

Reference assignment: Using language breakdown to choose between theoretical approaches

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Abstract

We report results of an experimental study with Dutch agrammatic aphasics that investigated their ability to interpret pronominal elements in transitive clauses and Exceptional Case Marking constructions (ECM). Using the obtained experimental results as a tool, we distinguish between three competing linguistic theories that aim at determining principles responsible for pronoun distribution: Government and Binding (Chomsky, 1981), Reflexivity (Reinhart & Reuland, 1993), and Primitives of Binding (Reuland, 2001). The obtained results are inconsistent with Government and Binding, but consistent with the latter two theories. We further show that the Primitives of Binding framework most naturally explains our results. Our proposal is based on the different performance demonstrated by patients in transitive clauses and ECM constructions, in combination with the often-made claim in the literature regarding the limitation of processing resources in this population (e.g., Haarmann & Kolk, 1991, 1994; Zurif, Swinney, Prather, Solomon, & Bushell, 1993, among others).

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1. Introduction

The referential behavior of pronominal elements has often been discussed in linguistic literature. There are three major theoretical approaches, namely, Government and Binding (Chomsky, 1981), Reflexivity (Reinhart & Reuland, 1993), and Primitives of Binding (Reuland, 2001), which were formulated to account for this behavior. In this study, we would like to distinguish between these theoretical approaches using language breakdown data from agrammatic aphasic speakers. Consequently, we believe that language breakdown data can provide us with information about the healthy system, and that any linguistic theory should at least be compatible with language breakdown data.

Some studies on agrammatism have shown that pronominal reference assignment is impaired in agrammatism and that this impairment is highly constrained by linguistic principles (see e.g., Avrutin, Lubarsky, & Greene, 1999; Blumstein, Goodglass, Statlender, & Biber, 1983; Grodzinsky, Wexler, Chien, Marakovitz, & Solomon, 1993; Love, Nicol, Swinney, Hickok, & Zurif, 1998; Piñango & Burkhardt, 2001). The present study aims at distinguishing between different linguistic approaches to Binding theory with data from Dutch-speaking agrammatic aphasic patients. We would like to show how these data could be used to understand the rules that govern the interpretation of pronominal elements.

The focus of our study will be on the interpretation of pronouns and anaphors in two different structures: transitive sentences and sentences with an exceptional case marking construction (henceforth ECM) as in (1a) and (1b). The crucial difference between those structures is

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that in (1a) the pronoun and the subject are both arguments of the same verb *tickles* (they are so-called coarguments), whereas in (1b) they are not.

- (1) a. *Transitive sentence*
 *Jane_i tickles her_i.
 b. *Exceptional Case Marking construction*
 *Jane_i sees her_i dance.

Reference assignment in these two structures and the differences therein are discussed in the light of different theoretical approaches: on the one hand Government and Binding Theory that does not make a distinction between reference assignment in these sentences (henceforth GB, Chomsky, 1981), and on the other hand the Reflexivity model (henceforth REFL, Reinhart & Reuland, 1993) and Primitives of Binding (henceforth PoB, Reuland, 2001)¹ that both distinguish between reference assignment in (1a) and (1b). First, we briefly introduce GB and some of its problems. After this, we discuss the interpretation of pronouns in transitive sentences and ECM constructions and the way the three different theories deal with it. In the following section, some relevant studies on reference assignment by aphasic speakers are summarized, and our predictions are formulated. Subsequently, the experimental part is described and its results are discussed in the final sections using the theoretical approaches on reference assignment as described in the theoretical background.

The first challenge to theories concerning the referential behavior of pronouns and reflexives is to explain the distribution of these categories as in the sentences (2a) and (2b).

- (2) a. Peter_i complained that Harry_j tickled him_{i/*j}.
 b. Peter_i complained that Harry_j tickled himself_{*i/j}.

In (2a) the pronoun *him* may refer to the matrix subject *Peter*, but cannot refer to the embedded subject *Harry*. The reflexive *himself* in (2b) must refer to the embedded subject *Harry*, and cannot refer to the matrix subject *Peter*. Chomsky presents the standard account for this distribution pattern of pronouns and reflexives in his Government and Binding theory (Chomsky, 1981). To briefly summarize:

¹ We focus on these three theories because they represent three clear cases of theoretical paradigms. GB argues that reference assignment is determined (or constrained) by structural considerations; Reflexivity argues for the interaction of structural, lexical and discourse factors, and PoB proposes an economy-based hierarchy as a crucial factor in reference assignment. Naturally, within each of these paradigms there are various ramifications, such as such as Lidz (2001, Rule R), Avrutin (1994, movement of Bound Variables), Chien and Wexler (1990, Principle P), among others. For our purposes it is sufficient to focus on the paradigmatic difference between theories.

*Binding Principles*² (GB, Chomsky, 1981)

A: An anaphor is bound within its governing category.

B: A pronoun is free in its governing category.

Binding is used here as a syntactic notion relevant for the establishment of referential dependencies. The principles state that anaphors must have a local antecedent on which they depend referentially, whereas pronouns must be locally free and have their antecedent outside their governing category. This leads to the prediction that the two elements must be in complementary distribution. There are, however, some problems with this descriptive account of binding phenomena, as discussed by Reinhart and Reuland (1993) and in Reuland (2003). First of all, the assumed complementary distribution between pronouns and reflexives does not hold (see 3). Also, some languages, such as Dutch and Spanish have two types of anaphors (SE³ and SELF-anaphors) that do not have the same distribution, as can be seen in (4). In (3), either a pronoun *her* or an anaphor *herself* may be used to refer to the subject *Jane*. In (4), both *zich* and *zichzelf* are anaphors; however, whether or not they can be locally bound seems to depend on the verb that is used. Clearly, Principles A and B of the GB cannot account for these facts.

- (3) Jane_i hid a present behind her_i/herself_i.
 (4) a. Peter_i ziet *zich_i/zichzelf_i.
 Peter_i sees *SE_i/himself_i.
 ‘Peter sees himself’
 b. Peter_i gedraagt zich_i/*zichzelf_i.
 Peter_i behaves SE_i/*himself_i.
 ‘Peter behaves himself’

The distribution of SE and SELF-anaphors (as in 4), as well as the reference of pronouns and anaphors in sentences like (3) are better captured within more recent models of reference assignment (Reinhart & Reuland, 1993; Reuland, 2001; for a detailed discussion of these structures, but see also Lidz, 2001).

Let us now have a look at the following two structures (that form the two crucial conditions of our study) with a pronoun in a transitive sentence (5a) and a pronoun in an ECM construction (5b):

- (5) a. *Janette_i kietelt haar_i.
 *Jane_i tickles her_i.
 ‘Jane tickles her’
 b. *Janette_i ziet haar_i dansen.
 *Jane_i sees her_i dance.
 ‘Jane sees her dancing’

² Where α is bound by β if β c-commands α and is coindexed with it and γ is a governing category for α if and only if γ contains α , a governor for α , and an accessible subject. Governing category can be loosely defined as ‘local domain,’ for a precise definition see Chomsky (1986).

³ SE = Simplex Expression, Reinhart and Reuland (1993).

In both sentences, the pronoun *haar* cannot refer to the subject of the sentence *Janette*. In (5a), the pronoun *haar* is the object of the predicate *kietelt*, whereas in (5b) it is the subject of the embedded predicate *dansen*. GB accounts for the ungrammaticality of both (5a) and (5b) by applying Principle B. The pronoun *haar* is ‘illegally’ bound within its governing category in both sentences. Therefore, both (5a) and (5b) do not obey principle B of GB and are thus ungrammatical. In other words, GB treats pronouns in these structurally different sentences in the same way. REFL (Reinhart & Reuland, 1993) and PoB (Reuland, 2001), on the other hand distinguish between (5a) and (5b).

