



University of Groningen

## Wh-questions in agrammatism: A movement deficit?

van der Meulen, I.; Bastiaanse, Y.R.M.; Rooryck, J

*Published in:*  
Stem-, spraak- en taalpathologie

**IMPORTANT NOTE: You are advised to consult the publisher's version (publisher's PDF) if you wish to cite from it. Please check the document version below.**

*Document Version*  
Publisher's PDF, also known as Version of record

*Publication date:*  
2005

[Link to publication in University of Groningen/UMCG research database](#)

*Citation for published version (APA):*

van der Meulen, I., Bastiaanse, Y. R. M., & Rooryck, J. (2005). Wh-questions in agrammatism: A movement deficit? *Stem-, spraak- en taalpathologie*, 13(1), 24 - 36.

### Copyright

Other than for strictly personal use, it is not permitted to download or to forward/distribute the text or part of it without the consent of the author(s) and/or copyright holder(s), unless the work is under an open content license (like Creative Commons).

### Take-down policy

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

Downloaded from the University of Groningen/UMCG research database (Pure): <http://www.rug.nl/research/portal>. For technical reasons the number of authors shown on this cover page is limited to 10 maximum.

# Wh-questions in agrammatism: a movement deficit?

Ineke van der Meulen<sup>1</sup>, Roelien Bastiaanse<sup>2</sup> and Johan Rooryck<sup>1</sup>

<sup>1</sup> *Universiteit Leiden Centre for Linguistics (ULCL)*, <sup>2</sup> *Graduate School of Behavioral and Cognitive Neurosciences (BCN), Groningen University*


Agrammatic Broca patients suffer from a language deficit related to syntactic movement. These patients have difficulties producing and comprehending sentences derived through syntactic movement. However, patients' performance on wh-questions shows an intriguing pattern. These constructions involve movement of the wh-word. Still, patients' comprehension of wh-questions seems to be intact, whereas their production is severely impaired. This raises the question whether the operation of wh-movement is only impaired in patients' production and does not affect patients' comprehension. This question is examined in several experiments on French-speaking Broca patients. French allows the wh-word either to remain in its base position or to move. Therefore, French forms a unique environment to examine the effect of wh-movement. The results show that wh-movement affects both the production and comprehension abilities of Broca patients. These results are discussed in light of the rapy studies on wh-questions in Broca's aphasia.

## 1. Introduction

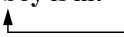
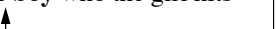
In theoretical linguistics, the derivation of sentences is assumed to involve an operation called *movement*. This operation refers to the finding that elements are often produced in a different position than the one in which they originate. For instance, it is assumed that *who* in (1b) starts out in the same position as *the queen* in (1a), namely at the right of the verb. The reason behind this assumption is that *who* and the *queen* have the same function: direct object of the verb *meet*. For reasons we will not discuss here, *who* in (1b) moves to a position at the beginning of the sentence.<sup>1</sup>

---

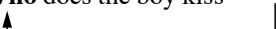
<sup>1</sup> See amongst others Rizzi (1990) and Cheng (1991) for the theoretical basis for wh-movement.

- 1 a. Bill has met the queen at the Ascot races.  
 b. Who has Bill met at the Ascot races?
- 

It has been observed that syntactic movement is a crucial factor underlying the language deficit in agrammatic Broca patients. These patients have severe difficulties producing and comprehending sentences derived through syntactic movement (Caramazza & Zurif, 1976; Grodzinsky, 1990, 2000; Hickok, Zurif & Canseco-Gonzalez, 1993; Maunder, Fromkin & Cornell, 1993; Bastiaanse & van Zonneveld, 1998; Bastiaanse, Koekkoek & van Zonneveld, 2003; Friedmann & Shapiro, 2003). Broca patients typically tend to avoid the production of constructions involving movement. In comprehension tasks they score at chance level on semantically reversible constructions in which the object has been moved, such as passives (2a) and object relative clauses (2b).

