



**Utrecht University**  
**MSc Clinical Language, Speech and Hearing Sciences**

Master's Thesis

**Comparison of the recovery pattern in verb use in fluent and non-fluent aphasics in the first six months after stroke.**

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June 15<sup>th</sup>, 2011

## **Abstract**

*Background:* Verbs in aphasia is a widely studied topic in the past decades. A distinction can be made between fluent and non-fluent aphasic patients. In the traditional view fluent aphasics primarily show lexical-semantic deficits, while non-fluent aphasics have mainly syntactic deficits. Yet, several studies disputed this traditional view. Syntactic deficits were found in fluent aphasics as well and non-fluent aphasics indeed show lexical-semantic deficits. The underlying deficit was denounced and a deficit on integration level was introduced (Bastiaanse and Bol, 2001). A reverse relation between the verb diversity and inflection in non-fluent aphasics was found, in which individuals show a high verb diversity, but poor verb inflection or vice versa. Most studies examined the use of verbs in the chronic phase of aphasia and used data collected at one time point post stroke.

*Aims:* The current study was designed to investigate (a) whether the reverse relation described by Bastiaanse and colleagues (and Jonkers, 1998; and Bol, 2001) is also found in fluent aphasics, (b) whether this reverse relation is also found in the acute phase of aphasia, (c) whether this reverse relation changes during recovery, (d) whether the relation in recovery has a reverse character as well and (e) whether two different tasks yield different results on all variables examined.

*Methods and Procedures:* Two groups of aphasics, fluent and non-fluent, were included. Speech samples on a story retelling task and the spontaneous speech were analyzed at 2 weeks and 6 months post stroke. Type token ratio of verbs (verb diversity) and finiteness index (inflection ability) were calculated and compared both within and between groups.

*Results:* In the group comparisons no reverse relation was found for either one of the groups at one time point post stroke. By examining the individual results, this reverse relation was found in both groups of aphasics. In the recovery, both groups of aphasics showed a reverse relation as well. In the comparison of two examined tasks, the spontaneous speech task showed a significant discrepancy between both groups of aphasics in the TTR and the story retelling task did not; in the FI no difference between the both tasks was found.

*Conclusions:* A wide individual variability was found in both groups of aphasic patients. This appears to be the reason for the discrepancy between the group comparisons and the examination of the individual results. The majority of both fluent and non-fluent aphasic patients showed a presence of a reverse relation between verb diversity and inflection ability at 6 months post stroke. A reverse relation in recovery was found as well; one of the variables increased at the expense of the other variable, which decreased. The spontaneous speech task appeared to be more informative in examining reverse relations.

## **Introduction**

The retrieval of verbs is a widely studied topic in the past decades. First, research focused on the differences between the retrieval of verbs versus the retrieval of nouns. Druks (2002) described a higher complexity in verbs, because of the convoluted morphological function and the syntactic contingency in the sentence. Agrammatic aphasics tend to produce fewer verbs than nouns, while anomics show the opposite pattern. In the last decade several studies focused on the underlying deficits of the verb retrieval problems, by examining the verb retrieval ability of both fluent and non-fluent aphasics in several different linguistic tasks. In this paper we will discuss the ability of fluent and non-fluent aphasics to retrieve and correctly inflect verbs in the (semi)spontaneous speech during the first 6 months post stroke.

### ***Types of aphasia***

Saffran et al. (1989) described two forms of aphasia. The first form involves sentence production impairment, 'characterized by non-fluent and dysprosodic speech, simple and poorly realized sentence structures, and frequent omission of bound and free grammatical morphemes' (Goodglass, 1968, 1976 in Saffran et al., 1989: 441). Conversely, in the second form sentence production impairment is 'characterized by fluent speech, better-realized but still non-normal sentence structures, with misuse (but not omission) of grammatical markers' (p.441). The first is defined as agrammatic and the latter as paragrammatic. Perlman Lorch (1989) described agrammatism as a type of aphasia in which primarily function words and inflections are impaired, and substantive words are relatively spared. Agrammatism is often referred to as telegraphic speech. Paragrammatism, on the other hand, is described as incorrectly aligned words and inflections. Semantic paraphasias and neologisms are often seen. The speech is defined as "empty" because of the lack of semantic content and the tendency towards garrulity. It is important to take into account that both types of aphasia have a certain amount of overlap. Saffran et al. (1989) mentioned several studies describing patients who produced e.g. sentences of normal length and complexity, but omitted grammatical morphemes or vice versa. These patients can not be classified as purely agrammatic or purely paragrammatic. Similarly, Bastiaanse and Edwards (2004) described the traditional distinction between Broca's versus Wernicke's aphasia as controversial. The difference is not as clearly-marked as described by the traditional view.

### ***Verbs in aphasia***

According to a paper by Kok, van Doorn and Kolk (2007), verbs in agrammatic speech are generally lacking or, if present, incorrect or not inflected. Bastiaanse (2011) defined an intact inflection ability and a low verb diversity in fluent aphasics.

The severe separation between fluent and non-fluent aphasics in their use of verbs was refined in the last couple of decades. The different studies have widespread results, resulting in an availability of several theories on verb retrieval. Zingeser and Berndt (1990) found a significantly different noun/verb ratio for fluent and non-fluent aphasics. In this study non-fluent aphasics have a significantly higher noun/verb ratio than both fluent aphasics and healthy controls, who do not differ mutually. However, Berndt et al. (1997) did not find a strong relation between noun/verb ratio and fluency. The group of participants in a study by Edwards and Bastiaanse (1998) included at least a few fluent aphasics with verb retrieval deficits. Webster et al. (2007) found a capacious individual variability in their group of aphasics. Importantly, they included both fluent and non-fluent aphasics in their study, without distinguishing between these two groups. Inspection of the individual performance showed extensively deviant patterns in both fluent and non-fluent aphasics. Specific performance patterns which could be used to divide fluent and non-fluent patients were not found, nor was there agreement found in the way fluent and non-fluent aphasics use verbs in their speech. Morphological errors in narrative speech were investigated as well. Normal speakers produced less than 1% morphological errors in narrative speech samples, while aphasics showed much more morphological errors. The errors were a combination of omissions and substitutions. The researchers found no significant correlation between the rate of speech and the percentage of morphological errors in the aphasic group. In other words, fluency had no effect on inflection ability.

Bastiaanse and Jonkers (1998) examined the use of verbs in more detail in their study. They included both agrammatic (non-fluent) and anomia (fluent) aphasic patients in the chronic phase and a control group. The type token ratio (the diversity of the used verbs) in the spontaneous speech was computed. Furthermore, the inflection index was determined: the total of finite verbs divided by the total number of clauses containing a verb. The fluent and non-fluent aphasics in this study all showed the same total number of verbs as the control group. The diversity of verbs (type token ratio) did not differ significantly between the two groups of aphasics, but was significantly worse for the aphasics than for the control group. The inflection index is an interesting factor, since this showed a difference between fluent and non-fluent aphasics. Fluent aphasics showed a normal pattern in verb inflection, whilst non-fluent aphasics performed significantly worse than both fluent aphasics and controls. Another interesting finding was that, in this study, there was no significant correlation between verb retrieval in a naming test and in spontaneous speech. The verb retrieval deficit in spontaneous speech might therefore have a syntactic cause rather than a lexical or morphological cause. Examining individual data demonstrated that some non-fluent aphasics show a high type token ratio, but a poor verb inflection, and others show the opposite pattern. This implies that a normal verb inflection is at the cost of diversity of verbs and vice versa. This reverse relation was not found in fluent aphasics.

Bastiaanse and Bol (2001) came up with a possible explanation for this reverse relation in their study using the same eight agrammatic aphasics that were studied by Bastiaanse and Jonkers (1998). All aphasics showed a certain amount of inflection in their spontaneous speech. In other words, they are indeed able to correctly inflect verbs. The same is true for verb retrieval: it is possible to a certain extent. Thus, the problems in the use of verbs can not be explained by a purely syntactic deficit, neither by a purely lexical semantic deficit. Bastiaanse and Bol implied that there might be an impairment at 'interface level where syntactic structures and lexical items are integrated' (p.281). Either verb inflection or verb diversity is (near to) normal, but not both.

