

The Breakdown of Binding Relations

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INTRODUCTION

Knowledge of the rules governing anaphora is an extremely important precondition to a speaker's functioning, hence central in linguistic theory and language acquisition, where extensive investigations of the development of children's knowledge of these systems have been conducted in recent years. In this study, we assessed the comprehension abilities of aphasics in this domain.

The motivation for the present study has arisen from a series of experiments by Wexler and Chien (1985, 1988; Chien & Wexler, 1990), who, following studies carried out previously with preschool children, have demonstrated that at age 5 children are not yet in full command of the rules governing anaphora. Their experiments confirmed once again the finding that children's ability to relate pronouns to their antecedents lags behind their abilities with reflexives. But, more importantly, they showed that even within the system of rules governing the distribution of pronouns, the language system of children as old as 5 makes very fine distinctions that have important consequences for linguistic theory. We review these in detail after the presentation of the relevant theoretical issues.

This study was aimed at extending the empirical scope of experiments

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on populations whose language faculty is incomplete, in order to obtain clues to the formulation of the rules that govern anaphoric relations in linguistic theory, and with the hope of gaining additional insights concerning the functional impairment that underlies deficiencies in this domain in children and aphasics. Experiments on aphasic adults, mainly those suffering from agrammatism in Broca's aphasia, have already proven to be an important source of evidence for the biological feasibility of particular rule systems (Grodzinsky, 1990; Grodzinsky, Pierce, & Marakovitz, 1991). Preliminary evidence that these patients are selectively impaired in their command of rules governing the relationship between anaphors and their antecedents (Blumstein, Goodglass, Statlender, & Biber, 1983) gave rise to the hypothesis that the abilities of agrammatic aphasics to interpret and judge the grammatical status of sentences containing anaphora might also reveal fine distinctions indicating how the brain divides up these cases and would thus provide important empirical evidence for linguistic theory, as well as contribute to the understanding of brain/language relations. We thus conducted with these patients an experiment similar to that of Chien and Wexler, with the purpose of gaining further clues to the correct formulation of the binding conditions. We also used a group of Wernicke's aphasics, to determine whether a deficit in the relevant domain is a consequence of insult to a particular brain area. To forecast, we found that the same dramatic distinctions children make, namely between bound variable anaphora and other coreference cases, are also evident in the partially impaired linguistic abilities of agrammatic aphasics. Aphasics with posterior lesions—Wernicke's aphasics—are also deficient, but the pattern of performance they attest is radically different. There are two possible explanations for these findings. On the one hand, both agrammatic aphasics and children might be lacking a particular piece of knowledge concerning the referential possibilities of pronouns (and, of course, the knowledge might be more general than that). We will call this "the knowledge account." On the other hand, these results, when considered together with the findings of Chien and Wexler, suggest a unified explanation which accounts, in processing terms, for the success of both populations in handling bound variable anaphora and their failure to block coreference in environments where it should be blocked. This account, proposed by Grodzinsky and Reinhart (1993), also explains other processing failures, independently discovered in both children and adult agrammatic aphasics (Swinney & Prather, 1989; Swinney, Nicol, & Zurif, 1989), thereby gaining generality. We will call this "the processing account." The success of this account in terms of empirical coverage is also claimed to have far-reaching consequences to linguistic theory.

These two views, while agreeing on the grammatical characterization of the deficit, obviously differ in the claim they make about its precise

nature. This issue is currently under debate, and we will suggest some relevant experiments. More important, however, is the central result: that children and agrammatic aphasics show the same subtle and specific pattern of loss. This leads to the clear conclusion that a very particular part of the system is deficient, whereas other central parts are not affected. There is a subtle distinction between stating this outcome in terms of knowledge and stating it in terms of processing. Nevertheless, the crucial result is that the same particular part of the system deviates from that of the normal adult in grammatically principled ways.

The method of study to be discussed here presents indirect grammaticality judgment tasks to speakers who are not in complete mastery of their language. The analysis of errors made by these subjects is taken to be indicative of either a gap in knowledge of a particular rule system or a processing limitation that pertains to the structures it governs. The linguistic abilities of both children and aphasics are incomplete, making both populations equally amenable to this type of experimentation.

Below we provide a brief review of the theoretical issue, the details of the experiment, its findings, possible explanations, and their implications for linguistic theory as well as for our understanding of brain/language relations.

