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Word order and finiteness in Dutch and English Broca's and Wernicke's aphasia

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Abstract

The effect of two linguistic factors in Broca's and Wernicke's aphasia was examined using Dutch and English subjects. Three tasks were used to test (1) the comprehension and (2) the construction of sentences, where verbs (in Dutch) and verb arguments (in Dutch and English) are in canonical versus non-canonical position; (3) the production of finite versus infinitive verbs. Proportions of errors as well as types of errors made by each aphasic group are similar on the sentence comprehension and sentence anagram tasks. On the verb production task the performance pattern is, again, the same, but the error types are different. The discussion focuses on how the similarities and differences across languages and across aphasia types may be interpreted with respect to the underlying deficit in Broca's and Wernicke's aphasia.

1. Introduction

Debates about the nature of aphasic deficits, the distribution of these deficits across aphasia types and the validity of aphasic syndromes continue to be lively and sometimes acrimonious. In this study, test data from production and comprehension tasks collected from two aphasia types, Broca's and Wernicke's, and in two languages, Dutch and English, were examined. The differences between the two language groups are non-controversial while the distinction between the two aphasia types, Broca's and Wernicke's aphasia may be. The exact nature of these two types of aphasia continues to be refined, and during this process arguments as to what constitutes the defining characteristics of each continue to be a matter of debate. This is especially true for Broca's aphasia, but the characteristics of Wernicke's aphasia, and the underlying nature of the language deficit are topics worthy of further discussion. These two types of aphasia are traditionally distinguished by both production and comprehension data. People with these two types of aphasia sound different and have different levels of comprehension abilities. Comprehension problems are less overt in Broca's aphasia and may only be revealed for certain sentence types while the comprehension difficulties in Wernicke's aphasia are more noticeable. It has also been claimed for many years that the nature as well as the level of severity of the comprehension difficulties found in these two groups varies and the industry to define Broca's aphasia (and the subgroup of agrammatism) continues to flourish (see for example Grodzinsky, Piñango, Zurif, & Drai, 1999) and the replies in later volumes of *Brain and Language*. As a consequence of the debate the selection criteria used for Broca's aphasic subjects is contentious (Caplan, 2001). There is less debate focused on Wernicke's aphasia but research over the last thirty years or so has led to a clearer definition of some aspects of this syndrome. Empirical work has often contrasted these two aphasia types and results have exposed differences that have, in turn, lead to some claims about the underlying differences in these two language disorders (for example Shapiro, Gordon, Hack, & Killacky, 1993) although not all researchers confirm these differences (Caplan, Waters, & Hildebrandt, 1997; Luzzatti et al., 2001).

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Traditionally, the contrast between Broca's and Wernicke's aphasia has been at two levels. At one level, the distinction has been made on what can be observed in spontaneous speech and performance in comprehension tasks. At another level, inferences about the nature of the underlying deficit have been drawn based on the errors made in spontaneous speech and from a range of psycholinguistic tasks. These inferences are based on various concepts of language, but at least at some level of interpretation, a distinction between aphasia types depends on conceiving language as comprising separate domains of grammar and lexis and allowing that these two domains can be independently damaged. Whereas in Broca's aphasia both production and comprehension exhibit grammatical deficits and thence the inference that grammar, or the implementation of grammar is faulty, in Wernicke's aphasia the deficit is thought to be within the domain of the lexicon and/or lexical processing and involve semantic and/or phonological representations. The relative damage to each of these two domains, the grammatical and the lexical, gives rise to different types of language disorders. This view encompasses both processing and representational claims.

In the next sections, results from off-line and on-line studies of comprehension and production in Broca's and Wernicke's aphasia will be discussed. This will lead to the research question; how different are the underlying deficits in Broca's and Wernicke's aphasia?

2. Off-line testing results

Caramazza and Zurif (1976) reported that their Wernicke's aphasic subjects made different error types on a sentence comprehension task compared with their subjects with Broca's aphasia (and conduction aphasia). Their Wernicke's subjects consistently performed poorly when required to select a target picture to match a sentence regardless of the type of distractor offered. Their Broca's (and conduction) subjects made more errors when the distractor involved the reversal of the two NPs in the sentence, that is when the NPs of agent and theme were reversed. The authors concluded that the error patterns of the Broca's and conduction subjects revealed problems with syntax while the 'Wernicke's pattern of performance remain uninterpretable' (p. 508). However, in later papers and following further work, a stronger interpretation of these and other results has arisen; Wernicke's subjects' problems are characterised as 'less syntactically focused' than that of Broca's subjects (Zurif, 1995: 383).

In Broca's aphasia, comprehension deficits are prominent when reversible sentences with non-canonial order of the arguments are tested. A recent discussion (Grodzinsky et al., 1999 and comments on this paper in *Brain and Language*) focused on whether or not this aphasic subgroup performs at chance level on these sentences, but many aphasiologists are persuaded that sentences such as reversible passives and object clefts, are more difficult than sentences in which the agent precedes the theme. Several explanations have been given for this phenomenon, but it is clear that a grammatical deficit underlies the comprehension problems for Broca's aphasia. Whether or not this deficit is confined to and defining Broca's aphasia is still unclear. Caplan et al. (1997) in a study of 52 aphasic subjects found that performance on comprehension tasks did not correlate with aphasic syndrome. Balogh and Grodzinsky (2000) mentioned that their group with Wernicke's aphasia performed similarly to their group with Broca's aphasia. These studies, however, offer no explanation for this similar behaviour. The nature of the comprehension deficit in Wernicke's aphasia, which remains controversial, is one of the issues that will be addressed in the present study.

3. On-line testing

Data from on-line testing of the influences of non-canonicity and verb argument structure between Broca's and Wernicke's aphasia are available from a series of experiments by the Swinney–Shapiro–Zurif group, who used the cross modal (lexical) priming technique. Zurif, Swinney, Prather, Solomon, and Bushell (1993) demonstrated that Broca's subjects had slow lexical activation and did not re-activate antecedents at 'gaps', while Wernicke's subjects did. The authors concluded that the difference in performance was one of syntactic ability: individuals with Wernicke's aphasia can re-activate the meaning of the antecedent in gap position, because this is a syntactic process; individuals with Broca's aphasia are syntactically impaired, and can therefore not reactivate the meaning of the antecedent. This complements the data of Shapiro and Levine (1990) that show that Broca's, but not Wernicke's subjects are sensitive to the argument structure of verbs. For the authors this is evidence that Broca's aphasia is a syntactic impairment, whereas Wernicke's aphasia is due to lexical-semantic problems.

4. Speech production

In this section, the focus is on the production of verbs and sentences. Traditionally, it was argued that Broca's aphasia could be characterised as a grammatical deficit and Wernicke's aphasia as a lexical semantic deficit. Studies show, however, that speakers with Broca's aphasia do have problems with lexical access, with a more severe deficit for verb than noun retrieval (e.g. Jonkers, 1998). Studies also show that speakers with

Wernicke's aphasia have problems with grammar. They use fewer complex sentences than non-aphasic speakers (Edwards & Bastiaanse, 1998; Goodglass, Christiansen, & Gallgher, 1993) and make inflectional errors (Butterworth & Howard, 1987; Edwards, 2002; Martin & Blosson-Stach, 1986). From these and other studies, it can be concluded that Broca's aphasia is predominantly grammatical and Wernicke's aphasia is predominantly lexical semantic in nature, although lexical processing is compromised in Broca's aphasia and grammatical errors are regularly observed in Wernicke's aphasia.

