

Published in final edited form as:

*J Neurolinguistics*. 2002 May ; 15(3-5): 239–264. doi:10.1016/S0911-6044(01)00032-X.

## Verbs: some properties and their consequences for agrammatic Broca's aphasia

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### Abstract

It has repeatedly been shown that agrammatic Broca's aphasics have serious problems with the retrieval of verbs on action naming tests (Miceli, Silveri, Villa & Caramazza, 1984; Kohn, Lorch & Pearson, 1989; Basso, Razzano, Faglioni & Zanolio, 1990; Jonkers, 1998; Kim & Thompson, 2000). Less attention has been paid to the production of verbs at the sentence level (but see Miceli, Mazzuchi, Menn & Goodglass, 1983; Thompson, Shapiro, Li & Schendel, 1995; Thompson, Lange, Schneider & Shapiro, 1997; Bastiaanse & Van Zonneveld, 1998; Bastiaanse, Rispens & Van Zonneveld, 2000; Friedmann, 2000), although it has been mentioned that in agrammatic spontaneous speech verbs are lacking (Saffran, Berndt & Schwartz, 1989; Thompson et al., 1995, but see Bastiaanse & Jonkers, 1998).

In this paper, three cross-linguistic studies are discussed to show that these problems with verbs have consequences for other grammatical morphemes and structures that have been mentioned to be impaired in agrammatic speech and that these consequences are different per language, depending on linguistic characteristics. The first study focuses on finiteness and compares the production of finite verbs in matrix and embedded clauses in Dutch and English, showing that a linguistic rule in Dutch (Verb Second), which does not exist in English, can explain the different performance of Dutch and English agrammatic Broca's aphasics. The second study focuses on determiners and (finite) verbs in German and shows that poor determiner production is directly related to poor verb production. The last study demonstrates that the ability to construct negative sentences is dependent on the language specific relation between verb movement and negation: Dutch and Norwegian agrammatics perform equally well on affirmative and negative sentences, whereas English and Spanish agrammatics are more impaired on negative sentences.

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<sup>1</sup>We use the term 'grammatical morphemes' to refer to both function/closed-class words and grammatical endings. 'Function words' and 'closed-class words' refer to the same word classes: determiners, prepositions, pronouns, etc.

<sup>2</sup>For comparisons of raw scores, parametric tests (*t*-tests and  $\chi^2$  tests) were used. For the results on the case and negation experiments, we worked with proportional scores because the number of items was not the same for the conditions and, hence, non-parametric tests have been used (Wilcoxon for within groups, Mann-Whitney *U*-test for between groups).

<sup>3</sup>Because the produced sentences were grammatically correct, we did a post-hoc analysis for which we removed the items in which the verb was omitted in the matrix clause. This does not change the results: for Dutch, the difference between the matrix and embedded clause is significant ( $\chi^2 = 4.28$ ,  $df = 1$ ,  $p < 0.05$ ), for English it is not ( $\chi^2 = 0.00$ ,  $df = 1$ ,  $p > 0.05$ ).

Overall, these studies show that the problems agrammatics encounter with verbs and their properties have a spin-off on the production of other word-classes and that the characterization 'problems with grammatical morphemes' is too general for telegraphic speech.

## Keywords

Verbs; Case; Negation; Agrammatism; Cross-linguistic research

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## 1. Introduction

During the last decade, more and more has been published on the production of verbs, mainly at the word level (Miceli et al., 1983; Williams & Canter, 1987; Caramazza & Hillis, 1991; Jonkers & Bastiaanse, 1996; Kim & Thompson, 2000).

Recently, an overview of studies on verb retrieval at the word level was given by Kemmerer and Tranel (2000a,b). Like many others, they showed that action naming is influenced by a huge number of factors and that these factors might affect individual aphasic patients differently. In daily life, however, we speak in sentences and it has repeatedly been shown that producing verbs in sentences is essentially different from action naming (Berndt, Mitchum, Haendiges & Sandson, 1997; Bastiaanse & Jonkers, 1998; Jonkers, 2000). Verbs play a central role in the sentence: they assign the thematic roles to the NPs, they express the relation between the event and time (by tense), in many languages they show which NP is the subject (by agreement in number and person) and they assign case to the subject and object.

Some of these factors have been shown to be impaired in agrammatic Broca's aphasics. Thompson et al. (1997) demonstrated that the number of arguments belonging to a verb and their optionality influenced the retrievability. They reported that the difficulty agrammatic aphasics have with the retrieval of verbs increase with the number of arguments. This implies that a verb like *to walk*, that has no internal arguments, is easier to retrieve than *to fix*, that has one internal argument, which is easier than *to put* that has two. Apart from that, the number of possible argument structures that belong to a verb influences the ease with which it is produced: *to fix* and *to read* both have one internal argument, but *to read* has two possible argument structures: one can say 'he is reading' and 'he is reading a book' and both sentences are perfectly grammatical as an answer to the question 'what is he doing?'. *To fix* has only one possible argument structure, in which the object is realized. \*'He is fixing' is an ungrammatical answer to 'what is he doing?'; only 'he is fixing the car' is grammatical. Agrammatic aphasics are sensitive to this distinction: verbs with one possible argument structure are easier to retrieve than verbs with two or three possible argument structures. With respect to tense, Friedmann (2000) reported on inflectional problems with verbs in agrammatic aphasia in several languages: her patients are almost perfect at inflecting verbs for agreement, but they make errors when they have to inflect a verb for tense.

The present paper deals with three phenomena related to verbs: finiteness, case and negation. These phenomena will be discussed within the framework of a linguistic theory. Three cross-linguistic studies will be presented to show that the problems agrammatic speakers encounter with verbs have a spin-off on other grammatical notions that have been mentioned to be impaired in agrammatic Broca's aphasia.

## 1.1. Some phenomena of agrammatic production

The speech of Broca's aphasics has often been characterized by the omission and/or substitution of free and bound grammatical morphemes (Goodglass, 1968; Caramazza & Berndt, 1985; Thompson, Shapiro & Roberts, 1993).

Although such definitions are still given in introductory texts to aphasia, most researchers agree that it is an overgeneralisation to treat grammatical morphemes<sup>1</sup> as one single grammatical class that is impaired in agrammatic aphasia. In the present paper, we propose that some of the problems agrammatic aphasics have with a number of (free and bound) grammatical morphemes are due to the fact that the functions of these morphemes are closely related to verbs. We will thus argue that the verb plays a crucial role in the characterization of the production of Broca's aphasics.