THE THEORETICAL ISSUE

There is an ongoing debate concerning the scope of condition B of the binding theory (BT). This module of the grammar, aimed at explaining the distribution of referentially dependent NPs—pronouns and anaphors—is formulated as follows (Chomsky, 1981):

(1) *The Binding conditions*

- A. An anaphor must be bound in its governing category.
- B. A pronoun must be free in its governing category (free ≠ bound).
- C. A R(eferential)-expression must be free.

Bound

α is bound by β if β c-commands α and is coindexed with it.

Governing category

G is governing category for α iff G contains α , a governor for α , and an accessible subject.

These conditions account for the standard phenomena of coreference, as exemplified in (2):

- (2) a. Igor touched himself.
- b. *Igor asked Natasha to touch himself.
- c. *Vladimir touched him (Vladimir = him).

- d. Vladimir asked Katya to touch him.
- e. *He touched Boris (he = Boris).

The grammar allows free coindexing between NPs, and the idea behind the binding conditions is that coindexing is free unless explicitly prohibited by BT. An index that an antecedent and a pronoun share is interpreted in the semantic component, yielding a semantic representation in which these two NPs corefer. Thus, coindexed NPs that do not violate the binding conditions are semantically interpreted. In such a system, the facts in (2) follow directly.

Yet several problems arise, forcing the amendment of these conditions. Some of them will be ignored below, being irrelevant to our discussion.¹ We will concentrate on one, central problem—asymmetries between the behavior of pronouns when they have R-expressions as antecedents, and when their antecedents are quantified expressions (the relevant interpretation below is always with the pronoun coreferring with either the quantified or the referential NP):

- (3) a. The woman next to Igor looked at him.
- b. *The woman next to every politician looked at him.
- (4) a. A coup without Gennadi bores him.
- b. *A coup without every politician bores him.
- (5) a. Most of her neighbours admire Tatyana.
- b. *Most of her neighbours admire every politician.

According to the binding theory, no difference is expected between the a and b sentences of (3)–(5), because it makes no distinction among different types of antecedents. For instance, since *Igor* in (3a) does not c-command *him*, and since binding requires a c-command relation, (3a) does not violate condition B, even though both NPs are contained in the same governing category. Yet nothing accounts for the ungrammaticality of (3b)—the antecedent there is also not a binder by the above definition. The theory, then, has an incorrect prediction in this case. The same considerations hold for the examples in (4)–(5). Thus, the problem appears to concern condition B of the binding theory, but there are other solutions.

The standard solution to this puzzle given in GB theory maintains that these contrasts are not related to the binding conditions. Rather, the ungrammatical sentences in (3b)–(5b) are ruled out due to a restriction on the kinds of variables that an operator can bind at the level of Logical

¹ For instance, as stated, pronouns and anaphors must be in complementary distribution, contrary to fact: (i) John likes stories about him/himself. See Chomsky (1986) for a proposed solution.

Form. On this analysis, considerations of scope force quantifiers to be raised at this level (by the movement rule of Quantifier Raising (May, 1977)), yielding the following representations:

- (6) a. [every politician] [[the woman next to t] [looked at him]].
 b. [every politician] [[a coup without t] [bores him]].
 c. [every politician] [[most of her neighbors] [admire t]].

In each of these representations a single operator (every politician) binds both a trace and a pronoun. Therefore, they violate the Bijection Principle (Koopman & Sportiche, 1982), which requires congruence between bound variables and operators at LF. In the a sentences in (3)–(5), however, no NP undergoes LF movement to determine its scope, and hence, this principle is not violated and the sentences are grammatical.

Note that the asymmetries of the type demonstrated in (3)–(5) do not occur when the antecedent (here in subject position rather than in object as in the former examples) c-commands the pronoun:

- (7) a. Vladimir asked Kazimir to touch him.
 b. Every demonstrator asked Kazimir to touch him.
 c. [every demonstrator] [t asked Kazimir to touch him].