The present study focuses on the grammatical aspects of comprehension and production in both aphasia types. It addresses two grammatical aspects: the influence of word order on comprehension and construction of sentences and inflection for tense and agreement in verb production. These aspects were studied in two languages, Dutch and English, and the same materials were used in both languages. Dutch and English differ in an important aspect: 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). For both languages, canonical and non-canonical order of the agent and theme were tested and for Dutch, the influence of the position of the verb was additionally examined. Production of finite and non-finite verbs in sentence context was also tested. Qualitative analyses were made to examine the nature of the grammatical deficit in both aphasia types. In this way, the influence of verb movement (in Dutch), canonial order of arguments, reversibility and inflection on the comprehension and production in the two aphasia types could be measured, and inferences drawn about the nature of the underlying deficit in these two aphasia types.

On the basis of previous research outlined above, we expect to find for Broca's aphasia: (1) selective problems with sentences in which the arguments are in non-canonical order; (2) selective problems for the production of finite verbs. On the comprehension task role reversal errors are expected and for the test for filling in finite verbs, inflectional and lexical errors are expected, as found by Bastiaanse and Van Zonneveld (1998) who used the same test materials. There was no prediction as to how the Dutch Broca's subjects would comprehend the sentences in which verb movement has taken place. According to Grodzinsky and Finkel (1998) comprehension of structures in which the verb has been moved is intact. Bastiaanse, Koekkoek, and Van Zonneveld (in press), however, showed that Dutch individuals with Broca's aphasia can judge the grammaticality of sentences in which the verb is in the right position, but when they judge ungrammatical sentences, in which the verb is illegally moved or not moved, they then perform at chance level. Because of these contradictory findings and the fact that for the present study comprehension is tested, not grammaticality judgement, no prediction is made.

For Wernicke's aphasia, problems with sentences in which the arguments are not in canonical order were expected. As for Broca's aphasia, it is unclear what to expect for the Dutch sentences in which the verb has been moved. Also, it is not clear on the basis of the literature, whether role reversals, lexical errors, or an unclear error patterns would emerge. On the basis of the literature, it is not expected that in Wernicke's aphasia a selective deficit for finite verbs will occur.

5. Methods

5.1. Subjects

Forty-seven aphasic subjects participated in this study: 24 Dutch speaking subjects (13 with Broca's aphasia, 11 with Wernicke's aphasia) and 23 English speaking subjects (12 with Broca's aphasia and 11 with Wernicke's aphasia). All but two participants were aphasic due to a single stroke in the left hemisphere; one English speaking patient was left-handed and had a stroke in the right hemisphere, one Dutch speaking patient had a Broca's aphasia due to traumatic brain injury. The aphasia type was established with the Aachen Aphasia Test (AAT; Graetz, De Bleser, & Willmes, 1992) for the Dutch and the Boston Diagnostic Aphasia Examination (BDAE; Goodglass & Kaplan, 1983) for the English speakers and confirmed by the examiners. All the participants with Broca's aphasia, except one, spoke in so-called *telegraphic speech*; the one exception was an English speaking patient with a severe verbal apraxia who had virtually no spoken output. All participants with Wernicke's aphasia had a fluent output with paraphasias. The subject data are give in Table 1.

The control group comprised the healthy speakers who participated in the standardisation of the Dutch and English version of the *Verb and Sentence Test (VAST)*, (Dutch version: Bastiaanse, Maas, & Rispens, 2000; English version: Bastiaanse, Edwards, & Rispens, 2002). Most of the aphasic speakers had participated in the standardisation study as well, but some additional subjects were tested subsequent to the standardisation in order to enlarge the groups of this present study.

5.2. Materials

The language behaviour of the individuals with aphasia was examined with three tasks of the VAST: (1) sentence comprehension, (2) sentence anagrams, and (3) filling in verbs.

For *sentence comprehension*, the task was to match a spoken, semantically reversible sentence to one of four

Table 1
Subject details

	Age	Gender	Handedness	Months post onset
	Mean (*SD*)	Female–male	Right–left	*Mean* (*SD*)
Dutch Broca	47.00 (13.17)	4–9	13–0	15.61 (13.41)
Dutch Wernicke	57.00 (13.67)	3–8	11–0	5.89 (9.36)
Dutch controls	48.40 (15.12)	20–20		
English Broca	63.18 (13.46)	4–7	11–0	56.36 (72.52)
English Wernicke	61.18 (17.19)	4–7	10–1	25.18 (30.85)
English controls	55.57 (8.32)	48–31		

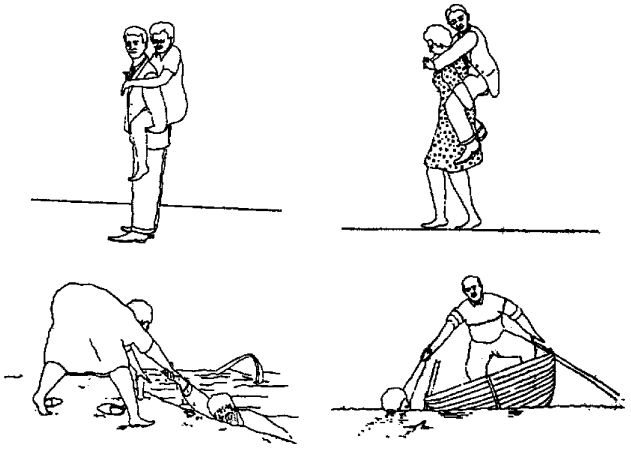

Fig. 1. An example of the sentence comprehension task. The target sentence is *The woman is saved by the man*.

pictures: the target picture, one with role reversals, one lexical distractor (a different verb) and one showing the lexical distractor and role reversals. An example is given in Fig. 1.

Four sentence types were tested for both languages. For Dutch, both verb movement and argument movement were tested (the moved constituents are in *italics*): (1) agent–theme–verb (canonical, embedded clause); (2) agent–*verb*–theme (matrix clause); and (3) *verb*–agent–theme (question); (4) *theme*–agent–verb (passive). For English, only argument movement was tested: simple actives, subjects and object clefts, and passives. The total number of items in each language was 40 (10 per sentence type).

For *sentence anagrams* a picture and three word cards were presented (for example, *the boy / eats / the apple; the child / is washed by / the mother*). The participant was asked to put the cards in the correct order. Half of the sentences were semantically reversible. For both the reversible and the irreversible sentences, half were active, half were passive. The total numbers of items for each language was 20. An example is given in Fig. 2.

The test *filling in verbs* consisted of two parts (finite verbs and infinitives). A picture was presented with a printed sentence underneath in which the verb was left out and the participant was asked to supply the missing word. The number of items for each task was 10 in both languages. Two examples are given in Fig. 3.

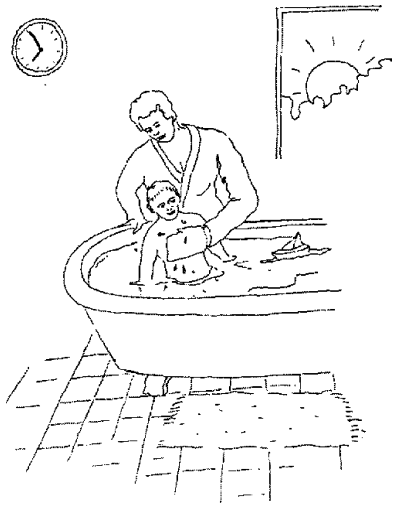

Fig. 2. An example of the sentence anagram test: *The child / is bathed by / the mother*.