Since there are many grammatical differences between languages, the effects of agrammatic aphasia will vary cross-linguistically (see e.g. Menn and Obler's (1990) extensive work on agrammatism in a large number of languages; Bates, Friederici & Wulfeck, 1987; Bates, Wulfeck & MacWhinney, 1991). Therefore, data from several languages will be presented to evaluate the effect of verbs and their properties on:

1. *Finiteness* in relation to the position of the verb in the sentence; data from Dutch and English will illustrate how a language specific rule such as 'verb movement' has an effect on verb inflection.
2. *Case and determiners* in relation to the presence of a (finite) verb; data from German will illustrate that the production of determiners is dependent on the production of the verb.
3. *Negation* in relation to verb movement; insertion of a negation marker in a sentence influences verb movement in some languages, but not in others. Data from Dutch, English, Norwegian and Spanish will illustrate that the ability to produce correct negative sentences is dependent on the relation between the negation word and verb movement.

These issues will be discussed within a linguistic framework, that is, Chomsky's *Government and Binding* theory.

## 1.2. Finiteness and the position of the verb

**1.2.1. Background**—Dutch has been analyzed as an SOV-language, meaning that the base-generated position of the verb is after the object (Koster, 1975). In the Dutch declarative matrix sentence, the finite verb has to be moved to second position. This movement is known as *Verb Second*. If the main verb clusters with a modal verb or auxiliary, the main verb remains in situ and the modal verb or auxiliary is moved to Verb Second position. In embedded clauses, the finite verb remains in its base-generated position. This is illustrated in (1–3), where *t* designates the canonical verb position, which is co-indexed with the Verb Second position.

(1)

de jongen	koopt <sub>t</sub>	een fiets	<sub>t</sub>
the boy	buys	a bike	

(2)

de jongen      wil<sub>i</sub>    een fiets kopen    t<sub>i</sub>



the boy      wants a bike (to) buy

(3) Embedded clause without modal verb/auxiliary

(ik denk) dat de jongen een fiets koopt

(I think) that the boy a bike buys

(I think that the boy buys a bike)

Here it is assumed that a verb is inserted in the structure in fully inflected form (Chomsky, 1995; for Dutch syntax, see Zwart, 1993). In the embedded clause, the finite verb remains in its base-generated position; in matrix clauses, only the finite verb moves to the left, the non-finite verb stays behind.

In English, an SVO-language, overt verb movement is restricted to auxiliaries and only found in questions (see 4).

(4)

is<sub>i</sub>      the boy      t<sub>i</sub> eating an apple?



The word order in declarative matrix and embedded clause is the same, however, contrary to Dutch. So, one of the properties of verbs is that their position in the sentence varies due to obligatory movement rules. It is this property that is subject of our first study. Dutch agrammatic patients have serious problems with the production of finite verbs in their spontaneous speech. Bastiaanse and Jonkers (1998) showed that the proportion of finite verbs these patients produce is significantly lower than in normal speech. Bastiaanse et al. (2000) suggested that this might be due to problems with verb movement: agrammatic aphasics are significantly more impaired in the production of finite verbs in the matrix clause than in the embedded clause (in which they perform almost faultlessly). As there were some methodological questions about this test, we decided to find more support for our hypothesis that verb movement was the critical issue here. A more sophisticated test was developed and presented to both Dutch and English speaking agrammatics. Based on the results of Bastiaanse et al. (2000) it is hypothesized that the production of moved finite verbs is more impaired than the production of non-moved finite verbs. It was therefore expected that there would be a difference between the production of finite verbs in the matrix and the embedded clause in the Dutch patients (as there is overt verb movement in the matrix clause) but not in the English patients.

## 2. Methods

### 2.1. Subjects

Six Dutch (one male, five female; mean age 47) and six English (five male and one female; mean age 56) speaking agrammatic Broca's aphasics participated in this study. All were aphasic due to a single stroke in the left hemisphere and at least 3 months post-onset. The

aphasia type was established with the Aachen Aphasia Test (Graetz, De Bleser & Willmes, 1992) for the Dutch and the WAB (Kertesz, 1982) for the English speaking patients and confirmed by both the therapist and the tester. The speech production of all aphasic patients was characterized as telegraphic.

## 2.2. Materials

The same materials were used in both languages. The patients were presented with two pictures in which the same person was performing the same action with a different person or object (Fig. 1). The patient was asked to complete a sentence with a finite verb and an object. There were two conditions: (1) a matrix clause that should be completed with a *finite verb-object*, (2) an embedded clause with the intended answer *object-finite verb* for Dutch and *finite verb-object* for English. There were 15 sentences in each condition. Two examples are:

Condition 1: matrix clause

Dutch (+movement)

Tester: Dit is de man die de tomaat snijdt en dit is de man die het brood snijdt. Dus deze man snijdt de tomaat en deze man...

Patient: *'snijdt het brood'*.

(lit: this is the man that the tomato cuts and this is the man that the bread cuts. So, this man cuts the tomato and this man...

[Patient: *'cuts the bread'*])

English (– movement)

Tester: This is the man that cuts the tomato and this is the man that cuts the bread. So, this man cuts the tomato and this man...

Patient: *'cuts the bread'*

Condition 2: embedded clause

Dutch (– movement)

Tester: Deze man snijdt de tomaat en deze man snijdt het brood. Dus dit is de man die de tomaat snijdt en dit is de man die...

Patient: *'het brood snijdt'*.

(lit: this man cuts the bread and this man cuts the tomato. So this is the man that the tomato cuts and this is the man that...

[Patient: *'the bread cuts'*])

English (– movement)

Tester: This man cuts the tomato and this man cuts the bread. So, this is the man that cuts the tomato and this is the man that...

Patient: *'cuts the bread'*

The reason to prompt the patient with the verb and the noun several times before s/he was supposed to produce it was to avoid interference with word-finding problems. Each set of pictures was used twice, once with a matrix clause and once with an embedded clause to complete. The test started with two examples that were repeated until it was clear that the patient understood the task.

The test has been presented to three (Dutch) healthy speakers, who had no problems with any of the items (all scored 100% correct). For a different study on language acquisition, the test has also been presented to ten 8-year-old (Dutch) children, who performed faultlessly (Zuckerman, Bastiaanse & Van Zonneveld, 2001). Therefore, all errors made by the agrammatic aphasics, were supposed to result from their aphasia and not from test construction.

### 2.3. Scoring

A simple correct/incorrect scoring system was used, in which determiner omission was ignored. Self-corrections were allowed and the final answer was the one that was analyzed. If requested, the examiner repeated the cueing sentences once. Post-hoc, an error analysis system was developed on the basis of the most frequently occurring errors: verb omissions, lack of finiteness, word order errors, and a class 'others', that contained semantic paraphasias, nil reactions etc.

## 3. Results<sup>2</sup>

### 3.1. Quantitative analysis

The results are shown in Table 1.