- 2 a. **The boy** is hit by the girl. *chance level*  
  
 b. I see **the boy** who the girl hits. *chance level*  


There is, however, one movement construction for which patients' comprehension seems to be intact: wh-questions. In sharp contrast to their chance performance on constructions exemplified in (2), English-speaking Broca patients score *above chance* on object wh-questions of the type in (3) (Hickok & Avrutin, 1996; Thompson et al., 1999).

3. **Who** does the boy kiss ? *above chance level*  


The constructions in (2) and (3) are similar in that they involve movement of the direct object. The difference between passives and relative clauses on the one hand and wh-questions on the other is that in the former a noun (*the boy*) has been moved and in the latter a wh-word (*who*).<sup>2</sup> The contrast between patients' performance on constructions in (2) and those in (3) suggests that the comprehension deficit in Broca's aphasia might be related to the *type of lexical element* that has been moved: movement of a *noun* does affect patients' comprehension, while movement of a *wh-word* does not.

In contrast to patients' relatively intact comprehension of wh-questions, their *production* of this construction is severely impaired (Myerson & Goodglass, 1972; Thompson, Shapiro & Roberts, 1993; Thompson et al., 1996; Friedmann, 2002).

<sup>2</sup> The derivation of relative clauses (2b) is a topic of debate in theoretical linguistics. This debate centers on the question whether it is the noun or the wh-operator *who* that has been moved. We follow the analysis assuming movement of the noun, defended amongst others by Kayne (1994).

Broca patients hardly ever produce wh-questions spontaneously and have severe difficulties with tasks eliciting production of wh-questions. This deficit is usually related to the movement of the wh-word (see for instance Thompson et al., 1996; Friedmann, 2002).

Wh-questions in Broca patients thus show a dissociation: intact comprehension, but impaired production. This raises several questions concerning the effect of wh-movement in Broca's aphasia. Is it possible that wh-movement is only impaired in patients' production and not in their comprehension? If so, how can this difference be explained? Alternatively, it might be that the operation of wh-movement is still intact in Broca's aphasia and that patients' difficulties in producing this construction are not related to syntactic movement. Obviously, the question then becomes what does underlie the deficit in producing wh-questions.

This paper presents the results of three experiments to the effect of wh-movement on patients' comprehension and production. We have examined wh-questions in French-speaking Broca patients. As is shown in (4), French allows the wh-word to remain in-situ (i.e. in its base position) or to move to the beginning of the sentence.<sup>3</sup>

- |       |                       |    |                             |
|-------|-----------------------|----|-----------------------------|
| 4. a. | Tu as vu <b>qui</b> ? | b. | <b>Qui</b> tu as vu _____ ? |
|       | you have seen who     |    | who you have seen           |
|       | 'Who did you see?'    |    | 'Who did you see?'          |

These questions do not differ in meaning. The only difference between these questions is the position of the wh-word. In (4a) it has not been moved, while in (4b) it has. This makes French a suitable language to examine wh-movement in Broca's aphasia. If wh-movement does only affect patients' production and not their comprehension, it is predicted that French-speaking Broca patients show better production of questions of the type in (4a) versus those in (4b) and that no such difference is found in patients' comprehension of these two types of wh-questions.

## 2. Experiments

Three experiments were developed to examine patients' comprehension and production of wh-questions. Two of these experiments tested patients' comprehension and one their production of wh-questions. We will first discuss the comprehension experiments.

---

<sup>3</sup> See Cheng & Rooryck (2000) for an analysis of these two types of wh-questions.

### 2.1. *Comprehension of wh-questions*

Both comprehension experiments compared patients' understanding of wh-questions without wh-movement with that of the variants involving wh-movement. One of these experiments contained only argument questions, while the other contained adjunct questions. The design of both experiments was identical and the experiments were done with the same patients. Therefore, the two experiments are presented here as one.<sup>4</sup>

The goal of these experiments is to examine whether wh-movement affects comprehension in Broca's aphasia. In order to do so, patients' comprehension of wh-in-situ questions (4a) is compared with that of their counterparts involving wh-movement (4b). If wh-movement affects comprehension in Broca's aphasia, questions of the type in (4a) will be better understood than those of the type in (4b). The research question of these experiments is given below.