In contrast to Bastiaanse and Jonkers (1998), Edwards and Bastiaanse (1998) found no group differences for the types and tokens of verbs between Dutch fluent aphasics and normal controls. The researchers explained this lack of significance, at least in part, by the wide individual variability in the aphasic group. Half the group of aphasics (5 out of 10) had a restricted diversity (low number of types of verbs) and 4 out of 10 aphasics had a number of tokens of verbs which exceeded the top range of the normal control group. It can be concluded that the individual variability was enormous.

In a later study by Bastiaanse and Edwards (2004), both Dutch and English aphasics, both fluent and non-fluent, were included. One of the factors measured was the performance on a filling in verbs task, in which the participants had to fill in both finite verbs and infinitives. From these data, it appeared that in Dutch aphasics, both groups performed equally on filling in verbs. In English aphasics, Broca's performed significantly worse than Wernicke's on this task. Yet, all groups had more problems filling in finite verbs than on filling in infinitives. In Dutch, hardly any inflectional errors were made on filling in infinitives. Most errors were semantic. When filling in finite verbs, Dutch Broca's made mostly inflectional errors and Wernicke's used mostly semantic paraphasias, although both subtypes also showed deficits on the opposite level. Both English aphasic groups, on the contrary, primarily made inflectional errors when filling in finite verbs. When the total amount of errors is considered, English Broca's aphasics showed more inflectional errors, while Wernicke's aphasics used more semantic paraphasias. It is important to take into account that this study used a filling in verbs task instead of an analysis of (semi)spontaneous speech.

Kok, van Doorn and Kolk (2007) described a lack of verbs and an omission of inflections in agrammatic speech. They distinguished an increase of inflection errors in agrammatic aphasics when the complexity of the task increased.

In a recent study by Bastiaanse (2011) two ways of dealing with the same problem are described. Both groups of aphasics were significantly impaired in producing grammatically complex verbs and verb forms (inflections). The discrepancy between both groups is found in the way these impairments were handled. 'Agrammatic speakers make predominantly grammatical errors on a test and produce simple verb forms in

spontaneous speech, whereas fluent mildly-aphasic speakers make lexical errors on a test and show little variation and a high frequency of their finite verbs in spontaneous speech' (p.170).

### ***The underlying deficit***

The traditional view on the underlying deficit of aphasia describes the problems of non-fluent aphasics as syntactic deficits and those of fluent aphasics as lexical semantic deficits.

However, several studies showed that both Broca's and Wernicke's aphasics had problems with lexical access and grammar (e.g. Bastiaanse and Edwards, 2004; Webster et al., 2007). Hence, they concluded that although both types of aphasia exhibited a predominant deficit, as described in the traditional view, both types of aphasia also exposed secondary deficits in the other section. The results of the study by Bastiaanse and Edwards (2004) indicated that performance decreased when grammatical complexity increased regardless of the type of aphasia. They suggested that as a consequence of a breakdown of one language area; 'the integration of lexical and grammatical processes breaks down' (p.100). The localisation of the disruption determines the clinical representation of the linguistic deficit. This deficit on the integration level was described by Bastiaanse and Bol (2001) as well. They detected a reverse relation between the type token ratio of verbs and the finiteness index for non-fluent aphasics. Only one of the variables was (close to) normal, at the expense of the other variable.

### ***English versus Dutch aphasics***

Bastiaanse and Edwards (2004) described the position of the verb as one of the important differences between Dutch and English. 'In Dutch the verb can be in different positions in the sentence: after the subject and the object (its base-generated position), between subject and object (in a declarative main clause) and before the subject and object (e.g. in a yes-no question)' (p.93). In a matrix clause the verb has to be moved from the base position to the position between subject and object, known as Verb Second. In English this verb movement does not take place in the matrix clause; the verb remains in its base position. Bastiaanse and van Zonneveld (1998) defined in their study that agrammatic aphasics had more difficulties in producing the correct inflected verb in a between-subject-and-object position (matrix clause) than in an after-object position (embedded clause). Bastiaanse and Thompson (2003) hypothesized that this discrepancy between both clauses would not be shown by English aphasics. The results of their study confirmed this hypothesis. In contrast, in fluent patients, Edwards and Bastiaanse (1998) did not distinguish any significant differences between the English and Dutch aphasics on both types and tokens of verbs.

It is important to take the cross-linguistic differences into account, when analyzing either of the languages. The comparison of results in different languages may not be entirely reliable.

### ***Individual variation***

In the majority of studies on aphasia, high individual variability is found (e.g. Bastiaanse and Jonkers, 1998; Bastiaanse and Bol, 2001). Webster et al. (2007) found a capacious variability in the performance of individual speakers. The researchers characterized this variability as a confirmation of 'the complex nature of sentence production difficulties in aphasia' (p.387). The current study therefore explored group effects as well as individual variation.

As Saffran et al. (1989) described, fluent versus non-fluent or agrammatic versus paragrammatic is one way to distinguish two types of aphasia. Yet, these categories are not all-embracing. Within these categories, the kind of deficits and abilities vary strongly between individuals and this should be taken into account when examining aphasia. As categorisation of aphasia has its obvious problems, we have chosen to use the broad categorisation of fluent versus non-fluent, rather than Broca's versus Wernicke's aphasia. As discussed in the methods section, fluency was based on the number of words per minute.

There is a large amount of studies available in which verb use of non-fluent aphasics is examined. For fluent aphasics this amount is considerably smaller. Besides that, most of the studies available have focused on the chronic phase of aphasia and did not explore the verb use in the (post) acute phase. In addition, the majority of studies analyse verb use at a single moment post stroke; recovery of verb use over time is not clear. Hence, the current study is designed to assemble to the existing studies, to examine the previously described gaps in the literature and to introduce a set-up for future research.

### ***Current study***

In the current study patients were tested both 2 weeks post stroke (acute) and 6 months post stroke (post acute). The verb retrieval and inflection ability were analyzed and the recovery over time was measured.

We attempted to answer the following research question:

*Does the recovery mostly affect the lexical entry or does the recovery mostly affect the grammatical ability?*

At the same time, several sub questions were addressed. **(a)** Is this effect the same in fluent and non-fluent aphasia?; **(b)** Is there a relation between finiteness index and type token ratio?; **(c)** Is this relation the same in fluent and non-fluent aphasia?; **(d)** Does this relation change over time?; **(e)** Is there a relation in recovery between finiteness index and type token ratio?; and **(f)** Is there a discrepancy on the finiteness index and type token ratio between a story retelling task and spontaneous speech?

The aims of the current study were: **(1)** To investigate whether the reverse relation described by Bastiaanse and colleagues (and Jonkers, 1998; and Bol, 2001) is also found in fluent aphasics. **(2)** To investigate whether this reverse relation is also found in the acute phase of aphasia. **(3)** To investigate whether this reverse relation changes during recovery. **(4)** To investigate whether the relation in recovery

has a reverse character as well. **(5)** To investigate whether the two different tasks yield different results on all variables examined.

If the traditional view is attended we would expect fluent aphasics to have a low verb diversity and a (close to) normal inflection ability (lexical semantic deficit). Non-fluent aphasics on the contrary would then be expected to have a (close to) normal verb diversity and an inflection deficit (syntactic deficit). However, according to Bastiaanse and colleagues (and Jonkers, 1998; and Bol, 2001; and Edwards, 2004), a reverse relation between verb diversity and inflection ability (integration deficit) would occur in both groups of aphasics. We expected to find the latter because of the high individual variability within the group of aphasics. Recovery might show a reverse relation between finiteness index and verb diversity as well; if one variable recovers, the other variable might remain stable. The high individual variability reported in previous studies, was expected to be found in the present study as well.