There is no significant difference between the total number correct of the two groups ( $t = 0.31$ ,  $df = 10$ ,  $p > 0.05$ ). For Dutch, there is a significant difference between matrix and embedded clauses ( $t = -2.79$ ,  $df = 5$ ,  $p < 0.05$ ), that is not found for English ( $t = 0.42$ ,  $df = 5$ ,  $p > 0.05$ ).

### 3.2. Qualitative analysis

A qualitative analysis has been performed (Table 2) to compare the errors in both language groups.

Both groups omit the verb: the Dutch speaking agrammatics only in the matrix clause, the English speaking mainly in the embedded clause. Notice that for the matrix clause this results in a grammatical sentence *this boy cuts the tomato and this boy the bread*, though not in the embedded clause *\*this is the boy that cuts the tomato and this is the boy that the bread*. Because none of the patients omit the verb in the matrix clause consistently and the patients often indicate that this is not the expected answer, it was decided to count these omissions as an error.<sup>3</sup> For a more linguistic account to justify scoring these omissions as incorrect, see Zuckerman et al. (2001).

It is interesting to note the clear dichotomy in the errors produced by the two populations. The most prominent error of the Dutch patients is the production of the wrong word order (i.e. embedded order in the matrix clause and vice versa). The most frequent error made by the English speaking patients, however, is the production of non-finite verbs (both infinitives/stems and gerunds), an error that is never made by the Dutch speaking agrammatics.

## 4. Discussion

The Dutch speaking agrammatic aphasics show the expected discrepancy between the production of finite verbs in the matrix and the embedded clause, whereas this discrepancy is not found in the English speaking agrammatics. One could argue that this discrepancy is not expected for the English patients, because they are prompted by the right order three times, whereas the Dutch hear the required order only once. However, if the number of times the correct order is prompted plays a role, then one expects the Dutch to be worse than the English patients and one expects no discrepancy between the matrix and embedded order for the Dutch, since in both cases they hear the correct prompt only once. We therefore interpret the results as supporting our hypothesis that verb movement is difficult for agrammatic aphasics in Dutch.

The error pattern reveals an absolute dichotomy between the Dutch and English speaking agrammatics: the Dutch patients make word order errors, but never finiteness errors whereas the pattern for the English speaking agrammatics is the opposite. Although different types of Broca's aphasia may exist (see for example Miceli et al. (1983) and Saffran et al. (1989) and the ongoing discussions in Brain and Language between Grodzinsky, Piñango, Zurif and Draï (1999), Draï and Grodzinsky (1999), Zurif and Piñango (1999) and Draï, Grodzinsky and Zurif (2001) on the one hand and Berndt and Caramazza (1999) and Caramazza, Capitani, Rey and Berndt (2001) on the other) and agrammatism may manifest itself differently in Broca's aphasia (Kolk & Heeschen, 1990), even within patients (Bastiaanse, 1995), it is unreasonable to assume that, incidentally, all English speaking agrammatics have a morphological disorder and all Dutch speaking agrammatics a syntactic one. Fortunately, there is a more plausible explanation. In Dutch, verb movement is obligatory in the matrix clause while it is forbidden in the embedded clause. This means that two possible word orders are allowed in Dutch: (subject)—finite verb—object (for the matrix clause) and (subject)—object—finite verb (for the embedded clause). Hence, even if the Dutch speaking agrammatics make word order errors, they produce a word order that is allowed in their language, though not in the present position. English has no clause type that allows for SOV word order, so the production of such an erroneous word order is not an option for English speaking agrammatics. In English, non-finite verbs (infinitives, gerunds), however, can precede the object and thus offer an alternative when agrammatic aphasics are not able to produce a finite verb, as in *cutting a tomato*. Returning to Dutch: non-finite verbs (infinitives and participles) *always* follow the object; they can never precede it and hence, the production of a non-finite verb followed by an object is not an option for the Dutch speaking agrammatics as this word order is *not* in *their* grammar.

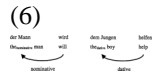
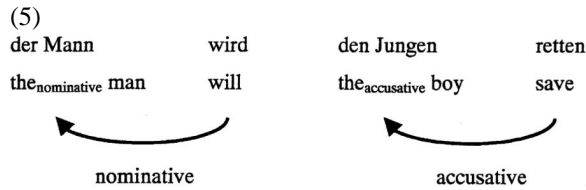
In conclusion: as hypothesized, a different performance on matrix and embedded clauses was found for the Dutch, but not for the English speaking agrammatics. The English speaking patients do make errors (just like the Dutch patients in the embedded condition), but these errors are qualitatively different from the ones produced by the Dutch patients. We suggest that both populations make errors that result in strings that are allowed in their grammar, though not in the condition in which they produce them.

### 4.1. Case, determiners and the realization of the verb

**4.1.1. Background**—As stated above, the verb plays a central role in the sentence. One property of the verb is that it assigns case. Case expresses the syntactic relation between a verb and its arguments. It specifies which noun phrase in a sentence is the subject, and which noun phrase is the object. Every language has case, even if not morphologically realized (e.g. Chomsky, 1986). In English, case can only be seen on pronouns, for example *I* vs. *me* and *he* vs. *him*. In German, however, the determiners in noun phrases are also marked for case. Subject noun phrases are assigned nominative case by the finite verb of the



sentence (see 5–6), which means that the production of properly case marked subject determiners is dependent on the presence of a finite verb. In the same way, the verb assigns accusative case to the direct object and dative case to the indirect object (Chomsky, 1986; see 5–6 for an example). Without a verb, no case can be assigned and hence, no object determiners should be present.



In a German sentence such as (5), the finite verb *wird* assigns nominative case to the grammatical role of subject *der Mann*, and the verb *retten* assigns accusative case to the grammatical role of object *den Jungen*. In (6) the verb *helfen* assigns dative case which is associated with the theta role ‘beneficiary’ to *dem Jungen*. Apart from verbs, some other categories can assign case, for example prepositions. Our focus, however, will be on case assignment by verbs: finite verbs assign case to subjects, the verb in general assigns case to (direct and indirect) objects.

Verb production and finiteness are difficult for agrammatic aphasics. Since, according to this theory, case assignment depends on the presence of a (finite) verb, and the production of determiners depends on case assignment, we expected a relation between the production of determiners on the one hand, and the realization of verbs on the other hand. Ruigendijk, Van Zonneveld and Bastiaanse (1999) demonstrated such a relation between the realization of a (finite) verb and the production of case-marked determiners and pronouns in Dutch and German agrammatic spontaneous speech. Their data showed that when no (finite) verb was realized, that is, when no proper case assigner was present, the determiner was virtually always omitted.

