"lime," "truck"–"trailer," and "lamp"–"light."
The following target–response pairs share a common phoneme and are made up of at least one other phoneme from a semantically related word: "clock"–"clotch" (clock–watch) and "calculator"–"compulator" (calculator–computer). (Boles 1997; Dell, et al., 1997; Fargo, et al., 2005)

1.4 Unrelated error

An unrelated error is a *real word* response that is neither semantically nor phonologically related to the target word (e.g. "clown" becomes "house"). (Dell, et al., 1997; Ruml, et al., 2000)

1.5 Non-word errors: phonological and neologistic non-words

There are two forms of non-words: phonological and neologistic non-word. Phonological errors are non-word errors that meet the criterion of phonological similarity (the answer shares either the initial phoneme or at least 1/3 of phonemes with the target, for example, 'dog' becomes 'deg' or 'dog' becomes 'dem' (Nicholas, et al., 1996)). Both phonological and formal paraphasias are errors that involve considerable phonological overlap with the target word. However they differ in lexical status. Formal paraphasias correspond to an existing word form, via either lexical misselection or phonological distortion (e.g. book → brook: a real word that phonologically resembles the target), while phonological paraphasias result in a pseudoword (e.g. book → dook: a non-word that phonologically resembles the target) (Nicholas, et al., 1996).

A neologistic non-word does not reach the criterion for phonological relatedness (i.e. sharing less than 1/3 of the phonemes with the target and with a different initial phoneme (Nicholas, et al., 1996)). Neologistic non-words can also be pseudo compound words (e.g. dog → kib, Ostrich → four west) (Dell, et al., 1997; Ruml, et al., 2000).
The difference between a phonological paraphasia and neologisms is one of degree. As with phonological paraphasias, neologisms conform to the phonology of the speaker's language. However, when the target for a phonological paraphasia is generally recoverable, the extreme phonological distortion of a neologism typically obscures the intended lexical target (Kohn, 1998; Robson, et al., 2003).

1.6 Other errors.

Other errors are all the errors that couldn't be placed in one of the previous error categories, like:

- Visual–semantic error: a response that is semantically related to the target word but is also similar visually (e.g., substituting the target word "zebra" with the word "horse" (Boles, 1997).
- Semantic rejection: the patient produces the rejection 'not a rake' for the correct answer 'rake' (Fargo, et al, 2005).
- Fragments responses: responses in which only the initial portion of the target word is given. The response may be any length short of the full word but not include any additional phonemes (e.g., substituting the target word "dragon" with "drag") (Dell, et al., 1997).
- Naming a part of the object or background of the stimulus (e.g., substituting the target word "beach" with the word "swimmer") (Dell, et al., 1997)
- Non-naming response: The patient declines to respond or indicates "don't know" or gives a description, generally multiword, that characterises the target or states its function (e.g., in response to the target stimulus "desk," the examinee says "a place where you can study") (Dell, et al., 1997; Nicholas, et al., 1996).
- Perseverations: The patient repeats a sentence or word that has been said earlier by the patient (Fargo, et al, 2005).
- Extremely vague or personal responses: 'I have one of those' or 'I forget the name of that thing' (Fargo, et al, 2005).

2. Paraphasias & aphasia syndromes

Here, the four main aphasia syndromes are described in short in order to indicate what type of aphasia we are dealing with. After this description the several naming deficits one can find in each syndrome are listed.

Wernicke's aphasia

Global description:

An important characteristic is paragrammatism and the fluent, excessive language production. Articulation and prosody are usually normal. Comprehension of language is poor, and some patients appear to understand no spoken language at all.

Specific naming deficits

The speech of the individual with Wernicke's aphasia is peppered with semantic and phonological paraphasias of all types, giving it a jargonlike quality. Failure and paraphasic errors characterise confrontation naming tasks. Also neologisms and generalisations are common in the language production.
(Dell, et al., 1997; Dharmaperwira-Prins, 2002; Doesborgh, 2004; Greatz et al. 1992; Love & Webb, 2001)

Anomic aphasia

Global description

These patients have also a fluent aphasia. When these aphasics produce language they have naming deficits and an overall intact sentence structure. Language comprehension is barely impaired and these patients have good communicative skills.

Specific naming deficits

These aphasic patients produce occasional semantic errors in the context of overt word searches, pauses, self corrections and circumlocutions. Sometimes they also produce formal paraphasias.
(Doesborgh, 2004; Greatz et al., 1992)

Broca's aphasia

Global description

These patients have a non-fluent aphasia. Most patients have a severely delayed language production with speech difficulties often due to verbal apraxia or dysarthria and impaired prosody. Another typical characteristic of this patient group is agrammatism. Their language comprehension is mildly impaired. The communicative abilities of these patients are severely impaired due to the expressive language disorders.

Specific naming deficits

Confrontation naming (naming objects & pictures) is poor: some phonological paraphasias and omissions can be observed. Sometimes they also produce semantic paraphasias which are strongly related to the target word.
(Dharmaperwira-Prins, 2002; Doesborgh, 2004; Greatz, et al., 1992; Love & Webb, 2001)

Global aphasia

Global description

These patients produce very limited language production due to language and speech disorders: they also have a non-fluent aphasia. Language comprehension is severely impaired. The communication abilities of these patients are very limited.

Specific naming deficits

Confrontation naming is severely or completely impaired in most patients. If the patient speaks at all, speech is restricted to recurring utterances or neologisms with occasionally an existing word.
(Dharmaperwira-Prins, 2002; Doesborgh, 2004; Greatz, et al., 1992; Love & Webb, 2001)

3. Paraphasias and linguistic disorders

Here, three linguistic disorders will be discussed: semantic disorder, semantic and phonological disorder and phonological disorder focused on disorders in the production of spoken words.

Semantic disorder

A patient with a semantic disorder may produce semantic paraphasias because the semantic encoder has problems with the retrieval of the right lemmas in the lexicon (Links, et al., 1996). Lemmas are abstract forms of words with semantic and syntactic information, while at the same time serving as a link between conceptual and form information (Goldrick & Rapp, 2002).
Semantic paraphasias can occur due to activation of related lemmas, for example 'cat' instead of 'dog'. Important to note is that when 'dog' is activated, this means that only a part of the semantic features are accessible by the patient and consequently the wrong lemma was selected (Links, et al., 1996). In a patient with a severe disorder even random lemmas can be selected and non-related errors will occur, for example 'cup' instead of 'dog'. In all verbal production tasks semantic paraphasias will occur (Links, et al., 1996).

Semantic and phonological disorder

When the route between the lemmas and the phonological word form level is disordered, problems will occur in the retrieval of words (Links, et al., 1996).
The problems depend on word frequency and are not consistent. It is possible that semantic paraphasias occur. The patient often has access to partly information of the word form, for example the first phoneme or some syllables (Links, et al., 1996). These retrieval problems are manifested in naming tasks and spontaneous speech and can be found in patients with an Anomic aphasia (Links, et al., 1996).
It's also possible that there is a problem in the access to the phonological word form level (Links, et al., 1996). The semantic representation used to address representations in the phonological output system can be insufficiently specified, and there can also be an additional problem in the accessing the phonological output system (Byng & Jones, 1997). In spontaneous speech a lot of phonological errors are presented besides the semantic paraphasias (Links, et al., 1996).

Phonological disorder

In a patient with a phonological disorder, phonological paraphasias are presented due to damage at the phonological encoder (Links, et al., 1996). The patient substitutes or replaces sounds in a word. Conduite d'appproche can also be a part of the speech of a patient with a phonological disorder (Links, et al., 1996). Here also formal paraphasic errors can occur due to a disruption in a phonological level of speech output. This can be expected to generate some phonologically related errors which would happen to be real words. It can happen because small phonological changes to many words yield to other real existing words, like the target 'dog' and a possible formal error answer 'desk'. The errors can be found in all speech production tasks (Links, et al., 1996).

4. Recovery in aphasic naming

Researchers have been investigating aphasic patients for naming and recovery in aphasia for centuries. In this paragraph I will discuss some findings about the recovery period, recovery in naming errors and recovery in aphasia syndromes. Finally, hypotheses are presented about the recovery pattern of semantic and phonological paraphasias in aphasic naming and *type of aphasia* and *type of linguistic disorder at inclusion*.

4.1 Recovery period

Several studies have been conducted which describe the recovery period in aphasia. Ferro et al. (1999) described some results from longitudinal studies of aphasia that have evaluated patients within the first month post onset and followed them up at 3, 6 and 12 months post onset.
Almost all studies agree that most of the spontaneous recovery takes place during the first 1 – 3 months (Lomas & Kertesz, 1978; Lazar, et al., 2008). Ludlow (1981) has described some results which are interesting to discuss. Recovery seems to be most rapid between the end of the first month and during the second month following onset, but it has been found to continue through the third month in almost all cases. Several reports also indicated that recovery continues to occur past the third month. However, with increasing time past the onset of aphasia, the amount of language change is continually decreasing (Ludlow, 1981). After one year, very little spontaneous recovery is to be expected, and language proficiency may even decline later (Ferro, et al., 1999).

4.2 Recovery in naming error types

Aphasic naming was examined across a range of severity and reliable associations between severity and error type can be seen.
Patients who achieved a low level of correctness on a picture-naming task are more prone to non-naming responses (omissions, circumlocutions) and to naming responses bearing no obvious relation to the target (Schwartz & Brecher, 2000). As severe patients recover, they produce a higher proportion of naming attempts and target related words and non-words (Schwartz & Brecher, 2000). Other studies have examined patterns of word retrieval errors over time and have indicated an evolution towards improved naming and reductions in the incidence of off-target errors such as neologisms and no-responses (Raymer, et al., 2000). Over time Raymer et al. (2000) observed a reduction in the number of unrelated unrecognizable answers and no-responses, as well as semantic errors. Some semantic errors persisted in naming tasks.
Important to realise is the comment of Kertesz and McCabe (1977) that anomia is a frequent end stage in the evolution of aphasic disability. This would suggest that naming is often a residual deficit found in aphasics and is, therefore, less amenable to the recovery process or at least has a longer time course in recovery than most other language tasks.

4.3 Recovery in aphasia syndromes

Another factor that influences the view on recovery is the type of aphasia. Among the factors purported to determine language recovery after stroke, initial syndrome severity and lesion size have been reported to be important predictors (Demeurisse, et al., 1980; Lazar, et al., 2008).

Broadly speaking, anomic and conduction aphasia syndromes have better outcomes. Transcortical aphasia and Broca's aphasia have intermediate prognosis, while Wernicke's aphasia and global aphasia have a worse prognosis (Ferro, et al., 1999). Lomas and Kertesz (1978) described a few studies which are in disagreement as to which type of aphasic improves most. Like a study by Vignolo (1964) of largely post-stroke patients in which this author found that those patients with expressive disorders had the poorest prognosis and these disorders negatively affected recovery to a far greater extent than receptive problems did. However, a later prospective study by Basso et al. (1975) found no significant differences in the rates of recovery for Broca's and Wernicke's aphasics (Lomas & Kertesz, 1978).

It has also been described in literature that some aphasia syndromes evolve during recovery into another aphasia syndrome.

Global aphasia

For example, a patient with global aphasia starts from a transient period of muteness and anarthria, to produce stereotype utterances and emotional expressions. The utterances differentiate by intonation following communication intent and become more varied. If recovery continues, agrammatical speech follows. The initiation of word production may be hampered by oral apraxia. (Ferro, et al., 1999).

Wernicke's aphasia

Similarly, severe Wernicke's aphasia usually evolves to anomic aphasia or less often to conduction aphasia.
A person with copious neologistic jargon with anosognosia, improves to a lower-frequency semantic jargon and eventually to anomia with occasional paraphasias. Green (1969) has also compared the various recovery levels of a jargon aphasic. He noted that there was a significant decrease – over a period of approximately a year – in the occurrence of jargon episodes, neologisms and unrelated phonological paraphasias. Literal paraphasias and semantic verbal paraphasias were more numerous in the final interviews. Thus after a period of time, "the phonological paraphasias get closer and closer to the target words" and "the number of neologisms gradually decreases" or disappear. As the neologisms begin to resolve, semantic paraphasias and circumlocutions will appear for a while. The word-finding difficulties become more obvious as marked by hesitations, circumlocutions, semantic paraphasias and use of semantically weak words (Buckingham, 1981). Kertesz and Benson (1970) also discussed evolution in jargon aphasia and showed that a clinical picture often follows a regular pattern throughout stages of recovery.

They state that “the clinical pictures changes from the more severe stage of jargon, where most of the speech is neologistic, to semantic jargon, where most words are recognisable, although inappropriate, and finally to anomic circumlocutory speech with meaning” (Buckingham 1981).

Broca’s aphasia

In Broca’s aphasia, during the very acute stages after stroke, these patients may only produce verbal stereotypes. Propositional speech may emerge slowly beginning as single words with a slow labored rate of production and frequent sound distortions. Once propositional speech begins to predominate the prognosis is improved (Ludlow, 1981).

Anomic aphasia

Raymer et al (2000) described that error patterns in a patient with an acute onset of anomic aphasia evolved from off-target and semantically related responses towards correct responses in a picture naming task. But an anomic aphasia can also occur following significant recovery from Wernicke’s or Broca’s aphasia (Ludlow, 1981). A patient with an anomic aphasia has problems with retrieving the correct phonological word form and present conduite d’approche. Formal errors and semantic paraphasias can occur (Dharmaperwira-Prins, 2002).

4.4 Hypotheses about recovery of semantic and phonological paraphasias and type of aphasia and type of linguistic disorder at inclusion

Based on the information gathered in Chapter 2 “Background”, the following hypotheses were made about the recovery pattern of semantic and phonological paraphasias in aphasic naming and type of aphasia and type of linguistic disorder at inclusion. These hypotheses will be tested with the results gathered in the micro analysis.

4.4.1 Hypotheses about recovery of semantic and phonological paraphasias and type of aphasia

In this study, there is a focus on fluent aphasic patients due to the linguistic models that are used for Part II of this study. Therefore only hypotheses will be made for the two main aphasia syndromes that present a fluent aphasia: Wernicke’s aphasia and Anomic aphasia.

- A patient with Wernicke’s aphasia is expected in recovery to evolve to a more anomic aphasia: paraphasic errors, the neologisms decrease in recovery to generalisations, semantic paraphasias, other errors (overt word searches, pauses, self corrections and circumlocutions), and some phonological paraphasias, so the mean score of phonological overlap index, the mean score of semantic relatedness and the proportion of correct answers increase.

- A patient with Anomic aphasia produces primary formal errors and occasional semantic errors that should evolve from off-target phonological (for the formal errors) and/or semantically (for the semantic errors) related responses toward correct answers in a picture-naming task, so the mean score of phonological overlap index, the mean score of semantic relatedness and the proportion of correct answers increase.

Important to note is that despite another underlying aphasia syndrome, the recovery patterns for patients with Wernicke's aphasia and Anomic aphasia are equal: it is expected that for both groups the mean score of phonological overlap index, the mean score of semantic relatedness and the proportion of correct answers increase.

4.4.2 Hypotheses about recovery of semantic and phonological paraphasias and type of linguistic disorder at inclusion

Hypotheses about the recovery pattern of semantic and phonological paraphasias and type of linguistic disorder are made for all three variants: phonological disorder, semantic disorder and phonological & semantic disorder.

- A patient with a phonological disorder will produce in recovery fewer neologisms and more phonological paraphasias, so the mean score of phonological overlap index and the proportion of correct answers increase.
- A patient with a semantic disorder will produce in recovery semantic paraphasias that get more and more related to the target word (qua semantic features), so the mean score of semantic relatedness and the proportion of correct answers increase.
- A patient with a semantic and a phonological disorder will produce fewer neologisms but the semantic and/or phonological paraphasias will remain and improve, so the mean score of phonological overlap index, the mean score of semantic relatedness and the proportion of correct answers improve.

