

The Comprehension of Number and Gender Information on Pronouns in Dutch Broca's aphasia

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The comprehension of pronouns is selectively impaired in agrammatic patients (e.g. Grodzinsky et al., 1993, Ruigendijk et al. in press). The present study aims at discerning between two theoretical models (Reflexivity, by Reinhart & Reuland, 1993 and Primitives of Binding by Reuland, 2001) by examining the agrammatic ability to use morphosyntactic features of number and gender when interpreting pronouns. It is possible that this type of information on the pronoun is accessible to the agrammatic patients and could aid them in the comprehension. We examined six agrammatic speakers with a grammaticality judgment task. The results show that agrammatic patients do have access to the number and gender information on the pronoun and do use it when deciding on the referent for the pronoun. Our results indicate that morphosyntactic information can be accessed in agrammatism and used to aid the comprehension. We argue that these results can be explained within Reuland's Primitives of Binding theory in combination with the often-made claim in the literature regarding the limitation of processing resources in agrammatic speakers.

1. Introduction

Assigning referents to anaphoric elements such as pronouns has been reported to be problematic for agrammatic Broca's aphasics (see e.g. Blumstein et al. 1983, Grodzinsky et al. 1993, Love et al. 1998, Avrutin et al. 1999 and Piñango & Burkhardt 2001 and Vasic & Ruigendijk, 2004). Furthermore, these experimental studies have indicated that the pattern of impairment follows linguistic principles in what is impaired and what is preserved with regard to pronoun resolutions. In their study, Grodzinsky et al. (1993) found that, in English simple transitive sentences, agrammatic patients have less trouble establishing reference for a reflexive (1) than for a pronoun (2) (referential dependency means that the pronoun or the reflexive indicated by *italics* refers to the Noun Phrase (NP) also indicated by *italics*). They allow the

pronoun in (2) to incorrectly refer to the local antecedent (an erroneous interpretation is indicated by *):

1. *Peter touches himself.*
2. **Peter touches him.*

In our previous study, conducted in Dutch (Ruigendijk et al., in press), we found that the interpretation of pronouns is not equally impaired across different linguistic structures containing these elements. In ECM (Exceptional Case Marking)¹ sentences such as (3) the pronoun *him* is more often incorrectly interpreted as referring to *Peter* than in transitive sentences such as (2).

3. **Peter zag hem dansen.*
Peter sees him dancing

On the basis of the Grodzinsky et al. study and our previous results, we conclude that there are two theoretical models of reference assignment, the Reflexivity model (Reinhart and Reuland, 1993) and the Primitives of Binding (Reuland, 2001), which can adequately account for the data presented above. Both theoretical frameworks capture the difference between the two structures; however, the source of the problem is different for the two models.

In the present study we aim at providing more insight into the underlying problems of agrammatic patients with regard to the interpretation of pronouns and also at offering evidence in support of the Primitives of Binding as opposed to the Reflexivity model. We do so by isolating and testing the crucial difference in predictions the two models make, namely, where the source of the problem lies. The characteristic that distinguishes between the two models is the accessibility of morphosyntactic features (number and gender) in Broca's aphasia. Let us look more closely at the predictions the two models make with regard to these features in simple transitive and ECM sentences containing a pronoun.

1.1. *The Reflexivity Model*

The Reflexivity account relies on the specification of the morphosyntactic features (number, gender, person) and their accessibility in language processing. The referential element (pronoun or reflexive) and its antecedent enter a dependency chain² whereby the final element of the chain must be referentially deficient, i.e. not fully

¹ In these sentences the subject NP Peter and the pronoun him are not arguments of the same verb (to see). The whole small clause (him dancing) containing the pronoun is the external argument of the verb.

² Somewhat simplified one could say that a Chain is a link between two elements in a sentence.

specified for the morphosyntactic features (see (4)). This condition on reference assignment is called the Chain condition³.

4. [Peter *himself/him*]
*Peter sees himself/*him.*

Reflexives are not fully specified for morphosyntactic features and are therefore acceptable as the final element of a chain [*Peterhimself*] in (4). Pronouns, on the other hand, are not referentially deficient; they are fully specified for number and gender and therefore cannot enter a chain as the final element. This is exemplified in the simple transitive sentence in (5) and the ECM sentence in (6), where *him* cannot be interpreted as referring to the local antecedent *Peter*. According to the Reflexivity theory this would be a violation of the Chain condition.