In German, determiners are marked for case, number and gender. De Bleser, Bayer and Luzzatti (1996) showed with a determiner insertion task that German agrammatic patients do not have problems when they have to inflect a single noun phrase for gender, that is they are able to produce the proper determiner for a given noun. However, when they have to insert a determiner complete a noun phrase in a sentence, they are far less accurate. This may mean that the problem with the production of determiners is related to case, rather than to gender. The question of the present study is whether case as such is the problem or whether the case problems are caused by the problems with (finite) verbs.

A test was developed to examine German agrammatic speakers. The test results of these patients were compared with their spontaneous speech. The hypothesis was that there is a relationship between problems with (finite) verb production and the production of determiners.

## 5. Methods

### 5.1. Subjects

A group of six German agrammatic aphasics participated in this study (five male, one female; mean age 58). All patients were aphasic due to a single stroke in the left hemisphere.



They were diagnosed as Broca's aphasics with the Aachen Aphasia Test (AAT, Huber, Poeck, Weniger & Willmes, 1983) and this diagnosis was confirmed by the tester and the speech therapist. The speech production of all aphasic patients was characterized as telegraphic. The experimental data of this group were compared to the data of a control group of 12 German non-brain damaged speakers (six male, six female; mean age 53).

## 5.2. Materials

First, spontaneous speech was elicited with a semi-structured interview (conform AAT standards). In this interview, the patient was asked to describe the history of his illness, his job, hobbies and family. The spontaneous speech was analyzed to investigate whether the patients produced determiners and whether the ability to do so depended on their ability to produce (finite) verbs. These spontaneous speech data were then compared with the data of the experimental tasks. The first test was a sentence completion task in which the subjects were presented with a picture and an incomplete SVO-sentence (Fig. 2) that was to be completed with a noun phrase.

Either the subject or the object noun phrase was missing. The patients were asked to read the sentence aloud (or to repeat it in case of reading difficulties) and to complete it. The sentence under the left picture in Fig. 2, for example, should be completed as *der Junge ähnelt dem Mann* (the<sub>nominative</sub> boy looks like the<sub>dative</sub> man). This task examines the patients' ability to produce a determiner when the case assigning finite verb is given. Secondly, a sentence production task was presented in which the same pictures were used, but now the infinitive was given. The subjects were asked to tell in one sentence what was happening in the right picture, using the given verb. For the picture in Fig. 2 they should produce a sentence such as *die Frau überwacht den Mann* (the<sub>nominative</sub> woman guards the<sub>accusative</sub> man). This task was included to examine whether the patients were able to inflect a verb for tense and agreement in combination with production of the correct determiner for the noun phrase. Both tasks aimed to elicit three different constituents: nominative subjects, accusative objects and dative objects. There were ten items for each constituent per test.

## 5.3. Scoring

Since it was hypothesized that there is a relationship between finite verb production and the production of determiners, the spontaneous speech data were analyzed with regard to determiner production in relation to verb production. All noun phrases were counted, and for each noun phrase it was established whether a correctly case marked determiner was realized. Then, it was examined whether a case assigner was present for each noun phrase. The difference between: (1) noun phrases plus determiner, plus case assigning verb and noun phrases without determiner, without case assigner was compared to (2) noun phrases without determiner, plus case assigning verb and noun phrases plus determiner, without case assigner. Occurrences such as: (1) are expected according to the theory, occurrences such as (2) are not.

The results of the spontaneous speech analysis were compared to the results of the experimental tasks. The elicited noun phrase was considered correct and complete, if it was produced with a correctly case-marked determiner. For a qualitative comparison, the errors were analyzed. There were four error categories: incorrect case marking on the determiner, incorrect gender marking on the determiner, determiner omitted and other errors (nil reactions or irrelevant reactions).

## 6. Results

### 6.1. Quantitative analysis

**6.1.1. Spontaneous speech**—All patients omitted at least some determiners in their spontaneous speech (Table 3). Together they produced 230 noun phrases. In 112 (49%) of these phrases the determiner was omitted. For 113 noun phrases no case assigning verb was present. There was a significant difference between: (1) expected combinations: noun phrases plus determiner, plus case assigning verb and noun phrases without determiner, without case assigning verb and (2) unexpected combinations: noun phrases plus determiner, without case assigning verb and noun phrases without determiner, plus case assigning verb ( $t = 4.309$ ,  $df = 5$ ,  $p < 0.01$ ).

**6.1.2. Experiments**—Since there was no difference between patients' results on the two experiments, the results on these experiments were taken together per patient (Table 4). The patients produced 71.1% of the noun phrases correctly, which is significantly worse than the control group of non-brain damaged speakers (95.7% correct; Mann–Whitney  $U$ -test:  $Z = -3.409$ ,  $p < 0.001$ ). As a group, they produced 95% of the nominative subjects correctly, 69.2% of the accusative objects and 49.2% of the dative objects. All patients were able to inflect the infinite verb in the sentence production task.

### 6.2. Qualitative analysis

An error analysis (Table 5) shows that the performances of the patients are quite similar. They made only a few gender errors (three in total), and only a few determiner omissions (five in total). Most errors ( $n = 82$ ) were case substitutions.

As can be seen in Table 4, all patients do relatively well on the production of nominative determiners in subject noun phrases. When they have to produce accusative and dative case marked determiners for object noun phrases, they make many errors. The individual scores show one remarkable difference. The patients can be divided into two groups, patients G1, G3, G4 and G6 are relatively good in producing accusative objects (respectively 80, 90, 80 and 90% correctly), but poor in producing dative objects (respectively 10, 10, 35 and 60% correctly). They often substitute accusative case by dative (77% of all dative objects). The two other patients G2 and G5 show the opposite pattern. They are good in producing the dative objects (respectively 85 and 95% correct), and make many errors with the accusative objects (45 and 30%), caused by producing the dative form instead (65% of all accusative objects).

## 7. Discussion

Based on the relationship between verb production and inflection on the one hand, and the production of determiners on the other hand, it was expected that more determiners are produced when a verb is realized. The results of this study support this hypothesis (Ruigendijk et al., 1999). Although all patients show problems in the production of determiners in their spontaneous speech, specifically when no case assigning verb is present, they are very well able to produce determiners in the experiments where the case assigning verb is given. In sentences with a given verb, the determiner is omitted in only five of the noun phrases. Important is that hardly any gender errors are made, but many case substitutions occur. With regard to these case substitutions, the patients show two different patterns. Four of the patients overgeneralize accusative case, and two patients overgeneralize dative case when producing an object noun phrase. Even if they have the verb, it seems that they still have problems in assigning the correct grammatical role to the object noun phrases. They know, however, what a sentence should look like. If the patients produce an object,

they produce it with objective case (accusative or dative) although not always the correct one. They hardly ever replace an accusative or dative case with a nominative. But most important, the results demonstrate that once the verb is realized, the production of determiners increases for agrammatic aphasics who omit determiners in their spontaneous speech when no (finite) verb is produced.