REFL consists of two modules that govern the referential properties of pronominal elements: the Binding module (with modified Principles A and B) and the Chain Condition.

Reinhart and Reuland's Binding Conditions (1993)

A: A reflexive-marked predicate must be interpreted reflexively.

B: A reflexively interpreted predicate must be reflexive-marked.

General Condition on A-Chains

A maximal A-Chain ($\alpha_1 \dots \alpha_n$) has exactly one link— α_1 , which is both +R and marked for structural Case. Where an element is +R when it is referentially independent and specified for all Φ -features.

According to Reinhart and Reuland, the distribution of pronouns and anaphors is the result of the interaction of these two independent syntactic modules.⁴ The sentence in (5a) is ruled out by Condition B and the Chain Condition. Condition B is violated since the predicate is interpreted reflexively, as indicated by the coindexation, but not reflexive-marked, that is, none of the arguments is realized as a SELF anaphor and the predicate *kietelt* is not lexically reflexive. The Chain Condition also rules out (5a). *Janette* and *haar* form an illicit chain, since both elements are +R and structurally marked for Case. In (5b), however, Condition B does not apply, since *Janette* and *haar* are not coarguments and Condition B applies to coarguments only. The external semantic argument of the predicate *ziet* is *Janette* and the internal argument is not *haar*, but the complete clause *haar dansen*. The pronoun *haar* itself is an argument of the embedded predicate *dansen*. It is the Chain Condition only that rules out (5b). As in (5a), the pair ‘*Janette, haar*’ forms a chain that violates the Chain Condition

⁴ Condition B accounts for the distinction between SE and SELF-anaphors. A predicate is reflexive-marked if one of the arguments is a SELF-anaphor, as in *Peter ziet zichzelf* or if the predicate is lexically reflexive, as in *Peter gedraagt zich*. A predicate can be lexically reflexive because of its lexical semantic properties, as is the case for some Dutch verbs.

since both elements are +R and marked for structural Case.⁵

Reuland (2001) takes the Binding conditions from the Reflexivity approach and integrates these in the Minimalist framework (based on Chomsky, 1995, 2000) to account for binding phenomena in his Primitives of Binding. The essential difference between REFL and PoB is that in the former the Binding conditions as well as the Chain condition are postulated, whereas in PoB Reuland shows how these conditions can be derived. Moreover, he discusses the different linguistic subsystems that are involved in binding (and coreference). The basic idea of PoB is that referential dependencies can be established at different linguistic levels. There is a difference in cost between these levels that depends on the number of interpretive steps necessary for interpretation of a referential element. A simpler, more economical type of dependency results from checking features in the *narrow syntax* and can therefore be called ‘syntactic.’⁶ The interpretation of pronouns is assumed to be more costly. The crucial difference between pronouns and SE elements in this theory is that pronouns, unlike SE elements, have *number* feature, which is interpretable and, therefore, cannot be deleted. As a result no syntactic dependency can be established between an antecedent and a pronoun as in (5a and b). In other words, the pronoun *haar* in (5) is necessarily interpreted as someone else, not *Janette*. Note that in this way the Chain effect (from REFL) is derived from the feature checking mechanism.

However, there is an additional aspect of PoB. Pronouns, in principle, can enter into a non-syntactic, discourse-related dependency (coreference) with their antecedents or into a semantics-related bound variable relationship. The question thus arises why in (5a), for

⁵ Notice that in Dutch ECM constructions as in (i) the SE anaphor *zich* is allowed, since it is not fully specified for Φ -features and therefore is –R.

- (i) *Janette_i ziet haar_{*i}/zich_i dansen.*
*Jane_i sees her_{*i}/SE_i dance.*
 ‘Jane sees her/herself dance’

⁶ The Dutch SE anaphor *zich* represents precisely the case where a syntactic dependency is formed (see ii).

- (ii) *Peter waste zich.*
Peter washed SE.
 ‘Peter washed himself’

Features of *zich* undergo movement to a functional head in the main clause for checking purposes. As a result, these features are deleted and the predicate ‘wash’ ends up being a one place semantic predicate. In other words, *zich* is invisible for semantic computation. Since not all predicates in Dutch allow for this arity reduction, only a limited number of verbs, so-called inherently reflexive verbs, can appear with *zich* as a complement. The dependency between *Peter* and the anaphoric *zich* in sentences like (ii) is the most economical for our interpretation system, since it requires a purely automatic syntactic operation only (Reuland, 2001).

example, *haar* cannot be interpreted as *Janette* if a discourse dependency or a semantic dependency is an option. Reuland (2001) proposed that various forms of dependencies form an economy hierarchy, the syntactic dependency being the most economical as it relies on the operation within one module (i.e., feature checking in narrow syntax). Other types of dependencies that require operations in more than one module, such as discourse, are possible only if a cheaper option is not available. Thus (5a and b) are ruled out (on the reading where *haar* is *Janette*) because of two reasons. First, due to the presence of number feature, the pronoun cannot enter into a syntactic dependency with the main subject, and second, it cannot enter a semantic or a discourse dependency because of economy considerations (a more economical type of dependency, syntactic, could be, in principle, possible in this configuration if the element in question—the pronoun—could check its features in narrow syntax).⁷ The difference between (5a) and (5b), according to PoB, lies in the fact that in (5a) the pronoun and the antecedent are both arguments of the same predicate, whereas in (5b) they are not. In (5a), the pronoun *haar* and the antecedent *Janette* cannot be interpreted as one argument because of the lexical restrictions on arity reduction. Only certain Dutch verbs (so called ‘inherently reflexives’ like *wassen* ‘to wash’ and *scheren* ‘to shave’) allow for arity reduction (i.e., for changing number of arguments), a verb like *kietelt* does not have this possibility and therefore *haar* cannot be interpreted as *Janette*. Arity reduction restrictions do not play a role in ECM constructions as in (5b) since the antecedent and pronoun do not belong to the same predicate. Interpretation of the pronoun *haar* referring to the subject *Janette* is therefore ruled out in (5a), but not in (5b). See also footnote 5, which shows that Dutch *zich* is therefore allowed in these ECM constructions. The PoB explanation for the ungrammaticality of (5a) and (5b) thus differs in one important respect from the REFL account: *the economy hierarchy of establishing dependencies*.

Let us summarize the crucial distinction between the three theories with respect to the constructions in question. Government and Binding theory, as mentioned above, represents a purely “geometrical” approach to the constraints on reference assignment, because the constraints are formulated in terms of locality and c-command. No distinction is made in this sense between simple transitive clauses and ECM constructions. In the Reflexivity theory, on the other hand, there is a distinction between simple transitive clauses and ECM constructions, the latter requiring the chain condition. The relevant constraints in this theory can be characterized

as both structural and morphosyntactic because the notion of +R(eferential) element is introduced, and it is this feature that is relevant for the chain condition. Finally, the Primitives of Binding approach seeks, in our view, to address the unification problem (Chomsky, 1994) by proposing that the acceptability of certain constructions can be dependent on processing factors. Indeed, the notion of economy hierarchy that is characteristic for this theory is a processing, not representational, notion. The different levels at which reference can be established represent different interpretational steps and according to Reuland:

“...there are intrinsic differences between the workings of each of these components. It appears to be quite uncontroversial that the operations of C_{HL} (narrow syntax) are entirely subliminal. They are automatic, hence, plausibly, cheap. Computations within the interpretive component (broad syntax/semantics) may well be generally more costly. They appear to be automatized to a considerably lesser extent, witness the problems speakers encounter processing and interpreting complex quantificational structures. The same has been argued for processes involving the discourse storage [for a recent discussion, see Van Geenhoven (1998)]. Note, that often the task of establishing a referent for some pronoun on the basis of preceding context requires processes that involve conscious access to various data structures, and hence may be slowed by non-linguistic factors” (Reuland, 2001, p. 472).