#### 5. *Research question of the comprehension experiments*

Do Broca patients understand wh-in-situ questions better than their counterparts involving wh-movement?

#### *Participants*

Nine French-speaking agrammatic Broca patients (mean age 51.7 years, three men, six women) participated in the comprehension experiment on argument questions. Seven of these patients also participated in the experiment on adjunct questions. Premorbidly, all patients were right-handed and monolingual speakers of French. In all patients, the aphasia resulted from a single stroke in the left frontal brain regions. They were classified as Broca patients on the basis of the Montréal-Toulouse test (Nespoulous et al., 1986) or the Batterie Longue de UCL/ULG (de Partz).

#### *Language Testing*

All patients were tested on the French version of the sentence comprehension task of the VAST (Verbs and Sentences Task, Bastiaanse, Edwards & Rispens, 2002). This was done for two reasons. First, it is important to examine whether the patients show the comprehension pattern typically associated with Broca's aphasia (i.e. better comprehension of active sentences, subject clefts and subject relative clauses than of

---

<sup>4</sup> The experiments presented in this paper are part of a larger research concerning the effect of syntactic movement on comprehension in Broca's aphasia. In Van der Meulen (2004) all of the experiments as well as the obtained results are discussed in detail. In the present paper, we do not go in to all of the topics of discussion yielded by the results on wh-questions. For instance, we will here not compare patients' production and comprehension of wh-questions. Rather, we will focus on the effect of wh-movement in both modalities. For more detailed discussions, the reader is referred to Van der Meulen (2004).

passive sentences, object clefts and object relative clauses). As can be seen in table 1, most patients matched this profile.<sup>5</sup> Secondly, the VAST examines comprehension of constructions involving movement of a noun (i.e. sentences of the type in (2)). By comparing the results obtained on the VAST with those obtained on our experiments on wh-questions, it can be determined whether comprehension in Broca's aphasia is related to the type of lexical element that moves. In other words, the results of the VAST allow us to compare the effect of two types of movement on patients' comprehension: movement of a noun versus that of a wh-word. This will provide better insight in the way in which syntactic movement affects comprehension in Broca's aphasia.

Table 1. Patient characteristics

Patient	Age	Sex	m.p.o.	Language comprehension (in % correct)			
				active	passive	subject cleft	object cleft
CA	35	F	134	100	37.5	62.5	75.0
JD	62	M	48	100	75.0	87.5	37.5
LD	48	F	23	87.5	37.5	75.0	37.5
MG	51	M	82	50.0	62.5	37.5	62.5
AM	68	F	72	50.0	25.0	75.0	25.0
SM	37	F	84	75.0	37.5	75.0	37.5
AR	68	M	164	100	75.0	100	25.0
BS	39	F	11	100	50.0	75.0	75.0
ST	57	F	209	87.5	50.0	75.0	12.5
<b>Total</b>				<b>83.3</b>	<b>50.0</b>	<b>73.6</b>	<b>43.1</b>

A control group of eleven non brain-damaged speakers of French was also tested (mean age 41.2 years, three men and eight women). These subjects performed perfectly and their results will not be given here.

### Materials

Comprehension of wh-questions was tested using a picture-pointing task. Each picture represented a reversible action performed by three persons. Figure 1a gives an example of a picture used for argument questions and figure 1b for adjunct questions.

<sup>5</sup> Patient MG shows the reverse pattern and patients CA and BS show no difference in their comprehension of subject and object clefts. Still, these patients are all classified as Broca patients. Variation in the individual results is a well-known finding in studies on Broca patients (Berndt, Mitchun & Haendiges, 1996; Caramazza, et al., 2001). Following Grodzinsky (1991), Grodzinsky et al. (1999), Zurif & Piñango (1999) and many others, we will not focus on the individual results, but rather on the pattern emerging out of the results of the *group* of patients. As a group, the patients in table 1 show the pattern associated with Broca's aphasia.