### *Spontaneous speech vs. story retelling*

When a story is told, the words used are activated in the long term memory of the listener. Those activated words facilitate the access to the long term memory when the listener wants to reproduce the story (“priming”) (see Levelt, 1993). Because of the mechanism of priming a higher type token ratio is expected to be found in the story retelling task than in the spontaneous speech. Moreover, spontaneous speech is presumed to be a more complex task than the story retelling task, because of the restricted character of the latter. Several studies demonstrated that the error rate increases for both verb retrieval and inflection when the task becomes more complex (for fluent aphasics e.g. McCann and Edwards, 2001; for non-fluent aphasics e.g. Bastiaanse and Edwards, 2004). Therefore higher type token ratio and finiteness index were expected in the story retelling task.

## **Methods**

### ***Participants***

The group of participants was selected from the SPEAK study (Sequential Prognostic Evaluation of Aphasia post stroke; El Hachioui, 2006), in which every patient was followed for one year post stroke. Fifteen fluent and 15 non-fluent patients were selected in 2010 by Siepel. She created the two groups by determining the speech rate of every patient. Patients with a speech rate between 0 and 50 words per minute were categorized as non-fluent, and patients with a speech rate above 90 words per minute were categorized as fluent (Siepel, 2010).

In the studies described earlier the terms agrammatic versus paragrammatic, Broca’s versus Wernicke’s and non-fluent versus fluent were used to make the distinction between two groups of aphasics. Günther et al. (2009) underlined the finding that the use of the traditional terminology to



categorize aphasia can evoke confusion because of the high individual variability within these categories. Therefore in this paper a broad categorisation in terms of non-fluent versus fluent were used to make the distinction.

The inclusion criteria of the SPEAK study were: (1) Aphasic after a single stroke which was not caused by a subarachnoidal bleeding; (2) 18 years or older; (3) Native Dutch speakers and non analphabetic; (4) No recent psychiatric history or an already existing dementia; (5) No severe dysarthria, developmental dyslexia or severe visual, perceptual or hearing disorder; and (6) Ability to perform the ScreeLing (Doesborgh et al., 2002) within 6 days post stroke. Siepel (2010) annexed the following inclusion criteria: (1) Availability of spontaneous speech samples at 2 weeks and 6 months post stroke; (2) Patients received therapy post stroke; (3) A score of <29 on the Token test (De Renzi and Faglioni, 1978) at 2 weeks post stroke; (4) Minimum duration of the spontaneous speech samples of 4 minutes. The current study added the inclusion criterion that the Sabadel speech samples were available at 2 weeks and 6 months post stroke.

The mean age and gender of the included patients are given in Table 1.

Type of aphasia	Age	Gender
Fluent	64;11 (23;6 – 87;7)	8 male; 7 female
Non-fluent	61;3 (38;3 – 85;9)	6 male; 9 female

**Table 1.** Participant information; mean age (range) at 2 weeks post stroke and gender.

## **Materials**

### Spontaneous speech

Questions according to the procedure of the Aachen Aphasia Test (Graetz et al., 1992) were asked:

- \* Can you tell me what happened?
- \* What was/is your profession? Can you tell me something about it?
- \* Can you tell me something about your family?
- \* Do you have hobbies / what do you like to do in your free time?

### Sabadel

Patients heard a story which was supported by pictures. Next, the patient was asked to retell the story. The pictures were shown during the retelling as well. Goodglass and Mayer (1958, in: Berko-Gleason et al., 1980) described that aphasics will not repeat sentences which they are not capable of producing. Berko-Gleason and colleagues therefore were confident that a story retelling task measures the capability of a patient to tell a story and not the ability to repeat it. Berko-Gleason and colleagues concluded in their study that the story retelling task appeared to be a “fruitful one”. They suggested that this defined task evokes speech in individuals who are not able to produce analyzable speech in a more unconfined situation like spontaneous speech. We presumed that these indications are applicable in the current study as well, although priming effects were expected to be found.

One of the reasons to include both speech samples is a clinical one. The information resulting from the comparison of both tasks can be used clinically by e.g. speech and language therapists in their assessments. If the same conclusions are drawn from both samples, the therapist only needs to include one of them in the assessment. If different conclusions are drawn, both should be included in the assessment.

#### ASTA

The ASTA (Boxum & Zwaga, 2007), 'Analyse voor Spontane Taal bij Afasie', is a Dutch standard for analyzing spontaneous speech. It is drawn up by the Dutch Union for clinical linguistics, VKL ('Vereniging voor Klinische Linguïstiek'). The manual of this standard will be used for analyzing the (semi)spontaneous speech of aphasics.

#### CLAN

CLAN (MacWhinney, 2000) stands for 'Computerized Language Analysis' and is mainly used for transcribing and analyzing child speech. In the current study this program was utilized for transcribing and analyzing speech samples as well. It was used to count the verbs used and also the number of correct inflections of verbs; it was used to apply the ASTA on.

#### ***Procedure***

The speech production of the 30 patients was analyzed in the spontaneous speech sample as well as in the retelling speech sample. To measure the recovery, the speech samples were analyzed at two points post stroke, namely 2 weeks and 6 months post stroke. Lazar et al. (2010) indicated that the recovery rate from aphasia is the highest in the first three months post stroke. However, they emphasize the wide and unexplained individual variability as well. El Hachioui et al. (2011) demonstrated that the spontaneous speech improves up to seven months post stroke. In the current study the first time point was chosen to affirm that the patients included were indeed aphasic and did not fully recover in the first 2 weeks post stroke. The second time point was chosen to obviate the individual variation in recovery and to ensure that the largest improvement was included. Every patient received speech therapy in the period between the two time points.

The spontaneous speech of every patient was already transcribed by Siepel in 2010. The speech samples on the Sabadel were now transcribed with the CLAN programs. Siepel was compelled to transcribe only 3 minutes of speech instead of 300 words as is described in the ASTA (Boxum and Zwaga, 2007), because non-fluent aphasics were included, who did not all produce 300 words in their speech sample. On the Sabadel, the complete story was analyzed, because this will likely provide the best representation of the patients' speech abilities (Bird and Franklin, 1996). To control for the obvious methodological confound of absolute numbers, we used relative measures to investigate performance.

In every speech sample, four factors were analyzed, that is: (1) Total number of different lexical verbs excluding ‘zijn’ (to be) (type); (2) Total number of lexical verbs excluding ‘zijn’ (to be) (tokens); (3) Number of correctly inflected verbs; (4) Number of obligatory inflected verbs. (1) and (2) will be used to calculate the Type token ratio (TTR) and (3) and (4) will be used to calculate the Finiteness Index (FI). The design of the study is illustrated in Table 2.

15 fluent / 15 non-fluent aphasic patients Story retelling and spontaneous speech samples		
2 weeks post stroke	T	6 months post stroke
Verb types	H	Verb types
Total verbs (token)	E	Total verbs (token)
Type token ratio	R	Type token ratio
Finite verbs	A	Finite verbs
Obligatory finite verbs	P	Obligatory finite verbs
Finiteness index	Y	Finiteness index

**Table 2.** Research design.

### **Statistics**

To explore the differences between fluent and non-fluent aphasics for both variables and both tasks on both time points (between groups), the non-parametric Mann Whitney U test was used, because of the small research group. To determine the differences in one group on both time points (within groups), the non-parametric Wilcoxon Signed Rank test was used, again because of the small research group. Finally, the Spearman’s rho was used to demonstrate the possible correlation between TTR and FI in both groups.

### **Results**

The speech samples of the story retelling task were transcribed and the speech samples of both tasks were analyzed by calculating the variables as described in the methods and set to statistical analysis. On the story retelling task four non-fluent patients were excluded due to a lack of verb retrieval and/or verb inflection in the speech sample. In the spontaneous speech task two non-fluent patients were excluded for the same reason as described above. No fluent patients needed to be eliminated on either one of the tasks.