Notice that the recovery pattern of a patient with a semantic and a phonological disorder is the same as a patient who is classified as a Wernicke's aphasia or Anomic aphasia (see above).

5. Theories about normal naming and about naming deficits

As mentioned earlier, naming deficits are a problem that all aphasic patients have. The severity of this disorder has a wide variation from very light to severe problems. Nowadays we already know that not all naming deficits have the same originating disorder and that there are different types of naming deficits. They also depend on the place and size of the lesion and the corresponding aphasia syndrome. (Dharmaperwira-Prins, 2002).

Research on spoken word production has been approached from two angles. In one research tradition, the measurement of picture naming latencies led to chronometric models accounting for distributions of reaction time in word processes. In another tradition, the analysis of spontaneous or induced speech errors led to models that can account for speech error distributions (Levelt, 1999).
Naming studies with patients remain an important source of data for testing competing models of speech production and in particular lexical access (Schwartz, et al., 2006).

In the literature about naming deficits you can find linguistic models of lexical access that share the core assumption that there are at least three distinct types of representations involved in speech production: semantic, lexical and phonological. Models also share the assumption that the semantic representation of the target words sends activation to the lexical layer, activating a set of semantically related lexical nodes. The lexical node with the highest activation level is selected from the set of activated nodes (Cuetos, et al., 2000).
Beyond this basic architecture there is little overlap among models. An important area of disagreement concerns the mechanism by which representations at each of these levels are activated. (Cuetos, et al., 2000). Another important area of disagreement is the degree in which there is a discrete or interactive relation between the separate modules (semantic, lexical and phonological module).

There are two theories that occupy extreme positions on the continuum of interactivity. Dell and colleagues (Dell, et al., 1997) present a model with a highly interactive position, in which the processes exert considerable mutual influence over one another. Levelt and colleagues' model (Levelt, et al., 1999) holds a highly discrete position, in which the processes occur virtually independently. Goldrick & Rapp (2002) state, that there is also an alternative position; the restricted interaction account. This is a result of combining aspects of the other two accounts. (Goldrick & Rapp, 2002)

In this study I have used the model by Rapp & Goldrick and the model by Levelt and colleagues. Before I explain the two models more extensively I just briefly mention the principle features of each.

Under the discrete account by Levelt and colleagues, semantic processing and phonological processing are independent, with semantic processing strictly preceding phonological processing (Levelt, et al., 1999). The characteristics of this model are:

- The processing proceeds in a strictly forward direction,
- Processing is confined to the current processing stage only,
- Only the item or items selected at the end of a given stage are processed at the following one, and
- There are clear selection points at the end of each processing stage (Rapp & Goldrick, 2000).

Under RIA (Restricted Interaction Account) by Rapp & Goldrick, both phonological and semantic processes are able to influence one another in a limited manner: while there is feedback from the phoneme level to the lexical level there is no feedback from the L-level up to the semantic level; furthermore the strength of the feedback from the phoneme level is also limited (Goldrick & Rapp, 2002).

The characteristics of this model are:

- The processing proceeds in a strictly forward direction, but there is a backward flow of activation specifically from the phoneme level back to the lexical level,
- Activation is not restricted to the current processing stage, but, instead, that activation cascades forward to subsequent processing stages, and,
- Although there are selection points at the end of each stage, processing of all items proceeds to the following stage (Rapp & Goldrick, 2000).

5.1 The discrete two-step model by Levelt and colleagues.

Levelt and colleagues (Levelt, 1989; Levelt, et al., 1999) have described one of the most detailed models of lexical access: the discrete two step model. This model conceives of lexicalisation as consisting of two independent stages. The model assumes a strictly feed forward flow of activation. It further assumes discrete processing, i.e. non-overlapping stages of semantic-syntactic and phonological processing. Crucially, the phonological form of a word is only accessed after its respective lemma has been selected (Bormann, et al., 2008).

5.1.1 Model's procedure

The strictly, serial discrete account like the one by Levelt and colleagues, assumes that all semantic processing is completed before any phonological processing begins. These assumptions work due to restricting activation flow. The model can be seen in figure 1. The following is a description of how the model works.

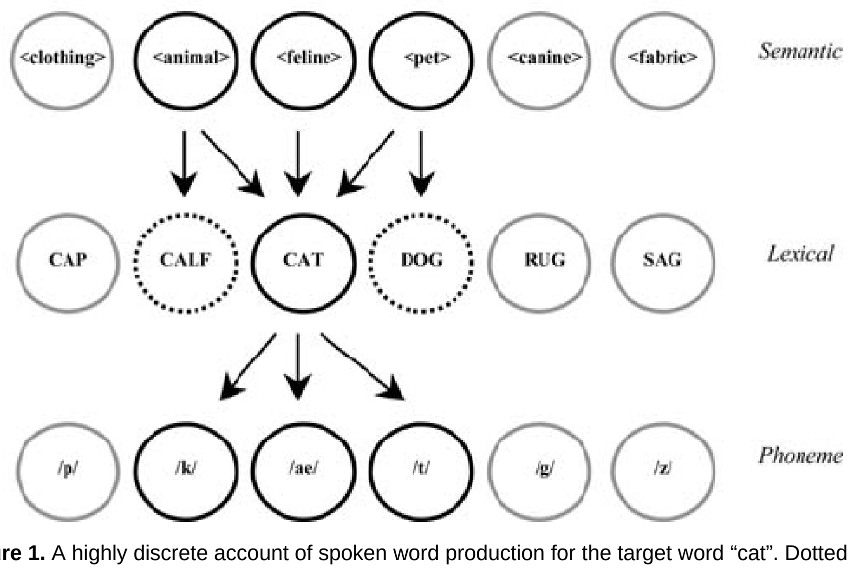


Figure 1. A highly discrete account of spoken word production for the target word "cat". Dotted lines and units show activation due to semantic overlap with the target; dashed lines and units show activation due to phonological overlap with the target. (Concentric circles denote units activated by both semantic and phonological overlap. Greyed-out units are not strongly activated by the target.) Rapp, et al., 2006).

Stage 1: Imagine a subject is shown a picture of a cat and asked to name it. The first stop in preparing a content word is to focus on a concept whose expression will serve a particular communicative goal. This process is called 'perspective taking'.

Some concepts are lexical concepts, those for which there is a lexical item in the mental lexicon. To initiate lexical selection, the speaker must focus on a lexical concept (Levelt, 2001). For this example let's use the concept <CAT>: feline, animal, pet. The theory assumes that during perspective taking there is co-activation of related concepts. Each active lexical concept spreads activation to the corresponding lexical item in the speaker's mental lexicon (Levelt, 2001). That item is called a lemma; it's an abstract form of the word with semantic and syntactic information, while at the same time serving as a link between conceptual and form information (Goldrick & Rapp, 2002).

The target lemma, i.e., the one activated by the focused concept, is selected under competition. The selection latency depends on the amount of co-activation of other lemmas (parallel activation). Lexical selection is complete as soon as the target lemma is selected (Levelt, 2001). The model thus allows for parallel activation at the lemma level, but strictly excludes activation of more than one entry at the form level (Bormann, et al., 2008). The phoneme units during this process are inactive.
The lemma that is eventually selected in turn activates its corresponding word form during the second stage of lexical access (Roelofs, 1997).

Stage 2: the selected lemma is the only unit that sends activation down to its phonemes. Thus, neither semantic nor syntactic neighbours of the target are active during stage 2. Activation spreads from just the selected lemma to the phonological codes it point to; no other codes get co-activated. Phonological codes are spelled out as ordered sets of phonological segments, for instance /k, ae, t/ (Levelt, 2001).
This forms the input to the operation of 'prosodification', which is largely syllabification. An item's syllabification is not stored in the mental lexicon but created on the fly, dependent on the current context (Levelt, 2001). As syllables are incrementally composed, they are input to a final encoding step, phonetic encoding.
A core assumption of the theory is the existence of a mental 'syllabary'. This is a repository of highly practiced syllabic gestures. As syllabication proceeds, the corresponding syllabic patterns are selected from the syllabary for execution.
Phonetic encoding also involves the smooth concatenation of retrieve syllabic routines.
The string of syllabic gestural routines that corresponds to the target phonological word is called articulatory score. It is the output of the form encoding and the final product of lexical access (Levelt, 2001).

5.1.2 Error types in this model

What I have described so far is the processing in normal naming. What can go wrong in this model? Within this model different errors may be associated with different stages of lexicalisation.

Lexical errors

Levelt's theory, by subdividing the semantic process into the conceptual and lemma stages, provides for several mechanisms of word substitution. Both semantically based errors and word blends due to the competition between two lemmas are possible within the scope of this model.

If competition occurs at the conceptual stage, a lemma corresponding to a related, but off-target concept may become activated, resulting in a semantic real word error. It could be possible that the lemma is not accessible and this will lead to semantic paraphasias (Bormann, et al., 2008).
At the conceptual level, links between the target concept and closely associated concepts may provide sufficient activation to one of the latter concepts. This results in its lemma being accessed in place of the more precise target lemma. This is particularly likely if the associated happens to be of a higher frequency than the target or if it is associatively linked to a recently used word. (Goodglass, 1998). The number of semantic errors tends to rise when many semantic competitors are available. When there are few semantic competitors, errors of emissions are more frequent (Bormann, et al., 2008). Substitution may also occur in the lemma stage, as a result of the semantic link between lemmas (Goodglass, 1998).

Non-word errors

According to Levelt's theory, phonologically based words substitution cannot occur before or during lemmas selection, because no phonology is available prior to that stage. One exception would be in the type of error cited immediately above, whether the phonology of two semantically related lemmas is telescoped into a single word or non-word. Such errors would have to be extremely rare and would require the competing lemmas to be equally plausible members of the set of potential responses. (Goodglass, 1998; Levelt, et al., 1999).

Word-finding blocks or tip of the tongue experiences have been associated with a temporary inability to access the word's phonological form: the phonological code of a selected target item is temporarily partly or wholly unavailable, where as syntactic, i.e., lemma information is largely preserved (Levelt, 2001).
Partial retrieval of word phonology appears in at least three distinct forms; production of an opening fragment, multiple attempts, always preserving with a proportion of the target word phonology in combination with extraneous sounds, evanescent appearance of portions of the target phonology in the course of multiple attempts.
In terms of Levelt's theory, all of these varieties of partial phonological production imply that the lemma has been accessed and that the failure is at the downstream point (Goodglass, 1998).

Phonemic paraphasias occur due to problems with the selection and arrangement of phonemes, but the phonological word form is correctly retrieved. This access seems to be in form with other accounts of anomic word finding difficulties in aphasia, which all allocated word-finding difficulties at the level of accessing phonological word forms (Levelt, et al., 1999). In most of these models, word form generation is assumed to be controlled by a threshold which must be reached by lexical activation. Words of higher frequency may have a lower threshold facilitating production. In case of an aphasic word finding block, or error of emission, no lexical entry is assumed to have received activation above its threshold and thus, no entry is being processed any further (Bormann, et al., 2008).

Mixed errors

The model cannot predict a mixed error effect because it does not allow for integration of semantic and phonological drive activation required to provide an advantage to a mixed neighbour over both semantically or formally related neighbours (Bormann, et al., 2008); Rapp & Goldrick., 2000). There is, of course, some probability that a semantic error will, by chance, be formally similar to the target and also that a phonological error will, by chance, be semantically related to the target. So, in a discrete system, mixed errors can occur, but at rates no greater than would be expected by chance during L-level and phoneme level selection (Goldrick & Rapp, 2002).

Summary

To summarize under the discrete account, Stage 1 errors are based only on semantic similarity, and Stage 2 errors are based only on phonological similarity. Importantly, this is not to say that Stage 1 error will bear only semantic similarity to the target, and Stage 2 errors will bear only phonological similarity to the target.
Important to note is that under the discrete account, lexical outcomes should not be favoured over non-lexical outcomes during Stage 2 processing. Given this, as phonological errors arise during this stage, the discrete account predicts that lexical outcomes should occur at chance level rates for errors that are phonologically similar to the target words (Goldrick & Rapp, 2002).

5.1.3 Hypotheses about recovery in aphasic naming in this model

For this study hypothesis were made about recovery of aphasic naming, based on the model by Levelt and colleagues. Since no aphasia syndromes are described in these models, the focus will be on three linguistic disorders: semantic disorder, phonological disorder and semantic & phonological disorder. These hypotheses will be tested with the results of the macro analysis.

1. Due to reduction of noise at lemma selection and/or lexical concepts, a patient who presents only semantic errors, will produce in recovery fewer semantic paraphasias and more correct answers.
2. Due to the reduction of noise at the selection of the phonological word form and/or combining of phonological segments, a patient who only presented non-word errors, will produce in recovery fewer neologisms and more phonological paraphasias and correct answers.
3. Due to reduction of noise at the lemma selection and/or lexical concepts and/or the selection and/or combining of the phonological segments, a patient who has a multiple error type pattern, will still produce them all in recovery but in a smaller degree and at the same rate (still fewer formal errors than non-word errors); will produce more correct answers, but produces more phonological paraphasias which are more related to the target instead of the extreme phonological distortion of a neologisms.

5.2 Restricted Interaction Account by Rapp & Goldrick

The Restricted Interaction Account (RIA) incorporates two mechanisms to create interaction, although restricted. This model uses cascading activation and feedback from the phoneme level to the lexical-level. The restricted interaction account also retains considerable discreteness by among other things, excluding feedback from the lexical level to the semantic level (Goldrick & Rapp, 2002).

5.2.1 Model's procedure

Roughly said, according to Rapp & Goldrick, the highly discrete position incorrectly predicts that semantic and phonologically based processing should never interact, and in contrast, the highly interactive position allows for too much interaction. In response to these challenges Rapp & Goldrick (2000) proposed an account that allows for interactions, but also restricts it: the restricted interaction account (RIA). How does this model work? Again the model is presented here and this model also works with two stages as shown in figure 2.

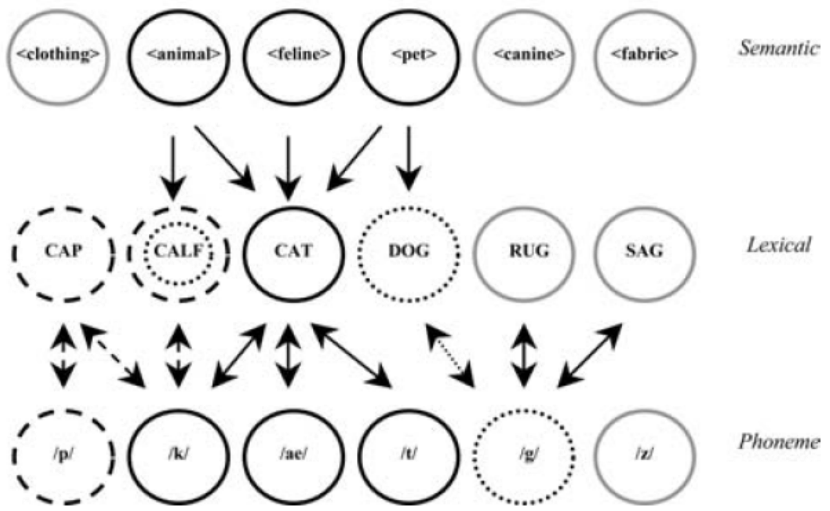


Figure 2. Restricted interaction accounts of spoken word production for the target word "cat". Dotted lines and units show activation due to semantic overlap with the target; dashed lines and units show activation due to phonological overlap with the target. (Concentric circles denote units activated by both semantic and phonological overlap. Greyed-out units are not strongly activated by the target.) Rapp, B. et al. (2006).