5. **Peter sees [him].*
 6. **Peter sees [him dance].*

Let us now consider the predictions this model makes with regard to the errors in the interpretation of pronouns agrammatic patients exhibit in both simple transitive sentences and ECM constructions. According to the Reflexivity model, the problem must be related to the inability to establish the appropriate chain (dependency) between the antecedent and the pronoun since the Chain condition is the only condition that applies to both cases. It is possible that agrammatic speakers treat pronouns as referentially deficient (as reflexives) because they are incapable of accessing number and/or gender features. If this is the case, then they should exhibit problems when interpreting pronouns in these sentences. Specifically, if agrammatic patients cannot access these features it should not matter whether there is a match or mismatch in number or gender between the local antecedent and the pronoun in these sentences. Both match and mismatch cases are expected to be equally problematic.

1.2. *The Primitives of Binding Model*

The Primitives of Binding model, on the other hand, assumes a particular Economy hierarchy of interpretative steps in reference assignment that needs to be respected. In the Economy hierarchy different elements establish referential relations at different levels such as syntax, semantics or discourse (e.g. (7)).

³ In addition to the Chain condition, in simple transitive sentences Condition B also plays a role in reference assignment and is a condition on predicates where the antecedent and the anaphoric element must both be arguments (coarguments) of the same verb. For ECM sentences this condition does not apply since the antecedent (the matrix subject NP) and the anaphoric element are not coarguments of the same verb. It is beyond the scope of this paper and also not relevant for the present discussion to deal in detail with these additional differences.

7. LEVEL	OPERATION
Narrow syntax ↓	feature checking
Semantics ↓	bound variable
Discourse	coreference

According to this model syntactic dependencies are the most economical, followed by semantic dependencies, and finally dependencies established through discourse. The condition that applies to both the simple transitive sentence in (5) and the ECM construction in (6) is the Economy hierarchy and in both cases a possibility of a syntactic dependency blocks the interpretation where *him* refers to the local NP *Peter*. The difference between (5) and (6) is related to the condition that applies to coarguments, therefore, this additional condition on predicates applies to (5), where the pronoun and the local NP are both arguments of the same verb and in (6) this is not the case (for a detailed discussion see Ruigendijk et al., in press).

The errors in both ECM and simple transitive constructions are, therefore, related to the problems within the Economy hierarchy. So, how does the accessibility of morphosyntactic features affect the hierarchy? If the problem with reference assignment in these constructions is related to problems within the Economy hierarchy then there is no reason to posit problems with features. The agrammatic patients should be able to access and use these features when interpreting pronouns in the simple transitive and ECM constructions.

Our present study aims at shedding more light on the way the agrammatic patients assign reference to pronominal elements. We also aim at using the results obtained to discern between the two theoretical models. The difference between these two models lies in the predictions they make with regard to the accessibility of the morphosyntactic features in agrammatism. The Reflexivity model predicts that these features play a crucial role in reference assignment and that the problems agrammatic patients exhibit with assigning reference to pronouns are related to problems with either access or use of these features when forming a chain (dependency). The Primitives of Binding model, on the other hand, assumes that mistakes are not related to features in any way but to the economy hierarchy of referential dependencies that is somehow disturbed in agrammatism. Therefore, by examining the agrammatic ability to use morphosyntactic features of number and gender when interpreting pronouns in either simple transitive sentences or ECM constructions, we hope to provide further evidence in favour of one of the two models. If the agrammatic patients show sensitivity to the information carried by the morphosyntactic features then we must conclude that the Reflexivity model cannot adequately describe our data.

There have not been many experimental studies examining the effect of morpho-syntactic features on processing of pronouns. In an elegant lexical priming study with non-brain damaged adults, Vicenci and Di Domenico (1999) found that very soon after presentation number was used to identify the antecedent, but not gender. The authors suggest that while gender is relevant to the lexical/semantic level of representation, number is relevant to the syntactic level of representation. To our knowledge there is only one study that examined the effect of the number and gender feature mismatch on processing of pronouns in Broca's aphasia. In an offline study conducted in English, Dutch and French, Friederici et al. (1991) found that agrammatic patients could use both number and gender information to decide on the appropriate antecedent for the pronoun. Their study, however, did have some methodological shortcomings, which is why we find their results questionable and cannot rely on their findings. Therefore, we decided to conduct an experimental study in Dutch in which we check whether the agrammatic aphasic patients can use morphosyntactic feature information in the comprehension of pronouns.