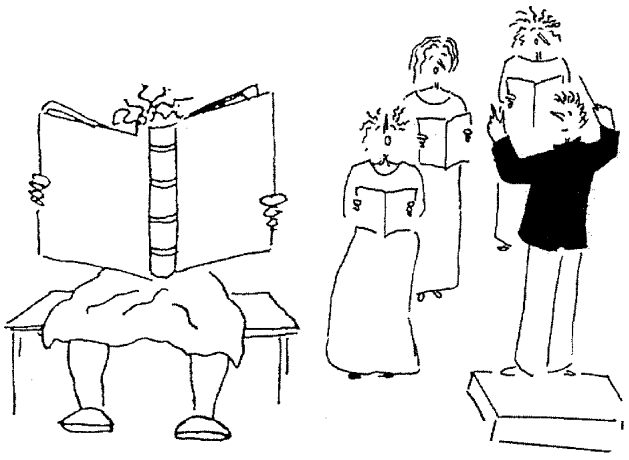

Fig. 3. An example of the test for filling in infinities (left) and finite verbs (right). Targets are *read* and *conducts*.

5.3. Procedure and scoring

Each task started with two examples, which were repeatedly performed with the subject until it was clear that the s/he was understanding the task. For the *sentence comprehension* task, the sentence was repeated

once if necessary. When the participant asked for more repetitions, the answer was counted as incorrect (nil reaction). One self correction was allowed per item; in cases where a participant corrected her/himself more often, this was also counted as a nil reaction. Incorrect picture selections were logged thus enabling a qualitative error analysis.

On the *sentence anagram* task, the examiner helped the participants to read the words on the cards when necessary. The participant was allowed to correct himself and only the final attempt was noted on the score-form. Incorrect orderings of anagram cards were recorded so that a qualitative error analysis could be made.

On the task for *filling in verbs*, the participant was encouraged to read the sentence aloud; if s/he made errors or needed help, the examiner read the sentence to her/him and hummed at the verb position. The answer of the participant was noted on the score form. Post hoc, three different error types were distinguished: (1) inflectional errors; (2) semantic paraphasias; (3) others. The final category, *others* was relatively small and included errors such as multiple errors, verb-noun substitutions, nil reactions and irrelevant responses.

The Dutch speaking participants with Broca's aphasia finished all tasks. For one Dutch speaking Wernicke's participant, the task for filling in verbs was broken off and his data were excluded on this task. All English speaking participants finished the sentence comprehension and the sentence anagram task save one participant who was unable to perform the sentence anagram task. Three English participants with Broca's aphasia did not finish the task of filling in verbs. One participant suffered from a severe verb apraxia that prevented him participating in the verb task and two were not tested because of time constraints. Two subjects with Wernicke's aphasia were also not tested on the verb task due to time constraints.

6. Results

First, a quantitative comparison of the results within and across languages on the three different tasks will be given. Then, qualitative comparisons will be made per task. In Table 2 an overview of the results on the three tasks is given. All four aphasic subgroups performed significantly worse than the control groups on each single task. The data of the control group will not be considered any further.

(1) *Sentence comprehension*. For Dutch, the participants with Broca's aphasia are significantly less impaired than those with Wernicke's aphasia ($t = 2.60, df = 22$, $p < .01$), a difference that is not found for English ($t = 0.72, df = 20, p > .05$). There is no significant difference between Dutch and English speakers with Broca's aphasia ($t = 0.10, df = 22, p > .05$), but there is a difference for Wernicke's aphasia ($t = 2.34, df = 20$, $p < .05$). The lowest scores are found in the Dutch speaking Wernicke's aphasic group.

(2) *Sentence anagrams*. For Dutch, there is no significant difference between the participants with Broca's and Wernicke's aphasia ($t = 0.86, df = 22, p > .05$), but there is for English ($t = 1.80, df = 20, p < .05$). There is no difference across the two language groups for either aphasia type (Broca's aphasia: $t = 0.29, df = 22, p > .05$; Wernicke's aphasia: $t = 0.59, df = 20, p > .05$). The English speaking Broca's aphasic group have the lowest score but it is not significantly different from the Dutch aphasic group.

(3) *Filling in verbs*. The Dutch speaking participants with Broca's and Wernicke's aphasia perform similarly ($t = 1.09, df = 21, p > .05$), but the English speaking participants with Broca's aphasia are significantly worse than those with Wernicke's aphasia ($t = 2.86, df = 15$, $p < .01$). They are also worse than the Dutch speaking participants with Broca's aphasia ($t = 3.98, df = 19$, $p < .001$). This difference across the two languages is not found for Wernicke's aphasia ($t = 0.58, df = 17$, $p > .05$). Again, the English speaking participants with Broca's aphasia is the worst performing group.

As can be seen from these data, there was not one group that performed best or worst on all tasks. In order to find out more about the cross-linguistic differences and the differences found between the aphasia types, each task has been analysed to show the effect of linguistic variables and to highlight the error types made by the subjects. Results are discussed for each task in turn, dealing first with the Dutch and then the English data. Comparisons have been made and significance of the findings will be discussed. More detailed data and statistics can be found in the appendices. The individual data are given in Appendix A; the results of statistic testing in Appendix B.

Table 2
The means (and standard deviations) for the Dutch and English subjects on the three subtests

	Control group			Broca's aphasia		Wernicke's aphasia	
	Max	Dutch	English	Dutch	English	Dutch	English
Sentence comprehension	40	39.77 (0.42)	39.90 (0.31)	29.92 (8.57)	29.64 (5.57)	22.45 (3.72)	27.82 (6.18)
Sentence anagrams	20	20 (–)	20 (–)	13.15 (5.03)	12.55 (5.16)	14.91 (4.93)	15.91 (3.81)
Filling in verbs	20	19.22 (0.50)	19.45 (0.55)	13.08 (3.52)	5.88 (4.76)	11.40 (3.84)	12.56 (4.85)

6.1. Sentence comprehension

In Dutch, four different sentence types have been tested: (1) embedded clauses with the canonical agent–verb–theme (AVT) order (*wijs aan op welk plaatje de man de vrouw redt*: lit. 'point on which picture the man the woman saves'); (2) matrix clauses in which the verb has been moved resulting in agent–verb–theme (AVT) order (*de man redt de vrouw*: lit. the man saves the woman); questions in which the verb has been moved resulting in verb–agent–theme (VAT) order (*op welk plaatje redt de man de vrouw*: lit. in which picture saves the man the woman?) and passives in which the theme has been moved resulting in theme–agent–verb (TAV) order (*de vrouw wordt door de man gered*: lit. the woman is by the man saved).

In Table 3 the results for the Dutch speaking participants with Broca's and Wernicke's aphasia are given.

The passive sentences (TAV) were significantly more difficult than each of the other three sentence types for the Dutch participants with Broca's aphasia. There was no significant difference between any of the other sentence types. For the Dutch participants with Wernicke's aphasia the passive sentences (TAV) were significantly more difficult than both declarative sentence types (ATV and AVT), but no significant difference was found between the passives and the questions. Comparison between the three active sentence types (ATV, AVT, and VAT) did not yield any statistical difference.