The same as Reflexivity, PoB does distinguish between simple transitive clauses and ECM constructions, but the distinction in this theory is derived on the basis of processing economy, rather than on the basis of representational constraints (e.g., Reflexivity’s chain condition).

Given such three-way distinction, the aphasiological data becomes very relevant as a tool to choose between theories. Indeed, as argued by many researchers (Avrutin, 1999; Burkhardt, Piñango, & Wong, 2003; Grodzinsky et al., 1993; Kolk & Heeschen, 1992; Piñango & Burkhardt, 2001; among others), agrammatic aphasic patients retain the necessary syntactic (structural) knowledge; however, their capacity to use it is severely reduced. In this view, brain damage results in a reduction of brain activation required, specifically, for the fast and automatic operations, such as syntactic operations. As a result, the computations are significantly slowed down while remaining qualitatively intact (Piñango, 1999; or Love, Swinney, & Zurif, 2001). Importantly, the authors’ claim about agrammatic Broca’s aphasia concerns specifically activation of the brain area involved in syntactic computations. Thus, it is the syntactic module in particular that is ‘weakened’ compared to other modules such as semantics or discourse (Avrutin, to appear). If so, one may hypothesize that the syntactic operations that are the most economical for non-brain-

⁷ The explanation is of course reminiscent of that offered in Grodzinsky and Reinhart (1993) for the relationship between bound variable anaphora and coreference. A complete picture, however, is more complex but we refer the reader to Reuland’s original presentation in Primitives of Binding.

damaged adult speakers may not be the most economical for agrammatic aphasic patients. In other words, the economy hierarchy proposed by Reuland in PoB (2001) for the non-brain-damaged population may not hold for agrammatic aphasic speakers. A change in the economy hierarchy will result in a different interpretation of pronominal elements, since non-syntactic ways of establishing a referential relationship become available, such as a bound variable interpretation or establishing a relationship through discourse. This leads to a clear prediction of the agrammatic performance on the interpretation of pronominal elements in simple transitive sentences and ECM constructions. Using non-syntactic ways to establish a referential dependency will result in an atypical interpretation of pronouns in ECM construction, such that *haar* in (5b) can refer to the subject of the matrix clause *Janette*. In transitive sentences like (5a), the incorrect local coreference will be ruled out by the lexical restrictions (i.e., on arity reduction) on the verb *kietelen* ‘tickle’,⁸ which should lead to a better performance than in the ECM sentences. Importantly, arity reduction does not take place in narrow syntax (see e.g., Reinhart & Siloni, 2005), and is therefore not expected to form a problem for agrammatic speakers.

Notice that GB does not predict any difference at all between simple transitive clauses and ECM constructions, and REFL does not predict any difference that could be related to the processing cost.

Several studies have used data from agrammatic aphasic speakers to discuss theoretical linguistic issues (e.g., Grodzinsky, 1990). One important presupposition in these studies is that the grammar of agrammatic speakers in some way reflects the normal grammar. Although there is some discussion about the relationship between impaired language and the healthy language system (e.g., Bates, McDonald, MacWhinney, & Applebaum, 1991; Caramazza, 1986, 1991; Grodzinsky, 1990), the idea that brain damage does not result in new processing mechanisms or a completely new grammar is generally accepted. Following Grodzinsky (1990), we take the position that language breakdown can help us answer questions that cannot be answered by grammaticality judgments of healthy speakers only. Moreover, we assume that any linguistic theory should at least be compatible with language breakdown data. This assumption allows us to distinguish between different linguistic approaches using language breakdown data as a tool. In the present study this tool consists of agrammatic comprehension data on the interpretation of pronominal elements.

Although the specific nature of the impairment in agrammatism is still not agreed on, there seems to be a general consensus in the field of aphasiology that processing capacity of these patients is significantly reduced.

⁸ Shapiro and Levine (1990) showed that speakers with Broca’s aphasia are sensitive to argument structure.

Grodzinsky et al. (1993), for example, argue that these patients make errors in the interpretation of pronouns in simple transitive sentences (exemplified in 6) due to the fact that they are unable to process two representations.

(6) The boy pointed at him.

Taking Reinhart’s approach to binding and coreference (Reinhart, 1983), the authors argue that a correct interpretation of the pronoun as an element that cannot be dependent on the subject is due both to syntactic constraints (some version of Principle B) and an extra-syntactic Rule I.

Rule-I –intrasentential coreference:

NP A cannot corefer with NP B if replacing A with C, C A-bound by B yields an indistinguishable interpretation.

Thus, to correctly reject a coreference option in (6), speakers have to be able to compare two representations: the bound variable and coreference interpretations. Grodzinsky et al. (1993) argue that the process of holding both representations in memory to compare them is beyond the processing capacity of agrammatic speakers (and young children), which results in their chance performance.

It is more often claimed, however, that a reduced processing capacity somehow affects *syntactic* operations, as discussed above (Avrutin, to appear; Burkhardt et al., 2003; Burkhardt, 2004; Haarmann & Kolk, 1991, 1994; Piñango, 1999). Piñango (1999, 2003) argues in her Slow Syntax Hypothesis (SSH) that the limitation of processing resources leads to a general slow down of syntactic operations. The SSH states that speakers with Broca’s aphasia are unable to construct syntactic structures *on time*, but that there is a point in time (delayed) at which these structures are fully formed and do not differ from ‘normal’ representations. A similar claim is made by Zurif and his colleagues (p.c., see also Love et al., 2001) on the basis of lexical priming experiments. They show that agrammatic patients show priming for the antecedent at the trace position at a later point compared to normal controls in the structure of type. The same result has been found by Burkhardt et al. (2003). They have found that in a sentence like (7), unlike non-brain-damaged controls, agrammatic aphasic speakers do not exhibit a significant reactivation at the trace *t* immediately after the verb *melted*, but 650 ms later they do show priming for the antecedent. These online results thus support the idea that syntactic processes are slowed down in Broca’s aphasia.⁹

⁹ One of our reviewers pointed out that there is recent data by Yee, Blumstein, and Sedivy (2004) and Thompson, Dickey, and Choy (2004) that indicates that processing is not simply slowed in agrammatism. We think, however, that these data can also be explained with a slowed down (syntactic) processing, which will take us, though, beyond the scope of this study.

Table 1

The hypotheses regarding the performance of agrammatic speakers on the interpretation of pronouns in simple transitive and ECM constructions for the three different linguistic theories

| Government and binding | Reflexivity | Primitives of binding |
|--|--|---|
| No theoretical difference between pronouns in simple transitive constructions and ECM constructions, hence no difference in performance is predicted | There is a difference between the two constructions (e.g., chain condition), but the difference is not related to the processing capacity. While the difference in performance on these two constructions may exist, it is not clearly related to limitation of processing resources | There is a difference between the two types of constructions, and agrammatic speakers are expected to perform worse on ECM, than on transitive sentences due to a different economy hierarchy |

- (7) The kid loved the cheese_j which_{j/i} the brand new microwave *melted* t_i yesterday afternoon while the entire family was watching TV.

Finally, Avrutin (2000) offers a processing limitation account for speakers with agrammatic Broca's aphasia on the basis of their difficulties with D-linked Wh-questions, which, as Shapiro (2000) demonstrates require additional resources.

All in all, it appears that as a result of a specific brain damage the amount of resources available for syntactic computation becomes limited. If so, establishing syntactic dependency by means of purely syntactic operations (e.g., feature checking resulting in a chain formation as in Reuland, 2001) may be no longer the cheapest option. In other words, agrammatic aphasic speakers represent an interesting natural population that is expected to behave differently precisely in those cases where specific predictions with regard to acceptability of utterances can be related to economy of processing. In particular, if for a non-brain-damaged speaker a certain construction is unacceptable on the basis of economy considerations, a different result may be expected from agrammatic aphasic speakers whose economy hierarchy may be different.