Stage 1: The processing starts with the activation of the semantic features that are associated with the lexical concept (here CAT). Activation from these features spreads to the lexical level and the syntactic features. Here the target and its syntactic (CALF) and semantic (DOG) neighbours are activated.
The activation is also passed on to the phoneme units. In this way the phonemes of the target and its semantic neighbours become active. In addition, the phoneme units feed back to the lexical level units, activating formally related neighbours of the target. This allows phonologically based processing to influence the outcome of Stage 1. However this activation does not feed back onto the semantic level in contrast to the highly interactive model (Goldrick & Rapp, 2002).

Stage 1 ends in the selection of the most active lexical level unit. This happens in the same manner as in the other accounts: this process enhances the activity of the selected lexical level unit relative to its competitors (Goldrick & Rapp, 2002).

Stage 2: Since the selected lexical level unit is more active than the other competitors, this will result in a domination of the stage 2 processing by this selected unit. Important to realise is that the other lexical level units are also allowed to pass on their activity to the phoneme level. Furthermore, activation also continues to feed back from the phoneme units to the lexical level units. This allows semantic and syntactic competitors to influence Stage 2 processing. Stage 2 ends with the selection of the most active phoneme units (Goldrick & Rapp, 2002; Rapp & Goldrick, 2000; Rapp, et al., 2003).

Goldrick et al (1999) proposed a post-lexical phonological process that takes as input the phonemes selected at the end of stage 2, and from them generates a detailed phonological representation that is used to drive articulatory processing.
This proposal is based on an often-made distinction between processes that *retrieve* stored phonological information and processes that *fill-in* and elaborate the stored information (Goldrick, et al., 1999).

5.2.2 Error types in this model

This model limits strong bi-directional interaction to processes which are involved in the same representational type. Rapp & Goldrick showed that the model can be damaged to account for both the multiple error types as well for the production of only semantic errors or only phonological errors (Goldrick & Rapp, 2002; Rapp & Goldrick, 2000; Rapp, et al., 2003). How can the error types be found in the model?

Lexical errors

In systems with cascading activation (with or without feedback), significant disruption to any of these three levels should result in at least some *semantic errors*. This is because in either discrete or interactive systems, semantic neighbours are, of course, very strong competitors at the semantic and L-levels; cascading activation provides support for semantic neighbours at the phonemes level as well. Thus the RIA would appear to predict that all aphasics should produce at least some *semantic errors* in naming.

Under the RIA, phonological effects can provide *mixed errors*. It's interesting to look at the phonological effect at the L-level, at the semantic level and at the phoneme level, to see in what way mixed errors are created.

The phoneme level to the L-level feedback in RIA allows for the possibility of a *mixed error* effect subsequent to L-Level damage. Because of the feedback, mixed L-level neighbours of a target such as CAT (e.g., RAT) receive top-down activation from the semantic neighbours and bottom-up activation from the phonemes they share with CAT. This gives them an advantage over both semantic neighbours (e.g., DOG) that receive only semantically based activation and formal neighbours (e.g., SAT) that receive only phonologically based activation.

At the same time, however, feedback between the phoneme and L-levels must be limited to prevent formal neighbours from becoming strong competitors at the L-level and appearing as errors subsequent to the l-level damage (Goldrick & Rapp, 2002). Simulation experiments by Rapp & Goldrick have confirmed the idea that it is possible to have a certain damage to the L-level with enough restricted feedback to avoid formal errors while still generating a *mixed error* effect (Goldrick & Rapp, 2002).

By allowing feedback from the L-level, RIA prevents phonological effects from arising at the semantic level. At his level, *mixed errors* (e.g., RAT) receive only semantically based activation. This should produce the same outcome under damage as expected by the highly discrete account. As all semantic neighbours are equally likely to be selected, there can be no mixed error effect at the semantic level in RIA (Goldrick & Rapp (2002)). Simulation experiments by Rapp & Goldrick, have confirmed the possibility of the *absence of mixed error* effects following damage to semantic processes. (Goldrick & Rapp, 2002).
Under RIA, at the semantic level formal neighbours of the target receive no activation (despite being active at the L-level). This renders them essentially inactive, and makes *formal errors* extremely unlikely error outcomes (Goldrick & Rapp, 2002).

As has been described earlier, RIA allows for a *mixed error* effect following L-level damage. But can RIA also allow for a mixed error effect following damage to the phoneme level? Because of cascading activation both prior and following L-level selection, semantic neighbours activate their phonemes (Goldrick & Rapp, 2002). Goldrick & Rapp have also simulated this effect and they found that damage to the phoneme level in the simulation yielded significantly more *mixed errors* than *formal errors* (Goldrick & Rapp, 2002).

Non-word errors

Goldrick and Rapp (2002) argue that the pattern of only *phonological errors* can be explained by damage to post-lexical phonological processing that occurs subsequent to the processing stages that have been discussed so far (Goldrick & Rapp, 2002). If a patient produces only *phonological errors*, the activation in the model does not cascade from the phoneme level to the post-lexical phonological level. Given this, errors during post-lexical phonological processing should be influenced solely by phonological factors, and not by semantic or lexical information.

Deficits at this stage of the model (phoneme level to post-lexical phonological level) should differ in more ways than simply with regard to the presence or absence of semantic errors (Goldrick & Rapp, 2002). Goldrick & Rapp (2002) concluded that that post-lexical phonological processing is sensitive to the phonological environment of segments, whereas processes at the phoneme level treat all segments similarly, regardless of syllabic processing (Goldrick & Rapp, 2002).

Multiple error types

An important mechanism that creates a bias for lexical outcomes generates more word errors than expected by a highly discrete account. However, such a mechanism does not necessarily generate, in absolute number, more word than non-word errors (Goldrick & Rapp, 2002).

However, Nickels (2000) has described aphasic patients that produce many error types in varying proportion and show an overall low level of accuracy. RIA does not produce such a pattern following damage to the semantic or the L-levels; damage to these levels primarily produces semantic errors (Goldrick & Rapp (2002)).
Multiple error types are not readily generated in RIA with damage to the phoneme level. Although damage to the phoneme level alone yields multiple error types and a lexical bias effect, formal errors are not produced in greater number than non-words. There are, however, at least two ways to generate this pattern under RIA. One is to assume that the subject that exhibits this pattern may have a form of L-level damage. Another is to assume mixed damage affecting both the L and phoneme levels (Goldrick & Rapp (2002)). Goldrick and Rapp found that both ways are possible to generate this pattern under RIA, but that based on the large number of formal errors (in excess of non-word errors), it is clear that these individuals have difficulty in L-Level selection.

5.2.3 Predictions about recovery in aphasic naming in this model

Rapp & Goldrick (2002) showed that the model can be damaged to account for both the multiple error types as well for the production of only semantic errors or only phonological errors (Goldrick & Rapp, 2002; Rapp & Goldrick, 2000; Rapp, et al., 2003). No research has been done about recovery error patterns in this model. Based on the error patterns, described in paragraph 3, predictions can be constructed on naming recovery in this model.

In a short meeting with Mrs. B. Rapp I discussed these predictions with her. One thing she expected was that during recovery the error patterns will not change, but the number of errors will decrease and the number of correct answers will increase. One other thing to keep in mind is that the type of therapy (phonological or semantic) will influence the recovery. If a patient with a phonological error pattern also receives semantic therapy, this patient could also develop semantic paraphasias and/or mixed errors.
Another thing that influences the making of predictions is that the last two levels are interactive which make the outcome due to the influence of therapy unpredictable (Cox, 2008).

Using the above information about the occurrence of errors under RIA the following error patterns and recovery hypotheses can exist in this model:
1. During recovery the noise at the post-lexical phonological processing will be reduced and a patient who has only a phonological disorder will produce fewer phonological errors will that resemble more and more the target (more correct phonemic features). The patient will also produce more correct answers
2. Due to reduced noise at the semantic level and/or to the L-level and/or the phoneme level, a patient who has only a semantic disorder will show recovery in semantic errors that will resemble more and more the target (qua semantic features) and will produce more correct answers.
3. During recovery the noise at the phoneme level will decrease and in a patient who has a semantic and phonological disorder, all error types remain but in a smaller degree and the same rates (no more formal errors than non-word errors and more mixed errors than formal errors) and the patient produces more correct answers.

5.3 Differences between the hypotheses for recovery of naming errors based on the model by Levelt and colleagues and the model by Goldrick & Rapp.

There are some main characteristics in the models which create some differences in the occurrence of some errors.
One difference is that due to the restricted interaction between the lexical and the phoneme level, the RIA can account for mixed errors more easily than the model by Levelt and colleagues. In the model by Levelt and colleagues, mixed errors can only occur due to two possible mechanisms which are not very likely to happen: There is some probability that a semantic error will, by chance, be formally similar to the target and also that a phonological error will, by chance, be semantically related tot the target. In the RIA, the phoneme level to the L-level feedback allows for the possibility of a mixed error effect subsequent to L-Level damage, as has been described in paragraph 5.2.2.
Another difference between the models is the rate of formal errors versus non-word errors. The Levelt model is expected to create more non-word errors than word errors. In the model by Goldrick & Rapp it is expected, also by influence of lexical bias, that there are more word errors (although this not necessarily means the generation in absolute numbers of more word than non-word errors).
The last difference that will be described here is that the RIA predicts that semantic errors can occur at each level (semantic, lexical and phoneme level) in contrary to the Levelt model where they can only occur at the semantic level. This difference is confirmed by information from other studies namely that most aphasic patients produce at least some semantic errors.

The hypotheses that were described for each model are different with respect to the theory of lexical-semantic access of each model and the level within each model at which you can expect noise to cause problems in the model. A comparison of these models can be found here:

Type of linguistic disorder	*Noise level in the model of Levelt and colleagues (1999)*	*Noise level in the model of Goldrick & Rapp (2002)*
Semantic disorder	Lemma selection	Semantic level and/or lexical level and/or phoneme level
Phonological disorder	Selection of phonological word form and/or combining of phonological segments	Post-lexical processing
Semantic and phonological disorder	Lemma selection and/or selection of phonological word form and/or combining of phonological segments	Phoneme level

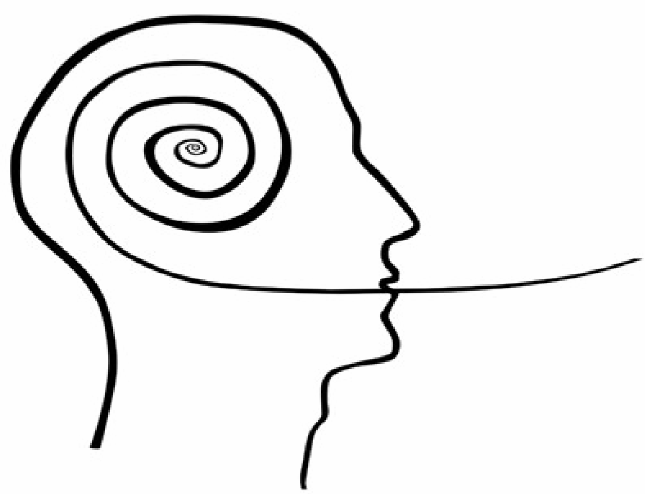
The recovery patterns that are expected in the hypotheses for both models are based on the information that was described in chapter 2 paragraph 3 "Recovery in aphasic naming" and the recovery patterns that are expected are for the phonological disorder and the semantic disorder for both models the same. For the semantic and phonological disorder the predicted recovery patterns in both models are different because these patients present a multiple error type pattern which is explained differently by each model. For example, these multiple error patterns yield to different error rates according to the two models. I will repeat therefore once more the two hypotheses from both models for patients with a semantic and phonological disorder who present a multiple error type pattern.
The hypothesis for recovery of aphasic naming based on the model by Levelt and colleagues (1999):
Due to reduction of noise at the lemma selection and/or lexical concepts and/or the selection and/or combining of the phonological segments, a patient who has a multiple error type pattern, will still produce them all in recovery but in a smaller degree and at the same rate (still fewer formal errors than non-word errors); will produce more correct answers, but produces more phonological paraphasias which are more related to the target instead of the extreme phonological distortion of a neologisms.

The hypothesis for recovery of aphasic naming based on the RIA by Rapp & Goldrick (2002):
During recovery the noise at the phoneme level will decrease and in a patient who has a semantic and phonological disorder, all error types remain but in a smaller degree and the same rates (no more formal errors than non-word errors and more mixed errors than formal errors) and the patient produces more correct answers.

The main differences between the underlying ideas of these two models make clear that the hypotheses for recovery in aphasic naming between these two models are different. All this taken together I expect that the hypotheses based on the RIA by Goldrick & Rapp can account for more error patterns in fluent aphasic patients than the hypotheses based on the model by Levelt and colleagues.

6. The objective of this thesis

This thesis presents an experimental design for a group study to investigate the recovery of naming errors in a naming task after treatment of aphasic patients. A macro analysis will be performed for Part II of this study whether predictions based on the model by Levelt and colleagues and the RIA by Rapp & Goldrick can be used to predict the recovery of aphasic naming. At this moment these models do not make predictions about recovery of paraphasias in the acute phase after stroke.
A micro analysis for Part I of this study, which focuses on correct answers, semantic relatedness and phonological overlap index, will provide an in-depth view in the recovery of aphasic naming and is also related to type of aphasia and type of linguistic disorder.



Chapter 3. Method

1. Short summary about the Rotterdam Aphasia Therapy Study 2.

In the Neurology ward of the Erasmus MC in Rotterdam (the Netherlands) under the guidance of Dr. E. Visch-Brink, several studies carried out around therapy for aphasia. As a clinical linguist intern I participated in the Rotterdam Aphasia Therapy Study (RATS-2). This study is co-ordinated from the Neurology ward by Drs. M. de Jong – Hagelstein who is a speech and language therapist and neuropsychologist.

In the RATS-2 are two types of aphasia therapy compared with each other from the acute stage after stroke. This study is an effect study that follows from RATS-1.
First the reason why the RATS-2 superseded RATS-1 is described.
In RATS-1 two Dutch cognitive-linguistic therapies were compared with each other: BOX (Visch-Brink & Bajema, 2001) and FIKS (Van Rijn, et al., 2000).
BOX is a therapy programme that focuses on lexical semantics, which means the coherence between word and meaning. They developed BOX because deficits in the lexical semantic processing measured with the Semantic Association Test (Visch-Brink, et al., 2005) occur in 56% of the aphasic population and is not related with the severity or type of aphasia. BOX focuses on the selection and ordening of phonemes.
The quality of the verbal communication was increased due to both programmes, but lead to selective profit for semantics or phonology. An important detail of RATS-1 is that the therapy started from four months post onset. The RATS-2 therapy will be started within three weeks post onset (Doesborgh, 2004; Doesborgh, et al., 2004; Visch-Brink, 2006).

In the Rotterdam Aphasia Therapy Study 2, the researchers will look for the effect of semantic and phonological treatment BOX and FIKS (Cognitive Linguistic Therapy, now referred to as CLT) on verbal communication in aphasic patients given from the acute stage after stroke. More detail information about these two therapy methods can be found paragraph 2.3.2 Therapy of this chapter.
Within this study CLT, will be compared with No-CLT, the control treatment. In practice Speech and Language Therapists use both CLT and No-CLT. CLT starts from the underlying mechanisms of the speech disorder and No-CLT directly influences the use of verbal communication in all day situations.
Under No-CLT therapy this research group understands all therapy tasks other than cognitive linguistic exercises. In practice, this means that the control therapy will contain exercises aimed at improving communicative strategies.