These results show that verb movement does not affect comprehension of semantically reversible sentences in either Broca's or Wernicke's aphasia, but argument movement does. When the sentences with canonical order of the arguments (ATV, AVT, and VAT) are taken together and compared with sentences with non-canonical order of the arguments (TAV), the sentences with non-canonical order of the arguments are significantly more difficult for both aphasia types (Broca's aphasia: $t = 1.98, df = 12, p < .05$; Wernicke's aphasia: $t = 2.40, df = 10, p < .05$).

In Table 4, the results of the error analysis are given. There were three types of distractors: role reversal (RR), lexical distractor which shows a different action (Lex) and role distractor with a different action (RR + Lex).

As can be seen from this table, role reversal errors are by far the most frequent in both Broca's and Wernicke's aphasia. There is no significant difference in error pattern between the two aphasia types ($\chi^2 = 3.79, df = 2, p > .05$).

Table 3
The means (and standard deviations) on the sentence comprehension test for Dutch

	ATV	AVT	VAT	TAV
Broca	7.69 (2.21)	7.85 (2.41)	7.92 (2.06)	6.46 (2.82)
Wernicke	5.82 (1.89)	6.82 (2.56)	5.55 (1.75)	4.27 (1.74)

A, agent; T, theme; V, verb. The moved constituent is underlined. The maximum possible score is 10 in each category.

Table 4
The numbers and types of errors made by the Dutch participants in the sentence comprehension task

	Total	RR	Lex	RR + Lex
Broca	130	105	9	16
Wernicke	194	145	25	26

RR, role reversal; Lex., lexical distractor.

On the English version of the sentence comprehension task, four sentence types have been tested: (1) simple actives (*the man saves the woman*) and (2) subject clefts (*it is the man who saves the woman*) with both agent–verb–theme (AVT) order, (3) object clefts with theme–agent–verb (TAV) order (*it is the woman who the man saves*), and (4) passives with theme–verb–agent (TVA) order (*the woman is saved by the man*). In Table 5 the results for the English speaking participants with Broca's and Wernicke's aphasia are given.

For the participants with Broca's aphasia, the subject clefts were significantly easier than any other sentence type, including the simple actives. Neither the passives, nor the object clefts were significantly more difficult than the simple actives. There was no significant difference between the object clefts and the passives. For the participants with Wernicke's aphasia, there is no significant difference between the actives and the subject clefts, nor between the passives and the object clefts. The actives and the subjects clefts are each significantly easier than both the passives and the object clefts.

The result found for the participants with Broca's aphasia may at first glance seem what surprising, because they perform unexpectedly well on the passives. When sentences with canonical (simple actives + subject clefts) and non-canonical (passives and objects clefts) order of the arguments are compared, however, the often reported pattern emerges: sentences with canonical order of the arguments are understood significantly better than non-canonical sentences ($t = 2.50, df = 10, p < .05$). The same is found for the participants with Wernicke's aphasia ($t = 4.67, df = 10, p < .001$).

In Table 6, the results of the error analysis are given for the English speaking groups.

Table 5
The means (and standard deviations) on the sentence comprehension test for English

	ATV Simple	ATV subj.cleft	TAV obj.cleft	TVA passive
Broca	7.64 (1.91)	8.36 (1.96)	6.55 (1.51)	7.09 (2.66)
Wernicke	7.73 (1.95)	8.09 (1.76)	6.00 (2.10)	6.00 (1.67)

A, agent; T, theme; V, verb. The maximum score is 10 in each category.

Table 6
The numbers of errors made by the English participants

	Total	RR	Lex	RR + Lex
Broca	125	103	16	6
Wernicke	133	116	8	9

RR, role reversal; Lex., lexical distractor.

As can be seen from Table 6, role reversal errors are by far the most frequent in both Broca's and Wernicke's aphasia, comparable to the Dutch data. There is no significant difference in error pattern between the two aphasia types ($\chi^2 = 3.07, df = 2, p > .05$).

In sum, for both aphasic subgroups in both languages, semantically reversible sentences are significantly more difficult when the arguments are in non-canonical order than when they are in canonical order. The error pattern is the same for both aphasia types in both languages: role reversals are by far the most frequently made error. Verb movement does not seem to affect the comprehension of semantically reversible sentences, but notice that verb position does not change the meaning of the sentence, whereas reversal of the thematic roles does.

6.2. Sentence anagrams

Four sentence types have been tested in both languages: reversible and irreversible actives and passives. In both languages the order of the active and passive sentences was the same: agent–verb–theme for the actives and theme–verb–agent for the passives. Notice that for Dutch this is a different construction than the one that has been tested with sentence comprehension: both theme–verb–agent and theme–agent–verb are possible in Dutch and if there is a difference between the two types, it is a very slight pragmatic one. Separate cards were used for the agent NP, the theme NP and the Aux-verb-preposition: *the mother/is washed by/the child.* Since the same sentence types were used in both languages, the results for Dutch and English are presented together. The results are given in Table 7.

In this task, there is no effect for reversibility in any group. For all groups, passives are significantly more difficult than actives. Notice that this is also the case for the English participants with Broca's aphasia, for whom no difference was found in the sentence comprehension task when the same sentences were used.

The performance on the passive sentences was analysed in more detail, as it has been mentioned in the literature that semantically reversible passives are particularly prone to errors, but for none of the groups was a significant difference found between reversible and irreversible passives, suggesting that it is canonicity of the arguments that is the critical factor in this test, not reversibility. The majority of the errors for all subgroups were reversals of the thematic roles, both for the reversible and irreversible sentences.

6.3. Filling in verbs

The same items and the same structures were used for Dutch and English, therefore the results will be presented together. The results are given in Table 8.

For all four groups, filling in finite verbs is significantly more difficult than filling in infinitives.

In Table 9, the different patterns for inflectional errors and semantic paraphasias are given. Notice that the inflectional errors made on the task *filling in infinitives* in English are substitutions of the infinitive with the gerund form (*-ing*), an error that cannot be made in Dutch as there is no gerund.

The Dutch participants made hardly any inflectional errors on the task of filling in infinitives. The majority of the errors for both Dutch groups are semantic in nature. In this task, when they have to fill in finite verbs, performance drops dramatically, resulting in mainly inflectional errors for the Broca group and mainly semantic paraphasias for the Wernicke group. The latter difference in error pattern is significant ($\chi^2 = 9.75$, $df = 1, p < .01$). This pattern can also be seen for the English groups on the task *filling in infinitives* ($\chi^2 = 13.80, df = 1, p < .01$). For both English aphasia subtypes, inflectional errors are most prominent when finite verbs need to be filled in. Overall, the English speaking participants with Broca's aphasia make more inflectional errors, whereas those with Werncike's aphasia make more semantic paraphasias. This difference is, again, significant ($\chi^2 = 18.77, df = 1, p < .01$). The conclusion from these data is that finite verbs are more difficult to produce than infinitives for each group

Table 7
The mean scores (standard deviations) for the sentence anagram tasks in Dutch and English

	Reversible	Irreversible	Active	Passive
Broca Dutch	7.15 (2.88)	6.54 (2.73)	8.31 (1.89)	4.85 (3.69)
Wernicke Dutch	6.91 (2.66)	7.27 (2.94)	8.73 (1.68)	6.18 (3.57)
Broca English	6.55 (2.66)	6.00 (2.61)	8.18 (2.52)	4.36 (3.56)
Wernicke English	7.91 (1.70)	7.55 (2.07)	9.09 (1.30)	6.36 (3.17)

Table 8
The mean scores (and standard deviations) for infinitives and finite verbs

	Infinitive	Finite verb
Broca Dutch	7.77 (1.24)	5.31 (2.93)
Wernicke Dutch	7.30 (1.57)	4.10 (2.85)
Broca English	4.75 (3.15)	1.13 (1.81)
Wernicke English	7.67 (2.06)	4.89 (3.76)

Table 9
The number of errors made on the tests for filling in infinitives and finite verbs

	Infinitive		Finite verb		Total	
	Inflection	Sem.par.	Inflection	Sem.par.	Inflection	Sem.par.
Broca Dutch	0	20	28	10	28	30
Wernicke Dutch	3	14	18	30	21	44
Broca English	13	6	29	7	42	13
Wernicke English	4	27	10	4	14	31

in each language and that the participants with Broca's aphasia tend to make more inflectional errors, whereas those with Wernicke's aphasia tend to make more semantic paraphasias.