Thus, a group of speakers with limited processing resources, such as patients with agrammatic aphasia, allow us to distinguish between competing theoretical accounts. Table 1 summarizes what predictions the three theories on Binding can make about agrammatic performance on simple transitive clauses and ECM constructions.

2. Methods

2.1. Subjects

Seven Dutch speaking aphasic patients, two females, five males with an average age of 57.4 years (range 38–82 years) participated in this study. Six of them were aphasic due to a single lesion in the left hemisphere. Patient AK had two CVA's in the left hemisphere. After the first, he had been diagnosed as having Broca's aphasia, which remained the same after the second stroke, although his language problems became more severe. All patients were right-handed. Individual patient data

can be found in Table 2. All patients were diagnosed with the Dutch version of the Aachen Aphasia Test (AAT, Graetz, De Bleser, & Willmes, 1992) and 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. The AAT scores of each of these patients are given in Appendix A.

The speech production of all patients was characterized as moderately to severely agrammatic based on the description of agrammatism in Menn, O'Connor, Obler, and Holland (1995), that is their speech production was non-fluent with non-finite utterances and relatively few pronouns and determiners.

The performance of the agrammatic speakers was compared to the performance of a group of 15 Dutch non-brain-damaged speakers (eight males, seven females; mean age 56.6, range 35–84 years) who were matched in age and education to the aphasic speakers.

2.2. Materials and procedure

A sentence comprehension task was developed to examine the interpretation of pronouns and anaphors in transitive sentences and in ECM constructions. This task was embedded in a larger task on the comprehension of pronominal elements consisting of 120 items in total, testing eight conditions of which only three are dealt with here.¹⁰ The complete test battery took the aphasic speakers two sessions of approximately 45 min each to finish. All 120 items were presented randomly and each session was started with some practice examples that were repeated when necessary. The real task did not start until the experimenter was convinced the subject understood the task. The sentences were presented orally to the subjects and repeated as often as necessary. The same experimenter administered the test to all patients to keep the testing conditions as consistent as possible.

The conditions that were relevant for this study were represented by 45 sentences in total, 15 per condition

¹⁰ Part of this task and some preliminary results is presented in Ruigendijk, Vasić, and Avrutin (2002), a paper reporting all data obtained with this task is in preparation. The same conditions have also been tested with Dutch children; see Zuckerman, Avrutin, and Vasić (2002).

Table 2
Patient data

| Subject | Sex | Age | Tpo | Diagnosis | Cause |
|---------|--------|-----|------|----------------------------|------------|
| AN | Male | 73 | 20y | Agrammatic Broca's aphasia | CVA-l, ACM |
| MJG | Male | 51 | 7m | Agrammatic Broca's aphasia | CVA-l |
| GK | Male | 60 | 3m | Agrammatic Broca's aphasia | CVA-l, ACM |
| AK | Male | 82 | 2y | Agrammatic Broca's aphasia | CVA-l |
| JW | Male | 41 | 2y6m | Agrammatic Broca's aphasia | CVA-l |
| AL | Female | 38 | 7m | Agrammatic Broca's aphasia | CVA-l ACM |
| IH | Female | 57 | 5m | Agrammatic Broca's aphasia | CVA-l |

tpo, time post-onset; y, year; m, months; CVA, cerebral vascular accident; l, left; ACM, artery cerebri media.

(see Appendix B for all test sentences with an English translation). The relevant conditions consisted of anaphors and pronouns in so-called transitive sentences and pronouns in ECM constructions, as in (8). The transitive sentences and the ECM sentences were constructed in such a way that they formed as close a minimal pair as possible. To achieve this, we constructed transitive sentences with the auxiliary *heeft* 'has' so that the main verb would be in clause final position the same as in the ECM construction (see 8b and c). The transitive sentences with a pronoun or an anaphor were identical apart from the pronominal element. The sentences with an anaphor (8a) were included as control items. No problems were expected with the comprehension of these sentences on the basis of previous literature (Grodzinsky et al., 1993).

- (8) a. *Anaphor in a transitive sentence:*
 ... en daarna heeft de vrouw_i zichzelf_{i/*j} aangeraakt
 ... and then has the woman_i herself_{i/*j} touched.
 '... and then the woman_i touched herself_{i/*j}'
- b. *Pronoun in a transitive sentence:*
 ... en daarna heeft de vrouw_i haar_{*i/j} aangeraakt.
 ... and then has the woman_i her_{*i/j} touched.
 '... and then the woman_i touched her_{*i/j}'
- c. *Exceptional Case Marking construction (ECM):*
 ... en daarna zag de man_i hem_{*i/j} voetballen.
 ... and then saw the man_i him_{*i/j} playing soccer.
 '...and then the man_i saw him_{*i/j} playing soccer.'

The test items formed the second conjunct of two conjoined sentences and were preceded by the first conjunct that introduced two possible referents for the pronoun. The introducing conjuncts belonging to the examples above are given in (9).

- (9) a. *Anaphor or pronoun in a transitive sentence:*
 Eerst hebben de vrouw en het meisje gelachen...
 First have the woman and the girl laughed...
 'First the woman and the girl laughed...'
- b. *Exceptional Case Marking Construction (ECM):*
 Eerst hebben de man en de jongen gegeten...
 First have the man and the boy eaten...
 'First the boy and the man ate...'

For each item four pictures were shown, which were presented on two pages of A4 size (see Fig. 1 for an example of the task from the ECM-condition). There was always one picture on the left page, belonging to the first conjunct of the sentence. One of the pictures at the right page depicted the second conjunct of the sentence (the picture in the middle in Fig. 1). The two other pictures formed the distracters, one (direct) distracter that showed a local binding interpretation of the sentence¹¹ (the upper picture in Fig. 1: the man sees himself playing soccer), the other by taking the same actors but another action (filler distracter: the lower picture in Fig. 1: the man sees him skating). The subject was asked to listen carefully to both parts of the sentence, look at the pictures and point at the one that depicts the sentence best. If necessary, the sentence was repeated as often as the patient asked for a repetition.

During the task, the experimenter scored the responses of the subject by indicating on the score form the number of the picture the subject pointed at. Afterwards it was established whether the subject had chosen the correct picture, its direct distracter or the filler distracter.

2.3. Results

The aphasic speakers made 62 errors in total, which is 19.7%, whereas the non-brain-damaged speakers made only 12 errors, which is about 1.8%. A Mann–Whitney *U* test revealed that the aphasic speakers performed significantly worse than the non-brain-damaged speakers on the ECM condition (MWU for ECM: $Z = -4.050$, $p < .001$). The agrammatic speakers performed also significantly worse than the control group on transitive sentences with pronouns (MWU: $Z = -2.425$, $p < .05$). The difference between the two groups did not reach significance for anaphors in transitive sentences: $Z = -1.934$, $p = .12$. Both the non-brain-damaged speakers and the agrammatic speakers hardly ever pointed to the indirect distracter (i.e., the picture with the wrong action) when making an error, but mostly

¹¹ Or for the conditions with an anaphor: a non-local binding interpretation.