## **A. GROUP ANALYSIS**

### ***Fluent versus non-fluent***

#### Story retelling

In Figure 1 the type token ratio and the finiteness index of fluent and non-fluent aphasics in the story retelling task at both 2 weeks and 6 months post stroke are shown. The results of the statistical analysis are shown in Table 3. At 2 weeks post stroke the range of non-fluent aphasics is larger than the range of fluent aphasics for both the TTR and the FI. At 6 months post stroke the range in TTR and FI of both groups are

approximately equal. The TTR does not significantly differ for fluent and non-fluent aphasics at both time points. The FI of fluent aphasics is significantly higher ( $p=0.002$ ) than the FI of the non-fluent group at 2 weeks post stroke. At 6 months post stroke the FI is still higher for fluent aphasics. This difference is not significant ( $p=0.064$ ), but it can be marked as a trend.

The TTR increases for both groups during the recovery period. This increase is significant ( $p=0.036$ ) for the fluent aphasics. The FI increases significantly for both fluent ( $p=0.039$ ) and non-fluent ( $p=0.004$ ) aphasics.

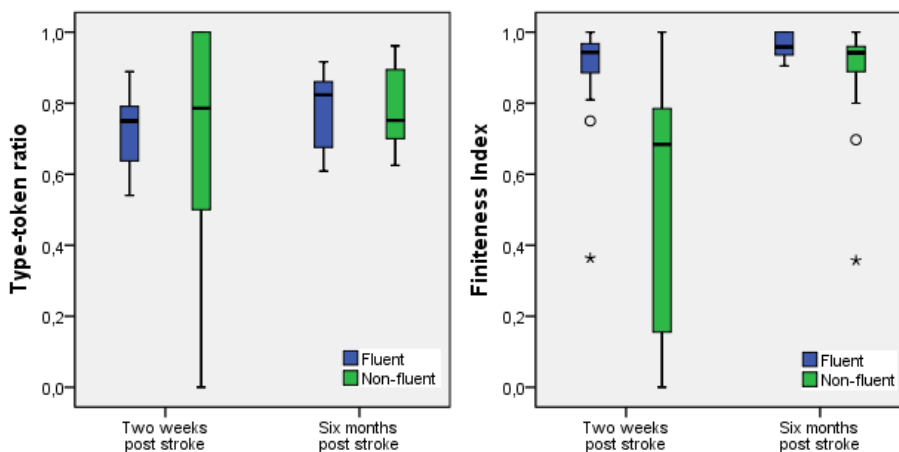


Figure 1. TTR and FI in story retelling task; fluent versus non-fluent aphasics and 2 weeks versus 6 months post stroke.

### Spontaneous speech

In Figure 2 the type token ratio and the finiteness index of fluent and non-fluent aphasics in the spontaneous speech at both 2 weeks and 6 months post stroke are shown. Table 3 exposes the results of the statistical analysis. The range in FI at both 2 weeks and 6 months post stroke is larger for the non-fluent aphasics than for the fluent group. The range in TTR of both groups at both time points is approximately equal.

The TTR is significantly higher for non-fluent than for fluent aphasics at both 2 weeks ( $p=0.000$ ) and 6 months ( $p=0.000$ ) post stroke. The FI in the spontaneous speech is higher for fluent aphasics at both 2 weeks and 6 months post stroke, although these differences are not significant. However, the 2 weeks post stroke data do display a strong trend ( $p=0.055$ ).

The TTR of both fluent and non-fluent aphasics decreases over time. But only the decrease of the non-fluent group is significant ( $p=0.019$ ). The FI increases significantly for both groups of aphasics ( $p=0.007$  and  $p=0.012$  respectively).

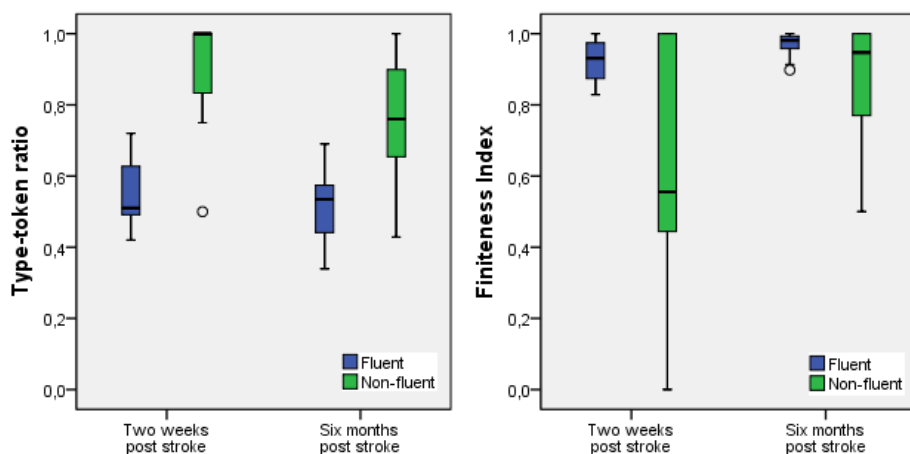


Figure 2. TTR and FI in spontaneous speech; fluent versus non-fluent aphasics and 2 weeks versus 6 months post stroke.

	<i>mean</i>		
	fluent	non-fluent	p-value
<b>TTR</b>			
Story retelling 2 weeks	0.719	0.676	0.567
Story retelling 6 months	0.778	0.777	0.710
p-value	0.036*	0.477	
Spontaneous speech 2 weeks	0.552	0.898	0.000*
Spontaneous speech 6 months	0.518	0.729	0.000*
p-value	0.397	0.019*	
<b>FI</b>			
Story retelling 2 weeks	0.887	0.490	0.002*
Story retelling 6 months	0.964	0.903	<i>0.064</i>
p-value	0.039*	0.004*	
Spontaneous speech 2 weeks	0.921	0.569	<i>0.055</i>
Spontaneous speech 6 months	0.967	0.903	0.147
p-value	0.007*	0.012*	

Table 3. Fluent versus non-fluent and 2 weeks versus 6 months; mean score and p-value. \* =  $p < 0.05$ , *italic* =  $p < 0.1$

### **Story retelling versus spontaneous speech**

In addition to the differences between fluent and non-fluent aphasics, the differences between the results on the story retelling task and the spontaneous speech were compared (Table 4).

Fluent aphasics score a significantly higher ( $p=0.002$ ) TTR on the story retelling task at 2 weeks post stroke than in the spontaneous speech. Conversely, non-fluent aphasics score a lower TTR on the story retelling task, although this difference is not significant. The FI is higher in the spontaneous speech for both groups at 2 weeks post stroke, although not significantly.

At 6 months post stroke fluent aphasics still score a significantly higher ( $p=0.001$ ) TTR on the story retelling task and also non-fluent aphasics score a (non-significantly) lower TTR on this task. The FI is approximately the same for both fluent and non-fluent aphasics at both tasks.

	<i>mean</i>		
2 weeks	Story retelling	Spontaneous speech	p-value
<i>TTR</i>			
Fluent	0.719	0.552	0.002*
Non-fluent	0.676	0.898	0.190
<i>FI</i>			
Fluent	0.887	0.921	0.975
Non-fluent	0.490	0.569	0.314
6 months	Story retelling	Spontaneous speech	p-value
<i>TTR</i>			
Fluent	0.778	0.518	0.001*
Non-fluent	0.777	0.729	0.510
<i>FI</i>			
Fluent	0.964	0.967	0.695
Non-fluent	0.903	0.903	0.297

Table 4. Story retelling versus spontaneous speech; mean scores and p-value. \*=  $p < 0.05$

### **Correlation**

Our research question refers to a relation previously found by Bastiaanse and colleagues (1998; 2001). One of the aims of the current study was to find out if this relation between TTR and FI could also be found in our group of participants. The Spearman's rho correlation matrix did not show a strong correlation between the TTR and FI. As was mentioned in the introduction, we expected to find a high variability within the groups. This is confirmed by the wide range shown in Figure 1 and 2. Because of this high variability obviously no correlation is found when one is examining the whole group. Hence, the TTR and FI of the individual participants were examined.

## **B. INDIVIDUAL ANALYSIS**

### ***Individual deviation from the group mean (z-scores)***

#### Story retelling

In Figure 3 and 4 the individual z-scores of the TTR and the FI for all subjects of both groups on the story retelling task are shown. The figures show the individual deviation of the group mean. For the fluent aphasics at 2 weeks post stroke 9 out of 15 individuals have a score beneath the group mean on one variable and a score above the group mean on the other variable. For the non-fluent aphasics this pattern is shown by 5 out of 11 individuals.