7. Discussion

On the basis of previous findings in the literature, the predictions for the subgroups with Broca's aphasia were that sentences in which the arguments were in non-canonical order would be more difficult than those in canonical order and that the production of finite verbs would be more impaired than the production of infinitives. These predictions were upheld. No predictions were made for Dutch sentences in which the verb is in non-canonical position. Comprehension of these sentences was found to be relatively spared.

For Wernicke's aphasia the expectations with regard to word order were the same as for Broca's aphasia and this is, again, supported by the data. Findings for the production of finite verbs and infinitives are contrary to the predictions.

Apart from these quantitative data, the qualitative results are also somewhat unexpected. On the sentence comprehension task, the individuals with Wernicke's aphasia make predominantly grammatical errors (role reversals) and the individuals with Dutch Broca's aphasia make more semantic errors than expected on the task for filling in infinitives.

These points will be discussed for each task. The goal of this discussion is to argue that although the same structures are difficult for both aphasia types, this does not necessarily mean that the underlying deficit is the same. Different explanations are considered.

7.1. The sentence comprehension task

All the subjects in this study found sentences in which the order of the arguments was non-canonical to be more difficult than the sentences where the arguments were in canonical order. There is a slight blip in the data: the English subjects with Broca's aphasia made most errors on the object cleft sentences but for these subjects, the number of errors on passive sentences was not significantly higher than the number of errors on the two sentence types with canonical order of arguments. However, when the two sentence types with canonical argument order are taken together and are compared with the two sentence types with non-canonical order, the expected significant difference is found. The Dutch subjects with Broca's aphasia also made significantly more errors on sentences with non-canonical argument order. The difference in the Dutch data for the non-canonical argument order rather than for verb position in the sentence comprehension task suggests that, at least for these subjects, it is argument movement rather than non-canonicity *per se* that is causing the comprehension problem (but see Bastiaanse et al., in press).

The error types in each of the aphasic group suggest that the processing of reversible sentences with non-canonical order of the arguments is problematic in Wernicke's as well as Broca's aphasia. Recall, both groups in both languages overwhelmingly chose the reverse role distrator in the sentence comprehension task. Looking at error types offers information about performance that needs to be taken into account when seeking an explanation. The Broca's aphasic subjects chose the reverse role, as would be predicted from the extensive number of studies on agrammatic comprehension. This may be interpreted as evidence of trace deletion (Grodzinsky, 1995 and elsewhere).

None of the available explanations given to date to account for the agrammatic comprehension deficit has been applied to Wernicke's aphasia. Yet the subjects of the present study, tested in similar conditions and in different languages, were making the same kinds of errors as those predicted and found in the Broca's data. If the Wernicke's subjects have a lexical-semantic deficit, as might be assumed from past studies, selection of the distractor with an alternative verb is expected. If, however, they 'recognise' the verb of a given sentence, that 'knowledge' would eliminate two of the distractors, the lexical distractor and the lexical + reverse role distractor. Thus, any problem in comprehending the sentence, whatever the nature of that problem, providing that the verb was 'understood,' would lead to the selection of either the target or the reverse role distractor. It has been argued that individuals with Wernicke's aphasia have diminished access to all possible arguments associated with a verb in a sentence (Shapiro et al., 1993) hence the caution in concluding that these subjects had

access to the full lexical information of each verb. Further, it could be that although the verb may have been recognised and was matched to the appropriate action picture, verb recognition could still be only partial. Notice that the verb distractor is not always closely semantically related. An inability to generate verb arguments could have interferred with these subjects' ability to recognise arguments required for each verb. Thus, they failed to identify the correct picture where each of the two NPs were depicted in a theta role that matched the stimulus sentence.

Alternatively, the problem for these subjects may have been the integration of lexical semantic information of the NPs and verb with the given syntactic structure. Non-canonicity was, for these listeners, an added complication and it was in these sentences, where the integration of the semantic and syntactic information was too great and difficulties occurred. Or, looking at the problem in a slightly different way, maybe the errors arose because the non-canonical sentences elicited slower activation of meaning and integration of meaning with the sentence structure. Either of these types of difficulties could have resulted in selection of the reverse role distractor, if, and only if, the subjects were not beguiled into selecting the sentence with the incorrect verb, which they were not. We cannot, then conclude from the results of the sentence comprehension test that the Wernicke's subjects had problems with assigning or processing thematic roles although this explanation remains a strong candidate.

7.2. The sentence anagram task

On this task, both aphasia groups in both languages encounter more problems with passive than with active sentences, while reversibility does not play a role. The latter is not surprising, because grammatical complexity is the same in both reversible and irreversible sentences. Notice that the subjects do not have an agent first strategy. Considering that word order errors are most prominent, all four subgroups perform above chance level on the active sentences and at chance for the passive sentences. As Grodzinsky has repeatedly argued (e.g.,1995; 2000), this cannot be explained by a agent first strategy, but only by guessing. Apparently, neither the subjects with Broca's aphasia, nor those with Werncike's aphasia can make a reliable representation of a passive sentence. That this is a purely grammatical matter, is shown by the fact that no difference is found between reversible and irreversible sentences: *the boy is eaten by the apple* seems to be as acceptable as the reverse.

7.3. Verb production in sentence context

The third test, the elicitation of finite verbs and infinitives within a given sentence, highlighted another problem with a grammatical process, verb finiteness in both types of aphasia. Here, there was no significant difference between the level of performance of the Dutch Broca's and Wernicke's subjects. For Dutch, it has been shown in a previous study that the finite verbs in matrix clauses are more difficult to produce than infinitives for Broca's subjects (Bastiaanse & Van Zonneveld, 1998). The findings in the present study suggest that this difficulty is also experienced in Wernicke's aphasia.

There were some cross-language differences in the type of errors produced. On the task for filling in of finite verbs, the difference between the two aphasia types is as expected: predominantly grammatical errors in Broca's aphasia, and predominantly semantic paraphasias in Werncike's aphasia. What is unexpected, is the relatively large number of semantic errors on the task for filling in infinitives in the Dutch individuals with Broca's aphasia. The English individuals with Broca's aphasia make more inflectional errors in the infinitive condition, most of them being gerunds. As said above, this verb form does not exist in Dutch, so this error cannot be made in Dutch. Notice that for Dutch Broca's aphasia, the data cannot be explained by a sole verb retrieval deficit, because in the task for filling in finite verbs the number of semantic paraphasias diminishes, and the number of inflectional errors increases dramatically. All these inflectional errors are made on correctly retrieved verbs. When the two verb production tasks are taken together, an equal number of inflectional errors and semantic paraphasias is produced. This shows that a grammatical deficit does not necessarily result in only grammatical errors, equally a lexical-semantic deficit does not only result in lexical semantic errors, as argued above for Wernicke's aphasia in relation to the sentence comprehension task. Apparently the integration of grammatical and lexical semantic processes may result in both grammatical and lexical semantic errors in both grammatically and lexical-semantically impaired speakers.