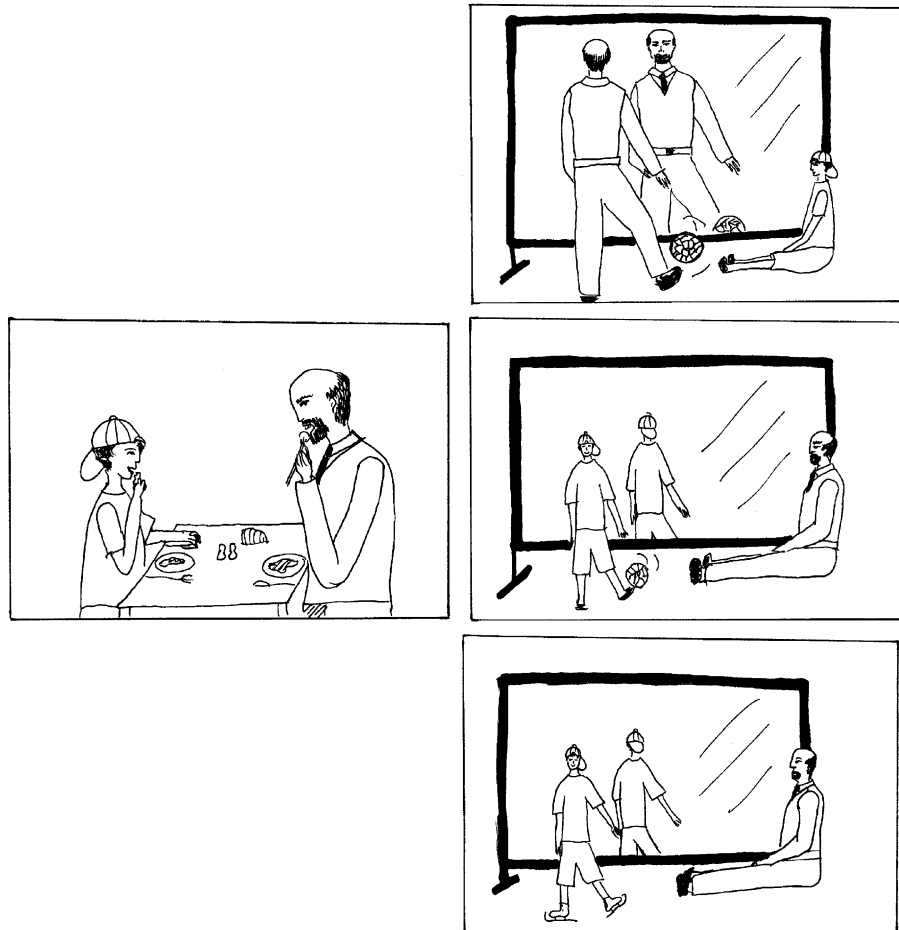


Fig. 1. An example of the picture decision task. Testing ECM: first the *boy* and the *man* ate and then the *man* saw *him* playing soccer. The middle picture on the right depicts the correct response.

to the picture with the wrong antecedent. Since we were interested in their abilities to establish reference for the pronouns, we decided to exclude the errors that were caused by pointing at the indirect distracter. The non-brain-damaged speakers pointed five times to the indirect distracter and the agrammatic speakers pointed four times to the indirect distracter. Table 3 shows the numbers of antecedent errors the agrammatic speakers and the non-brain-damaged speakers made on the three test conditions (i.e., the total numbers of errors minus the indirect distracter errors).

To test whether there was a difference between the performance of the agrammatic speakers on the two crucial conditions (pronouns in transitive sentences and ECM constructions), we compared the correct responses of the agrammatic speakers on these conditions with a Wilcoxon Signed Ranks Test ($Z = -2.388$, $p < .05$). A significant difference was found, which indicates that the performance on the ECM sentences was worse than on the transitive sentences. Finally, we examined whether the agrammatic speakers performed differently from chance-level on the two important conditions. The patients pointed almost always at the direct dis-

Table 3

Total and mean number of errors on anaphors and pronouns in transitive sentences (SVO) and ECM sentences by the aphasic speakers and the control group

| | Anaphor in SVO | Pronoun in SVO | Pronoun in ECM |
|---------------------------------------|-------------------|-------------------|-------------------|
| AN | 0 | 1 | 5 |
| MJG | 0 | 0 | 7 |
| GK | 0 | 0 | 4 |
| AK | 4 | 3 | 5 |
| JW | 1 | 0 | 7 |
| AL | 1 | 2 | 8 |
| IH | 2 | 2 | 6 |
| Total errors/no. of items analysed | 8/105 | 8/104 | 42/102 |
| Mean | 1.14 | 1.14 | 6.00 |
| SD | 1.46 | 1.22 | 1.41 |
| Control group | | | |
| Mean (SD) | 0.00 (0.00) | 0.20 (0.41) | 0.27 (0.59) |

tracter (with four exceptions), choosing the local binding interpretation when making an error. They seemed to choose between the correct picture and the direct distracter only. For this reason we decided to assume that

chance level performance on this task was 50%, although 33% would be the real chance level when randomly choosing between the three pictures. A binomial test showed that the patients' scores on the transitive sentences with pronouns did differ significantly from chance level ($p < .001$), that is, the patients performed above chance on this condition. The scores on the ECM sentences did not differ from chance level performance ($p = .092$).

3. Discussion and further results

The results clearly show that the interpretation of pronouns in transitive sentences is less difficult for agrammatic aphasic patients than the interpretation of pronouns in ECM constructions. Whereas they make hardly any errors with the interpretation of pronouns in transitive sentences, their performance on ECM constructions is at chance level. Second, the agrammatic patients do not have problems with the interpretation of anaphors, as expected and supporting former results by Grodzinsky et al. (1993). These results suggests that we do need a theory for reference assignment that can distinguish between the two sentences types, such as Reinhart and Reuland's Reflexivity theory (1993) or the more recent Primitives of Binding account (Reuland, 2001). In principle, however, it can be argued that the problem is not related to the interpretation of pronouns in ECM constructions, but to the potential complexity of these constructions per se. We therefore conducted additional testing to make sure that the problems agrammatic speakers have with the interpretation of pronouns in ECM sentences is not simply caused by the ECM structure as such. This time the task consisted of four conditions, with one condition for testing the interpretation of anaphoric elements in ECM sentence, using the same sentences as for the pronoun in ECM condition, but now with the anaphoric element 'zichzelf' (himself or herself, see 10). The other three conditions are part of another study (also involving pronouns) and will not be discussed here.

- (10) ... en daarna zag de man_i zichzelf_{i/*j} voetballen.
 ... and then saw the man_i himself_{i/*j} playing soccer.
 '...and then the man_i saw himself_{i/*j} playing soccer.'

Data from other studies suggest that agrammatic speakers do not have problems interpreting anaphoric elements in ECM sentences, or at least not as much as interpreting pronouns (Baauw & Cuetos, 2003; on Spanish).

We examined 10 non-brain-damaged speakers (mean age 38) and three agrammatic speakers with this new experiment. All three (AN, JW, and IH) also participated in the first experiment reported here. Unfortunately,

Table 4

Total and mean number of errors on anaphors in ECM sentences by the aphasic speakers and the control group

| | Anaphor in ECM |
|------------------------------------|----------------|
| AN | 0 |
| JW | 0 |
| IH | 1 |
| Total errors/no. of items analysed | 1/45 |
| Mean | 0.33 |
| SD | 0.57 |
| Control group | 0/150 |
| Mean (SD) | 0 (0) |

we were unable to trace all former participants; however, we trust that these three reflect the same behavior as the previous sample. The results of the three patients on the new task are presented in Table 4.

Table 4 clearly shows that the agrammatic aphasic speakers do not have any problems interpreting anaphoric elements in ECM constructions. Only one error is made in the interpretation of an *anaphor* in ECM sentences, whereas these three patients made 5, 7, and 6 errors, respectively, on the interpretation of *pronouns* in ECM sentences (which is significantly more, $\chi^2 = 17.079$, $p < .001$).