Examples of No-CLT therapy tasks are: development of conversational strategies, conversational coaching of the patient and his/her partner or relative, story telling, training of specific situations, training of nonverbal communicative channels, e.g. gestures, drawing. Randomised clinical trials conducted for the effect of certain therapy on aphasia and recovery in aphasia are scarce. RATS-2 seems to answer this question for Dutch CLT and No-CLT. (Visch-Brink, 2006; Hagelstein, et al., 2006).

The treatment of an aphasic patient will start within three weeks post onset and will stop as part of this study six months post onset. The included patients are randomised in two groups: CLT and No-CLT. The hypothesis that will be tested in RATS-2 is that CLT is more effective than No-CLT (Hagelstein, et al., 2006).

For RATS-2 all hospitalised patients with aphasia due to stroke will be screened for eligibility by the trail co-ordinator and the participating speech and language therapists. A patient is included if he/she matches the following inclusion/exclusion criteria and is testable with the ScreeLing (a screening test to measure cognitive-linguistic deficits (Hagelstein, et al., 2006).

For RATS-2 the inclusion and exclusion criteria are presented in the next table:

Inclusion criteria	*Exclusion criteria*
- Aphasia due to stroke; - Within three weeks post onset; - Age 18 – 85 years; - Language near native Dutch; - Life expectancy > six months.	- Severe dysarthria; - Premorbid dementia; - Illiteracy; - Severe developmental dyslexia; - Severe visual perceptual disorders; - Existing aphasia; - Subarachnoidal haemorrhage; - Recent psychiatric disorder.

(Hagelstein, et al., 2006).

Patients also were required to show a semantic and/or phonological disorder from the tests performed on the patient. This means the following:

I. Amsterdam-Nijmegen Everyday Language Test (ANELT, Blomert, et al., 1995),
scale A score < 38;

II. And;
  a. A semantic disorder, measured by Semantic Association Test (verbal version, Visch-Brink, et al., 2005) score < 26 and/or Semantic Association words with low imageability (PALPA, Bastiaanse, et al., 1995) score < 12;
  And/or:
  b. A phonological disorder, measured by Auditory Lexical Decision (PALPA, Bastiaanse, et al (1995)) score < 76 and/or Repetition Non-words (PALPA, Bastiaanse, et al., 1995) score < 20.
  And/or:
  c. Boston Naming Test (Kaplan, et al., 2001): disturbed (according to BNT norms) and > 50% phonological and/or semantic errors.

Patients were enrolled into the study if they gave a written informed consent (Hagelstein, et al., 2006). All included patients will be monitored in the treatment settings that they attended (rehabilitation centres, out-patient clinics, nursing homes, private practices) (Hagelstein, et al., 2006).

While being a participant in this study, the participants are tested at three test moments. At these test moments, the participants will be put through a special RATS-2 test battery. The test battery consists of several linguistic tests which will help to map the different aspects of the aphasia. Several tests are used as an inclusion test.
The test moments are:
1) Within three weeks post onset,
2) Three months post onset, and
3) Six months post onset.

Six weeks post onset the Dutch version of the Aachener Aphasia Test (Greatz, et al., 1992) will be held to determine the type of aphasia (Hagelstein, et al., 2006).
The primary outcome test is the ANELT (Amsterdam Nijmegen Everyday Language Test-A). The ANELT-A consists of ten scenarios from everyday life. The correctness of the answer of the patient on a certain scenario will be assessed.

The other tests are for the secondary outcome of this study and most of them are phonological and semantic tests together with connected speech. The complete test battery looks like the following:

Type of outcome	*Used tests*
Primary outcome	ANELT-A
Screening aphasia and language (deficits):	ScreeLing
Semantic secondary outcome measures	Semantic Association Test-Verbal, Semantic word association with low imaginability, Semantic Fluency.
Phonological secondary outcome measures	Repeating non-existing words, auditive lexical decision, phonological Fluency.
Other outcome measures:	Boston Naming Test (evaluation Naming disorders), Token Test (severity of the aphasia), Spontaneous speech (degree of verbal communication), Sabadel (to asses connected speech), Partner Communication Question list (PCQ: communicative functioning in everyday life from the partner point of view), AAT (Aachen Aphasia Test (type of aphasia).
General outcome measures	EuroQol (Quality of Life), Rankin (every day life) en Barthel (every day life).

(Hagelstein, et al., 2006).

2. Method present study

2.1 Design

Naming errors will be analysed with the Boston Naming Test in 20 Dutch patients (mean age 65.90, range 30-81 years) who participated in RATS-2 and received six months of cognitive linguistic therapy within 0 – 6 months post onset.

As already mentioned in the chapter 1 “Introduction”, this thesis is divided into two parts. This also results in two different ways of looking at the data.
For Part I in which I will provide an in-depth view in recovery of naming errors, by performing a microanalysis of the Boston Naming Test data at three test moments and testing the hypotheses for recovery in type of aphasia and type of linguistic disorder tested. The microanalysis focuses on correct answers, degree of semantic relatedness and degree of phonological overlap index.
For Part II in which I will present and test predictions about the recovery of naming errors derived from the RIA by Rapp & Goldrick and the model by Levelt and colleagues, I have conducted a macro analysis of Boston Naming Test data at three test moments and tested the hypotheses based on the models by Levelt & colleagues and Rapp & Goldrick are tested.
In practice this means that first the macro analysis will be performed, followed by the micro analysis.

2.2 Subjects

The subjects all exhibit fluent output, word finding difficulties and have had a lesion in the left hemisphere.

The language profiles of these subjects, according to the Dutch version of the Aachen Aphasia Test (AAT, Graetz, et al., 1992) include Wernicke’s (6 patients) and Anomic aphasia (8 patients).
There are also six patients who couldn’t be classified according to the ALLOC programme, but still have a fluent aphasia and they present a phonological, a semantic or a phonological & semantic disorder at test moment 1. Therefore they are included into this study.
Patients with the clinical classification of Broca’s aphasia are not selected as subjects, since production deficits in this group are not necessarily entirely attributable to failures in lexical and phonological encoding, but may involve motor planning processes as well, particularly if apraxia is present.

Table 1 lists the relevant background information about the patients. A description of the used levels of education can be found in Appendix I. Important to note is that all patients had at least 2 hours of therapy a week and had a mean total therapy time of 58,35 hours. All patients received semantic and phonological therapy (BOX and FIKS), except patients 14 and 15: they received primarily BOX.

Table 1: Patient Background Information

Patient number	Sex	Age	Level of Education	Aphasia type	Type of therapy	Total therapy hours	Type of linguistic disorder at inclusion (<3 weeks post onset)
1	Male	72	LBO	Wernicke's aphasia	BOX & FIKS	69,25	semantic and phonological disorder
2	Female	66	MAVO/MBO	Anomic aphasia	BOX & FIKS	65,20	semantic disorder
6	Female	34	LBO	Anomic aphasia	BOX & FIKS	47,90	semantic and phonological disorder
11	Female	81	elementary school	Wernicke's aphasia	BOX & FIKS	63,50	semantic and phonological disorder
12	Male	69	LBO	Wernicke's aphasia	BOX & FIKS	55,93	phonological disorder
14	Male	72	LBO	Wernicke's aphasia	BOX & FIKS	69,25	semantic and phonological disorder
15	Male	61	MAVO/MBO	Unclassified	BOX	59,60	semantic and phonological disorder
19	Male	75	LBO	Anomic aphasia	BOX & FIKS	66,90	semantic and phonological disorder
22	Female	71	MAVO/MBO	Anomic aphasia	BOX & FIKS	41,30	semantic and phonological disorder
26	Female	30	LBO	Unclassified	BOX & FIKS	55,50	semantic and phonological disorder
33	Female	72	elementary school	Anomic aphasia	BOX & FIKS	81,60	semantic and phonological disorder
35	Female	66	LBO	Anomic aphasia	BOX & FIKS	67,50	phonological disorder
40	Female	70	HAVO/VWO /HBO	Unclassified	BOX & FIKS	80,75	phonological disorder
43	Female	66	MAVO/MBO	Anomic aphasia	BOX & FIKS	55,00	semantic and phonological disorder
45	Male	79	LBO	Unclassified	BOX & FIKS	50,00	semantic and phonological disorder
46	Male	60	LBO	Wernicke's aphasia	BOX & FIKS	65,50	semantic and phonological disorder
50	Male	63	LBO	Unclassified	BOX & FIKS	28,38	semantic and phonological disorder
54	Male	68	elementary school	Wernicke's aphasia	BOX & FIKS	95,43	semantic and phonological disorder
59	Female	77	LBO	Unclassified	BOX & FIKS	2,83	semantic and phonological disorder
62	Male	66	elementary school	Anomic aphasia	BOX & FIKS	46,08	semantic and phonological disorder

2.3 Interventions

2.3.1. Assessment

For RATS-2 a whole test battery is conducted for each patient (see paragraph 1 in this chapter). For this study only the data from the Boston Naming Test for 0, 3 and 6 months post onset for every patient has been used.

2.3.2. Therapy

All patients in this study were randomly assigned to receive cognitive linguistic therapy. Therapy is applied with a minimum of two hours a week, partly individual and partly as homework. There will be five hours of total therapy time aimed at each patient per week.

To ensure the treatment procedure was similar from patient to patient and between therapists, the cognitive linguistic therapy consisted of only two methods: BOX and FIKS. Depending on how the language disorder manifests itself, each patient can receive BOX or FIKS or a combination of the two treatment programs.
BOX (Visch-Brink & Bajema, 2001) is focused on the interpretation of the semantic features of written word, sentences, and texts. It consists of more than 1000 exercises. Exercises are in multiple choice or right/wrong format. Language production is preferable, but never required. Most exercises have three levels of difficulty, depending on the number of distracters, the strength of the semantic relation, the ambiguity or the degree of imaginability, frequency, length and abstractness of the word. The speech and language pathologist can freely choose from the available exercises. He/she can adapt the level of difficulty and the type of exercise to the needs of the patient. It is also possible to switch from word level to sentence- or text level and the other way around.
BOX is available in a paper version as well as a computerised version. The paper version will be used mainly in the individual therapy sessions; the computer version will be used mainly for homework in addition to the individual therapy.
There are 8 different types of exercises:

- Semantic categories;
- Syntagmatic and paradigmatic relationship;
- Semantic gradation;
- Adjectives and exclamations;
- Part whole relationship;
- Anomalous sentences;
- Semantic definition;
- Semantic context.

(Hagelstein, et al., 2006; Visch-Brink & Bajema, 2001; Doesborgh, et al., 2004).

FIKS (Van Rijn, et al., 2000) is focused on sound structure and word form. It consists of more than 1000 exercises for selecting and sequencing speech sounds on word-, sentence- and text level. The SLT can also in this programme choose freely from the available exercises. He/she can adapt the level of difficulty and the type of exercise to the need of the patient. It is also possible to switch from word level to sentence- or text level and vice versa.
FIKS is also available in a paper version and in a computerised version. There are 10 different types of exercises:

- Rhyming;
- Consonant clusters;
- Stress patterns;
- Compiling words;
- Word length;
- Phonemic similarity;
- Texts;
- Phonetics and syllabification;
- Homophones;
- Analysis and synthesis.

(Hagelstein, et al., 2006; Van Rijn, et al., 2000; Doesborgh, et al., 2004).

2.4 Procedures

- *Procedure Boston Naming Test*

Kaplan, Goodglass and Weintraub introduced in 1983 the revised version of the Boston Naming Test (BNT). This is a visual picture-naming task consisting of 60 out-line drawings of objects and animals. The test was constructed in order of word frequency. The difficulty grades from item 1 (bed) to item 60 (abacus).
It has been long recognised and repeatedly stressed that this test is a highly sensitive tool to identify naming deficits and impaired word-retrieval capacities in a variety of cerebral pathologies, also in the evaluation of focal left hemisphere cerebrovascular accidents (Marien, et al., 1998). The BNT is more sensitive for recording light naming problems in aphasic patients than the naming part of the Aachen Aphasia Test. Heesbeen (2001) showed that patients who acquired an (almost) maximum score at the naming part of the Aachen Aphasia Test show mutually large variability on the BNT.

In this study, each subject will be administered the Boston Naming Test (BNT) (Kaplan, et al., 1983) in a similar way. Pictures will be presented one at a time and patients will be asked to name them. All patients receive the entire test in one session. No cues will be given to the subjects to help with the retrieval of the target word. For each patient naming data will be recorded and scored for accuracy and error type online by an experienced speech and language therapist. Following the session, both sources will be used to generate the final transcription of the session. Disagreements will generally be resolved in favour of the online scoring.

- *Procedure assigning hypotheses*

After test moment 1 (< 3 weeks post onset) the data are analysed. Based on the error pattern that the patient shows at this test moment, hypotheses for the recovery pattern based on the model by Levelt and colleagues and the RIA by Rapp & Goldrick are assigned. The hypotheses can be found in Chapter 2 “Background”, paragraph 5. In Chapter 4 “Results” you can find these assignments in paragraph 1.1.These hypotheses are only used for the macro analysis of the naming problems of the patients.

In the macro analysis all the naming error types will be discussed, instead of the micro analysis which only focuses on the proportion of correct answers, the mean semantic relatedness score and the mean phonological overlap index score.
The hypotheses for the recovery in aphasic naming for type of aphasia and type of linguistic disorder at inclusion are also assigned after test moment 1.
The hypotheses for the recovery in aphasic naming for type of aphasia is assigned based on the ALLOC classification from the AAT.
The hypotheses for the recovery in aphasic naming for type of linguistic disorder at inclusion is assigned based on the classification by the RATS-2 trail coordinator based on all the test results from test moment 1.

2.5 Analysis of the Boston Naming Test

2.5.1. Procedure macro error analysis

For the error analysis, the following responses are excluded:
1. No responses (instances where the subject failed to say anything;
2. Comments such as “I forget the name of that thing”;
3. Extremely vague or personal responses such as “I have one of those” that do not provide information about the object;
4. Negative responses such as “not a rat” (these can’t be rated on a semantic relatedness scale); and
5. Fragment responses such as “cla-“(Nicholas, et al., 1996).

Further, response classification will be based on final word response, that is, the patient’s final choice for the target name (Laine, et al., 1998).
The following scoring procedure is identical to the one described by Dell et al. (1997).
An answer is considered correct only if it matched the picture item perfectly.
Errors are scored according to the criteria established by Dell et al. (1997), Hirsch (1998), Kohn & Goodglass (1985) and Nicholas, et al. (1996) and can seen in table 2.

For each patient a case summary is made for each test moment. A global recovery pattern is described and the assigned hypotheses based on the models by Levelt and colleagues and Rapp & Goldrick are presented. In this case summery is also described whether the two assigned hypotheses matched the shown recovery pattern.

2.5.2 Procedure micro error analysis

- *Micro analysis of correct answers*

For each patient the proportion of correct answers is calculated by the following formula per test moment:

$$Correct\_answers\_proportion = \frac{total\_correct\_answers}{total\_given\_answers}$$

- *Micro analysis of semantic errors and semantic relatedness*

The semantic error responses that were scored in the macro analyses will then be rated for semantic relatedness to their targets by three independent raters. Each rater has at least 17 years of education, is working in the neurolinguistics field and is familiar with the Boston Naming Test. These raters are not familiar with or informed about the purposes of this study.

The semantic error responses will be randomly ordered with fillers so the raters would have no information about the origin of the word. There will be a 10-point rating scale for the single-word responses. The rating of single-word responses ranges from 1 (not at all similar in meaning) to 10 (very similar in meaning). Items will be arranged on the rating sheets in the order they appear in the BNT, and responses to each BNT item are grouped together.