At 6 months post stroke 8 out of 15 fluent aphasics show the pattern of one variable above the group mean and the other variable beneath it. For the non-fluent aphasics this pattern is found in 7 out of 14 patients.

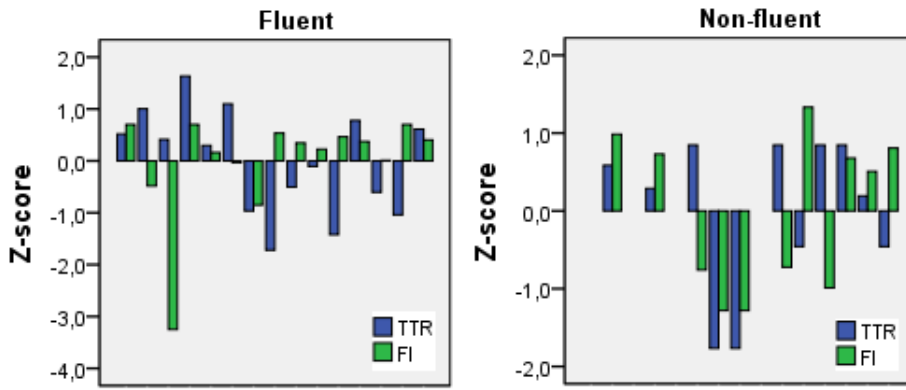


Figure 3. Individual z-scores type token ratio (TTR) and finiteness index (FI) on story retelling at 2 weeks post stroke.

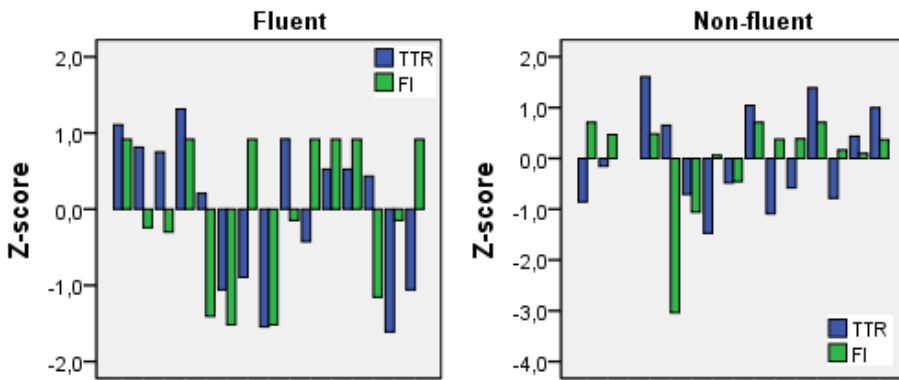


Figure 4. Individual z-scores type token ratio (TTR) and finiteness index (FI) on story retelling at 6 months post stroke.

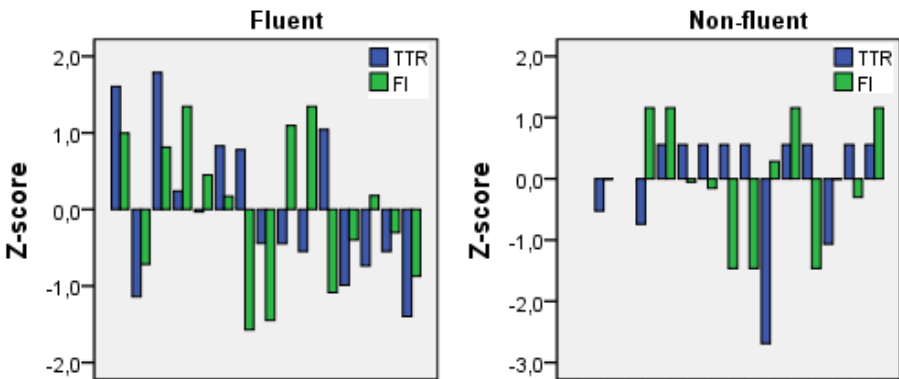


Figure 5. Individual z-scores type token ratio (TTR) and finiteness index (FI) in spontaneous speech at 2 weeks post stroke.

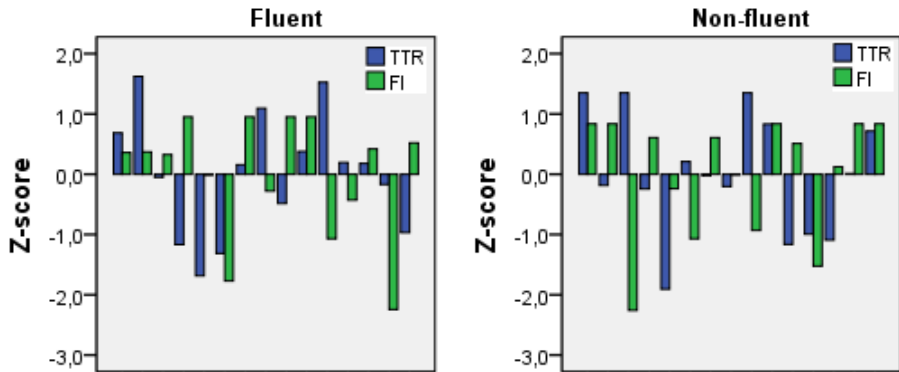


Figure 6. Individual z-scores type token ratio (TTR) finiteness index (FI) in spontaneous speech at 6 months post stroke.

### Spontaneous speech

Figures 5 and 6 show the individual z-scores of the TTR and the FI for all subjects of both groups in the spontaneous speech. At 2 weeks post stroke 6 out of 15 fluent aphasics show a TTR or a FI above the group mean and the other variable beneath it. For the non-fluent aphasics 10 out of 13 patients show the pattern of one of the variables scoring above the group mean and the other beneath it. At 6 months post stroke 8 out of 15 fluent aphasics score above group mean on one variable and beneath it on the other variable; 10 out of 15 non-fluent aphasics show that same pattern at this time point.

### ***Discrepancy 2 weeks versus 6 months post stroke***

#### Story retelling

Figure 7 shows the discrepancy between the scores on the story retelling task at 2 weeks and 6 months post stroke. This figure shows that in 3 out of 15 fluent patients one of the variables increases over time, while the other decreases. For the non-fluent group 6 out of 11 patients show this pattern of increasing on one variable at the expense of the other variable.

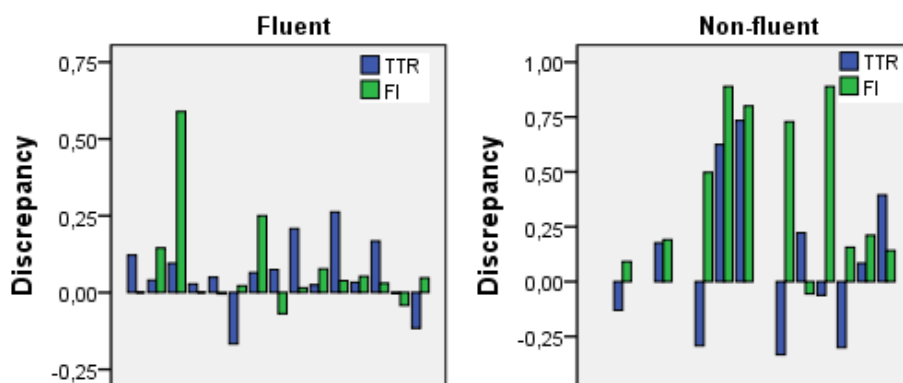


Figure 7. Story retelling; discrepancy TTR and FI at 2 weeks and 6 months post stroke.

### Spontaneous speech

Figure 8 shows the discrepancy between the scores in the spontaneous speech at 2 weeks and 6 months post stroke. For the fluent aphasics 8 out of 15 patients increase in one variable, while decreasing in the other. In the non-fluent group 8 out of 13 patients increase in FI at the expense of the TTR, which decreases.