## 7.1. Negation and the relation to verb movement


**7.1.1. Background**—The two earlier studies reported that in agrammatic aphasia, the ability to express case is related to verb production and the ability to express tense and agreement is related to verb movement. Another linguistic property connected with verbs is negation.

In order to express a sentence that carries a negative meaning, one can produce a grammatical morpheme marking negation in a sentence, which, in English, is the word *not*. When one inserts this negation marker in an affirmative sentence, this may have consequences for its structure. In some languages sentential negation is related to verb movement, in the sense that it either prevents the verb from moving or that it entails cliticizing the negation morpheme onto the verb. Below, negative sentences in four languages will be discussed: Dutch, Norwegian, English and Spanish.

### 7.1.2. Negation in Dutch

—(7) Pieter eet<sub>i</sub> de appel *t<sub>i</sub>*

Peter eats the apple

(8)  


Example (8) shows that negating the affirmative sentence in (7), by adding the morpheme *niet*, does not interfere with verb movement as the verb passes over *niet* to the second position in the sentence.

**7.1.3. Negation in Norwegian**—Another language in which negation is not related to verb movement is Norwegian. Examples (9) and (10) show that negating the affirmative sentence in (9) by inserting the negation marking morpheme *ikke* does not influence movement of the verb.

(9) Pjotter ser katten

(Peter sees the cat)

(10)  


**7.1.4. Negation in English**—In English, inserting a negation marking morpheme in an affirmative sentence such as (11) is ungrammatical (see example 12):

(11) Peter eats the apple

(12)

## \* Peter eats ; not t ; the apple



The correct version of the negative sentence is:

(13) Peter does not eat the apple

The derivation of this structure can be explained as follows. If the verb needs to (covertly) move out of the VP, it cannot pass over the negation morpheme *not*. However, a finite verb is needed to produce a grammatical sentence. A solution is to insert *do* for expressing tense and agreement, which is base-generated to the left of *not*, resulting in (13). In spoken language, the negation marker cliticizes with the auxiliary: *doesn't, don't, can't, ain't*.

**7.1.5. Negation in Spanish**—In Spanish, negating an affirmative sentence (see example 14), by inserting the negation morpheme *no*, affects movement of the verb. Rather than just moving over *no*, the negation morpheme cliticizes to the left of the verb and joins it on its way to the proper position in the sentence (as can be seen in sentences 15 and 16):

(14) Pedro come la manzana

Peter eats the apple

(15) \*Pedro come no la manzana

(16)

(16) Peter eats the apple. Peter does not eat the apple.  
Pedro come no la manzana  
(16) Peter eat eat the apple. Peter does not eat the apple.

In sum, the four languages differ with respect to the relation between verb movement and negation: in Dutch and Norwegian, insertion of the negation morpheme does not affect verb movement, whereas in English and in Spanish, verb movement interferes with negation.

We hypothesize that this dependency between verb movement and negation plays a role in the construction of negative sentences in agrammatic aphasia. It is expected that it is harder to form negative sentences for agrammatic patients if verb movement is related to negation, since verb movement is affected in agrammatic production (see first study above).

Bastiaanse et al. (2000) report on a study testing this assumption for Dutch and English. They found that English agrammatic patients were significantly more impaired in producing negative sentences than Dutch patients, but that their ability to form affirmative sentences was comparable, confirming our expectations.

This hypothesis is elaborated upon in the present study by including data from two more languages: Norwegian and Spanish. Based on the properties of negative sentences in these two languages, we expect that the Spanish agrammatic patients perform similarly to the English and that the performances of the Norwegian agrammatic patients follow the pattern of the Dutch patients. The English and Spanish patients will encounter more problems with constructing negative sentences than affirmative sentences, while this difference is not expected to show up in the Dutch and Norwegian agrammatic aphasics.

## 8. Methods

### 8.1. Subjects

Three Dutch, two Norwegian, one Canadian–English and one British–English patient and two Spanish patients participated in this study (four female, five male, mean age 53.6). They were all aphasic due to a single stroke in the left hemisphere and were at least 6 months post-onset. All patients were diagnosed as Broca's aphasics using standard aphasia tests (AAT for Dutch patients, several standard tests for the Norwegian patients, WAB for Canadian patient, BDAE for British and the Spanish patients). They were all classified as agrammatic by their speech therapists and the testers on the basis of their adequate auditory comprehension in conversation and their telegraphic speech output (e.g. omissions and substitutions of inflections, determiners and pronouns). Nine healthy control subjects participated in this study matching the aphasic patients on language, age, educational level and gender. They did not make any errors on the two tasks and their performances will further be ignored.

### 8.2. Materials

Two sentence anagram tasks were developed to investigate production of affirmative and negative sentences in Dutch, Norwegian, English and Spanish.

**8.2.1. The sentence anagram task with pictures**—This task investigated how patients use negation when this was elicited by the picture. The test consisted of 18 items: nine negative and nine affirmative control sentences. The patient was presented with a picture and anagram cards with the negation morphemes, the subject, the object and the verb printed on them. S/he was asked to make a sentence matching the picture, but was explicitly told that s/he would not need to use all anagram cards to make a correct sentence (in half of the test sentences the negation had to be left out). The cards were presented in a semi-random order, but never in the grammatical order. An example of the test pictures with the target sentence is given in Fig. 3.

**8.2.2. The sentence anagram task without pictures**—The goal of this test was the same as above, but with this test syntactically more complex sentences were elicited. The task consisted of 30 items; half of them were negative; half of them were affirmative control sentences. Three structures were tested: ten active, ten passive and ten present perfect tense sentences. The patient was asked to use all cards to form a sentence. An example of this test is:

Target sentence: the mouse is not caught by the cat

Anagram cards: [the mouse] [is] [not] [caught] [by the cat]

In the passives the *by*-phrase was printed on one card so that the patient did not have to choose which NP was agent or theme.

### 8.3. Scoring

The results of the two anagram tasks were taken together. Only word order errors were counted in the anagram tasks; semantic reversibility errors were not scored. Incorrect presence or absence of the negation morpheme was scored as an error. Furthermore, negative sentences in which constituent negation, rather than sentential negation was used were also scored as incorrect when this was not permitted in the language of the patient. Constituent negation differs from sentential negation in the way that the former only negates a restricted domain within the sentence. An example is given in (17):

(17) The boy eats not the grapefruit.