4. General discussion

The results of these two experiments convincingly demonstrate that pronouns in ECM sentences are particularly hard to interpret for agrammatic aphasic speakers, compared to anaphors in ECM sentences or pronouns in transitive sentences on which almost no errors are made. This implies that indeed a theory is needed that can distinguish between reference assignment in transitive and ECM sentences, such as Reflexivity theory or Primitives of Binding. How can we account for these data in terms of the Reflexivity model or in terms of Primitives of Binding? We will address this question in the following paragraphs. However, before we move on notice that unlike our patients, the patients Grodzinsky et al. (1993) examined performed at chance level on the comprehension of simple transitive sentences with a pronoun. This can be explained by comparing the two different methods used in our and Grodzinsky et al.'s study.¹² Grodzinsky et al. used a truth-value-judgment task, whereas in our experiment a picture selection task was used. In a truth-value-judgment task, the participant has to process the sentence that has been presented

¹² There are more studies that report a difference in the scores on pronouns in transitive sentences elicited with a truth value judgment task or a picture selection task (see, Baauw & Cuetos, 2003; Zuckerman, Baauw, & Avrutin, 2003). See also Crain and Thornton (1998) on the different results with these methodologies in child language.

and check whether there is a possible interpretation of that sentence that fits the picture. A picture selection task as used in our study is much easier for the participants, since they are not forced to evaluate the acceptability of a specific interpretation (as depicted in a picture) of the presented sentence. The participant has to choose the interpretation (i.e., the picture) that matches the sentence best and is therefore able to avoid an interpretation that may be more difficult to process (the ‘illegal’ coreference interpretation). In this task, s/he can simply choose the interpretation whose acceptability is beyond doubt (i.e., the pronoun refers to an antecedent outside the sentence).¹³ We do not want to claim that agrammatic speakers have no problems interpreting pronouns in transitive sentences, in fact our agrammatic speakers still perform worse on these sentences than the non-brain-damaged controls. The crucial result for our investigation is a significantly worse performance on pronouns in ECM constructions.

4.1. The agrammatic performance and the linguistic theories

It is clear that the performance of the agrammatic speakers on the two important test conditions is not the same. Pronouns in ECM constructions are more difficult to interpret than pronouns in transitive sentences. The agrammatic speakers in fact interpret sentences like *the woman sees her dancing* half the time as if the pronoun *her* refers to *the woman*. This performance is not found for pronouns in transitive sentences. Therefore, we assume that there must be a difference between these two types of sentences and we argue that this difference is best captured within either the Reflexivity model or Primitives of Binding. Remember that according to the Government and Binding theory local binding in the two conditions (repeated in 11) is ruled out by the same Principle, Principle B ‘A pronoun is free in its governing category’.

- (11) a. *Pronoun in a transitive sentence:*
 ... en daarna heeft de vrouw_i haar_{*i/j} gekieteld.
 ... and then has the woman_i her_{*i/j} tickled.
 ‘... and then the woman_i tickled her_{*i/j}.’
- b. *Exceptional Case Marking constructions (ECM)*
 ... en daarna zag de jongen_i hem_{*i/j} fietsen.
 ... and then saw the boy_i him_{*i/j} cycle.
 ‘... and then the boy_i saw him_{*i/j} cycle.’

¹³ As one of the reviewers pointed out, the difference between Grodzinsky et al.’s (1993) and our data could also be caused by a difference between English and Dutch. This may be true; however, since to our knowledge there is no cross-linguistic difference, we prefer to explain the difference as a task effect.

The only way to account for the agrammatic performance and still use GB to describe binding phenomena is to assume an extra-linguistic factor that causes the difference between the two conditions. The sentences have an equal number of words in both conditions ($n = 7$), and the distance between the pronoun and the (illicit) antecedent noun phrase is exactly the same too (no intervening words), ruling out an explanation on the basis of working memory limitations. Therefore, the extra-linguistic factor does not seem to be affecting their performance.

One could also claim that the pictures for the ECM constructions are more complicated than for the transitive sentences since they show the action reflected in a mirror (see Fig. 1). This may be true, but there is evidence that shows this cannot be the cause for the difference. The subjects’ behavior during testing makes very clear that they understand the pictures with the mirrors. One of the patients said during testing: ‘you said ‘sees her’? Well, it is either this one, or that one (indicating the correct picture and its direct distracter), it’s really fifty–fifty,’ showing that she understands the picture and what the task is about. Moreover, the patients (almost) never point to the filler distracter, that is, they are not randomly picking one of the three pictures, which would have been an indication of confusion by the ‘mirror pictures.’ Finally, the good performance on the second experiment with anaphors in ECM sentences shows that agrammatic speakers neither have problems with the pictures with mirrors, nor with the ECM sentences as such. The difficulty with pronouns in ECM sentences hence cannot be ascribed to problems with the ‘mirror’ pictures or with the ECM structures.

We therefore suggest that the difference in the performance on the pronouns in transitive and ECM sentences is due to the linguistic difference between them, and—more importantly—that the agrammatic speakers are sensitive to this linguistic difference. There is some preliminary cross-linguistic evidence from two other studies with a slightly different design than ours that also found a worse performance on ECM constructions than on transitive sentences (for Spanish: Baauw & Cuetos, 2003; for English: Varlokosta & Edwards, 2002). This distinction therefore seems to be a robust finding that cannot be ascribed to the experimental design of the study. The conclusion then is that a theory is needed to account for this structural difference. REFL and PoB are both compatible with the apparent difference that has been observed between the interpretation of pronouns in transitive and ECM sentences. But, how can these approaches be combined with a theory on agrammatic comprehension and thus account for the observed pattern?

According to REFL, local binding of pronouns in transitive sentences is ruled out by both the Chain Condition and Condition B (as in 11a), but local binding of pronouns in ECM constructions is ruled out by the

Chain Condition only (since Condition B applies to co-arguments only, see 11b). If patients for some reason have problems applying Condition B, they may have problems with pronouns in transitive sentences, but not with pronouns in ECM constructions. This clearly is not the case, suggesting that Condition B is not the only cause of the comprehension difficulties here. Let us assume that it is the Chain Condition they fail to apply. Then, the local binding interpretation of pronouns in transitive sentences like (11a) is still ruled out by Condition B. Patients will then reach the correct conclusion that the interpretation ‘the woman_i tickles her_i’ where *the woman* and *her* refer to the same person is not correct in a sentence like this. In ECM constructions like (11b), the Chain Condition is the only condition that rules out binding between the pronoun *him* and its antecedent *the boy*. If the Chain Condition cannot be applied, the pronoun can go into a local dependency relationship with the antecedent, causing the agrammatic patient to point to the incorrect picture on which the boy sees himself cycling (in the mirror). The cause of the agrammatic problems would then lie in the Chain Condition. The following questions arise at this point: Why do the agrammatic speakers perform at chance level? And why is it that agrammatic speakers cannot apply the Chain Condition? Is it the Chain Condition itself that is problematic? Or do the speakers lack some feature knowledge of pronouns, such as case, gender or number, thus interpreting pronouns as –R? There is no independent evidence, however, that agrammatic speakers lack such specific syntactic knowledge. On the contrary, in a recent study we showed that agrammatic aphasic speakers are very well able to use gender and number information to guide pronoun interpretation (Vasic & Ruigendijk, 2004).

We believe that a more natural explanation of the data follows from Primitives of Binding. Reuland (2001) revised the Reflexivity theory of pronominal dependencies providing a new mechanism based on Chomsky’s (1995) Minimalist approach. PoB captures the effect of the Chain Condition in a different way. The Chain Condition effect is derived from the feature checking mechanism. No syntactic dependency can be formed between a pronoun and its antecedent, since the pronoun, unlike a SE-anaphor, has the *number* feature, which is interpretable and therefore cannot be deleted and thus no *syntactic* dependency can be established. It is, in principle, possible for a pronoun to establish a dependency through semantics or discourse, however, here is where the economy hierarchy comes in.