### ***Individual recovery***

To answer the research question we refer to Table 5. This table shows the individual recovery on the TTR and FI on both tasks for both groups. It should be taken into account that even the slightest change is marked as a deviation. A comparison of standard deviations would be a more elegant procedure. However, due to a lack of multiple baselines in our study, the individual standard deviation could not be determined. See for the raw data Appendix A.



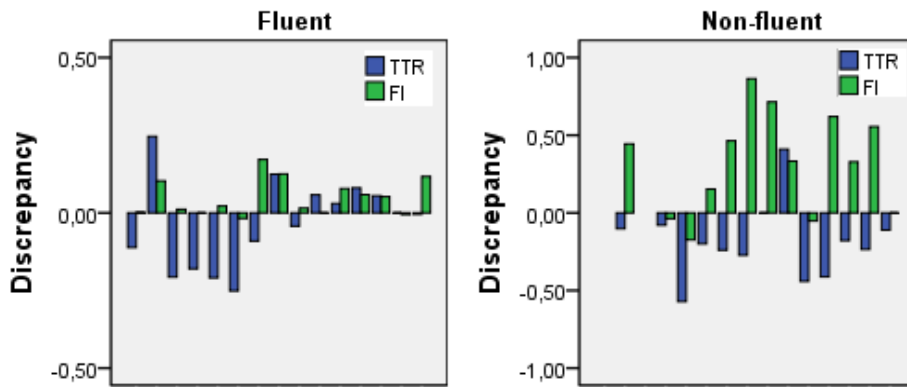


Figure 8. Spontaneous speech; discrepancy TTR and FI at 2 weeks and 6 months post stroke.

Fluent. In the story retelling task both the TTR and the FI increase during recovery for most fluent patients. In the spontaneous speech most patients show an increase on the FI, whereas the TTR increases in half of the patient group, but decreases in the other half.

Non-fluent. Over time, similar amounts of non-fluent patients display an increase and a decrease on the TTR in the story retelling task. The FI in this task increases for the majority of the non-fluent patients. In the spontaneous speech the TTR generally decreases, while the FI increases for most patients.

<b>Fluent</b>				
	<i>Increase</i>	<i>Decrease</i>	<i>Stable</i>	Total
TTR				
- Story retelling	12	2	1	15
- Spontaneous	6	7	2	15
FI				
- Story retelling	10	2	3	15
- Spontaneous	10	2	3	15
<b>Non-fluent</b>				
	<i>Increase</i>	<i>Decrease</i>	<i>Stable</i>	Total
TTR				
- Story retelling	6	5	0	11
- Spontaneous	1	11	1	13
FI				
- Story retelling	10	1	0	11
- Spontaneous	9	3	1	13

Table 5. Individual recovery on TTR and FI in number of individuals.

## Discussion

In this study we examined the verb diversity and inflection ability of both fluent and non-fluent aphasics at two time points post stroke. The relation between the two variables at one point in time and during recovery is investigated. In this section we will discuss the results focusing on the difference between fluent versus non-fluent aphasics as a group at both time points, on the recovery of both groups of aphasics, on the discrepancy between both speech tasks and we will expound the results of the individual analysis whereby the reverse relation both at one time point and in recovery is discussed. Finally the sub questions will be answered, an integration of the findings of the current study and the theories of lexical

reorganisation and neural networks is made, the clinical implications of the findings of the current study are discussed and several recommendations for future research will be made.

## A. GROUP ANALYSIS

### *Fluent versus non-fluent aphasics*

The TTR does not differ for fluent and non-fluent aphasics on both time points in the story retelling task. In the spontaneous speech it does differ for the two groups of aphasics; non-fluent aphasics score a significantly higher TTR than fluent aphasics at both time points. For the FI, fluent aphasics generally exhibit a higher score in both tasks than non-fluent aphasics. This discrepancy is only significant at 2 weeks post stroke on the story retelling task and a trend is found at 6 months post stroke on the story retelling task and at 2 weeks post stroke in the spontaneous speech. These findings oppose those described by Webster et al. (2007), who found no differences in inflection ability between both groups. The found discrepancy in FI does correspond with the study by Bastiaanse and Jonkers (1998), who reported a lower FI for non-fluent aphasics. However, these authors did not find any differences in the TTR between fluent and non-fluent aphasics, which is not in line with our present data.

For our group of participants, we can conclude that overall fluent aphasics are more capable of inflecting verbs correctly, while non-fluent aphasics have a higher verb diversity. The inflection problems of non-fluent aphasics were also found by Bastiaanse and Jonkers in 1998. In this study verb use in the chronic phase was analyzed. The current study shows that the discrepancy in inflection between fluent and non-fluent aphasics is also found in the (post)acute phase. The discrepancy in verb diversity for both groups that we observed was not found by Bastiaanse and Jonkers. A possible explanation for this is the use of different time points in both studies. The current study shows that fluent aphasics have a lower verb diversity than non-fluent aphasics in the (post)acute phase, while Bastiaanse and Jonkers did not find a significant difference between the groups in the chronic phase. Possibly the fluent aphasics recover over time.

The outcomes of group comparisons used in the present study assemble the traditional view in which fluent aphasics are described as lexical-semantically affected and non-fluent as syntactically affected.

### *Recovery in fluent versus non-fluent aphasics*

#### Story retelling

A recovery period of 6 months has a significantly positive effect on the variability of lexical verbs at the story retelling task in fluent aphasics. The positive effect in non-fluent aphasics is not significant. The recovery period does have a significantly positive effect on the degree of correct verb inflection in both fluent and non-fluent aphasics. In general, both verb diversity and inflection ability in story retelling recover significantly over time, with the exception of the TTR in non-fluent aphasics.

### Spontaneous speech

In contrast, in the spontaneous speech the recovery period has a significantly negative effect on the variability of lexical verbs in non-fluent aphasics. In the fluent aphasics no significant effect is detected. The degree of correct verb inflection does profit from the recovery period significantly for both patient groups. Noteworthy is that the non-fluent aphasics show a decrease in variability of lexical verbs and an increase in the degree of correct verb inflection. For the non-fluent aphasics it appears that the increase in the degree of correct inflection has a negative effect on the variability of lexical verbs. As described in the introduction we expected this effect to happen; i.e. that the increase of one factor would occur at the expense of the other factor. In the current study it appears that for non-fluent aphasics an increase in the degree of correct inflection is at the expense of the variability of lexical verbs. This can be explained by a change of energy distribution over time. A certain amount of energy is used to produce speech. If one factor increases, in the current study the degree of correct inflection, this factor will use more energy. Because the total amount of energy is limited, another factor will receive less energy and consequently performance on this factor will decrease or stagnate over time (in the current study the variability of lexical verbs). This can also be referred to as the common pool of resources from which both lemmas and inflected forms are lexical retrieved. Because of a lack of this effect for fluent aphasics, it appears that the mechanism of recovery for both types of aphasia is disparate.

An expedient reason for the fact that this reverse recovery effect is only found in spontaneous speech is the way both short term and long term memory are used in both tasks. In story retelling, goal words are activated by hearing the story. These words are primed and consequently facilitate the access to the long term memory. The spontaneous speech on the other hand is conceptually driven; it starts with a thought, for which the words needed should be activated in the long term memory (see Levelt, 1993). The results from the current study suggest a possibly distinct effect of recovery of the two ways of using both memory types described.

### *Story retelling versus spontaneous speech*

The story retelling task appears not to be sensitive enough to show the difference in variability of lexical verbs between the fluent and the non-fluent group, whereas the spontaneous speech does. Both the story retelling task and the spontaneous speech do seem to be sensitive enough to show the difference in inflection ability in the fluent and non-fluent group at 2 weeks post stroke. The finiteness index at 6 months post stroke is close to 1 for both groups, thus understandably no discrepancy is found between both groups.