Responses are randomly presented in terms of error or filler for a given item. Because all the responses for a given item are grouped together it is expected that the raters will find it easier to make consistent ratings. (Nicholas, et al.,1996).
Once these participants have completed the task, the average rating score, standard deviation and median value for each example will be calculated across all participants.

After these calculations, all the semantic errors can be analysed again and rated with a weighted score to the target word. All scores are added up and divided trough the total number of given answers. This gives the mean score of semantic relatedness per test moment per patient.

Table 2: Target error coding criteria

Error	Description	Example
Lexical (real word)		
Semantic	**Real word** that was semantically related to the target. These errors are superordinates, in class coordinates, contextual associates or materials from which the target was made.	Dog → cat
Formal	**Real word** that reaches the criterion for phonological similarity (shared either the initial phoneme or at least 1/3 or more phonemes with the target (Nicholas, et al., 1996)).	Dog → desk Pan → pen
Mixed	**Real word** that was both semantically and phonologically related to the target or the target–response pair shares a common phoneme and are made up of at least one other phoneme from a semantically related word.	Motorcycle → bicycle Clock → clotch (clock–watch) or Calculator → compulator (calculator–computer).
Unrelated	**Real word** that was not related to the target in any obvious way	Dog → apple
Non-lexical (nonword)		
Phonological	**Non-word** that reaches the criterion for phonological similarity (shared either the initial phoneme or at least 1/3 of phonemes with the target (Nicholas, et al., 1996)).	Dog → deg Dog → dem
Neologistic	Non-word **not** reaching the criterion for phonological similarity (i.e. sharing less than 1/3 of the phonemes with the target and with a different initial phoneme (Nicholas, et al., 1996)). Non-words that are pseudo compound words.	Dog → kib Ostrich → four west
Other errors		
No Response	- Indication that response was unknown, negative responses, fragment responses, or if item was not responded to at all. - Extremely vague, comments or personal responses that do not provide information about the object	"I don't know", "not a rat", "cla-" or silence. "I have one of those", "I forget the name of that thing"
Description	Attempts to describe as opposed to name item. Multiple word responses.	Finger → when you point
Visual errors		
Perseverations	If the same answer was given within maximum of three previous given answers.	

(Dell, et al., 1997; Hirsch, 1998; Kohn & Goodglass, 1985; Nicholas, et al., 1996)

- *Micro analysis of phonologic errors and neologisms and Phonological Overlap Index.*

Since in the BNT not only single syllable words are included, but also multiple syllable words, it's important to try to make an even error analysis for all the target words. Folk et al's (2002) Phonological Overlap Index (POI) considers the number of phonemes shared between target and error regardless of position (Nshared) as well as phonemic length of the target (LT) and phonemic length of the error (LE). The following formula is used for calculating the POI:

$$POI = \frac{Nshared \times 2}{(LT + LE)}$$

The POI equation results in rates that range from 0 to 1, with 1 representing complete overlap (Bose, et al., 2007). The POI will be calculated for all neologisms and phonological errors.
The proportion of shared phonemes for each target-response pair is then averaged to generate an overall POI value for each individual per test moment (Rapp & Goldrick, 2000).

- *Micro analysis: assigning and testing hypotheses*

Besides the statistical calculations for the micro analysis there are also hypotheses for recovery of naming errors and *type of aphasia* and *type of linguistic disorder at inclusion* assigned to each patient. For each patient the author of this thesis will compare the raw data from the interval BNT1 – BNT3 with the predictions that were assigned to each patient.

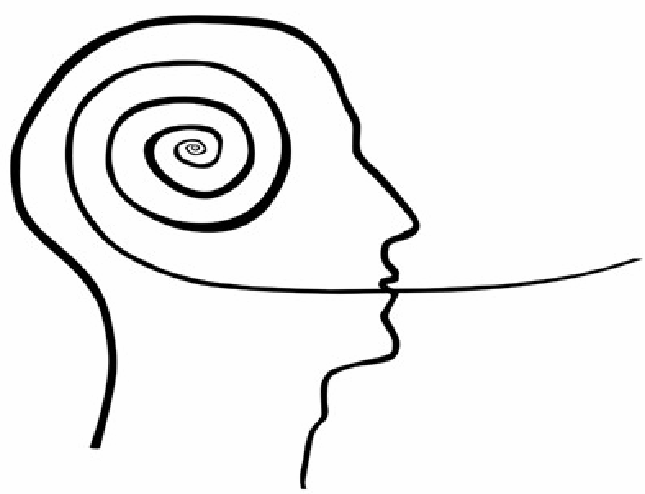
Before comparing the data with the hypotheses, all the data will be summarised into one table, in which the patient number, type of aphasia, type of linguistic disorder at inclusion and the degree of recovery are given per patient per measure.
This table shows whether there was recovery within a patient on each measure. The recovery is reported in this table by using "+" or "-". A "+" means recovery within 0-6 months or a score on BNT3 that remains at comparing score at BNT1/BNT2 and a "-" means no recovery within 0-6 months.
For each measure will be described what information the data provide for each type of aphasia and each type of linguistic disorder.
Whether the hypotheses for recovery in type of aphasia and type of linguistic disorder are confirmed or not will be described as last and final part of the micro analysis.

2.5.3 Procedure statistical analysis

The data of the micro analysis will be analysed on a personal computer using the Statistical Package for Social Science for Windows (SPSS version 14.0) software. Calculations are made for the recovery of the phonological overlap index (POI for phonological errors and neologisms), the recovery of semantic relatedness (for semantic errors) and for the increase of correct answers in a split-plot repeated measures design. The data are analysed with the GLM repeated measures procedure of SPSS.

The within-subject factor is the ‘time’ factor (three levels) for three measures.
After these calculations the GLM repeated measures procedure is repeated with the addition of the between-subject factors type of aphasia (three levels) and type of linguistic disorder at inclusion (three levels).

Important to note is that the POI at BNT2 and the POI at BNT gave an abnormal distribution of the data on the One- Sample Kolmogorov-Smirnov Test. The other variables gave a normal distribution of the data on the One- Sample Kolmogorov-Smirnov Test.



Chapter 4. Results

In this chapter the results of the micro and macro analysis are presented. In paragraph 1 the macro analysis is presented by describing the error patterns for all the patients.
These are the necessary data for answering the research question for Part II of this study:

> *Can predictions be made about recovery of aphasic naming, based on the model of lexical access by Levelt & colleagues and by Rapp & Goldrick?*

In paragraph 2 the results of the recovery of correct answers are presented. In paragraph 3 the values of semantic relatedness are presented with the mean scores of the patients per test moment. In paragraph 4 the same is done for the phonological overlap index.
These are the data that will be needed for answering the research question for Part I of this study:

> *What is the recovery pattern of semantic and phonological paraphasias in aphasic naming in aphasic patients who received six months of cognitive linguistic therapy?*

1. Macro analysis: description of errors per patient

The error patterns are described in this paragraph. In these summaries you can find the macro-analysis: for each patient the recovery pattern is described and can be found if the hypothesised pattern was matched.

1.1. Case summaries

In this paragraph the results of the three test moments are presented. The errors are divided into eight categories and described by patient: correct answer, semantic error, formal error, mixed error, unrelated error, phonological error, neologism and other errors.
Under each error pattern you can find whether or not a prediction based on the model by Levelt or by Goldrick & Rapp was assigned and you can see if the prediction matched the recovery pattern presented by each participant. This means: the predicted recovery pattern based on the model was found in the case summary, including the error rates that are described in the predictions.

Patient 1

BNT1:	The patient produces mostly other errors (22), had some correct answers (2), neologisms (6) and a formal error. There were 29 missing items.		
BNT2:	The patient produces correct answers (8), one semantic error, formal errors (3), unrelated errors (3), phonological errors (3), neologisms (25) and other errors (17).		
BNT3:	The patient produces 15 correct answers, one formal error, unrelated errors (12), one phonological error, neologisms (8) and other errors (23).		
Description error pattern:	At BNT1 the patient produces mostly errors that are related to phonology (neologisms, formal errors). At BNT2 the patient produces more phonologic related errors (formal errors, phonological errors and a lot of neologisms). At BNT3 the correct answers are increased and other error types have decreased; the patient produces less formal errors, phonological errors and neologisms.		
Prediction Levelt:	3	Confirmed yes/no:	No, doesn't show an increase in phonological errors as was predicted.
Prediction RIA:	3	Confirmed yes/no	No, produces more formal errors than mixed errors and this was not predicted.

Patient 2

BNT1:	The patient produces multiple errors; some correct answers (9), semantic errors (2), one mixed error, one unrelated error, one neologism and other errors (12). There were 34 missing items.		
BNT2:	The patient produces 37 correct answers, semantic errors (11), one mixed error, one unrelated error, one neologism and other errors (9).		
BNT3:	The patient produces 40 correct answers, semantic errors (6), one mixed error, one phonological error, one neologism and other errors (11).		
Description error pattern:	At BNT1 the patient produces multiple error types (semantic, mixed or unrelated errors, neologisms and other errors). At BNT2, the number of correct answers and semantic errors has increased, but the other numbers for the remaining error types were equal. At BNT3 the number of correct answers increased a bit more, the semantic errors decreased slightly, but the remaining error types were equal. The patient still produces multiple error types.		
Prediction Levelt:	No prediction can be assigned, since the patient produces a mixed error.	Confirmed yes/no:	n/a
Prediction RIA:	3	Confirmed yes/no	No, patient still produces multiple error types in same degree.

Patient 6

BNT1:	The patient produces mostly correct answers (21), semantic errors (10), 2 mixed errors, 2 phonological errors, 3 neologisms and 22 other errors. There were 12 missing items.		
BNT2:	The patient produces 29 correct answers, semantic errors (10), one mixed error, one unrelated error, 3 phonological errors, one neologism and other errors (15).		
BNT3:	The patient produces 32 correct answers, semantic errors (9), one mixed error, one unrelated, one phonological error, 2 neologisms and other errors (14).		
Description error pattern:	At BNT1 the patient shows us a multiple error pattern, besides 1/3 correct answers and some missing items. At BNT2 the number of correct answers and semantic errors has increased. The neologisms and phonological errors have remained. The number of other errors has decreased. AT BNT3 the patient still shows a multiple error type pattern: lexical and non-words, and even mixed errors.		
Prediction Levelt:	No prediction can be assigned, since the patient produces a mixed error.	Confirmed yes/no:	n/a
Prediction RIA:	3	Confirmed yes/no	Yes

Patient 11

BNT1:	The patient produces three correct answers, three semantic errors, two mixed errors, four neologisms and 30 other errors. There were 18 missing items.		
BNT2:	The patient produces three correct answers, one semantic error, one unrelated error, neologisms (5) and other errors (29). There were 21 missing items.		
BNT3:	The patient produces two correct answers, one mixed error, one neologism and other errors (10). There were 46 missing items.		
Description error pattern:	The patient presents a multiple error type pattern at all the test moments: lexical errors and non-words. There are a lot of missing items within this patient.		
Prediction Levelt:	No prediction can be assigned, since the patient produces a mixed error.	Confirmed yes/no:	n/a
Prediction RIA:	3	Confirmed yes/no	No, patient shows no/little increase in correct answers and/or decrease in other error types.

Patient 12

BNT1:	The patient produces mostly neologisms (23), phonological errors (10) and other errors (15). Furthermore this patient produces correct answers (4), one semantic error, one formal error and 6 unrelated errors.		
BNT2:	The patient produces 44 correct answers, semantic errors (7), mixed errors (2), phonological errors (3), one neologism and other errors (3).		
BNT3:	The patient produces 52 correct answers, semantic errors (6), one phonological error and one other error.		
Description error pattern:	At BNT1 this patient mostly produces phonologic related errors (neologisms, phonological errors and formal errors), next to some lexical errors. At BNT2 some errors are still present (semantic, mixed, phonological and other errors), where others have increased (correct answers) or decreased (neologisms). At BNT3 the patient produces a lot correct answers but still multiple error types (lexical and non-word errors).		
Prediction Levelt:	3	Confirmed yes/no:	No, doesn't show an increase in phonological errors as was predicted.
Prediction RIA:	3	Confirmed yes/no	Yes

Patient 14

BNT1:	The patient produces mostly other errors (44). The patient produces also 3 correct answers, 4 semantic errors, one mixed error, 7 unrelated errors and one neologism.		
BNT2:	The patient produces 5 correct answers, 8 semantic errors, one mixed error, one unrelated error, one phonological error, neologisms (3) and other errors (41).		
BNT3:	The patient produces 8 correct answers, semantic errors (7), one unrelated error and mostly other errors (44).		
Description error pattern:	This patient presents a multiple error type pattern at all test moments. In the beginning the patient shows mainly semantic and phonological related errors, but at the last test moment, the phonological errors have decreased, the correct answers, semantic errors and the other errors have increased.		
Prediction Levelt:	No prediction can be assigned, since the patient produces a mixed error.	Confirmed yes/no:	n/a
Prediction RIA:	3	Confirmed yes/no	No, patient shows no/little increase in correct answers and/or decrease in other error types.

Patient 15

BNT1:	The patient produces 35 correct answers and furthermore multiple error types: semantic errors (5), mixed errors (2), unrelated errors (2), one phonological error, three neologisms and other errors (12).		
BNT2:	The patient produces 45 correct answers, semantic errors (4), neologisms (3) and other errors (8).		
BNT3:	The patient produces 46 correct answers, semantic errors (8), one mixed error, one neologism and other errors (4).		
Description error pattern:	The patient presents a multiple error type pattern at all test moments. During recovery the correct answers have increased, just like the semantic errors, and the other error types have decreased.		
Prediction Levelt:	No prediction can be assigned, since the patient produces a mixed error.	Confirmed yes/no:	n/a
Prediction RIA:	3	Confirmed yes/no	No, the patient presents an increase of semantic errors which is not predicted.

Patient 19

BNT1:	The patient produces only two correct answers. There are 58 missing items.		
BNT2:	The patient produces 28 correct answers, semantic errors (6) and other errors (26).		
BNT3:	The patient produces 39 correct answers, semantic errors (5), neologism (3) and other errors (13).		
Description error pattern:	The patient produces in the beginning just 2 answers, but in recovery the patient shows an increase in correct answers, semantic errors, neologisms and a decrease in other errors.		
Prediction Levelt:	3	Confirmed yes/no:	No, doesn't show an increase in phonological errors as was predicted.
Prediction RIA:	3	Confirmed yes/no	Yes

Patient 22

BNT1:	The patient produces other errors (22) and correct answers (5). There are 33 missing items.		
BNT2:	The patient produces 13 correct answers, semantic errors (4), one mixed error, one unrelated error, neologisms (6) and other errors (35).		
BNT3:	The patient produces 16 correct answers, semantic errors (2), one mixed error, one phonological error, neologisms (5) and other errors (35).		
Description error pattern:	The patient shows a multiple error type pattern. The correct answers, semantic errors, neologisms increase and other errors increase but the number of missing items decreases.		
Prediction Levelt:	3	Confirmed yes/no:	No, the patient produces mixed errors during recovery. This can't be predicted by the model of Levelt & colleagues. The patient also doesn't show an increase in phonological errors as was predicted.
Prediction RIA:	3	Confirmed yes/no	yes

Patient 26

BNT1:	The patient produces 30 correct answers, semantic errors (5), one mixed error, one unrelated error, phonological errors (4), neologisms (5) and other errors (14).		
BNT2:	The patient produces 41 correct answers, semantic errors (7), one mixed error, one phonological error, one neologism and other errors (9).		
BNT3:	The patient produces 37 correct answers, semantic errors (9), phonological errors (3), one neologism and other errors (10).		
Description error pattern:	The patient produces a multiple error type pattern, also during recovery. The number of correct answers and semantic errors increase, but the number of phonological related errors decreases, just like the other errors.		
Prediction Levelt:	No prediction can be assigned, since the patient produces a mixed error.	Confirmed yes/no:	n/a
Prediction RIA:	3	Confirmed yes/no	No, there is an increase of semantic errors and phonolo-gical errors and decrease of correct answers which is not predicted.