2. Experiment

2.1. Subjects

We tested six Dutch-speaking agrammatic aphasic patients. Of the six agrammatic patients, four were female and two male with an average age of 58 years (range 41-73 years). All of them were aphasic due to a single lesion in the left hemisphere, and all were right-handed. Individual patient data can be found in Appendix I. All patients were diagnosed with the Dutch version of the Aachen Aphasia Test (AAT, Graetz et al., 1992). Five of them were classified as having Broca's aphasia on the basis of the AAT results, as well as by their speech therapist and an experienced clinical linguist. One of the patients (AD) could not be classified into one of the major syndromes with the help of AAT at the moment of testing. Since an earlier AAT did classify her with Broca's aphasia and her speech production did fit the pattern of agrammatism, we decided to include her in this study. The AAT scores of each of these patients are given in Appendix I.

The speech production of all patients was characterized as moderately to severely agrammatic based on the description of agrammatism in Menn et al. (1995), i.e. their speech production was non-fluent with non-finite utterances and relatively few pronouns and determiners.

The performance of agrammatic patients was compared to the performance of a control group of 9 Dutch non-brain-damaged speakers (4 male, 5 female; mean age 43.4, range 27-69 years) who were matched in age and education to the aphasic speakers.

2.2. Method and procedure

Subjects were tested with a truth-value judgment task⁴. Each subject was presented with the target sentence orally. Prior to each test sentence the participants in the action portrayed on each picture were introduced. After hearing the target sentence subjects were asked to respond with *yes* or *no* indicating whether they found that the picture correctly portrayed the meaning of the target sentence. There were 4 conditions each containing 16 items. Items were presented in two versions: one paired with a picture where the expected response was YES and another with a picture that depicts a reflexive or reciprocal action with an expected NO response (see Figure 1 for an example).

Experimental conditions:

Number/gender match:

1. SINGULAR-SINGULAR

De man spuit *hem* nat.

The man sprays *him* (wet)

Number mismatch:

2. SINGULAR-PLURAL

De man spuit *hen/hun*⁵ nat.

The man sprays *them* (wet)

3. PLURAL-SINGULAR

De mannen spuiten *hem* nat

The men spray *him* (wet)

Gender mismatch:

4. GENDER MISMATCH

De vrouw spuit *hem* nat.

The woman sprays *him* (wet)

Example singular-plural YES condition:



Example singular-plural NO condition:



Figure 1. Examples of the Truth Value Judgment task

⁴ This particular task was chosen in order to replicate Grodzinsky et al., (1993) results where agrammatic patients scored at chance level with pronouns in simple transitive sentences. In our later study (Ruigendijk et al., in press) we used a picture selection task, which we suppose is easier for the patients and the results we obtained with pronouns in simple transitive sentences were significantly above chance.

⁵ In the standard Dutch grammar, the appropriate form for the direct object without a preposition in Dutch is *hen* and for the indirect object it is *hun*. Nevertheless, in spoken language *hun* is the more frequently used form for the direct object, which is why we opted for this form.

2.3. Results

Table 1 shows the overall results for both agrammatics and controls. The agrammatics performed worse than the controls on the singular match condition (Mann-Whitney test - $Z = -2.928$, $p < .003$). Their performance on the plural-singular mismatch condition was also significantly worse than that of controls ($Z = -2.279$, $p < .023$), whereas in the singular-plural match condition ($Z = -.816$, $p = .414$) and the gender mismatch condition ($Z = -1.793$, $p = .073$) it was not different than the controls.

We compared the differences between the singular-singular match condition and the three mismatch conditions using the Wilcoxon Signed Rank test. The agrammatic patients scored significantly better on all mismatch conditions as opposed to the singular-singular match condition (singular-singular vs. singular-plural - $Z = -2.032$, $p < .042$; singular-singular vs. plural-singular - $Z = -1.947$, $p < .052$; singular-singular vs. gender mismatch - $Z = -2.060$, $p < .039$). There was no significant difference in their performance on the singular-plural vs. plural-singular mismatch conditions ($Z = -1.633$, $p < .102$).