The English data are more straightforward. In Broca's aphasia there are more inflectional than semantic paraphasic errors. However, in Wernicke's aphasia, although there are more semantic paraphasic errors than inflectional errors made in the infinitive task, there are more inflectional errors in the task requiring the production of a finite verb. Overall, the English subjects with Wernicke's aphasia made more semantic paraphasic errors than inflectional errors but the difference between supplying an infinitive and a finite verb, remains. Like the English Broca's subjects, they made more errors when asked to produce a finite verb compared with an infinitive. However, most of the errors they produce do not fall into one of the two error categories: many neologisms, combined, and uninterpretable errors were made by the individuals with Wernicke's aphasia on the task for filling in finite verbs. Lexical access difficulties

are a feature of Wernicke's aphasia so problems with these tasks were expected, but the difficulty in lexical retrieval was not expected to be dependent on the presence or absence of inflection. The results suggest that verb retrieval is exacerbated when a grammatical process, inflection, is added to the task.

7.4. The underlying impairment(s): Integration of the results

Generally speaking, both aphasic groups, in both languages had the same kind of difficulties on a task of sentence comprehension, a task of sentence construction (the anagram task) and a task that required them to produce inflected verbs. The data suggest that the same task features, canonical order of argument structure in the sentence tasks and finiteness in the verb task, compounded the subjects' difficulties. These findings are unexceptional for Broca's aphasia but were not expected for Wernicke's aphasia where comprehension problems have been described as 'less syntactically focussed than [it is] for Broca's patients' (Zurif, 1995: 383). There have been other studies where the performance of subjects with Wernicke's aphasia has been similar to that of the Broca's aphasic subjects (for example in sentence comprehension, Balogh & Grodzinsky, 2000; Caplan et al., 1997; Luzzatti et al., 2001) but none where similar performances for these two patient groups have also been found for sentence construction (via an anagram task) and verb inflection (on a sentence completion task).

The last issue to be addressed is whether the similar performances are related to similar underlying deficits. It has previously been argued that similar performance seen in Broca's and Wernicke's aphasia may reflect different disorders (Balogh & Grodzinsky, 2000: 101) The basic question is: are lexical-semantic representations and processes intact in Broca's aphasia and is grammatical processing intact in Werncike's aphasia? It is well known that word finding problems exist in Broca's aphasia, especially for verbs. Bastiaanse (2001, 2003) has argued that this is not so much caused by representational or selection restrictions, but by dimished grammatical encoding abilities: the amount of information that the verb representation contains plays a crucial role (see, for example, Kim & Thompson, 2000) and the same verbs are more difficult to retrieve when more grammatical encoding is impaired. Such limitations of grammatical abilities are in line with the present findings: sentences in non-canonical order are more difficult to comprehend and construct, and production of finite verbs is more impaired than production of infinitives. Bastiaanse et al. (in press) therefore argue that the central deficit in Broca's aphasia is an inability to deal with non-basic sentence order (remember that the finite verbs as tested are in non-canonical position in Dutch).

There is every reason to believe that in Wernicke's aphasia lexical-semantic processes and/or representations are affected: severe word finding problems, even at the word level, are the main characteristic of this aphasia type and it is illogical to argue that this is due to a grammatical deficit. The critical issue here is whether or not individuals with Wernicke's aphasia suffer from an *additional* grammatical deficit or whether grammatical processing compounds the lexical semantic deficit. Although the present data cannot exclude a grammatical impairment, we would like to opt for alternative account. In the present study, the sentence level was investigated and the results show that performance drops with increasing grammatical complexity.

At the sentence level, grammatical operations and lexical processing must be integrated. The data show that when language breaks down, integration at the sentence level breaks down and complex structures (sentences in non-canonical order, finite verbs) are vulnerable *regardless of the aphasia type*, in other words, regardless of the site of the lesion. When one of the language areas is affected and complex grammatical materials must be processed, the integration of lexical and grammatical processes breaks down. In comprehension, this results in role reversal errors in both Broca's and Wernicke's aphasia. For Wernicke's aphasia, this was not predicted although on reflection, these results are compatible with earlier work. Shapiro et al. (1993) showed that individuals with Wernicke's aphasia are not as sensitive to the full argument structure of the verb, although that does not necessarily mean that individuals with Wernicke's aphasia do not grasp the core meaning of the verb. On the present sentence comprehension test, awareness of the core meaning is sufficient to exclude the pictures with the lexical distractor. But success in the task requires that a representation of the grammatical structure is made. Although individuals with Wernicke's aphasia do reactivate the meaning of the antecedent at gap position, their reaction times are extremely slow (slower than those of non-brain-damaged speakers and slower than individuals with Broca's aphasia Zurif et al., 1993). Slow processing may well impact on the comprehension of sentences with arguments in non-canonical positions. The data that were presented here show that these are the sentences which cause the most problems. This means that the errors produced on the sentence comprehension and sentence construction tasks can be explained by a combination of poor, slow or partial activation of the full lexical representation of the verb and a slow reactivation of the antecedent at the gap position, resulting in role reversal errors on both tests when arguments are not in canonical order. For individuals with Broca's aphasia, it has been argued that their inability to link the antecedent to the gap (or 'trace' in linguistic terminology) alone is enough to cause the role reversal errors in sentences with

non-canonical argument order (e.g. Grodzinsky, 1995, 2000) and on the basis of the results of the present study, there is no reason to doubt this.

The same negative influence of grammatical complexity on the performance of Dutch speakers with Wernicke's aphasia is shown when they have to produce finite verbs in sentence context. Although this effect of verb finiteness was not expected, the errors show that the underlying impairment must be different from the one in Broca's aphasia: although verb retrieval diminishes when complex grammatical operations are required, semantic paraphasias are the result and grammatical errors are less frequently observed. Unfortunately, this clear pattern is not found in the English Wernicke's aphasic data although finiteness does exert an influence on the types of errors made. For this group more grammatical (i.e. inflectional) errors are made when the speakers are required to produce a finite verb.

In summary, the data show that grammatical complexity influences the performance in comprehension and production in Broca's and Wernicke's aphasia: the same grammatical structures are vulnerable. It has been argued that grammar is not the primary locus of language deficits in Wernicke's aphasia and that the semantic paraphasias produced by the (mainly Dutch) individuals with Broca's aphasia are not caused by a lexical semantic deficit. Our theory is that the integration of the lexical-semantic and grammatical processes at sentence level is problematic. For the present study, the influence of an increased complexity of grammatical processes was investigated and the data demonstrate that this increase of complexity has the same influence in Broca's and Wernicke's aphasia, although the underlying impairments and the lesion sites differ.