In English, constituent negation is only grammatical if combined with a contrastive phrase (*the boy eats not the grapefruit, but the banana*). In Dutch, constituent negation is allowed (but highly marked) in active and present perfect tense sentences but not in passives. If the patients used constituent negation correctly in Dutch, the items were scored as correct, although the Dutch control subjects never constructed sentences with this type of negation. In Norwegian, constituent negation is only grammatical in active sentences and in Spanish it is never allowed.

## 9. Results

The data of the aphasic speakers will first be discussed per language after which a cross-linguistic comparison is made.

### 9.1. Quantitative analysis

**9.1.1. The Dutch patients**—The Dutch patients show a mixed pattern of results; they are able to form grammatical negative sentences but often use constituent negation (see Table 6 for their performances). There is no significant difference between the construction of negative and affirmative sentences (Wilcoxon:  $z = -1.50$ ,  $p = 0.134$ ).

**9.1.2. The Norwegian patients**—The Norwegian patients show the same pattern as the Dutch: there is no difference between the construction of negative and affirmative sentences (Wilcoxon:  $z = -1.50$ ,  $p = 0.134$ ; Table 6). One patient almost always constructs sentences with constituent negation when he does not construct the target negative sentences; the other one shows a more diffuse pattern of performance: he also uses constituent negation but always in combination with other errors (word order errors).

**9.1.3. The English patients**—Both English patients show severe problems with constructing negative sentences as opposed to affirmative sentences: 95% of the negative sentences are constructed incorrectly, compared to only 0.05% of the affirmative sentences. This difference is significant (Wilcoxon:  $z = -2.12$ ,  $p = 0.034$ ; Table 6). The way the patients construct negative sentences is strikingly similar; they either omit the negation morpheme (in the task with pictures) or they construct sentences with constituent negation (e.g. *the boy does read not the book*) in the task without pictures. One patient places the negation morpheme at the end of the sentence twice (e.g. *the boy reads the book not*).

**9.1.4. The Spanish patients**—The Spanish patients are significantly more impaired in constructing negative sentences than affirmative sentences (Wilcoxon:  $z = -2.29$ ,  $p = 0.022$ ; Table 6). Both patients resort to two types of sentences when they construct ungrammatical negative sentences: they either place *no* at the end of the sentence or they use constituent negation rather than sentential negation. One patient tends to put grammatical morphemes, such as the auxiliaries *ha* (has) and *es* (is), in affirmative passives and present perfect tense sentences in final sentence position, just as he does with the negation morpheme. Both patients have specific difficulties with the passives and sentences in the present perfect tense, both of the affirmative and negative type. This may obscure the problems they experience with negation: if only the results of the active sentences are analyzed, the difference between the two sentence types is clear: 77% of the negative sentences are constructed ungrammatically whereas all affirmative sentences are constructed correctly.

## 9.2. A cross-linguistic comparison

The four patient groups are comparable in their ability to construct affirmative sentences. Fig. 4 shows the comparisons between the four groups. However, statistical analyses of the results of the negative sentences reveal differences in performance between the groups: the scores of the Spanish and English patients are comparable but both perform significantly worse than the Dutch and Norwegian patients whose performances are not significantly different.

## 10. Discussion

Based on the relation between negation and verb movement, we expected that the English and Spanish patients would perform worse in constructing negative sentences than affirmative sentences in contrast with the Dutch and Norwegian patients, for whom we expected that construction of negative sentences would not be any harder than affirmative sentences.

A cross-linguistic difference in the performances of the four groups was hypothesized and the data support this hypothesis. The English and Spanish patients have significantly more difficulties with constructing negative sentences than affirmatives. They perform worse than the Dutch and Norwegian agrammatic speakers when they have to construct negative sentences, even though the ability to form affirmative sentences is comparable between the four groups.

How can these cross-linguistic differences be explained? In English and Spanish, negation interferes with verb movement which is not the case in Dutch and Norwegian. We assume that the relation between verb movement and negation impacts on a patient's ability to produce negative sentences, since verb movement is affected in agrammatism.

A qualitative analysis of the data shows that all patients tend to make the same type of 'errors' when they are constructing negative sentences: they tend to resort to constituent negation rather than sentential negation and this is a marked form of negation with a more narrow scope than sentential negation, only involving a restricted domain within a sentence.

However, there are still questions to answer: why is it that the Dutch and Norwegian patients also make errors in constructing negative sentences and what is it that makes constituent negation a more favorable option for agrammatic patients than sentential negation, even when the latter does not affect verb movement? For English and Spanish the answer to this question seems relatively clear: constituent negation circumvents interference with verb movement. The performances of the Dutch and Norwegian patients, however, cannot readily be explained.

In sum, cross-linguistic evidence from Spanish and Norwegian supports the hypothesis that the ability to construct negative sentences is dependent on the relationship between negation and verb movement.

## 11. General discussion

These three cross-linguistic studies have shown that the problems agrammatic Broca's aphasics encounter with verbs and their properties have a spin-off on other word classes and syntactic operations. Verb movement is difficult and therefore Dutch agrammatics have more problems producing finite verbs in the matrix than in the embedded clause. This discrepancy is not observed in agrammatics speaking English, a language that does not have different word orders in matrix and embedded clauses. The second study demonstrates that the omission of determiners is related to the problems German speaking agrammatics have



with verbs: once they are presented with the (finite) verb, the production of determiners increases. The final study shows that the relation between negation and verb movement influences agrammatic speakers' ability to form negative sentences: agrammatic patients speaking Dutch and Norwegian, languages in which verb movement is not related with negation, are better in constructing negative sentences than English and Spanish speaking agrammatics; a difference that does not exist for the affirmative sentences.

This section will first discuss whether the problems with verbs and their properties may be the central deficit in agrammatic aphasia. Then, the question of what a linguistic theory can offer in our understanding of agrammatism will be addressed. Finally, the clinical consequences of the results will be discussed.

### 11.1. The status of the verb problems

It was shown that the problems with finiteness and negative sentences relates to verb movement and that the production of determiners relates to the production of (finite) verbs. So far, we have not considered other grammatical morphemes that are reported to be omitted or substituted in agrammatic aphasia, but there is some support in the aphasiological literature that the omission/substitution pattern of other grammatical morphemes might be related to verb production as well. For example, Bennis, Prins and Vermeulen (1983) showed that the difficulties Dutch agrammatic speakers have with prepositions is dependent on the function of the preposition in the sentence: prepositions that are subcategorized by the verb or by the argument structure of the verb (such as *to* in *listening to* or *giving to*) are more difficult to produce than prepositions that bear a lexical meaning (such as *to* in *walking to the car*).