The PoB approach allows for an alternative account that does not assume any deficit in knowledge. Reuland’s account is essentially a processing account of various types of dependencies: it makes claims about cost of establishing dependency, where establishing a dependency through narrow syntax is less costly than establishing

a dependency through semantics or discourse. But suppose that syntactic computation, and hence establishing dependency in the narrow syntax, is not the most economical option for agrammatic aphasic patients. This would not be surprising because, as discussed above, there is sufficient evidence that patients with agrammatic Broca’s aphasia have limited processing resources (e.g., Haarmann & Kolk, 1991, 1994; Kolk & Heeschen, 1992; Piñango & Burkhardt, 2001; Zurif, Swinney, Prather, Solomon, & Bushell, 1993). Moreover, a lack of processing resources has already been used to account for problems with establishing pronominal reference by other authors (e.g., Grodzinsky et al., 1993; Piñango & Burkhardt, 2001) as we have seen in Section 1.

Thus, establishing syntactic dependencies for these patients is not the most economical option as it is in healthy speakers. Note that this does not mean that establishing these dependencies is completely impossible. It has been shown that agrammatic speakers have a lot of syntactic structure still available (see e.g., Burkhardt et al., 2003). We propose, however, that syntactic operations are more costly and therefore less available. If this is true, it is clear why it becomes acceptable that pronouns in ECM constructions refer to their subject antecedent. Patients do have all feature specification preserved, and their knowledge of when syntactic dependencies can or cannot be established is preserved as well. However, they allow for either a bound variable (semantic) dependency or a discourse dependency (coreference) because the higher cost of potential syntactic computations in these populations makes these types of dependency at least equally economical with discourse dependency. Imagine that the agrammatic speakers try to interpret the pronoun *haar* as referring to the subject *de vrouw* in a sentence like (11a) through a bound variable dependency. Such an interpretation will mean that the two arguments of the predicate ‘tickle’ are identical (tickle (x, x)). As argued by Reuland (2001), the computational system in this case treats the two arguments as one—they are, indeed, indistinguishable. This in turn means that the predicate has to be interpreted as one place contrary to its lexical-semantic specification. In other words, the predicate has to undergo arity reduction, which is not an option for this particular predicate (i.e., *kietelen* is not inherently reflexive). The patients therefore will correctly reject this interpretation. In other words, they will perform above chance on the interpretation of pronouns in transitives like (11a). Note that a discourse interpretation of the pronoun in (11a) would be possible in principle too. We assume however, following Grodzinsky et al. (1993) that processing *both* dependency options (i.e., coreference and bound-variable) is more costly for the agrammatic speakers. After checking the bound variable interpretation, they can already

find a picture, i.e., the correct one that fits the sentence. So, there is no need for them to even consider establishing a dependency through discourse. The kind of task we used thus most of the times leads them to the correct interpretation where *haar* is not *de vrouw*.

For ECM constructions such as (11b), a dependency can be established between *hem* and *de jongen* using both the semantic and discourse interpretation. In other words, both a bound variable interpretation (since arity reduction does not play a role here) and a coreferential dependency will lead the agrammatic speakers to the incorrect interpretation for ECM constructions. The fact that patients do not perform 100% incorrect on these sentences can be accounted for by the same processing account. There are two possible explanations. One is that the relationship between the syntactic and the extra syntactic mode is dynamic in the sense that the balance can be easily tipped towards one of the two systems in competition. What exactly can change the balance is not clear at the moment, but in any case, the observed chance performance would be consistent with such a situation. In those cases where the narrow syntax wins, patients would correctly reject subject–pronoun dependency because they retain the knowledge of number feature on the pronoun. If the narrow syntax in a particular case loses the competition, patients can opt for either a semantic or a discourse type of dependency without violating the economy hierarchy.

The second option is that the discourse dependency is always more economical than syntactic dependencies for these patients, and they can always, in principle, establish such dependency between the pronoun and the main subject. However, since there is a choice between two possible referents (either inside or outside the sentence) in our task, they could in principle choose between the two, thus yielding overall a chance performance again. At the present moment we cannot distinguish between these two explanations, but we would like to emphasize that both options are consistent with the limitation of processing resources approach and do not require making any unwarranted claims about loss of knowledge of pronominal feature specification.

Finally, it is interesting that another population with limited resources, namely children, exhibit the same pattern with regard to the two sentences structures. Several studies (Philip & Coopmans, 1996; Baauw, 2002; Zuckerman et al., 2002) find that children, like our aphasic patients, have more problems comprehending pronouns in ECM constructions than in normal transitive sentences.

We would like to mention that our view is also consistent with the claim offered in Avrutin (1999, to appear) regarding production in agrammatic aphasia. Avrutin argues that the well-known pattern of (optional) omission of functional categories in agrammatism (e.g., Determiners, Tense) is a result of non-syntactic

introduction of discourse referents.¹⁴ The reason, Avrutin speculates, is precisely the same: The narrow syntax in agrammatic patients and children is “weak” (not in terms of lack of knowledge, though, but in terms of availability of resources to carry out computations in real time). Thus, the observed pattern of omission in these populations should not be viewed as a sign of syntactic deficiency but rather as a demonstration of an alternative means of structuring information.

5. Conclusion

Not all pronouns are equally difficult to interpret for agrammatic aphasic speakers. Their difficulty is closely related to syntactic structure, and thus to the linguistic constraints that license their interpretation. We focused on the following theories: Government and Binding Theory (Chomsky, 1981), the Reflexivity model (Reinhart & Reuland, 1993) and Primitives of Binding (Reuland, 2001). The agrammatic data presented here to discern between the available theories can most naturally be explained using Reuland’s Primitives of Binding. The fact that agrammatic patients made more errors on the interpretation of pronouns in ECM structures can be explained by the claim that these patients have reduced capacity for conducting syntactic operations in real time. Such lack of resources leads to a change in the economy hierarchy for establishing pronominal reference, in the sense that syntactic dependency becomes less economical for agrammatic speakers. When syntax is less economical, establishing a relationship through semantics or discourse becomes possible, allowing for the abnormal interpretation of the pronoun in ECM constructions as reflected in the agrammatic patients’ comprehension pattern.

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¹⁴ Using Heim’s (1982) File Change Semantics, Avrutin (1999) argues that agrammatic patients and children allow for a non-syntactic, discourse-based introduction of Individual and Event file cards, that is, the units of discourse representation.

Appendix A

| Subject | Spontaneous speech | Token Test | Repeating | Written language | Naming | Comprehension | Diagnosis |
|---------|--------------------|------------|-----------|------------------|--------|---------------|-----------|
| AN | 3/3/2/4/4/1 | 17 | 122 | 97 | 104 | 82 | Broca |
| MJG | 2/2/5/3/5/1 | 35 | 38 | 22 | 50 | 57 | Broca |
| GK | 3/2/4/3/2/2 | 39 | 82 | 7 | 90 | 83 | Broca |
| AK | 2/3/3/3/4/2 | 29 | 116 | 81 | 95 | 70 | Broca |
| JW | 3/5/3/4/4/2 | 18 | 112 | 82 | 99 | 107 | Broca |
| AL | 2/4/5/3/1/1 | 18 | 90 | 34 | 67 | 96 | Broca |
| IH | 3/3/5/3/4/2 | 26 | 80 | 67 | 95 | 60 | Broca |

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

The numbers under spontaneous speech refer to: communicational behavior, articulation and 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.

Patients MJG, GK, AL, and IH have been tested with a shorter version of the AAT that has been developed by Heesbeen and Loon-Vervoorn (2002). Their scores are derived from their scores on the shorter version using the Heesbeen and van Loon-Vervoorn method.