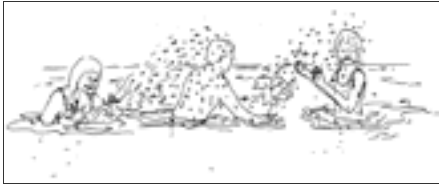


Figure 1a. Example of an argument question



Figure 1b. Example of an adjunct question

Argument wh-questions were subject and object wh-questions. Here, only the results on object wh-questions will be discussed.<sup>6</sup> For each picture, a question was read out aloud and patients were asked to point to the person representing the answer to the question. Each picture was presented twice, in the wh-in-situ condition and in the wh-movement condition. The two types of wh-questions belonging to figures 1a and 1b are given below.

6. *argument questions*
- a. Le garçon arrose **qui**? - *wh-movement*  
 b. **Qui** est-ce que le garçon arrose ? + *wh-movement*
- ↑ \_\_\_\_\_ |  
 ‘Who does the boy splash?’
- adjunct questions*
- c. La fille dort sur **qui**? - *wh-movement*  
 d. Sur **qui** est-ce que la fille dort ? + *wh-movement*
- ↑ \_\_\_\_\_ |  
 ‘On whom does the girl sleep?’

The argument experiment contained 18 different item-pairs, the adjunct experiment 22. Fillers were also included. Filler questions never related to the depicted action. For instance, a filler question for figure 1a is ‘Which girl doesn’t look happy?’ Stimulus sentences were presented in random order in both conditions. The order of the stimulus sentences was counterbalanced across participants. Prior to testing, participants received two practice items. All participants demonstrated understanding of the task after these items. Items were repeated upon request, but never more than once.

### Results

Table 2 gives the individual results obtained in the comprehension experiments.

<sup>6</sup> See van der Meulen (2004) for the results on subject questions.





type in (4b). If wh-movement is impaired, it is expected that questions such as (4a) will be repeated better than those of the type in (4b).

### 7. *Research question of the production experiment*

Do Broca patients produce wh-in-situ questions better than their counterparts involving wh-movement?

#### *Participants*

All of the patients participating in the comprehension experiments did the first session of the repetition experiment. However, the task proved to be extremely difficult. Patients found it very hard to repeat rather than to answer a wh-question. Further, the test was very long and tiresome. Most patients were unable to repeat wh-questions at all and gave up after the first session. Still, three of them completed the entire task.

#### *Materials*

The repetition task contained argument and adjunct questions in two conditions: with and without wh-movement. The argument questions were all object questions. The adjunct questions were *when* or *where* questions. Examples of the conditions are given below.

8. *argument questions* a. Le garçon invite **qui** à son anniversaire? - *wh-movement*  
 b. **Qui** est-ce que le garçon invite à son anniversaire? + *wh-movement*  
 'Who does the boy invite on his birthday?'
- adjunct questions* c. Le garçon regarde la télévision **quand**? - *wh-movement*  
 d. **Quand** est-ce que le garçon regarde la télévision? + *wh-movement*  
 'When does the boy watch television?'

The questions were read aloud to patients who were asked to listen to the question and repeat it after the experimenter was finished. On request, the target question was repeated by the experimenter. This was never done more than once. Patients could make as many attempts as they wanted. The best attempt was counted.

#### *Results*

Table 3 presents the percentage of correctly repeated wh-questions. An utterance was counted as correct if it contained all the lexical items (subject, verb, object, wh-word) in the same order as the target question. Semantic errors (e.g. *girl* for *boy*) as well as phonological errors and omission of determiners and verbal inflection were not taken

into account and counted as correct.<sup>8</sup> Examples of incorrect repetitions are: producing a *wh*-in-situ question for a target *wh*-question involving overt *wh*-movement (e.g. repeating (8b) as (8a)), omitting the *wh*-word, and omitting the verb or the subject.