### Verb diversity

Fluent aphasics appear to profit by the story retelling task in the domain of lexical verb variability. This can be explained by the theory that words are activated when heard, so-called priming. When a patient has to retell a story, the goal words are previously activated and hence facilitate the retrieval of these goal words and related words in a speech task. In non-fluent aphasics this advantage seems to be lacking; the verb variability for non-fluent aphasics is equal in both tasks. This can be explained by a certain degree of obligation to use the goal words in this task. The restricted character of the task possibly enhances verb retrieval in fluent aphasics, but inhibits the ability to use alternative forms of description in non-fluent aphasics. Another explanation could be the presence of perseverations, which non-fluent aphasics find hard to avoid. The goal words are activated by hearing the story. But because of the presence of perseverations in non-fluent aphasics, only a few goal words can be reproduced resulting in a lack of priming effect on verb diversity in these patients.

As described in the introduction, deficits in language increase when the complexity of the task increases, regardless of the type of aphasia (Bastiaanse and Edwards, 2004). In the current study this phenomenon is confirmed for fluent aphasics; the verb diversity decreases in the more complex task (spontaneous speech). However, for non-fluent aphasics this pattern is not detected. This group appears not to be affected by the increased complexity of the task. A possible explanation for this is the ceiling effect, or better in this case: the floor effect. The non-fluent group appears to have reached the bottom of verb retrieval; they do not profit from the priming effects in the story retelling task, but do not experience any disadvantage of the increasing complexity as well.

### Inflection ability

The character of both tasks does not seem to influence the patients' inflection ability. The priming effect as described above for verb retrieval does not seem to be present for inflection. This can be explained by the theory that verb retrieval and inflection ability require a different memory type; the declarative/procedural (DP) model. For verb retrieval the declarative memory is consulted, while for verb inflection the procedural memory is used (Ullman, 2004). We propose to test this hypothesis by studying regular (procedural memory) and irregular (declarative memory) verbs separately.

Generally, our study shows that the spontaneous speech is a more sensitive and thus useful task to detect the discrepancy in TTR between fluent and non-fluent aphasics. The discrepancy in FI between fluent and non-fluent can be demonstrated in both tasks. This is of clinical importance; speech and language therapists should take these outcomes into account when selecting a task.

## B. INDIVIDUAL ANALYSIS

Because of the high variability within the groups, the individual data are examined to detect putative relations.

### *Reverse relation at one time point*

#### Story retelling

In more than half of the fluent aphasics a reverse relation between TTR and FI is found on the story retelling task at 2 weeks post stroke. When one variable is above the mean, the other is beneath it. Almost half of the non-fluent aphasics show a reverse relation in this situation as well. At 6 months post stroke approximately the same amount of fluent aphasics show a reverse relation between both variables. The amount of non-fluent aphasics showing a reverse relation increased slightly. In the story retelling task the reverse relation described by Bastiaanse and colleagues (and Jonkers, 1998; and Bol, 2001) is more explicitly present in fluent aphasics than in non-fluent aphasics at 2 weeks post stroke. At 6 months post stroke approximately the same percentage of individuals in both groups show this reverse relation. Our results partly agree with the outcomes of Bastiaanse and colleagues. In the current study a proportion of both fluent and non-fluent aphasics show a reverse relation between TTR and FI. The occurrence of this relation is not as large as found by Bastiaanse and colleagues, who found it in 75% of the non-fluent aphasic group. Besides that, in the story retelling task, we also found the reverse relation in fluent aphasics, which was not reported by Bastiaanse and colleagues. However, it should be taken into account that Bastiaanse and colleagues only analyzed the spontaneous speech, and thus the results of Bastiaanse and colleagues should only be compared to the spontaneous speech analyses of the current study.

#### Spontaneous speech

In the spontaneous speech at 2 weeks post stroke only one third of the fluent aphasics show a reverse relation between both variables. This concurs with the findings of Bastiaanse and colleagues (and Jonkers, 1998; and Bol, 2001), who did not find a reverse relation in fluent aphasics either. In contrast, the non-fluent aphasics do show this reverse relation. For the majority a pattern is found in which one variable is above the mean while the other is beneath it. The current study shows that this relation is present for non-fluent aphasics as early as the acute phase of aphasia. At 6 months post stroke more than half of the fluent aphasics show a reverse relation, which developed over time. At 6 months our findings do not cohere with those of Bastiaanse and colleagues. A possible reason for this is the distinction in number of participants. Bastiaanse and colleagues included 8 patients in both groups of aphasics, while in the current study both groups of aphasics included 15 patients. Because of the high individual variability within the aphasic population, the chance to detect a reverse relation increases when the amount of inclusions increases.

The current study demonstrates the presence of a reverse relation between type token ratio and finiteness index for non-fluent aphasics at 2 weeks and 6 months post stroke and for fluent aphasics at 6 months post stroke. Like Bastiaanse and Bol (2001) point out, every patient is capable of producing and inflecting verbs; the competence is present, but does not always emerge. For that reason the underlying deficit of the verb retrieval and inflection problems of both fluent and non-fluent aphasics is equivocal. The traditional view of fluent aphasics being semantically affected and non-fluent aphasics being grammatically affected is no longer sufficient. The impairment at interface level implied by Bastiaanse and Bol appears to be plausible. The findings of the current study, particularly the presence of a reverse relation in both fluent and non-fluent aphasics, amplify the theory formulated by Bastiaanse and Bol.

A possible explanation for the discrepancy between the reverse relation found on the story retelling task and the one found in the spontaneous speech is the low sensitivity in detecting significant differences in the type token ratio of verbs of the story retelling task, as concluded after comparing both tasks above. This task does not detect a deficit in verb diversity when an analysis of the spontaneous speech does. Reasonably a possible reverse relation will not be detected either.

#### *Reverse relation over time*

When comparing the recovery between groups a reverse relation pattern in the spontaneous speech is already described. A significant increase of correct verb inflection and a significant decrease of verb variability are found in the non-fluent group. In the fluent group no significant pattern is found.

Examining the individual data on the story retelling task does not bring up any pattern in the in- or decrease of one variable against the other either. Conversely, the spontaneous speech task does show an interesting pattern. More than half of both fluent and non-fluent aphasics show a reverse relation between TTR and FI during recovery. If one variable increases over time, the other variable decreases. Recovery of one variable occurs at the expense of the other variable. For the majority of patients the reverse relation is in favour of the FI. If the reverse relation occurs, the FI increases and the TTR decreases. This resembles the group comparison for the non-fluent group, but does not cohere with it for the fluent group. A possible explanation for this could be the wider individual variability within the fluent group. Although no relation is found in the group comparison, it does emerge when we examine the individual data. The reverse relation appears to be stronger in recovery than at either one time point for the non-fluent group. The relation in the first is already demonstrated in the group comparison, while the latter becomes visible when individual data are examined. The individual variability for this relation appears to be lower than at one point in time.

#### ***Lexical entry versus grammatical ability***

By examining the individual recovery, the research questions can be answered. As can be found in Table 5 the recovery in the story retelling task versus the spontaneous speech is not equal. On the story retelling

task recovery in the fluent group affects both the lexical entry and the grammatical ability. In the non-fluent group recovery mostly affects the grammatical ability and to a lesser extent the lexical entry. In the spontaneous speech the recovery of both groups mostly affects the grammatical ability. Overall, for both groups of aphasics recovery primarily affects grammatical ability. This effect is largely the same in fluent and non-fluent aphasia (sub question (a)). Sub questions (b) and (c) are answered by the analysis of the individual scores at one time point. A reverse relation between FI and TTR is found in both fluent and non-fluent aphasia. In the story retelling task this relation hardly changed over time, while in the spontaneous speech it did. The fluent aphasics do not show a reverse relation at 2 weeks post stroke, but the majority does show this relation at 6 months post stroke (sub question (d)). The relation between both variables during recovery is studied to answer sub question (e). As described above a reverse relation in recovery of TTR and FI is found in the spontaneous speech for both groups. The TTR and FI are compared per task to answer sub question (f). Especially for the TTR both tasks show different scores. The spontaneous speech appears to be more sensitive to detect deficits in this modality; for the FI no differences are found.