This theory is confirmed by recent neuro-imaging data that show that in non-brain-damaged speakers both Broca's and Wernicke's area are activated when comprehension of grammatically complex sentences becomes more complex (Friederici, 2002; Thompson, 2000). Thus when sentence processing takes place, a complex neural network of processes is activated at different sites in the left hemisphere. When this neural circuit that serves language is interrupted, the integration of information from different sources is affected and as a result, more complex linguistic processing fails. The site of the lesion (both anatomical and functional) determines how the linguistic deficit reveals itself clinically: agrammatic with relatively spared comprehension or paragrammatic with semantic paraphasias with impaired comprehension as in the subjects with Broca's and Wernicke's aphasia respectively, as the present data showed. Fine-grained testing can reveal how these opposite patterns obscure the similarities between these two aphasic syndromes.

Appendix A

*A.1. Individual data of the Dutch speaking individuals with Broca's and Wernicke's aphasia. * = did not complete the test and was excluded from the analyses*

Sentence comprehension Dutch speaking Broca's aphasia

Pat.	+	VAT				ATV				AVT				TAV			
		+	RR	L	LR	+	RR	L	LR	+	RR	L	LR	+	RR	L	LR
db1	27	7	1	1	1	7	2	0	1	7	3	0	0	6	4	0	0
db2	38	10	0	0	0	9	1	0	0	10	0	0	0	9	0	0	0
db3	20	7	2	0	1	5	5	0	0	5	5	0	0	3	6	0	1
db4	35	9	1	0	0	8	2	0	0	10	0	0	0	8	2	0	0
db5	16	4	5	0	1	3	5	0	2	4	4	0	2	5	4	0	1
db6	40	10	0	0	0	10	0	0	0	10	0	0	0	10	0	0	0
db7	19	6	3	1	0	6	3	1	0	4	6	0	0	3	5	0	2
db8	30	9	1	0	0	8	2	0	0	10	0	0	0	3	6	1	0
db9	21	5	4	1	0	6	4	0	0	6	3	0	1	4	4	1	1
db10	37	9	1	0	0	8	2	0	0	10	0	0	0	10	0	0	0
db11	40	10	0	0	0	10	0	0	0	10	0	0	0	10	0	0	0
db12	36	10	0	0	0	10	0	0	0	8	2	0	0	8	1	1	0
db13	30	7	2	1	0	10	0	0	0	8	0	1	1	5	4	0	1
Mean	*29.92*	*7.92*				*7.69*				*7.85*				*6.46*			
SD	*8.57*	*2.06*				*2.21*				*2.41*				*2.82*			

V, verb; A, agent; T, theme; RR, role reversal; L, lexical distractor; LR, role reversal + lexical distractor.

Sentence comprehension Dutch speaking Wernicke's aphasia

Pat.	+	VAT				ATV				AVT				TAV			
		+	RR	L	LR	+	RR	L	LR	+	RR	L	LR	+	RR	L	LR
dw1	15	4	5	0	1	5	2	0	2	4	3	2	1	2	7	1	0
dw2	15	4	4	1	1	4	4	1	1	1	7	0	2	6	3	1	0
dw3	21	5	5	0	0	4	4	0	2	7	2	1	0	5	4	0	1
dw4	24	5	4	1	0	5	4	1	0	9	1	0	0	5	5	0	0
dw5	26	7	3	0	0	8	2	0	0	8	2	0	0	3	7	0	0
dw6	19	7	1	1	1	3	3	2	2	6	1	3	0	3	7	0	0
dw7	26	8	2	0	0	5	3	1	1	6	4	0	0	7	1	2	0
dw8	27	6	3	1	0	8	2	0	0	8	2	0	0	5	5	0	0
dw9	24	8	1	0	1	6	4	0	0	7	3	0	1	3	7	0	0
dw10	23	4	1	3	2	8	2	0	0	9	1	0	2	2	5	1	2
dw11	27	3	6	1	0	8	2	0	0	10	0	0	0	6	1	1	1
Mean	*22.45*	*5.55*				*5.82*				*6.82*				*4.27*			
SD	*4.44*	*3.07*				*1.89*				*2.56*				*1.74*			

V, verb; A, agent; T, theme; RR, role reversal; L, lexical distractor; LR, role reversal + lexical distractor.

Sentence anagrams Dutch speaking Broca's aphasia

Pat.	Total	Reversible	Irreversible	Active	Passive
db1	7	5	2	7	0
db2	18	10	8	9	9
db3	11	6	5	9	2
db4	20	10	10	10	10
db5	13	9	4	8	4
db6	19	10	9	10	9
db7	10	6	4	8	2
db8	13	6	7	8	5
db9	5	0	5	5	0
db10	10	5	5	8	2
db11	20	10	10	10	10
db12	15	8	7	8	7
db13	12	5	7	10	2
Mean	*13.31*	*6.92*	*6.38*	*8.46*	*4.77*
SD	*4.87*	*2.96*	*2.47*	*1.45*	*3.79*

Sentence anagrams Dutch speaking Wernicke's aphasia

Pat.	Total	Reversible	Irreversible	Active	Passive
dw1	20	10	10	10	10
dw2	11	6	5	6	5
dw3	9	3	6	6	3
dw4	20	10	10	10	10
dw5	20	10	10	10	10
dw6	17	9	8	9	8
dw7	8	5	3	8	0
dw8	18	8	10	10	8
dw9	17	7	10	10	7
dw10	9	4	4	7	1
dw11	16	9	7	10	6
Mean	*15.00*	*7.36*	*7.55*	*8.73*	*6.18*
SD	*4.80*	*2.54*	*2.70*	*1.68*	*3.57*

Finite/non-finite Dutch speaking Broca's aphasia

Pat.	Finite	Infinitive
db1	2	7
db2	6	7
db3	8	8
db4	7	8
db5	5	6
db6	6	7
db7	1	6
db8	3	9
db9	0	8
db10	8	9
db11	9	7
db12	6	9
db13	8	10
Mean	*5.31*	*1.24*
SD	*2.93*	*1.24*

Finite/non-finite Dutch speaking Wernicke aphasia

Pat.	Finite	Infinitive
dw1	5	8
dw2*		
dw3	1	9
dw4	7	8
dw5	5	8
dw6	3	6
dw7	5	6
dw8	9	9
dw9	5	8
dw10	0	7
dw11	1	4
Mean	*4.10*	*7.30*
SD	*2.85*	*1.57*

*A.2. Individual data of the English speaking individuals with Broca's and Wernicke's aphasia. * = did not complete the test and was excluded from the analyses*

Sentence comprehension English speaking Broca's aphasia

Pat.	+	Active (AVT)				Subject cleft (AVT)				Object cleft (TAV)				Passive (TVA)			
		+	RR	L	LR	+	RR	L	LR	+	RR	L	LR	+	RR	L	LR
eb1	28	6	4	0	0	8	2	0	0	7	3	0	0	7	3	0	0
eb2	25	6	4	0	0	7	1	1	1	6	4	0	0	6	3	1	0
eb3	33	9	1	0	0	9	1	0	0	6	4	0	0	9	1	0	0
eb4	28	8	2	0	0	9	1	0	0	9	0	0	1	2	7	1	0
eb5	32	9	1	0	0	10	0	0	0	5	5	0	0	8	2	0	0
eb6	34	10	0	0	0	10	0	0	0	4	6	0	0	10	0	0	0
eb7	36	10	0	0	0	10	0	0	0	7	3	0	0	9	1	0	0
eb8	19	5	3	2	0	4	2	1	3	7	3	0	0	3	6	0	1
eb9	38	9	1	0	0	10	0	0	0	9	1	0	0	10	0	0	0
eb10	25	5	4	1	0	6	3	1	0	6	3	1	0	8	2	0	0

Appendix A.2. (*continued*)

Pat.	+	Active (AVT)				Subject cleft (AVT)				Object cleft (TAV)				Passive (TVA)			
		+	RR	L	LR	+	RR	L	LR	+	RR	L	LR	+	RR	L	LR
eb11	28	7	0	3	0	9	0	1	0	6	4	0	0	6	2	1	1
eb12*																	
Mean	*29.64*	*7.64*				*8.36*				*6.55*				*7.09*			
SD	*5.57*	*1.91*				*1.96*				*1.51*				*2.66*			

V, verb; A, agent; T, theme; RR, role reversal; L, lexical distractor; LR, role reversal + lexical distractor.