Table 3. Production of *wh*-questions (percentage correctly repeated *wh*-questions)

Patient	Argument questions		Adjunct questions	
	- <i>wh</i> -movement	+ <i>wh</i> -movement	- <i>wh</i> -movement	+ <i>wh</i> -movement
CA	58.3	0	66.7	33.3
ST	100	83.3	58.3	8.3
SM	75.0	91.7	58.3	41.7
<b>Total</b>	<b>77.8</b>	<b>58.3</b>	<b>61.1</b>	<b>27.8</b>

For both argument and adjunct questions, the questions without *wh*-movement are repeated better than the ones with *wh*-movement. Due to the limited number of patients, this difference does not reach significance everywhere. For argument questions, the difference between patients' performance on the questions without *wh*-movement and those with *wh*-movement is not significant ( $\chi^2=3.13$ ,  $p>0.05$ ). For adjunct questions, this difference is significant ( $\chi^2=8.10$ ,  $p<0.01$ ). Importantly, however, all patients show the same pattern of better performance on *wh*-in-situ questions than on the variants involving *wh*-movement.<sup>9</sup>

A second observation following from these data is that patients' production of argument *wh*-questions is significantly better than that of adjunct *wh*-questions ( $\chi^2=8.16$ ,  $p<0.01$ ). Patients' better performance on argument questions contrasts with the findings of Friedmann (2002), who observed that in Hebrew-speaking Broca patients the production of adjunct questions is better than that of argument questions. However, Thompson et al. (1996) found no difference in patients' production of argument and adjunct questions. A discussion of this issue is outside the scope of this paper, but see Van der Meulen (2004).

### 3. Discussion

The goal of the experiments reported here was to examine the effect of *wh*-movement on patients' comprehension and production. To this extent, patients' performance on

<sup>8</sup> It has been argued that patients' difficulties in producing verbal inflection are related to syntactic movement in that the verb has to move in order to obtain inflectional morphemes (Bastiaanse & van Zonneveld 1998). Inflectional errors thus also reveal impaired syntactic movement. Despite the interesting observations that might be obtained from an analysis of inflectional errors, we discuss here only errors related to *wh*-movement. Both on theoretical and empirical grounds, there are important reasons to distinguish verb movement and *wh*-movement. A discussion of the differences between these two types of movement is outside the topic of this paper. We therefore focus on *wh*-movement.

<sup>9</sup> The only exception is the performance on argument questions of patient SM.

wh-questions without wh-movement was compared to that in which the wh-word had been moved. For convenience, the examples in (4) are repeated here as (9).

9. a. Tu as vu **qui**?  
       you have seen who  
       ‘Who did you see?’
- b. **Qui** tu as vu \_\_\_\_\_ ?  
       ↑  
       who you have seen  
       ‘Who did you see?’

The results showed that for French-speaking Broca patients wh-questions without wh-movement are easier to understand and to produce than the variants involving wh-movement. This suggests that wh-movement does affect both the comprehension and the production abilities of Broca patients.

Recall that the reason for examining the effect of wh-movement was the observed difference between patients’ comprehension of object relative clauses and that of object wh-questions. Broca patients are unable to understand semantically reversible object relative clauses. However, English-speaking Broca patients score considerably better on object wh-questions (cf. the pattern in (2) and (3)). We hypothesized that this difference might be due to the type of lexical element that had been moved: movement of a noun does affect comprehension in Broca’s aphasia, while that of a wh-word does not. The results obtained on French-speaking Broca patients show that this is not a possible explanation. Wh-movement clearly does affect comprehension in Broca’s aphasia. However, the results of French-speaking Broca patients are similar to those obtained on English-speaking Broca patients in that these patients too score better on object wh-questions involving movement of the wh-word (e.g. 10a) than on object clefts involving movement of the object noun (e.g. 10b).