Appendix B. Test sentences

B.1. Anaphors in transitive sentences

1. Eerst hebben de vrouw en het meisje gedanst en daarna heeft de vrouw zichzelf gekieteld.
First the woman and the girl danced and then the woman tickled herself.
2. Eerst hebben de man en de jongen gegeten en daarna heeft de man zichzelf geslagen.
First the man and the boy ate and then the man hit himself.
3. Eerst hebben de man en de jongen iets gedronken en daarna heeft de jongen zichzelf gestreeld.
First the man and the boy drank something and then the boy caressed himself.
4. Eerst hebben de vrouw en het meisje gezongen en daarna heeft het meisje zichzelf geschminkt.
First the woman and the girl sang and then the girl made herself up.
5. Eerst hebben de vrouw en het meisje geapplaudiseerd en daarna heeft de vrouw zichzelf gefotografeerd.
First the woman and the girl applauded and then the woman took a picture of herself.
6. Eerst hebben de man en de jongen geschaatst en daarna heeft de man zichzelf gefilmd.
First the man and the boy skated and then the man filmed himself.
7. Eerst hebben de vrouw en het meisje gelezen en daarna heeft het meisje zichzelf geknepen.
First the woman and the girl read and then the girl pinched herself.
8. Eerst hebben de vrouw en het meisje gelopen en daarna heeft de vrouw zichzelf gewassen.
First the woman and the girl walked and then the woman washed herself.

9. Eerst hebben de man en de jongen gezwaaid en daarna heeft de jongen zichzelf gekrabd.
First the man and the boy waved and then the boy scratched himself.
10. Eerst hebben de vrouw en het meisje geschrobd en daarna heeft het meisje zichzelf gebeten.
First the woman and the girl scoured and then the girl bit herself.
11. Eerst hebben de vrouw en het meisje gelachen en daarna heeft de vrouw zichzelf aangeraakt.
First the woman and the girl laughed and then the woman touched herself.
12. Eerst hebben de man en de jongen gevoetbald en daarna heeft de man zichzelf opgenomen.
First the man and the boy played soccer and then the man recorded himself.
13. Eerst hebben de man en de jongen gefietst en daarna heeft de jongen zichzelf ingesmeerd.
First the man and the boy cycled and then the boy put some oil on himself.
14. Eerst hebben de man en de jongen gehuild en daarna heeft de man zichzelf omarmd.
First the man and the boy cried and then the man embraced himself.
15. Eerst hebben de man en de jongen gekropen en daarna heeft de man zichzelf aangekleed.
First the man and the boy crawled and then the man dressed himself.

B.2. Pronouns in transitive sentences

1. Eerst hebben de vrouw en het meisje gedanst en daarna heeft de vrouw haar gekieteld.
First the woman and the girl danced and then the woman tickled her.

2. Eerst hebben de man en de jongen gegeten en daarna heeft de man hem geslagen.
First the man and the boy ate and then the man hit him.
3. Eerst hebben de man en de jongen iets gedronken en daarna heeft de jongen hem gestreeld.
First the man and the boy drank something and then the boy caressed him.
4. Eerst hebben de vrouw en het meisje gezongen en daarna heeft het meisje haar geschminkt.
First the woman and the girl sang and then the girl made her up.
5. Eerst hebben de vrouw en het meisje geapplaudiseerd en daarna heeft de vrouw haar gefotografeerd.
First the woman and the girl applauded and then the woman took a picture of her.
6. Eerst hebben de man en de jongen geschaatst en daarna heeft de man hem gefilmd.
First the man and the boy skated and then the man filmed him.
7. Eerst hebben de vrouw en het meisje gelezen en daarna heeft het meisje haar geknepen.
First the woman and the girl read and then the girl pinched her.
8. Eerst hebben de vrouw en het meisje gelopen en daarna heeft de vrouw haar gewassen.
First the woman and the girl walked and then the woman washed her.
9. Eerst hebben de man en de jongen gezwaaid en daarna heeft de jongen hem gekrabd.
First the man and the boy waved and then the boy scratched him.
10. Eerst hebben de vrouw en het meisje geschrobd en daarna heeft het meisje haar gebeten.
First the woman and the girl scoured and then the girl bit her.
11. Eerst hebben de vrouw en het meisje gelachen en daarna heeft de vrouw haar aangeraakt.
First the woman and the girl laughed and then the woman touched her.
12. Eerst hebben de man en de jongen gevoetbald en daarna heeft de man hem opgenomen.
First the man and the boy played soccer and then the man recorded him.
13. Eerst hebben de man en de jongen gefietst en daarna heeft de jongen hem ingesmeerd.
First the man and the boy cycled and then the boy put some oil on him.
14. Eerst hebben de man en de jongen gehuild en daarna heeft de man hem omarmd.
First the man and the boy cried and then the man embraced him.
15. Eerst hebben de man en de jongen gekropen en daarna heeft de man hem aangekleed.
First the man and the boy crawled and then the man dressed him.

B.3. ECM sentences (pronoun/anaphor)

1. Eerst hebben de vrouw en het meisje gelachen en daarna zag de vrouw haar/zichzelf dansen.
First the woman and the girl laughed and then the woman saw her/herself dancing.
2. Eerst hebben de man en de jongen geschaatst en daarna zag de man hem/zichzelf eten.
First the man and the boy skated and then the man saw him/himself eating.
3. Eerst hebben de man en de jongen gehuild en daarna zag de jongen hem/zichzelf drinken.
First the man and the boy cried and then the boy saw him/himself drinking.
4. Eerst hebben de vrouw en het meisje geschrobd en daarna zag het meisje haar/zichzelf zingen.
First the woman and the girl scoured and then the girl saw her/herself singing.
5. Eerst hebben de vrouw en het meisje gelopen en daarna zag de vrouw haar/zichzelf applaudiseren.
First the woman and the girl walked and then the woman saw her/herself applauding.
6. Eerst hebben de man en de jongen gekropen en daarna zag de man hem/zichzelf schaatsen.
First the man and the boy crawled and then the man saw him/himself skating.
7. Eerst hebben de vrouw en het meisje gezongen en daarna zag het meisje haar/zichzelf lezen.
First the woman and the girl sang and then the girl saw her/herself reading.
8. Eerst hebben de vrouw en het meisje gelezen en daarna zag de vrouw haar/zichzelf lopen.
First the woman and the girl read and then the girl saw her/herself walking.
9. Eerst hebben de man en de jongen gefietst en daarna zag de jongen hem/zichzelf zwaaien.
First the man and the boy cycled and then the boy saw him/himself waving.
10. Eerst hebben de man en de jongen gezwaaid en daarna zag de man hem/zichzelf voetballen.
First the man and the boy waved and then the man saw him/himself playing soccer.
11. Eerst hebben de vrouw en het meisje geapplaudiseerd en daarna zag het meisje haar/zichzelf schrobben.
First the woman and the girl applauded and then the girl saw her/herself scouring.
12. Eerst hebben de vrouw en het meisje gedanst en daarna zag de vrouw haar/zichzelf lachen.
First the woman and the girl danced and then the woman saw her/herself laughing.
13. Eerst hebben de man en de jongen gegeten en daarna zag de jongen hem/zichzelf huilen.
First the man and the boy ate and then the boy saw him/himself crying.

14. Eerst hebben de man en de jongen gevoetbald en daarna zag de man hem/zichzelf kruipen.
First the man and the boy played soccer and then the man saw him/himself crawling.
15. Eerst hebben de man en de jongen gedronken en daarna zag de jongen hem/zichzelf fietsen.
First the man and the boy drank and then the boy saw him/himself cycling.

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