Omission of pronouns can also be explained by the verb production problem. Pronouns need case, just like determiners, which is visible in, for example, English (*I/me, he/him, she/her*). Ruigendijk et al. (1999) showed that pronouns without case assigner hardly occur in Dutch and German agrammatic speech, like determiners, as demonstrated above. We therefore suggest that it is not grammatical morphemes (or function/closed-class words) as a class that is affected in agrammatic speech, but *verbs* as a class, with many consequences for sentence construction, constrained by the grammar of the aphasic speaker. Of course, we do not wish to claim that problems with verbs can explain all characteristics of Broca's aphasia, or that Broca's aphasia is basically a problem with verbs. There is ample evidence from comprehension studies that non-canonical order of the thematic roles is problematic for at least a large group of Broca's aphasics. Recently, we compared the production of sentences with and without object movement. The preliminary results show that the sentences with moved objects are significantly more difficult. Apart from that, not all agrammatics seem to suffer from verb retrieval problems (Bastiaanse, 1995; Nespoulous, Dordain, Perron, Ska, Bub, Caplan, Mehler & Lecours et al., 1988), although problems with the production of verbs and/or their properties, such as inflection, determiners, subcategorized prepositions are often mentioned in these case studies (Miceli et al., 1983). In earlier work, we suggested that there might even be an interaction between verb retrieval and the production of properties related to verbs (Bastiaanse, 1995; Bastiaanse & Jonkers, 1998). For some authors the different manifestations of Broca's aphasia are reason to assume that Broca's aphasia is not a homogeneous syndrome (Caramazza & McCloskey, 1988; Miceli et al., 1983; Miceli, Silveri, Romani & Caramazza, 1989). We would like to argue, however, that these different manifestations might stem from one underlying problem, in which the verb plays a crucial role.

The hypotheses for each of the presented studies were derived from a linguistic theory and each of them was confirmed. However, although significant differences were found, the better group or condition was never perfect, nor was the worst group or condition ever

completely impaired. Although this variation among individuals and conditions is normal, no agrammatic aphasic performed like the non-brain-damaged speakers. This means that some questions remain. Three of them will be addressed, each one related to one of the studies.

It is unclear how to deal with the errors with the finite verbs made by the English speaking agrammatics. Although the discrepancy between performance on the matrix and embedded clause was not found, as expected, the production of finite verbs was impaired. Hence, there must be other factors than verb movement alone that influence the ability to produce finite verbs.

Another issue is related to case assignment. It was shown that the poor production of determiners is related to verbs and that gender does not play a major role, but it is unclear yet why German agrammatics mix up dative and accusative case, once they produce the verb. A similar problem arises when the negation data are considered. Again, our hypothesis was confirmed, but the Dutch and Norwegian agrammatics do make errors, even though in these languages insertion of a negation marking morpheme does not affect verb movement.

Nevertheless, our suggestion remains that the poor production of at least some grammatical morphemes in the speech of agrammatic Broca's aphasics is for a large part due to the poor production of verbs.

## 11.2. The role of a linguistic theory

In this paper, Chomsky's Government and Binding Theory (GB) has been used to derive hypotheses about the deficits in agrammatic speech production. This framework offers a description of the underlying structure of language and this may help us to understand how brain damage may affect linguistic processing. Chomsky's theory about the relation between case and (finite) verbs seems appropriate to explain the problems German speaking agrammatic aphasics encounter with determiners. Chomsky's case theory, however, is not only about German. It states that every phonetically realized noun phrase must have case, even in languages where this is not always visible. Therefore, it should be applicable to explain the presence or absence of that same characteristic in other languages. In languages such as Dutch and English, for example, determiners are not marked for case, but they are often omitted in agrammatic speech. Ruigendijk et al. (1999) showed that Chomsky's case theory, with a small adaptation, describes determiner omission in Dutch agrammatic speech very well. Using a linguistic theory (Government & Binding theory or any other) to describe a characteristic of agrammatic Broca's aphasia in one language may thus lead to predictions about this aphasia type in other languages. One may or may not like these interpretations of agrammatic Broca's aphasia, a fact is that a linguistic theory can offer a framework to form and test hypotheses to describe the phenomena.

This does not mean that aphasiology should be dictated or led by linguistic theories (this would be rather hard, as these change every other year, whereas agrammatic behavior is stable), but these theories have shown to be fruitful to describe agrammatic behavior and to form and test hypotheses about agrammatic performance.

## 11.3. Some clinical consequences

Assuming that the verb is responsible for many problems in agrammatic speech production, it seems reasonable to focus treatment on the central role of the verb. Springer, Huber, Schlenk and Schlenk (2000) showed, for example, that in German agrammatic patients who were trained on verb production, production of complete noun phrases increased as well. However, the usefulness of training the production of *finite* verbs is doubtful, at least for Dutch speaking agrammatic aphasics, considering the results of the first study. If verb

movement is difficult, the therapist might prefer to focus on sentences in which the verb does not move (ellipses or sentences with modal finite verbs and the lexical, non-finite verb in base-generated position). Bastiaanse and Jonkers (1998) showed in a study to the spontaneous speech of Dutch agrammatic Broca's aphasics, that there is a reverse relationship between the production of finite verb forms and the variety of verbs produced. Those patients who used a (close to) normal proportion of finite verbs had little variety in the produced verbs, whereas patients with a (close to) normal variety of verbs were severely compromised in the production of finite verbs. This may reflect a trade-off between morpho-syntactic and lexical-semantic characteristics of verbs. Therefore, from a communicative point of view, the therapist might emphasize lexical-semantic content, and focus on the production of non-finite verbs (i.e. infinitives, participles and (for English) gerunds), thus ignoring the training of finite verbs.

## 12. Conclusion

Three studies have been discussed investigating the effect of problems with verbs and their properties can have on the production of grammatical morphemes in agrammatic aphasia. It has been demonstrated that the ability to express finiteness, determiners and negative sentences can be related to verb movement and the ability to produce verbs. A specific linguistic framework (*Government & Binding Theory*) has proven to be a useful tool to describe these characteristics of agrammatic aphasia.

## Acknowledgments

The authors wish to thank Susan Edwards, Judith Feiken, Gonia Jarema, Inger Moen, Martina Penke, Maria Jesus Rodriguez, Mieke van de Sandt and Luise Springer for referring their patients. We are grateful to Dirk den Ouden for his comments on an earlier version of this paper.