Compare now the LF representation in (7c) to any of those in (6). In the former, the trace of LF movement is in subject position and is c-commanding the pronoun. In the representations in (6), by contrast, neither the pronoun nor the trace c-command each other. This difference accounts for the difference in grammaticality. The claim is that the trace in (7) functions as an operator, binding the pronoun, while the moved quantified antecedent binds the trace. No violation of the bijection principle thus follows because each variable is bound by a distinct operator. This is contrasted, then, with the cases in (6), where no such account is available, and hence the ungrammaticality of these examples (see Montalbetti & Wexler, 1985, for further discussion).²

Reinhart (1983) proposes a different solution to the asymmetries in (3)–(5). Rather than taking the standard position that the binding condition B allows for both the grammatical and the ungrammatical sentences in (3)–(5) and invoking an additional principle that would rule out the bad ones at LF, she proposes to restrict the scope of the coindexing procedure such that only c-commanding antecedents fall under it. Recall that the standard BT allows for free indexing and that the reason for the

² Note that there is yet another possible configuration that is not ruled out by the Bijection Principle, which is a case when an operator binds a pronoun which binds a trace, as in:

(i) [Which boys]_i did they_j like t_i.

The Bijection Principle has an incorrect prediction here, quite clearly. However, these cases, known as Strong Crossover, are thought to be ruled out by an independent principle.

grammaticality of (3a) was the fact that indices can be generated freely, yet in this particular instance the common index did not violate condition B because the antecedent did not c-command the pronoun and hence did not bind it according to the definition of “bound.” The semantic component interprets the coindexing just as it would in cases like (2a,2d), where there is a c-commanding antecedent that satisfies BT. Yet Reinhart’s solution to the problem in (3)–(5) seeks to restrict the scope of syntactic coindexing to cases of true syntactic binding—only when a pronoun has a c-commanding antecedent is a common index allowed. The ungrammaticality of (3b)–(5b) thus follows immediately: in both cases the antecedent (every politician) does not c-command the pronoun, so that these two NPs cannot share an index, according to Reinhart. However, what also follows, contrary to fact, is the ungrammaticality of (3a)–(5a). Reinhart’s theory, just like the standard approach to binding, also does not make distinctions among antecedents, referring only to the structural relations that hold between pronouns and antecedents. So, while the standard BT is in a sense too permissive with respect to coindexing, forcing an additional LF condition to rule out (3b)–(5b), Reinhart’s proposal is too restrictive, ruling out, incorrectly, the grammatical (3a)–(5a) because the antecedents in these sentences do not c-command the pronouns, and hence no binding is possible. As binding in Reinhart’s system is the only way for syntactic coindexing, these sentences are predicted to be ungrammatical, again contrary to fact.

Yet Reinhart claims that the relation holding between the pronoun and the antecedent in these cases is not identical with binding. Based on well-known distinctions between different coreference readings, she distinguishes between variable binding (governed by BT) and coreference (governed by independent rules). The relevant cases are like (8), a case of VP deletion:

- (8) Thelma burned her car and Zelma did too.
 A. Thelma burned Thelma’s car, and Zelma burned Zelma’s car.
 B. Thelma burned Thelma’s car, and Zelma burned Thelma’s car.

Sentence (8) is ambiguous, between readings A and B. This, for Reinhart, is evidence for the existence of two different relations between pronouns and their antecedents. For this sentence to be interpreted, the deleted VP must be copied from the first conjunct to the second. Reading A clearly contains a variable, because the value of the pronoun in the second conjunct is determined by the identity of its local antecedent. Hence, what had been copied from the first, in this case, must have been a variable and not a pronoun whose reference had been fixed. The relation in this case is thus variable binding. For reading B, however, a pronoun, with its link to an antecedent, should have been copied so that its reference will be fixed prior to copying. Thus, there are two kinds of relations

between pronouns and their antecedents. Reinhart argues that only the relation underlying reading A is a true binding relation, whereas the other is a case of coreference. Binding, in this narrow sense, is also the only instance of syntactic coindexing of pronouns. Thus coreference necessitates a special rule. The relevant cases are those like the sentences in (3)–(5). Therefore, a special rule is invoked to guarantee the grammaticality of a coreference reading for these cases. This rule, in fact, will be stated such that it covers a broader range of cases, obviating the need for condition C of BT. We go into the details of it here because it plays a central role in later sections, where we discuss the results of our experiment with aphasics.