10. a. Qui est-ce que le garçon arrose \_\_\_\_\_ ?  
       ↑  
       ‘Who does the boy splash?’
- b. C’est la fille que le garçon arrose \_\_\_\_\_ .  
       ↑  
       ‘It is the girl who the boy splashes.’

As can be seen in table 2, French-speaking Broca patients obtained a score of 72.2% correct on questions of the type in (10a). By contrast, their performance is considerably worse on sentences of the type in (10b): only 43.1% correct (see table 1). It thus seems that movement of a wh-word does affect comprehension in Broca’s aphasia (patients’ comprehension of (9a) is better than that of (9b)), but to a lesser extent than movement of a noun. Further research is needed to explain the difference in patients’ performance on object wh-questions and that on other constructions involving movement of the object.

#### 4. A note on therapy

The results of French-speaking Broca patients showed that wh-movement affects both the comprehension and production abilities of Broca patients. These findings are consistent with the results of therapy studies by Thompson and colleagues (Wambaugh & Thompson, 1989; Thompson et al., 1993, 1996). This group developed a training program based on the linguistic structure of wh-questions. In this program, patients were trained to produce wh-questions starting with the underlying structure (11a) and subsequently moving the wh-word (11b). This program successfully improved patients' production of wh-questions.

11. a. The soldier is pushing who?  
 b. Who is the soldier pushing \_\_\_\_\_ ?  
 ↑

Combining the results of Thompson and colleagues with the results obtained on French-speaking Broca patients, the following conclusions can be drawn. First, wh-movement is a syntactic operation affecting both patients' comprehension and production. It is, however, not completely impaired, but can be reacquired by explicit training of this operation.

Thompson and colleagues have focused on English-speaking Broca patients. Wh-movement is, however, an operation occurring in a large number of languages. It would therefore be interesting to examine the effects of these therapy methods in Broca patients speaking other languages than English. Further, to our knowledge it has not yet been examined whether this therapy also leads to improved *comprehension* of wh-questions by Broca patients. This is a question for further research.

#### 5. Conclusion

The theoretical linguistic notion wh-movement is also empirically relevant in that this operation affects both the comprehension and the production of Broca patients. This conclusion is based on several findings. First, wh-questions involving wh-movement are more difficult to understand and to produce for Broca patients than wh-questions in which the wh-word has not been moved. Secondly, if the operation of wh-movement is explicitly trained in Broca patients, their production of this construction improves. Further research will hopefully show whether such a training also yields better comprehension of wh-questions.