Patient 33

BNT1:	The patient produces correct answers (18), semantic errors (14), one formal error, one phonological error, two neologisms and other errors (24).		
BNT2:	The patient produces 40 correct answers, semantic errors (11), one mixed error and other errors (8).		
BNT3:	The patient produces 40 correct answers, one formal error, semantic errors (4), mixed errors (2), one phonological error, one neologism and other errors (11).		
Description error pattern:	The patient produces a multiple error type pattern, also during recovery. The number of correct answers increases but all the error types decrease.		
Prediction Levelt:	3	Confirmed yes/no:	No, the patient produces mixed errors during recovery. This can’t be predicted by the model of Levelt & colleagues.
Prediction RIA:	3	Confirmed yes/no	Yes

Patient 35

BNT1:	The patient produces mostly correct answers (35), semantic errors (9), one mixed error, phonological errors (3) and other errors (12).		
BNT2:	The patient produces 48 correct answers, semantic errors (7), phonological errors (2) and other errors (3).		
BNT3:	The patient produces 42 correct answers, semantic errors (5), one mixed error, one unrelated error, phonological errors (2), neologisms (2) and other errors (7).		
Description error pattern:	The patient produces a multiple error type pattern, also during recovery. The number of correct answers increases but all the error types decrease or remain at the same level.		
Prediction Levelt:	No prediction can be assigned, since the patient produces a mixed error.	Confirmed yes/no:	n/a
Prediction RIA:	3	Confirmed yes/no	No, there is a decrease of correct answers which is not predicted.

Patient 40

BNT1:	The patient produces 40 correct answers, six semantic errors, one mixed error, one phonological error, two neologisms and 10 other errors.		
BNT2:	The patient produces 50 correct answers, semantic errors (2), one mixed error, phonological errors (2) and other errors (5).		
BNT3:	The patient produces 52 correct answers, semantic errors (3), one mixed error, one neologism and other errors (3).		
Description error pattern:	The patient produces a multiple error type patterns, also during recovery. The number of correct answers increases but all the error types decrease (semantic errors, phonological error, neologism, other error) or remain at the same level (mixed error)		
Prediction Levelt:	No prediction can be assigned, since the patient produces a mixed error.	Confirmed yes/no:	n/a
Prediction RIA:	3	Confirmed yes/no	Yes

Patient 43

BNT1:	The patient produces mostly other errors (31), one phonological error and neologisms (22). There are 6 missing items.		
BNT2:	The patient produces 40 correct answers, semantic errors (5), mixed errors (2), one unrelated error, one phonological error and other errors (11).		
BNT3:	The patient produces 45 correct answers, semantic errors (2), one mixed error, one unrelated error, one neologism and other errors (10).		
Description error pattern:	The patient produces an error pattern that mostly consists of phonological related errors. These errors also remain during recovery, and an increase of correct answers and semantic errors can also be seen.		
Prediction Levelt:	3	Confirmed yes/no:	No, during recovery also other error types start to occur, like mixed errors which aren’t predicted by the model.
Prediction RIA:	3	Confirmed yes/no	No, during recovery also other error types start to occur.

Patient 45

BNT1:	The patient produces 26 correct answers, semantic errors (9), one formal error, one unrelated error, phonological errors (3), neologisms (2) and 18 other errors.		
BNT2:	The patient produces 41 correct answers, semantic errors (9), one phonological error, neologisms (3) and other errors (6).		
BNT3:	The patient produces 49 correct answers, semantic errors (3) and other errors (8).		
Description error pattern:	The patient produces multiple error type patterns, also during recovery. The number of correct answers increases but all the error types decrease: the phonological related errors even disappear.		
Prediction Levelt:	3	Confirmed yes/no:	No, patient shows no increasing number of phonological errors as predicted.
Prediction RIA:	3	Confirmed yes/no	Yes

Patient 46

BNT1:	The patient produces three correct answers, semantic errors (8), one mixed error, unrelated errors (2), one phonological error and mostly other errors (45).		
BNT2:	The patient produces 8 correct answers, semantic errors (8), one phonological error, one neologism and mostly other errors (42).		
BNT3:	The patient produces 6 correct answers, semantic errors (5), mixed errors (3), phonological errors (2), one neologism and mostly other errors (43).		
Description error pattern:	The patient produces multiple error type patterns, also during recovery. The number of correct answers, mixed errors, phonological errors and neologisms increases. The number of semantic errors decreases and the other error types remain the same.		
Prediction Levelt:	No prediction can be assigned, since the patient produces a mixed error.	Confirmed yes/no:	n/a
Prediction RIA:	3	Confirmed yes/no	No, there is an increase of mixed errors and phonolo-gical errors and decrease of correct answers which is not predicted.

Patient 50

BNT1:	The patient produces 25 correct answers and 25 other errors. Furthermore the patient made semantic errors (7), one mixed error, one phonological error and one neologism.		
BNT2:	The patient produces 43 correct answers, semantic errors (3), mixed errors (2) and other errors (12).		
BNT3:	The patient produces 38 correct answers, semantic errors (4), one phonological error and other errors (17).		
Description error pattern:	The patient produces a multiple error type pattern, also during recovery. The number of correct answers increases but all the error types decrease.		
Prediction Levelt:	No prediction can be assigned, since the patient produces a mixed error.	Confirmed yes/no:	n/a
Prediction RIA:	3	Confirmed yes/no	No, there is an increase of semantic errors and decrease of correct answers which is not predicted.

Patient 54

BNT1:	The patient produces mostly other errors (35), had one correct answer, neologisms (20), one phonological error and three unrelated errors.		
BNT2:	The patient produces 3 correct answers, semantic errors (3), one formal error, unrelated errors (2), phonological errors (7), neologisms (28) and other errors (16).		
BNT3:	The patient produces 5 correct answers, formal errors (2), one semantic error, mixed errors (2), unrelated errors (2), phonological errors (3), neologisms (29) and other errors (16).		
Description error pattern:	The patient produces error patterns that mostly consists of phonological related errors. These errors also remain during recovery, and an increase of correct answers and semantic errors can also be seen.		
Prediction Levelt:	2	Confirmed yes/no:	No, during recovery also other error types start to occur, for example, mixed errors and the patient shows no increasing number of phonological errors which can not be predicted by the model.
Prediction RIA:	1	Confirmed yes/no	No, there is an increase several error types which is not predicted.

Patient 59

BNT1:	The patient produces 29 correct answers, semantic errors (7), two mixed errors, one unrelated error, four phonological errors, four neologisms and 13 other errors.		
BNT2:	The patient produces 43 correct answers, semantic errors (4), two phonological errors, one neologism and other errors (10).		
BNT3:	The patient produces 43 correct answers, semantic errors (3), mixed errors (2), three unrelated errors and other errors (9).		
Description error pattern:	The patient produces a multiple error type pattern, also during recovery. The number of correct answers increases between BNT1-BNT2 but not between BNT2-BNT3. The number of semantic errors, phonological errors and other errors decreases. The neologisms disappear but unrelated errors appear.		
Prediction Levelt:	No prediction can be assigned, since the patient produces a mixed error.	Confirmed yes/no:	n/a
Prediction RIA:	3	Confirmed yes/no	No, the patient shows no increase in correct answers.

Patient 62

BNT1:	The patient produces nine correct answers, semantic errors (3), two mixed errors, unrelated errors (7), eleven neologisms and other errors (28).		
BNT2:	The patient produces 33 correct answers, semantic errors (9), one mixed error, neologisms (8) and other errors (9).		
BNT3:	The patient produces 35 correct answers, semantic errors (6), neologisms (2) and mostly other errors (17).		
Description error pattern:	The patient shows a multiple error type pattern. The correct answers, semantic errors and mixed errors increased. Neologisms and other errors decreased.		
Prediction Levelt:	No prediction can be assigned, since the patient produces a mixed error.	Confirmed yes/no:	n/a
Prediction RIA:	3	Confirmed yes/no	No, the patient shows an increase in other errors which is not expected.

1.2 Summary: results case summaries

Before continuing with the summary of the results of the case summaries, I will repeat the hypotheses from each model.

The hypotheses about recovery of aphasic naming based on the model by Levelt and colleagues:

1. Due to reduction of noise at lemma selection and/or lexical concepts, a patient who presents only semantic errors, will produce in recovery fewer semantic paraphasias and more correct answers.
2. Due to the reduction of noise at the selection of the phonological word form and/or combining of phonological segments, a patient who only presented non-word errors, will produce in recovery fewer neologisms and more phonological paraphasias and correct answers.
3. Due to reduction of noise at the lemma selection and/or lexical concepts and/or the selection and/or combining of the phonological segments, a patient who has a multiple error type pattern, will still produce them all in recovery but in a smaller degree and at the same rate (still fewer formal errors than non-word errors); will produce more correct answers, but produces more phonological paraphasias which are more related to the target instead of the extreme phonological distortion of a neologisms

For eight patients, the predictions from the Levelt model were assigned, but not confirmed. For the other 12 patients no predictions from the Levelt model could be assigned. The distribution per prediction can be seen in table 1.

Table 1: Distribution of assigned, confirmed and not confirmed Levelt predictions

Levelt prediction	Assigned	Confirmed	Not confirmed
1. only semantic errors	n/a	n/a	n/a
2. only phonological errors	1	0	1
3. semantic and phonological errors	7	0	7
Total	8	0	8

The hypotheses about recovery of aphasic naming based on the model by Rapp & Goldrick:

1. During recovery the noise at the post-lexical phonological processing will be reduced and a patient who has only a phonological disorder will produce fewer phonological errors will that resemble more and more the target (more correct phonemic features). The patient will also produce more correct answers
2. Due to reduced noise at the semantic level and/or to the L-level and/or the phoneme level, a patient who has only a semantic disorder will show recovery in semantic errors that will resemble more and more the target (qua semantic features) and will produce more correct answers.
3. During recovery the noise at the phoneme level will decrease and in a patient who has a semantic and phonological disorder, all error types remain but in a smaller degree and the same rates (no more formal errors than non-word errors and more mixed errors than formal errors) and the patient produces more correct answers.

For 7 patients the predictions made from the RIA model were assigned and confirmed. For the remaining 13 patients predictions were assigned but not confirmed. The distribution per prediction can be seen in table 2.

Table 2: Distribution of assigned, confirmed and not confirmed RIA predictions

RIA prediction	Assigned	Confirmed	Not confirmed
1. only phonological errors	1		1
2. only semantic errors	n/a	n/a	n/a
3. multiple error types	19	7	12
Total	20	7	13

Shortly can be said, that the RIA by Goldrick & Rapp can assign and match with the prediction of one hypothesis and can assign more hypotheses about the recovery of aphasic naming than the model by Levelt & colleagues. Further discussion of these results can be found in Chapter 5.

2. Micro analysis: correct answers

Since the literature claims that the correct answers also increase during recovery, these data are also looked at. In table 3 the proportion of correct answers at each test moment can be found.

Table 3: Proportion correct answers per test moment per patient.

Patient number	Proportion correct answers BNT1	Proportion correct answers BNT2	Proportion correct answers BNT3
1	,0645	,1333	,2500
2	,2647	,6167	,6667
6	,4375	,4833	,5333
11	,0714	,0769	,1428
12	,0667	,7333	,8667
14	,0645	,1333	,2500
15	,5833	,7500	,7667
19	1,0000	,4667	,6500
22	,1852	,2167	,2667
26	,5000	,6833	,6167
33	,3000	,6667	,6667
35	,5833	,8000	,7000
40	,6667	,8333	,8667
43	,0000	,6667	,7500
45	,4333	,6833	,8167
46	,0500	,1333	,1000
50	,4167	,7167	,6333
54	,0167	,0500	,0833
59	,4830	,7167	,7167
62	,1500	,5500	,5833

2.1 Statistical analysis: correct answers

The correct answers in this within-subject design were analysed with the GLM repeated measures procedure of SPSS. The recovery within the test moments is significant $F(2,38) = 13.375$. When combining the within-subject data with between-subjects grouping variables the following results were given.

- For the grouping variable *Type of aphasia* the three test moments are not significant for the Proportion of Correct Answers $F(4,34) = 0.088$.
- For the grouping variable *Type of disorder at inclusion* the three test moments are not significant for the Proportion of Correct Answers $F(4,34) = 0.905$.

2.2 Summary: correct answers

What can be concluded for the correct answers is that they recover significant in time. If grouping variables are used, none of the only grouping variables gave a significant result.

3. Micro analysis: semantic errors and semantic relatedness

For each patient the mean semantic relatedness score is calculated per test moment and presented in table 4.

Table 4: Mean Semantic Relatedness score per test moment per patient.

Patientnumber	Mean score SR BNT1	Mean score SR BNT2	Mean score SR BNT3
1	1,0000	,9939	1,0000
2	,9718	,9467	,9711
6	,9533	,9483	,9549
11	,9801	,9923	1,0000
12	,9978	,9739	,9733
14	1,0000	,9939	1,0000
15	,9678	,9717	,9528
19	1,0000	,9689	,9800
22	1,0000	,9728	,9894
26	,9733	,9722	,9549
33	,9150	,9189	,9772
35	,9544	,9644	,9694
40	,9717	,9894	,9917
43	1,0000	,9700	,9900
45	,9572	,9450	,9911
46	,9589	,9394	,9678
50	,9589	,9878	,9828
54	1,0000	,9711	,9911
59	,9683	,9839	,9877
62	,9761	,9388	,9694

3.1 Statistical analysis: semantic errors and semantic relatedness

The Semantic Relatedness in this within-subject design were analysed with the GLM repeated measures procedure of SPSS. The recovery within the test moments is significant F(2,38) = 4.124. When combining the within-subject data with between-subjects grouping variables the following results were given.

- For the grouping variable *Type of aphasia* the three test moments are *not* significant for the semantic relatedness F(4,34) = 2.015.
- For the grouping variable *Type of disorder at inclusion* the three test moments are *not* significant for the semantic relatedness F(4,34) = 0.429.

3.2 Summary: semantic errors and semantic relatedness

For the semantic relatedness can be concluded that that the mean score of semantic relatedness significantly recovers in time. If grouping variables are used, none of the only grouping variables gave a significant result.

4. Micro analysis: phonological errors, neologisms and Phonological Overlap Index

For each patient the Phonological Overlap Index (POI) is calculated and presented in table 5.

Table 5: Mean Phonological Overlap Index per test moment per patient.

Patientnumber	Mean score POI BNT1	Mean score POI BNT2	Mean score POI BNT3
1	,9192	,7840	,9098
2	,9615	,9833	,9884
6	,9671	,9801	,9884
11	,9131	,8958	,9285
12	,7263	,9753	,9963
14	,9192	,7840	,9098
15	,9731	,9669	,9897
19	1,0000	1,0000	,9698
22	1,0000	,9461	,9658
26	,9306	,9855	,9727
33	,9883	1,0000	,9885
35	,9920	,9965	,9778
40	,9697	,9967	,9928
43	,7229	,9967	,9857
45	,9665	,9720	1,0000
46	,9983	,9778	,9844
50	,9866	1,0000	,9984
54	,7564	,6650	,6749
59	,9508	,9959	1,0000
62	,8965	,9381	,9719

4.1 Statistical analysis: phonological errors, neologisms and Phonological Overlap Index

The Semantic Relatedness in this within-subject design were analysed with the GLM repeated measures procedure of SPSS. The recovery within the test moments is not significant F(2,38) = 1.684. When combining the within-subject data with between-subjects grouping variables the following results were given.