### ***Lexical organisation in fluent versus non-fluent aphasics***

When we integrate the results of our study in the theory of neural networks, we can make a proposal of what deficits may occur in verb retrieval in fluent and non-fluent aphasics and what happens during recovery. For verb retrieval, the neural network theory defines certain families of words, in which the verb lemma is connected to all possible morphological forms. Each family is connected to, amongst others, semantically related families, which results in a neural network of related families. In aphasia the connections can be broken or damaged both within a family, resulting in inflection deficits, and between families, resulting in verb retrieval deficits. When a within-family connection is broken, this morphological form can not be accessed any longer; while in contrast, when a between-family connection is broken, the family can be accessed by another connection, though decelerated.

The more within-family connections are broken, the lower the FI; the more between-family connections are broken, the lower the TTR. When a within-family connection is broken and a between-family connection is damaged, the latter connection might receive all energy, which results in a (close to) normal between-family connection, and vice versa. When both connections are damaged, the energy might be distributed proportionally, resulting in a beneath average verb inflection and diversity. Another option is that all resources will be committed to one of the connections, which results in a reverse relation between FI and TTR; one variable is (close to) normal, while the other is beneath the mean.

In our group of participants both options are demonstrated. In non-fluent aphasics the majority shows a reverse relation; in fluent aphasics the majority shows an equal distribution of energy at first (2 weeks post stroke), but transforms to a reverse relation at a later time point (6 months post stroke). A choice has

to be made; both variables operate at half pressure, or one variable operates optimally and the other operates minimally, which can be referred to as lexical reorganisation.

In recovery the same options can occur; either both connections receive the same amount of energy and thus recover simultaneously, or one of the connections receives the majority of energy available and thus recovers at the expense of the other connection. However, when the connections are broken, the recovery period will not influence the within-family connection, since this morphological form can not be accessed by another connection. In contrast, the recovery period might influence the between-family connection, since the families are accessible by other routes, which can be stimulated by therapy.

### ***Clinical implications***

As mentioned above, the spontaneous speech appears to be more sensitive in detecting deficits in verb diversity and also in detecting a possible reverse relation between TTR and FI both at one time point and during recovery. It can be concluded that the spontaneous speech task is the most reliable in reflecting the speech ability in daily life. Other tasks can be used to examine the possible entrances for therapy, although it should be taken into account that these tasks may facilitate the lexical entry; a mechanism available in a less extent in daily life. Broken within-family connections in the neural network are expected not to recover, while broken between-family connections and damaged connections of both types may recover as a result of therapy. The story retelling task might show damaged connections; the patient is able to retrieve and/or inflect verbs, although in a weakened extent. Therapy should than focus on these damaged connections.

Important is to take the reverse relation during recovery into account. Focusing on one variable might result in recovery on this variable at the expense of the other variable. In the current study the type of therapy given is unknown. For that reason we can not pronounce on the effects of specific types of therapy. When therapy is proportional distributed over both verb retrieval and inflection, this might result in an increase of both variables, although further research is necessary.

### ***Future research***

While writing this paper, several issues were raised that were beyond the scope of the current study. Therefore we recommend the following for future research.

- Comparison with a normal control group. To make more firm statements aphasic speech samples should be compared to speech samples of a control group. No speech sample is completely error-free, hence aphasics' deficits should be compared to controls' deficits.
- Distinguish between lexical verbs, auxiliaries, copulas and modals in calculating both TTR and FI. This information might be valuable to understand the verb use in aphasics. Bastiaanse and Jonkers (1998) described that fluent aphasics may use modals and copulas to replace finite lexical verbs



because of their high-frequency character. Expected is that fluent aphasics do not inflect lexical verbs very often, which results in a low FI for lexical verbs, and inflect the other verb types correctly, resulting in a (close to) normal FI for these verb types.

- Characterize sentence types in which inflection deficits occur. As described in the introduction Dutch aphasics appear to show more inflection deficits in the matrix clause than in the embedded clause, because of Verb Second (Edwards and Bastiaanse, 1998; Bastiaanse and Van Zonneveld, 1998; Bastiaanse and Edwards, 2004). Fluent aphasics possibly use more embedded clauses and have therefore a higher FI than non-fluent aphasics. A possible explanation for this possible phenomenon is a lack of adaptation by non-fluent aphasics. Fluent aphasics might adapt to the verb movement deficit by producing primarily embedded clauses, while non-fluent aphasics are not able to adapt in this way.
- Make a distinction between the inflection of regular and irregular verbs, because of the possibility of the use of different memory types to retrieve these verbs (Ullman, 2004). A discrepancy between both verb types can possibly contribute to confirming one of the theories on the underlying deficit. When the inflection of both regular and irregular verbs is examined separately, it is expected that fluent aphasics will show more deficits in irregular verb forms, because the retrieval of these verb forms consults the declarative memory. This type of memory appears to be affected in fluent aphasics, as the verb diversity, which consults the declarative memory, is low. In contrast, non-fluent aphasics are expected to show a (close to) normal inflection of irregular verbs, because the verb diversity in this group appears to be (close) to normal.
- Consider both group comparisons and individual data, the latter can be highly informative because of the wide individual variability.

## **Conclusion**

The relation between FI and TTR in fluent and non-fluent aphasics is examined on two types of speech tasks in the (semi)acute phase of aphasia. In the between group comparison the traditional view, in which non-fluent aphasics are described as syntactically affected and fluent aphasics as lexical semantically affected, is confirmed. In contrast, when individual data is examined a reverse relation between verb diversity and inflection is found for both groups of aphasics. In the group comparison of the recovery over time, different patterns are found in the different tasks. In the story retelling task both verb diversity and verb inflection increase after a recovery period of 6 months. In the spontaneous speech, a reverse relation pattern is found for non-fluent aphasics. For fluent aphasics, this reverse relation is found as well when examining individual data. When comparing both speech tasks, it can be concluded that the spontaneous speech is

more sensitive to detect verb diversity deficits. Both tasks are equally sensitive in detecting inflection deficits. The recovery of the two variables on both tasks is dissimilar.

A high individual variability is found, which assembles the findings of previous studies. Important is to take this into account in future studies. It is advisable to examine both group data and individual data. These can be highly informational studying aphasia. Besides that the different kind of memories used in producing language should be taken into account. Different language tasks can conduct to divergent results, which should be interpreted differently.

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**Appendix A: raw data individual recovery**

**Fluent**

Patient	Story retelling		Spontaneous speech	
	discrepancy TTR	discrepancy FI	discrepancy TTR	discrepancy FI
3	0,12	0	-0,11	0
4	0,04	0,15	0,25	0,10
5	0,10	0,59	-0,21	0,01
10	0,03	0	-0,18	0
27	0,05	0	-0,21	0,02
28	-0,17	0,02	-0,25	-0,02
36	0,07	0,25	-0,09	0,17
39	0,07	-0,07	0,12	0,12
51	0,21	0,02	-0,04	0,01
70	0,02	0,08	0,06	0
71	0,26	0,04	0,03	0,08
74	0,03	0,05	0,08	0,06
86	0,17	0,03	0,05	0,05
87	0	-0,04	0	-0,01
89	-0,12	0,05	0	0,12

**Non-fluent**

Patient	Story retelling		Spontaneous speech	
	discrepancy TTR	discrepancy FI	discrepancy TTR	discrepancy FI
13	x	x	x	x
18	-0,13	0,09	-0,10	0,44
19	x	x	x	x
21	0,18	0,19	-0,08	-0,04
25	x	x	-0,57	-0,17
26	-0,29	0,50	-0,20	0,15
38	0,63	0,89	-0,24	0,46
53	0,73	0,80	-0,27	0,86
54	x	x	0	0,71
63	-0,33	0,73	0,41	0,33
66	0,22	-0,06	-0,44	-0,05
78	-0,06	0,89	-0,41	0,62
85	-0,30	0,16	-0,18	0,33
98	0,08	0,21	-0,24	0,56
115	0,39	0,14	-0,11	0

**Legend**

Light Gray	Increase
Dark Gray	Decrease
Medium Gray	Stable