## References

- Bastiaanse, R. & Van Zonneveld, R. (1998). On the relation between verb inflection and verb position in Dutch agrammatic aphasics. *Brain and Language* 64, 165-181.
- Bastiaanse, R., Edwards, S. & Rispens, J. (2002). *Verb and Sentences Test (VAST)*. Suffolk: Thames Valley Test Company.
- Bastiaanse, R., Koekkoek, J. & Van Zonneveld, R. (2003). Object scrambling in Dutch Broca's aphasia. *Brain and Language* 86, 287-299.
- Berndt, R. Mitchun, C. & Haendiges, A. (1996). Comprehension of reversible sentences in 'agrammatism': a meta-analysis. *Cognition* 58, 289-308.
- Canseco-Gonzalez, E., Shapiro, L., Zurif, E. & Baker, E. (1990). Predicate-argument structure as a link between linguistic and nonlinguistic representations. *Brain and Language* 39, 391-404.
- Caramazza, A. & Zurif, E. (1976). Dissociation of algorithmic and heuristic processes in language comprehension: evidence from aphasia. *Brain and Language* 3, 572-582.
- Caramazza, A., Capitani, E., Rey, A. & Berndt, R. (2001). Agrammatic Broca's aphasia is not associated with a single pattern of comprehension performance. *Brain and Language* 76, 158-184.
- Cheng, L. (1991). *On the typology of wh-questions*. PhD Dissertation, MIT.
- Cheng, L. & Rooryck, J. (2000). Licensing wh-in-situ. *Syntax* 3, 1-19.
- Friedmann, N. (2002). Question production in agrammatism: the Tree Pruning Hypothesis. *Brain and Language* 80, 160-187.
- Friedmann, N. & Shapiro, L. (2003). Agrammatic comprehension of simple active sentences with moved constituents: Hebrew OSV and OVS structures. *Journal of Speech, Language, and Hearing Research* 46, 288-297.
- Grodzinsky, Y. (1990). *Theoretical perspectives on language deficits*. Cambridge, Mass.: MIT Press.
- Grodzinsky, Y. (1991). There is an entity called agrammatic aphasia. *Brain and Language* 41, 555-564.
- Grodzinsky, Y. (2000). The neurology of syntax. *Behavioral and Brain Sciences* 23, 1-73.
- Grodzinsky, Y., Piñango, M., Zurif, E., & Drai, D. (1999). The critical role of group studies in neuropsychology: comprehension regularities in Broca's aphasia. *Brain and Language* 67, 134-147.
- Hickok, G. & Avrutin, S. (1996). Comprehension of wh-questions in two Broca's aphasics. *Brain and Language* 52, 314-327.
- Hickok, G., Zurif, E. & Canseco-Gonzalez, E. (1993). Structural description of agrammatic comprehension. *Brain and Language* 45, 371-395.
- Kayne, R. (1994). *The antisymmetry of syntax*. Cambridge, Mass.: MIT Press.
- Maurer, G., Fromkin, F. & Cornell, T. (1993). Comprehension and acceptability judgments in agrammatism: disruptions in the syntax of referential dependency. *Brain and Language* 45, 340-370.
- Myerson, R. & Goodglass, H. (1972). Transformational grammars of three agrammatic patients. *Language and Speech* 15, 40-50.
- Nespoulous, J-L., Lecours, A., Lafond, D., Lemay, A., Puel, M., Joannette, Y., Cot, F. & Rascol, A. (1986). *Protocole Montréal-Toulouse d'Examen Linguistique de l'Aphasie: Module Standard Initial* (version Bèta), Laboratoire Théophile-Alajouanine, Montréal.

- Partz, M-P., de. *Examen du langage UCL/ULG*. Unpublished testing material.
- Rizzi, L. (1990). *Relativized Minimality*. Cambridge, Mass. MIT Press.
- Shapiro, L., McNamara, P., Zurif, E., Lanzoni, S. & Cermak, L. (1992). Processing complexity and sentence memory: evidence from amnesia. *Brain and Language* 42, 431-453.
- Shapiro, L., Nagel, H. & Levine, B. (1993). Preference for a verb's complements and their use in sentence processing. *Journal of Memory and Language* 32, 96-114.
- Thompson, C., Shapiro, L. & Roberts, M. (1993). Treatment of sentences production deficits in aphasia: a linguistic-specific approach to wh-interrogative training and generalization. *Aphasiology* 7, 111-133.
- Thompson, C., Shapiro, L., Tait, M., Jacobs, B. & Schneider, S. (1996). Training wh-question production in agrammatic aphasia: analysis of argument and adjunct movement. *Brain and Language* 52, 175-228.
- Thompson, C., Tait, M., Ballard, K. & Fix, S. (1999). Agrammatic aphasic subjects' comprehension of subject and object extracted wh-questions. *Brain and Language* 67, 169-187.
- Van der Meulen, I. (2004). *Syntactic movement and comprehension deficits in Broca's aphasia*. PhD Dissertation, ULCL, Leiden University.
- Wambaugh, J., & Thompson, C. (1989). Training and generalization of agrammatic adults' wh-interrogative production. *Journal of Speech and Hearing Disorders* 54, 509-525.
- Zurif, E., & Piñango, M. (1999). The existence of comprehension patterns in Broca's aphasia. *Brain and Language* 70, 134-138.