- For the grouping variable *Type of aphasia* the three test moments are *not* significant for the semantic relatedness F(4,34) = 0.663.
- For the grouping variable *Type of disorder at inclusion* the three test moments are *not* significant for the semantic relatedness F(4,34) = 0.944.

4.2 Summary: phonological errors, neologisms and Phonological Overlap Index

For the Phonological Overlap Index can be concluded that that the mean score of the Phonological Overlap Index does not recover significantly in time. If grouping variables are used, none of the only grouping variables gave a significant result. This can be due to the fact that the variables *mean POI score BNT2* and *mean POI score BNT3* were not normally distributed. This is an important assumption for using repeated measures.

5. Micro analysis: assigning and testing hypotheses

Besides the statistical calculations for the micro analysis there are also hypotheses for recovery of naming errors and *type of aphasia* and *type of linguistic disorder at inclusion*. By taking a closer look at the raw data, the sample can also be divided into groups according to the hypotheses for *type of aphasia* and *type of linguistic disorder at inclusion*.
Table 6 shows whether there was recovery within a patient on each measure on the raw data for the interval BNT1 – BNT3.

5.1 Micro analysis and type of aphasia

- *Type of aphasia and proportion of correct answers*

The proportion of correct answers in the patients showed a statistically significant result, but it’s also interesting to look for the combination raw data at BNT1-BNT3 and the type of aphasia. As said earlier, there are six patients with Wernicke’s aphasia.
If we compare the raw data for BNT1 with BNT3 all patients have an increase in the proportion of correct answers. There are 8 patients with Anomic aphasia in this sample, which all showed an increase in the raw data interval BNT1-BNT3. For the 6 patients with a fluent aphasia, which could not be classified, can be said that they also presented an increase in the raw data interval BNT1-BNT3.

Table 6: Recovery per patient on each measure

Patient number	Aphasia type	Type of linguistic disorder at inclusion (<3 weeks post onset)	Proportion of correct answers	Mean score of semantic relatedness	Mean Phonological Overlap Index
1	Wernicke's aphasia	semantic and phonological disorder	+	+	-
2	Anomic aphasia	semantic disorder	+	+	+
6	Anomic aphasia	semantic and phonological disorder	+	+	+
11	Wernicke's aphasia	semantic and phonological disorder	+	+	+
12	Wernicke's aphasia	phonological disorder	+	-	+
14	Wernicke's aphasia	semantic and phonological disorder	+	+	-
15	Unclassified	semantic and phonological disorder	+	-	-
19	Anomic aphasia	semantic and phonological disorder	+	+	-
22	Anomic aphasia	semantic and phonological disorder	+	+	+
26	Unclassified	semantic and phonological disorder	+	-	+
33	Anomic aphasia	semantic and phonological disorder	+	+	+
35	Anomic aphasia	phonological disorder	+	+	-
40	Unclassified	phonological disorder	+	+	+
43	Anomic aphasia	semantic and phonological disorder	+	+	+
45	Unclassified	semantic and phonological disorder	+	+	+
46	Wernicke's aphasia	semantic and phonological disorder	+	+	-
50	Unclassified	semantic and phonological disorder	+	+	-
54	Wernicke's aphasia	semantic and phonological disorder	+	+	-
59	Unclassified	semantic and phonological disorder	+	+	+
62	Anomic aphasia	semantic and phonological disorder	+	-	+

- *Type of aphasia and mean score of semantic relatedness*

Now, the combination of mean score of semantic relatedness and type of aphasia is reviewed. Important to note is that there are patients who scored a semantic relatedness of 1 at BNT1. This is due to missing items, the fact that no semantic error were presented by the patient or a combination of these two facts.
Five patients with Wernicke’s aphasia presented for the raw data in the interval BNT1-BNT3 an increase in the mean score of semantic relatedness, while one patient showed a decrease. In the group of patients with an Anomic aphasia, again one patient showed a decrease while the others presented an increase in the mean score of semantic relatedness. The unclassified patients with a fluent aphasia had two patients who presented a decrease in the mean score of semantic relatedness, whereas the other four patients showed an increase in the mean score of semantic relatedness.

- *Type of aphasia and mean score of phonological overlap index*

Finally, the combination of mean score of phonological overlap index and type of aphasia is reviewed.
Two patients with Wernicke's aphasia presented for the raw data in the interval BNT1-BNT3 an increase in the mean score of phonological overlap index, while the other four patients showed a decrease in the mean score of phonological overlap index. In the group of patients with an Anomic aphasia, two patients showed a decrease while the others presented an increase in the mean score of phonological overlap index. All the unclassified patients with a fluent aphasia showed an increase in the mean score of phonological overlap index.

5.2 Micro analysis and type of aphasia: Testing the hypotheses

In this study, there is a focus on fluent aphasic patients due to the linguistic models that are used for Part II of this study. Therefore only hypotheses were made for the two main aphasia syndromes that present a fluent aphasia: Wernicke's aphasia and Anomic aphasia. Here the two hypotheses will be repeated once more:

- A patient with Wernicke's aphasia is expected in recovery to evolve to a more anomic aphasia: paraphasic errors, the neologisms decrease in recovery to generalisations, semantic paraphasias, other errors (overt word searches, pauses, self corrections and circumlocutions), and some phonological paraphasias, so the mean score of phonological overlap index, the mean score of semantic relatedness and the proportion of correct answers increase.
- A patient with Anomic aphasia produces primary formal errors and occasional semantic errors that should evolve from off-target phonological (for the formal errors) and/or semantically (for the semantic errors) related responses toward correct answers in a picture-naming task, so the mean score of phonological overlap index, the mean score of semantic relatedness and the proportion of correct answers increase.

For 14 aphasic subjects a hypothesis could be assigned. For the six subjects who couldn't be classified by the ALLOC programme no hypotheses could be assigned. The distribution per hypotheses can be seen in table 7. For one patient with Wernicke's aphasia and for five patients with Anomic aphasia the hypotheses were confirmed.

Table 7: Distribution of assigned, confirmed and not confirmed Type of aphasia hypotheses

Type of aphasia hypotheses	**Number of assigned hypotheses**	**Confirmed**	**Not confirmed**
Wernicke's aphasia (increase CA, SR and POI)	6	1	5
Anomic aphasia (increase CA, SR and POI)	8	5	3
Total	14	6	8

5.3 Micro analysis and type of linguistic disorder at inclusion

- *Type of linguistic disorder and proportion of correct answers*

First, the combination proportion of correct answers and type of linguistic disorder is discussed. There was only one patient with a semantic disorder at inclusion, which presented an increase in the proportion of correct answers for the interval BNT1 – 3. There were three patients with a phonological disorder at inclusion. They all showed an increase of the proportion of correct answers for the interval BNT1-BNT3.
The remaining patients had a semantic and phonological disorder at inclusion and again all these patients presented an increase of the proportion of correct answers for the interval BNT1-BNT3.

- *Type of linguistic disorder and mean score of semantic relatedness*

Now, the combination of means semantic relatedness score and type of linguistic disorder at inclusion is discussed. There was only one patient with a semantic disorder at inclusion, which presented very small increase in the mean score of semantic relatedness for the interval BNT1-BNT3. Two of the three patients with a phonological disorder at inclusion showed an increase of the mean score of semantic relatedness for the interval BNT1-BNT3; unfortunately one patient did not.
Fourteen of the remaining patients had a semantic and phonological disorder at inclusion presented an increase of the mean score of semantic relatedness for the interval BNT1-BNT3 and three patients showed a decrease of this score for this interval.

- *Type of linguistic disorder and mean score of phonological overlap index*

Finally, the combination of mean score of phonological overlap index and type of linguistic disorder is discussed. There was only one patient with a semantic disorder at inclusion, which presented an increase in the mean score of phonological overlap index for the interval BNT1-BNT3. Two of the three patients with a phonological disorder at inclusion showed an increase of the mean score of phonological overlap index for the interval BNT1-BNT3; unfortunately one patient did not. Twelve of the remaining patients had a semantic and phonological disorder at inclusion presented an increase of the mean score of phonological overlap index for the interval BNT1-BNT3 and five patients showed a decrease of this score for this interval.

5.4 Micro analysis and type of linguistic disorder at inclusion: Testing the hypotheses

Hypotheses about the recovery pattern of semantic and phonological paraphasias and type of linguistic disorder were made for all three variants: phonological disorder, semantic disorder and phonological & semantic disorder. Here, the hypotheses will be presented:

- A patient with a phonological disorder will produce in recovery fewer neologisms and more phonological paraphasias, so the mean score of phonological overlap index and the proportion of correct answers increase.

- A patient with a semantic disorder will produce in recovery semantic paraphasias that get more and more related to the target word (qua semantic features), so the mean score of semantic relatedness and the proportion of correct answers increase.
- A patient with a semantic and a phonological disorder will produce fewer neologisms but the semantic and/or phonological paraphasias will remain and improve, so the mean score of phonological overlap index, the mean score of semantic relatedness and the proportion of correct answers improve.

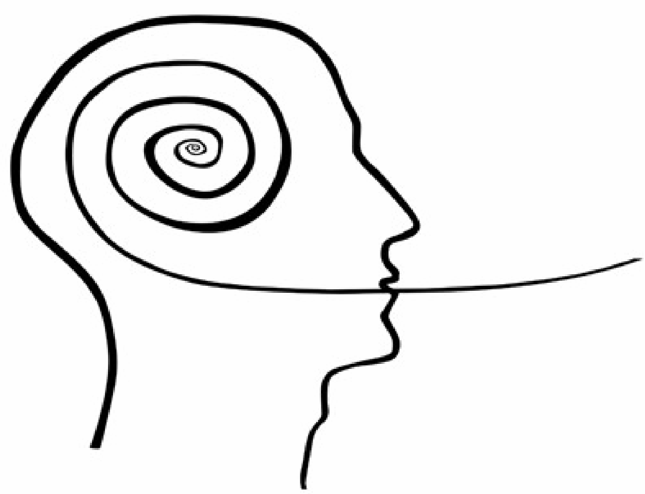
For all patients a hypothesis could be assigned and for eleven patients the hypotheses could be confirmed (two patients with a phonological disorder, one patient with a semantic disorder and eight patients with a phonological & semantic disorder). The distribution per hypotheses can be seen in table 8.

Table 8: Distribution of assigned, confirmed and not confirmed Type of linguistic disorder at inclusion

Type of linguistic disorder hypotheses	**Number of assigned hypotheses**	**Confirmed**	**Not confirmed**
Phonological disorder(increase CA and POI)	3	2	1
Semantic disorder (increase CA and SR)	1	1	n/a
Semantic and phonological disorder (increase CA, SR and POI)	16	8	8
Total	20	11	9

6. Summary of Micro analysis

It is interesting to see that there is a significant recovery in time for proportion of correct answers and mean score of semantic relatedness, but not for the mean score of phonological overlap index.
By looking at the raw data of the micro analysis, only 6 subjects seem to recover based on the prediction for recovery of aphasic naming and their type of aphasia and 11 subjects seem to recover based on the prediction for recovery of aphasic naming and their type of linguistic disorder.



Chapter 5. Discussion

Twenty patients with a stroke in the left hemisphere participated in a randomised clinical trial. All demonstrated a fluent aphasia with naming problems at inclusion, which decreased over a six months period for most patients.
First, in Part I, the degree of recovery of correct answers, Semantic Relatedness and Phonological Overlap Index (POI) is discussed, also for type of aphasia and type of linguistic disorder at inclusion.
Secondly, in Part II, the predictions about recovery of naming errors that were made based on the model by Levelt and colleagues and the RIA by Rapp & Goldrick are discussed; than the use of linguistic models for predicting recovery is discussed.

1. Degree of recovery based on proportion of correct answers, Semantic Relatedness and Phonological Overlap Index.

1.1 Degree of recovery based on proportion of correct answers

The micro analysis for correct answers confirms the idea in the literature that the accuracy of the answers increases as the patients recover. The data show a significant result on the GLM-repeated measures procedure. Unfortunately for the grouping variables Type of Aphasia and Type of Disorder at Inclusion, no significant results were found. This could be due to the variability within the subgroups, since they consisted of a low number of subjects.
By looking at the raw data we see that all patients improved their proportion of correct answers for the interval BNT1/2 – BNT3.

1.2 Degree of recovery based on Semantic Relatedness

The significant results of the micro analysis for the recovery of the mean score of the semantic relatedness subscribes the idea that the patients start to produce semantic errors that are more and more semantically related to the target. Again, the grouping variables Type of Aphasia and Type of Disorder at Inclusion didn't show significant results. Probably also due to the variability within the subgroups, since they consisted of a low number of subjects
By looking at the raw data for the interval BNT1/2 – BNT3 we see that 16 patients have improved their mean score of semantic relatedness.

1.3 Degree of recovery based on Phonological Overlap Index

The Phonological Overlap Index (POI) is the only measure which doesn't show a significant result within the three test moments. This is probably due to the fact that two of these variables are not normally distributed. Of course there are also no significant differences in the grouping variables. Another problem that could have influenced the mean POI in each patient, and also the mean group POI, is that both neologisms and phonological errors are used to create a POI.
For the mean score of POI we can see in the raw data that 14 subjects improved this score.

1.4 Micro analysis: assigning and testing hypotheses

For the hypotheses for recovery in the type of aphasia it can be said that the hypothesis for Wernicke's aphasia was only confirmed in one of 6 patients. This can be due to the fact that some of these patients have only an improved score in correct answers combined. The hypothesis for Anomic aphasia was confirmed for 5 of the 8 Anomic aphasia patients.
Since there was the focus on fluent aphasic patients for six unclassified patients no hypothesis could be assigned. It would be interesting to see whether these patients could be fit into another aphasia syndrome outside the range of the four main syndromes and if these patients should have their own prediction made based upon their aphasia syndrome for recovery of naming errors.
Another thing that should be discussed is that the hypotheses for Wernicke's aphasia and Anomic aphasia were the same for the recovery of aphasic naming: the mean score of phonological overlap index, the mean score of semantic relatedness and the proportion of correct answers should increase in both Wernicke's aphasia and Anomic aphasia. If we put the data together only 6 of the 14 patients with an assigned prediction (Wernicke's and Anomic aphasia patients only) based on their aphasia syndrome show recovery.

For the hypotheses for recovery in the type of linguistic disorder it can be said that for all patients a hypothesis could be assigned and for eleven patients the hypotheses could be confirmed (two patients with a phonological disorder, one patient with a semantic disorder and eight patients with a phonological & semantic disorder). It should be noted that the recovery pattern described for the phonological & semantic disorder is equal to the pattern described for Wernicke's and Anomic aphasia.
It's interesting to see that if we classify patients according to their linguistic disorder at inclusion, more error patterns can match a predicted recovery pattern.

Important to note is that there were 6 patients not classified by the ALLOC programme into one of the four main aphasia syndromes. These patients didn't get a recovery hypothesis, while perhaps they had for example a mild form of an Anomic aphasia. If we compare this to hypotheses for recovery of phonological and semantic paraphasias and type of linguistic disorder at inclusion, one can see very clearly already one difference: to all patients a hypothesis was assigned. It should be noted that there was only one patient who had only a semantic disorder and only two patients who had only a phonological disorder. The other 17 patients had a semantic & phonological disorder. It would be interesting to optimize these hypotheses, at least for this large group of patients, so that the hypotheses can account for more patients.