Sentence comprehension English speaking Wernicke's aphasia

Pat.	+	Active (AVT)				Subject cleft (AVT)				Object cleft (TAV)				Passive (TVA)			
		+	RR	L	LR	+	RR	L	LR	+	RR	L	LR	+	RR	L	LR
ew1	21	6	1	1	2	7	1	1	1	5	5	0	0	3	5	0	1
ew2	24	5	4	1	0	7	3	0	0	5	5	0	0	7	3	0	0
ew3	19	5	5	0	0	5	4	1	0	3	7	0	0	6	4	0	0
ew4	22	6	4	0	0	8	1	1	0	3	7	0	0	5	4	0	1
ew5	28	8	2	0	0	6	4	0	0	8	2	0	0	6	3	1	0
ew6	30	9	1	0	0	8	1	0	1	6	2	1	1	7	2	0	1
ew7	24	8	2	0	0	8	1	1	0	4	6	0	0	4	5	0	1
ew8	37	10	0	0	0	10	0	0	0	8	2	0	0	9	1	0	0
ew9	33	10	0	0	0	10	0	0	0	8	2	0	0	5	4	0	0
ew10	33	8	2	0	0	10	0	0	0	8	2	0	0	7	3	0	0
ew11	35	10	0	0	0	10	0	0	0	8	2	0	0	7	3	0	0
Mean	*27.82*	*7.73*				*8.09*				*6.00*				*6.00*			
SD	*6.18*	*1.95*				*1.76*				*2.10*				*1.67*			

V, verb; A, agent; T, theme; RR, role reversal; L, lexical distractor; LR, role reversal + lexical distractor.

Sentence anagrams English speaking Broca's aphasia

	Total	Reversible	Irreversible	Active	Passive
Pat.					
eb1	14	8	6	10	4
eb2*					
eb3	17	9	8	10	7
eb4	10	5	5	10	0
eb5	8	4	4	6	2
eb6	20	10	10	10	10
eb7	11	7	4	7	4
eb8	4	2	2	2	2
eb9	8	4	4	7	1
eb10	18	9	9	10	8
eb11	18	9	9	9	9
eb12	10	5	5	9	1
Mean	*12.55*	*6.55*	*6.00*	*8.18*	*4.36*
SD	*5.16*	*2.66*	*2.61*	*2.52*	*3.56*

Sentence anagrams English speaking Wernicke's aphasia

Pat.	Total	Reversible	Irreversible	Active	Passive
ew1	10	6	4	9	1
ew2	11	5	6	8	3
ew3	16	8	8	10	6

Appendix A.2. (*continued*)

Pat.	Total	Reversible	Irreversible	Active	Passive
ew4	15	7	8	8	7
ew5	14	8	6	6	8
ew6	19	9	10	10	9
ew7	13	7	6	10	3
ew8	19	10	9	10	9
ew9	20	10	10	10	10
ew10	13	7	6	9	4
ew11	20	10	10	10	10
Mean	*15.45*	*7.91*	*7.55*	*9.09*	*6.36*
SD	*3.62*	*1.70*	*2.07*	*1.30*	*3.17*

Finite/infinitive English speaking Broca's aphasia

	Finite	Infinitive
Pat.		
eb1	1	8
eb2	0	2
eb3	4	8
eb4	4	9
eb5	0	2
eb6*		
eb7	0	4
eb8	0	1
eb9*		
eb10*		
eb11*		
eb12	0	4
Mean	*1.13*	*4.75*
SD	*1.81*	*3.15*

Finite/infinitive English speaking Wernicke's aphasia

	Finite	Infinitive
Pat.		
ew1	0	3
ew2	1	8
ew3	5	8
ew4	9	6
ew5	0	9
ew6*		
ew7*		
ew8	6	8
ew9	10	9
ew10	7	10
ew11	6	8
Mean	*4.89*	*7.67*
SD	*3.76*	*2.00*

Appendix B. Statistics

Sentence comprehension	*t*	*df*	*p*
Dutch Brocas			
VAT–ATV	0.67	12	>.05
VAT–AVT	0.23	12	>.05
VAT–TAV	2.66	12	<.05
ATV–AVT	0.38	12	>.05
ATV–TAV	1.98	12	<.05
AVT–TAV	2.47	12	<.05
Canonical–non-canonical	**1.98**	**12**	**<.05**
Dutch Wernickes			
VAT–ATV	0.33	10	>.05
VAT–AVT	1.36	10	>.05
VAT–TAV	1.69	10	>.05
ATV–AVT	1.66	10	>.05
ATV–TAV	1.88	10	<.05
AVT–TAV	2.63	10	<.05
Canonical–non-canonical	**2.40**	**10**	**<.05**
English Brocas			
Active–subject cleft	2.67	10	<.05
Active–object cleft	1.42	10	>.05
Active–passive	0.80	10	>.05
Subject cleft–object cleft	2.39	10	<.05
Subject cleft–passive	1.85	10	<.05
Passive–object cleft	0.51	10	>.05
Canonical–non-canonical	**2.50**	**10**	**<.05**
English Wernickes			
Active–subject cleft	0.94	10	>.05
Active–passive	4.25	10	<.005
Active–object cleft	2.79	10	<.01
Subject cleft–passive	4.08	10	<.005
Subject cleft–object cleft	3.52	10	<.005
Passive–object cleft	0.00	10	>.05
Canonical–non-canonical	**4.67**	**10**	**<.005**
Comparisons of error patterns in sentence comprehension			
English Wernickes and Brocas		$\chi^2 = 3.07$, $df = 2$, $p > .05$	
Dutch Wernickes and Brocas		$\chi^2 = 3.79$, $df = 2$, $p > .05$	

Sentence Anagrams	*t*	*df*	*p*
Dutch Brocas			
Reversible versus irreversible	1.06	12	>.05
Active versus passive	4.14	12	<.005
Reversible versus irreversible passive	0.86	12	>.05
Dutch Wernickes			
Reversible versus irreversible	0.75	10	>.05
Active versus passive	3.22	10	<.01
Reversible versus irreversible passive	0.39	10	>.05
English Brocas			
Reversible versus irreversible	1.75	10	>.05
Active versus passive	3.76	10	<.001
Reversible versus irreversible passive	1.79	10	>.05

Appendix B. (*continued*)

English Wernickes			
Reversible versus irreversible	1.08	10	>.05
Active versus passive	2.80	10	<.01
Reversible versus irreversible passive	0.00	10	>.05
Finite verbs and infinitives	*t*	*df*	*p*
Dutch Brocas			
Finite versus infinitive	3.18	12	<.005
Dutch Wernickes			
Finite versus infinitive	4.00	9	<.005
English Brocas			
Finite versus infinitive	5.33	7	<.005
English Wernickes			
Finite versus infinitive	2.29	8	<.05

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