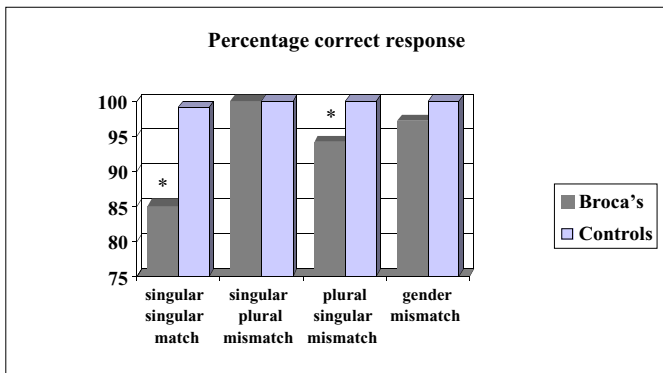


Figure 2. percentages correct on the Truth Value Judgment task

Table 1. Percentage correct response in all 4 conditions

	Singular-singular	Singular- plural	Plural- singular	Gender-mismatch
Aphasics	85.4	100	93.8	96.9
Controls	98.8	98.8	100	100

3. Discussion

The results show that agrammatic patients' performance improves in sentences with a mismatch in number or gender between the pronoun and its antecedent (local NP) vs. sentences where the two match in number and gender. These results support the claim

that agrammatic patients do have access to the number and gender information on the pronoun and do use it when deciding on the referent for the pronoun. Therefore, our results indicate that morphosyntactic information can be accessed in agrammatism and is used to aid the comprehension of sentences containing pronouns.

The problem with assigning reference to pronouns in agrammatism does not lie in the underspecification or inability to access morphosyntactic features, as would be expected from the predictions that can be drawn on the basis of the Reflexivity model. Our results can, therefore, be better explained as related to the disturbed Economy hierarchy of the Primitives of Binding model. In combination with our previous results we propose that the syntactic operations are not the most economical in agrammatism, which affects the Economy hierarchy in agrammatism in such a way that it becomes different than for the non-brain-damaged adults. This proposal is along the lines of the slower-than-normal lexical activation hypothesis (see Zurif, 2003) and the Slow-Syntax Hypothesis proposed by Piñango (1999) where they claim that syntactic operations demand more resources than in the non-brain damaged adults.

Finally, we failed to replicate the results obtained by Grodzinsky et al., (1993) where the agrammatic patients score at chance level in simple transitive sentences with a match in number and gender between the pronoun and the local antecedent. In our experiment we used the same method as Grodzinsky et al., and the same type of materials in Dutch. The reason why we opted for the same methodology was that we wished to replicate the chance performance on the baseline condition (singular-singular) in order to check whether a mismatch in number or gender would improve their performance. Our results for the singular-singular match condition where the agrammatic patients score significantly above chance (85.4 %) were surprising and they indicate that pronominal reference assignment in simple transitive sentences is not impaired to a similar degree as the patients in the Grodzinsky et al. study. They tested six agrammatic patients⁶ and had six data points per condition. We tested six patients and had 16 data points per condition, which gives more statistical power and makes our results more convincing.

4. Conclusion

In our study we showed that agrammatic Broca's patients can access and use the number and gender information on pronouns when comprehending sentences that contain these elements. These results undermine the claim that the problem in interpreting sentences with pronouns can be ascribed to the underspecification of morphosyntactic

⁶ Eight patients were tested but two patients were excluded from the analysis because of their deviant performance (see Grodzinsky et al., 1993).

features as predicted by the Reflexivity model of reference assignment. The Primitives of Binding model according to which the problem in reference assignment in agrammatism is related to the Economy hierarchy of referential dependencies better captures our data. We are presently conducting studies that further investigate the ways in which the hierarchy of referential dependencies is affected in aphasia by looking at the online (Ruigendijk & Burkhardt, in preparation) and also by looking at other constructions involving other types of dependencies (Vasic, Avrutin & Ruigendijk, subm.).