The advantage of evaluating individual deficits rather than global characterisations (e.g. Wernicke's and Broca's aphasia's) is because of wide range of profiles within each of these syndromes; and that disturbances be highly idiosyncratic, especially when the lesions are smaller. Moreover it has been shown in large studies of acute post stroke aphasia, that only slightly more than half of the patients that have the classic syndromes that comprise aphasiology (Lazar, et al., 2008). Dividing aphasias into syndromes has the advantage that other medical disciplines can form immediately an image about the symptoms of certain aphasias (Links, et al., 1996). A classification into syndromes is not enough for a good speech and language therapy plan. It's better to treat aphasia when underlying disorders are taken into account (Links, et al., 1996). By using the underlying disorders is also possible to make for more patients predictions about recover of aphasic naming.

In this study it has been shown again that classification based on aphasia syndromes is quite useless because of the wide range of profiles within the sample. The classification based upon linguistic disorder at inclusion seems to be a more valid way of classifying patients into categories if you still want to.

1.5 Summary and discussion degree of recovery

What do these results of the micro analysis tell us? This sample of 20 fluent aphasic patients suggests that the proportion of correct answers and the mean score of semantic relatedness increases significantly in time, but this can't be said about the mean score of phonological overlap index, although a comparison of the raw data for the interval BNT1/2 – BNT3 shows that 14 subjects present an improved mean score of phonological overlap index.

Stroke rehabilitation is commonly referred to as a 'black box' because the content is not clearly defined. There are many types of therapy and not all are evidence based. Many published articles testify the ability of the injured brain to recover from damage. The mechanisms underlying functional recovery include the use of alternative pathways, strengthening of existing neural connections and even modest re-growth of neurons (Pomeroy & Tallis, 2000; Rothi, et al., 2000).

In this study all patients received cognitive linguistic therapy (CLT), which is directed at linguistic levels and aims to let the brain make new or alternative pathways and strengthening of existing pathways which are leading to or are in the language areas in the brain. The cognitive linguistic therapies Box and Fiks are therapies that do not have emphasis on adaption to the impairments, but more on exploiting the possibilities to reverse the impairment. The recovery of some patients in this present study might have been increased besides spontaneous recovery, due to this therapy.

This micro analysis also shows us that it's important to think about the usefulness of classification of patients in aphasia syndromes or linguistic disorders.

2. Predictions linguistic models: confirmed or not?

2.1. Predictions model by Levelt and colleagues: confirmed or not?

For 12 patients, no Levelt-prediction could be assigned because these patients made mixed errors at the first test moment which aren't predicted by the model. For 8 other patients, the Levelt-predictions could not be confirmed because of various reasons:

- The patient shows no increase in the number of phonological errors as was predicted.
- The patients started to produce mixed errors during recovery; this is not predicted by the model.
- The patient started to produce other error types during recovery; this is not predicted by the model
- A combination of reasons described above.

2.2. Predictions RIA by Rapp & Goldrick: confirmed or not?

For all patients a RIA-prediction could be assigned and for 7 patients the predictions were confirmed. For the remaining 13 patients, the assigned predictions could not be confirmed due to various reasons:

- The patient produces more formal errors than mixed errors and this was not predicted.
- The patient still produces multiple error types in same degree.
- The patient shows no/little increase in correct answers and/or decrease in other error types.
- The patient presents an increase of semantic errors and / or phonological errors and / or mixed errors and/or other errors; and/or a decrease of correct answers which is not predicted.
- The patient started to produce other error types during recovery, which is not predicted.
- A combination of reasons described above.

Prediction 3 (multiple errors) is a special one, since it was assigned to 19 patients and was confirmed 7 times.

2.3. The value of predictions based on linguistic models

We have seen that it possible to make predictions based on linguistic models. It is interesting to use them to predict recovery patterns.
Unfortunately for the Levelt-model based predictions it was only possible to assign them for a few patients and it was not possible to confirm any of the predictions.
The predictions by the RIA model by Rapp & Goldrick could be assigned to all patients but unfortunately it was not possible to confirm the predictions for 13 patients.
It seems to be that the model by Rapp & Goldrick is more capable of predicting recovery in aphasic patients than the model by Levelt and colleagues.

This could be due to the use of restricted interaction between the lexical and phonological level. A lot of patients make mixed errors and according to the model by Rapp & Goldrick these errors can exist due to restricted interaction between the lexical and phonological level. This restricted interaction also makes it difficult to make concrete predictions for recovery in aphasic naming, due to the variability that can arise due to the restricted interaction between the lexical level and the phonological level. Multiple error types can occur, for example mixed errors but also semantic errors can occur in the RIA at each level in contrast with the model by Levelt and colleagues were semantic errors can only exist at the semantic level. Another study by Bormann et al (2008) also found that in aphasic naming semantic errors do not result from completely discrete phases of information processing. Their data strongly suggest that semantic errors stem from overlapping processes and not from independent processing sources.

The mixed errors were a problem for the model by Levelt and colleagues, which assumes that mixed errors can't exist in this model. The most given reason for not assigning a prediction to a patient at BNT1 were due to these mixed errors, which were present in 12 patients at this test moment. Two predictions were assigned to eight patients but couldn't be confirmed because during recovery (perhaps also due to semantic and phonological therapy) mixed errors started to occur, but also due to other reasons, like the part of hypothesis 3 which said that in recovery a patient with a semantic and phonological disorder should present an increase of phonological errors, but that this couldn't be seen in some patients.
Some patients also present mixed errors in their recovery course. This could be an indication that mixed errors don't just happen on purpose, but should be a part of linguistic system for lexical production. The model by Goldrick & Rapp can account for this statement.

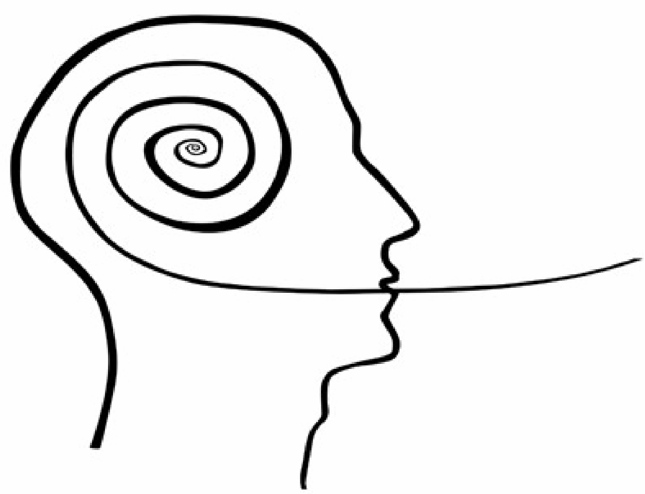
Another difference between the two models was the rate of formal errors versus non-word errors. The Levelt model is expected to create more non-word errors than word errors but the model by Goldrick & Rapp is expected also by influence of lexical bias that there are more word errors (although this not necessarily means the generation in absolute numbers of more word than non-word errors). What could be seen in the macro analysis is that only a few patients presented formal errors: at BNT1 there are three patients who produce formal errors (and in the rate formal errors < non-words), at BNT 2 there are three other patients than at BNT1 who produce formal errors (and in the rate of formal errors < neologisms) and at BNT3 there are four patients who produce formal errors in the rate of formal errors < neologisms (the three patients from BNT2 with one of BNT1 added to this group).
This is interesting to see, because based on the articles from Rapp & Goldrick (2000, 2002) one would expect many more patients to produce formal errors. Besides that, one would expect a larger number of formal errors in contrast to the low numbers that can be seen in these patients.

Something else that should be taken into account is the type of therapy the subjects received, and the possible influence on recovery and possible resulting problems for the predictions based on the two linguistic models. For this study, therapy probably influenced the recovery of the naming errors.

For example, perhaps patients with a more phonological error pattern at BNT1, like patient 54, start to produce other errors not only due to recovery, but also due to the fact that these patients received semantic therapy (BOX) on top of phonological therapy (FIKS). From these methods it is known that they influence both linguistic levels (Doesborgh, et al., 2004).
Some suggestions for further research involving predictions based on linguistic models for recovery patterns in naming can be found in Chapter 6 “Conclusion”, paragraph 2.

3. Limitations of this study

As in every study, there are also some limitations to this study. Despite these limitations, this study is still interesting since it is only one of few group studies about recovery in aphasic naming. Besides that, Heesbeen (2001) stated that although there is enough interest in the literature for the BNT, there has been little research about testing the value of this instrument to measure recovery of (aphasic) language problems.
In this study, the BNT has been used to measure recovery of aphasic language problems and it has been very useful. Unfortunately, by using the Boston Naming Test few items per patient (only 60 items per test moment) were acquired. Perhaps by using the Philadelphia Naming Test you could get more items per patient per test moment and gather more evidence for confirming or rejecting the predictions. Unfortunately, for the Dutch language, the Philadelphia Naming test is not standardized.
An important limitation is the number of subjects (N=20). The sample is restricted to the fact that the two linguistic models that were used to make predictions about recovery can only be used for fluent aphasic patients. The problem gets even worse if you divide them in subgroups, based on type of aphasia or type of linguistic disorder at inclusion. Still for research with aphasic patients, it’s quite a high number of included patients.
Another limitation in this study was that the author of this thesis didn’t acquire the recordings. The recordings were made by colleagues of the speech language therapists of each patient and this could have led to some variability in the quality of the recordings. Perhaps if some patients were corrected during the testing, they could have produced more single word answers instead of the given multiple word answers or descriptions (which are all scored as “other error”). An advantage however of not acquiring these recordings myself is that you get some sort of automatic blinding, when analysing the data.
The use of the ALLOC programme for the classification of type of aphasia based on the data from Dutch version of the Aachen Aphasia Test is also a limitation of this study. This way of classifying your patients is not 100% watertight, since it is possible that there are patients who could be classified to an aphasia type, but they performed to good on the AAT and have a light aphasia. It’s also possible that there are patients who are now classified as “unclassified”, but have an aphasia type other than the four main types which are used in the ALLOC programme.
Something that should be kept in mind is that the Phonological Overlap Index (POI) and the Semantic Relatedness are two measures which can be easily influenced by other error types. Some patients got a high proportion of POI or semantic relatedness because there are none or only a few semantic or phonological errors.



Chapter 6. Conclusion

1. General conclusions

In this present study naming errors were analysed on the Boston Naming Task in 20 patients with fluent aphasia and naming problems who participated in RATS-2 (Rotterdam Aphasia Therapy Study – 2; Visch-Brink, 2006) and received six months of cognitive linguistic therapy within 0 – 6 months post onset. In this thesis I have presented an experimental design and results for the group study. The conclusions can be divided into two parts each with its very own research question.

- Conclusion Part I: Recovery of degree of correct answers, degree of semantic relatedness and degree of phonological overlap in aphasic patients

In Part I of this thesis I have presented a view in recovery of naming errors, by performing a microanalysis which focused on correct answers, degree of semantic relatedness and degree of phonological overlap in patients who received six months of cognitive linguistic therapy, because of the following research question:

What is the recovery pattern of semantic and phonological paraphasias in aphasic naming in aphasic patients who received six months of cognitive linguistic therapy?

The data of the 20 fluent aphasic patients in this study suggest that the proportion of correct answers and the mean score of semantic relatedness increase significantly in time. Unfortunately this can't be said for the mean score of phonological overlap index, despite the fact that 14 patients have shown an improved score within the raw data for the interval BNT1/2 – BNT3.
The hypotheses for recovery of aphasic naming and type of aphasia were only confirmed for 6 patients and the hypotheses for recovery of aphasic naming and the type of linguistic disorder were confirmed for 11 patients.
It was easier to assign the hypotheses based on the type of linguistic disorder since classification based on type of linguistic disorder can endure more variation than the classification based on the type of aphasia. The usefulness of classification of aphasic patients into aphasia syndromes and/or linguistic disorder types was discussed in Chapter 5.

- Conclusion Part II : Recovery of aphasic naming based on the model of lexical access by Levelt and colleagues and by Rapp & Goldrick

In Part II of this thesis I have presented and tested predictions about the recovery of naming errors derived from the model by Goldrick & Rapp and the model by Levelt and colleagues, because of the following research question:

Can predictions be made about recovery of aphasic naming, based on the model of lexical access by Levelt & colleagues and by Rapp & Goldrick?

Predictions based on the discrete model by Levelt and colleagues and the Restricted Interaction Account by Rapp & Goldrick were created to predict the recovery course of paraphasias in naming.
The discrete model by Levelt and colleagues was found unable to assign and confirm predictions about recovery, mainly due to existing or ascending mixed errors which cannot be reconciled by this model and the decreasing number of phonological errors which were predicted to have the opposite outcome.
The RIA by Rapp & Goldrick had one prediction for patients with a multiple error type pattern that was able to be assigned (to 19 patients) and confirmed for seven patients. To one patient with a semantic disorder the matching hypothesis about the predicted recovery was assigned but not confirmed.

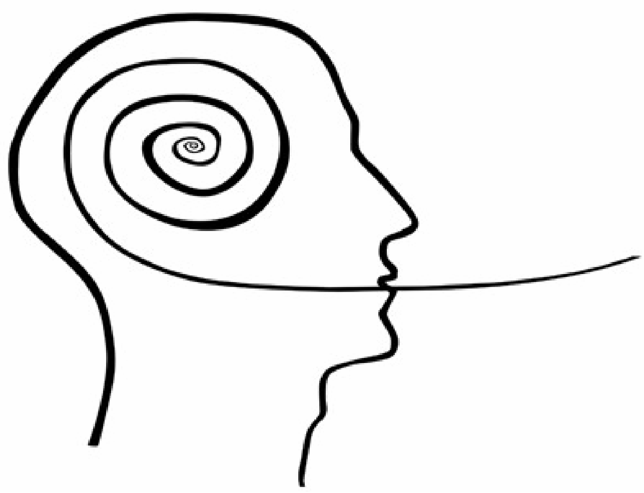
More research should be conducted to make more fine-grained hypotheses about recovery in aphasic naming. Preferably the model by Goldrick & Rapp should be used to make predictions, since this model provides several error patterns that can be assigned to different types of aphasic patients due to the fact that they can account for more variations with the type of errors that can occur and the rate between several error types.

2. Suggestions for further research

I will end this thesis with some suggestions for further research.

- In the RATS-2 study the control group got no-CLT. In this study I only looked at patients who all received CLT, not at the control group with No-CLT. It would be interesting to compare the two groups for the three test moments for the BNT and to find out whether the two groups show different recovery patterns due to the type of therapy.
- RIA Prediction number 3 (multiple errors) was assigned to 19 patients and was confirmed 7 times. It would be interesting to investigate whether the several not confirmed multiple error patterns with low accuracy can also exist under this model of restricted interaction and if these patterns can also be predicted for recovery.
- It would be interesting to make predictions for recovery of naming in non-fluent aphasic patients, as soon as there are models which describe naming in this group of aphasic patients.
- Predictions should be made for patients who are not classified by the ALLOC programme into one of the four main aphasia syndromes and perhaps belong to the other aphasia syndromes that are known (e.g. conduction aphasia, transcortical aphasia).

- It would be interesting to make separate predictions for the first three months post onset and the following three months post onset (until six months post onset) since a lot of patients show a certain degree of recovery of errors in the first three months post onset, but this recovery is decreased during the following three months. This is of course also related to results of other longitudinal studies which have shown that the most of the spontaneous recovery takes place during the first 1 – 3 months post onset (Ferro, et al (1999), Lazar, et al (2008)).



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Appendix

I.	< Elementary school	Less than 6 years of elementary school.
II.	Elementary school	Elementary school
III.	< LBO	Elementary school and unfinished specific education
IV.	LBO	Technical and vocational training for 12-16 year olds
V.	MAVO/MBO	Lower general secondary education or Intermediate vocational education
VI.	HAVO/VWO/HBO	Higher general secondary education, Pre-university education or higher vocational education
VII.	University	University education