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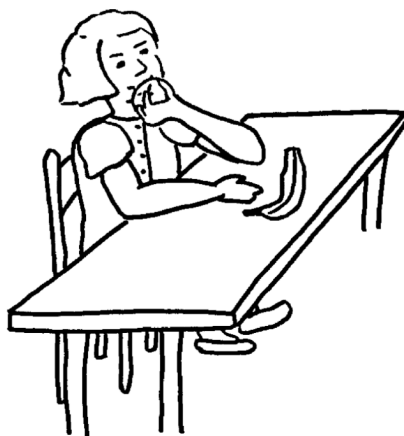


**Fig. 1.**  
The pictures used to test the production of finite verbs.



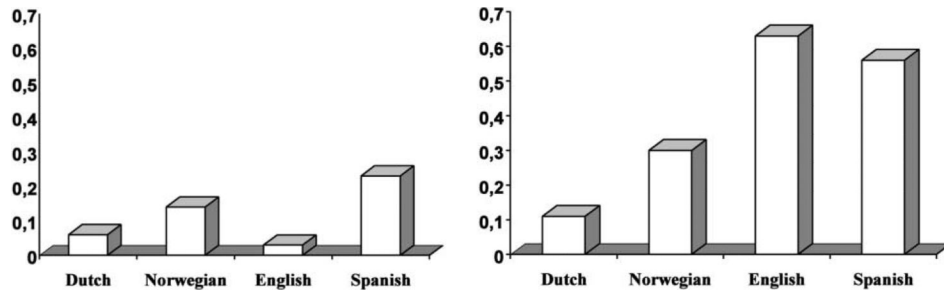
**Fig. 2.** Two examples of the test for the production of determiners (left: sentence completion; right: sentence construction).





**[the girl] [does] [not] [eat(s)] [the banana]**

**Fig. 3.**  
Example of a picture used in the negation test: [the girl] [does] [not] [eat(s)] [the banana].



**Fig. 4.**

A cross-linguistic comparison between the four patient groups. Left figure (mean number of errors on the affirmative sentences): the four patient groups do not differ significantly from each other. Mann-Whitney  $U$ -tests were used for comparison. (Dutch–Norwegian:  $z = -0.39$ ;  $p = 0.695$ , Dutch–English:  $z = -1.52$ ,  $p = 0.127$ , Norwegian–English:  $z = -1.00$ ;  $p = 1.0$ , Norwegian–Spanish:  $z = -0.11$ ;  $p = 0.912$ , English–Spanish:  $z = -1.33$ ;  $p = 0.182$ ). Right figure (mean number of errors on the negative sentences): the Dutch and Norwegian ( $z = -0.39$ ;  $p = 0.695$ ) and the Spanish and English ( $z = -1.09$ ;  $p = 0.276$ ) results are comparable. The English and Spanish perform significantly worse than the Dutch and Norwegian patients (English–Dutch:  $z = -2.84$ ;  $p = 0.005$ , English–Norwegian:  $z = -2.47$ ;  $p = 0.0013$ , Spanish–Dutch:  $z = -2.22$ ;  $p = 0.027$  and Spanish–Norwegian:  $z = -2.16$ ;  $p = 0.031$ ).

**Table 1**

The individual scores of experiment 1 of the Dutch (D1–D6) and the English (E1–E6) speaking agrammatic aphasics. (— V = verb omission; order = word order error; — finite = a non-finite verb)

	Correct		Errors matrix clause			Errors embedded clause					
	Total	Matrix	Embedded	—V	Order	Finite	Other	—V	Order	—Finite	Other
D1	16	5	11	7	3	0	0	0	1	0	3
D2	18	10	8	0	2	0	3	0	6	0	1
D3	11	7	14	5	3	0	0	0	1	0	0
D4	20	7	13	0	7	0	1	0	0	0	2
D5	24	10	14	0	5	0	0	0	1	0	0
D6	26	12	14	2	1	0	0	0	1	0	0
Mean	20.83	8.50	12.33								
E1	26	13	13	1	0	0	1	0	0	0	2
E2	17	8	9	3	0	1	3	5	0	0	1
E3	20	10	10	0	0	4	1	0	0	5	0
E4	26	12	14	0	0	1	1	1	0	0	0
E5	23	12	11	1	0	0	2	4	0	0	0
E6	8	4	4	0	0	8	3	2	0	7	2
Mean	20.00	9.83	10.16								

Table 2

Errors types: total number of errors for each category

	Matrix clause				Embedded clause			
	No. verb omissions	No. fin. features omissions	No. word order errors	No. other errors	No. verb omissions	No. fin. features omissions	No. word order errors	No. other errors
Dutch	14	0	21	4	0	0	10	6
English	5	16	0	19	12	1.3	0	4

**Table 3**

The total number of determiners produced in the spontaneous speech of six German agrammatic speakers in relation to the use of a case assigner (the expected combinations are in bold)

	<b>+ Case assigning verb</b>		<b>- Case assigning verb</b>	
	<b>+ Determiner</b>	<b>- Determiner</b>	<b>+ Determiner</b>	<b>- Determiner</b>
G1	<b>0</b>	0	1	<b>32</b>
G2	2	8	1	<b>24</b>
G3	<b>18</b>	2	2	<b>12</b>
G4	<b>51</b>	0	2	<b>3</b>
G5	<b>25</b>	2	9	<b>18</b>
G6	<b>5</b>	4	2	<b>7</b>
Total	<b>101</b>	16	17	<b>96</b>

**Table 4**

The percentages of correct noun phrases produced on the sentence completion and sentence production task (NBD-speakers: non-brain-damaged speakers)

<b>Patient</b>	<b>Nominative</b>	<b>Accusative</b>	<b>Dative</b>
G1	85	80	10
G2	90	45	85
G3	100	90	10
G4	95	80	35
G5	100	30	95
G6	100	90	60
Total	95	69.2	49.2
NBD-speakers	99.5	98.3	89.4

**Table 5**

Error types: total number of errors for each category

	No. case substitutions	No. gender substitutions	No. determiner omissions	No. other errors	Total
No. of errors	82	3	5	14	104



Table 6

Proportional error scores of the four patient groups

Languages	Dutch			Norwegian			English			Spanish		
	1	2	3	4	5	6	7	8	9			
<i>Negative sentences</i>												
Anagrams + pictures	0.00	0.00	0.00	0.11	0.33	1.00	1.00	0.88	0.44			
<i>Anagrams – pictures</i>												
Actives	0.00	0.00	0.20	0.20	0.40	1.00	0.80	0.80	1.00			
Passives	0.20	0.40	0.00	1.00	0.20	1.00	1.00	1.00	1.00			
PPT	0.00	0.40	0.20	0.40	1.00	1.00	0.80	0.60	1.00			
<i>Affirmative sentences</i>												
Anagrams + pictures	0.00	0.00	0.00	0.00	0.11	0.00	0.00	0.00	0.00			
<i>Anagrams – pictures</i>												
Actives	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.00	0.00			
Passives	0.00	0.40	0.00	0.20	1.00	0.20	0.20	0.80	1.00			
PPT	0.00	0.40	0.00	0.00	0.20	0.00	0.00	0.20	0.80			