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References

- Avrutin, S. (1999). *Development of the Syntax-Discourse Interface*. Dordrecht, The Netherlands: Kluwer Academic Publishers.
- Blumstein, S., Goodglass, H., Statlender, S. & Biber, C. (1983). Comprehension strategies determining reference in aphasia: a study of reflexivization. *Brain and Language*, 18, 115-127.
- Burkhardt, P. & Ruigendijk, E. (in preparation). Pronoun-antecedent dependencies in Broca’s aphasia: Evidence for delayed syntactic structure building.
- Friederici, A.D., Weissenborn, J. & Kail, M. (1991). Pronoun Comprehension in Aphasia: A Comparison of Three Languages. *Brain and Language*, 41, 289-310.
- Graetz, P., De Bleser, R. & Willmes, K. (1992). *Akense Afasie Test*. Lisse: Swets & Zeitlinger.
- Grodzinsky, Y., Wexler, K., Chien, Y.-C., Marakovitz, S. & Solomon, J. (1993). The breakdown of binding relations. *Brain and Language*, 45, 396-422.
- Menn, L., O’Connor, M., Obler, L. & Holland, A. (1995). *Non-fluent aphasia in a multilingual world*. Amsterdam: John Benjamins.
- Piñango, M. (1999). *Some syntactic and semantic operations and their neurological underpinnings*. Ph.D. Dissertation. Brandeis University.
- Piñango, M & Burkhardt, P. (2001). Pronominals in Broca’s aphasia comprehension: the consequences of syntactic delay. *Brain and Language*, 79, 1, 167-168.
- Reinhart, T. & E. Reuland. (1993) Reflexivity. *Linguistic Inquiry*, 24, 657-720.
- Reuland, E. (2001). Primitives of Binding. *Linguistic Inquiry*, 32, 439-492.
- Ruigendijk, E., Baauw, S., Zuckerman, S., Vasic, N., de Lange, J. & Avrutin, S. (in press) A cross-linguistic study on the interpretation of pronouns by children and agrammatic speakers: Evidence from Dutch, Spanish and Italian. In: E. Gibson & N. Pearlmutter (eds.), *Processing and Acquisition of Reference*.

- Zurif, E. (2003). The neuroanatomical organization of some features of sentence comprehension: Studies of real-time syntactic and semantic composition. *Psychologica*, 32, 13-24.
- Vasic, N. & Ruigendijk, E. (2004). Interpretatie van persoonlijke voornaamwoorden door Nederlandse Broca-patienten, *Afasiologie*, 26,(1), 18-22.
- Vasic, N., Avrutin S. & Ruigendijk, E. (subm.). Interpretation of pronouns in VP-ellipsis constructions in Dutch Broca's and Wernicke's aphasia.
- Vicenzi, M. de & di Domenico, E. (1999). A Distinction Among ϕ -Features: The Role of Gender and Number in the Retrieval of Pronoun Antecedents. *Revista di Linguistica*, 11, 1, 41-74.

Appendix I

Individual scores of the aphasic speakers on the Aachen Aphasia Battery.

Subject	Spontaneous speech	Token Test		Written language	Naming	Comprehension	Diagnosis
		Test	Repeating				
AD	3/5/5/4/4/2	17	115	73	110	112	non-classifiable
AN	3/3/2/4/4/1	17	122	97	104	82	Broca
JW	3/5/3/4/4/2	18	112	82	99	107	Broca
IH	3/3/5/3/4/2	26	113	67	95	60	Broca
EM	2/3/2/4/2/1	24	99	48	100	86	Broca
MK	2/3/3/3/4/1	34	108	39	94	98	Broca

The numbers under spontaneous speech refer to: communicational behaviour, articulation & prosody, automatic language, semantic structure, phonological structure, and syntactic structure respectively. Scores go from 0 to 5, 0 referring to maximum disorder, 5 minimal problems, except for syntactic structure, where 1 or 2 refer to short and syntactic incomplete utterances. Under Token Test the number of errors is given (max 50). The maximum score for repeating is 150, for written language 90, for naming 120, and for comprehension also 120.

Patient IH has been tested with a shorter version of the AAT that has been developed by Heesbeen & van Loon-Vervoorn (2002). Their scores are derived from their scores on the shorter version using to the Heesbeen & van Loon-Vervoorn method.

Patient data. Tpo = time post onset; y = year; m = months; CVA-1 = Cerebro Vasculair Accident left; ACM = Arteria Cerebri Media.

Subject	Sex	Age	Tpo	Diagnosis	Cause
AD	Female	52	3y4m	non-classifiable aphasia	CVA-1, ACM
AN	Male	73	20y	Agrammatic Broca's aphasia	CVA-1, ACM
JW	Male	41	2y6m	Agrammatic Broca's aphasia	CVA-1
IH	Female	57	5m	Agrammatic Broca's aphasia	CVA-1
EM	Female	58	12y4m	Agrammatic Broca's aphasia	CVA-1
MK	Female	64	1y6m	Agrammatic Broca's aphasia	CVA-1