Rule-i

In order to understand the motivation for the particular formulation of this rule, we must first review the cases it covers. Condition B, as formulated by Reinhart, has a narrower scope than that of the standard BT, as it told only of pronouns with c-commanding antecedents. This leaves a number of cases unexplained, most notably, the instances where coreference is possible between a pronoun and a non-c-commanding antecedent, as we saw before in (3)–(5). Reinhart proposes that these cases be regarded as patterning with others, usually regarded as falling under condition C. This way, condition C becomes redundant and can be dispensed with. The relevant cases, then, are the following:

- (9) a. Most of her_i friends can't stand Natasha_i.
 b. A demonstration without Natasha_i annoys her_i.
- (10) a. Igor_i adores him_k.
 b. He_i adores Igor_k.
 c. He/Igor_i thinks that Igor_k is a great politician.

How should the possibility of coreference in (9) and its impossibility in (10) be captured? A special procedure must be invoked for that, since the only interpretation allowed for coindexation is that of bound-variable (c-commanded) anaphora. Reinhart argues that the coreference interpretation is not obtained via syntactic coindexing at all. There are many reasons to believe this to be true, among them the possibility of Condition C violations when the context is set up properly. This can be seen in the following examples (some of which are taken from Grodzinsky & Reinhart, 1993):

- (11) a. David and I have a lot in common. *We* are both in love with *him*.
 b. Sometimes I'm so bad, even *I* don't like *me*. (Bill Laimbeer, Detroit Pistons, due to Pinker)
 c. I dreamt that I was Brigitte Bardot and *I* kissed *me*. (due to Lakoff)

- d. That must be John. At least *he* looks like *him*. (Chien & Wexler, 1990)
- e. (Who is this man over there?) *He* is *Colonel Weisskopf*.
- f. Only *Churchill* remembers *Churchill* giving the speech about blood, sweat, toil, and tears. (Fodor, 1975, p. 134)
- g. Everyone has finally realized that Oscar is incompetent. Even *he* has finally realized that *Oscar* is incompetent. (Evans, 1980, p. 52)
- h. I know what Ann and Bill have in common. She thinks that Bill is terrific and *he* thinks that *Bill* is terrific. (adapted from Evans, 1980, p. 49)
- i. *Oscar is sad. *He* thinks that *Oscar* is incompetent.

Thus, the idea is to capture coreference as a subcase of the broader issue of reference resolution. To assign a pronoun a reference mentioned in a previous sentence, it is clearly not necessary that the two be syntactically coindexed. There is no principled reason why things should be different when assigning a reference mentioned in the same sentence. The assumption, then, is that coreference is the assignment of referential identity to NPs with distinct syntactic indices.

Reinhart argues, therefore, that the constraint on intrasentential coreference cannot be syntactic. Rather, it involves an inference based on knowledge of grammar, meaning, and appropriateness to context (the ungrammaticality of (11i) shows that not any context will do). The relevant generalization can be stated as the rule in (12), which replaces both binding condition C and the coreference residue of condition B.

(12) *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.

The intuition behind (12), stated as a noncoreference rule, is that if the structure could allow bound-variable anaphora, coreference is preferred only if this is motivated, i.e., if it is distinguishable from bound-anaphora (on the notion of distinguishability, see Heim, 1992).

The upshot of this rule, then, is that coreference is possible when a pronoun cannot be bound or when a bound-variable interpretation distinct from the coreference interpretation. This accounts for the grammaticality of (9) because no bound alternative is available there, due to a lack of a c-commanding antecedent. It also accounts for the impossibility of coreference in (10) because no distinguishable interpretation is available, and for the possibility of coreference in (11a–11g) because there context induces a distinction between the bound and the coreference interpretation.

We thus have two contrasting approaches: The standard BT approach views bound-variable anaphora and coreference as cases of

syntactic coindexing and blocks the ungrammatical surplus (i.e., non-commanding quantified antecedents) through an LF condition on the relationship between variables and operators. Reinhart's approach assumes only conditions A and B (but not C) of BT, where condition B is narrow in its scope, to cover only bound-variable anaphora. For coreference, a special rule is invoked (see Grodzinsky & Reinhart, 1993, for a more detailed presentation).

Having presented the theoretical issue, we can now return to the findings that motivated this study, namely those of Chien and Wexler (1990). Their main findings are the following: (1) Children's performance on reflexives indicates adult-like abilities on any relation governed by condition A of the binding theory. (2) Their performance on sentences containing pronouns is split—children correctly reject coindexing between a pronoun and an antecedent when the latter is a quantified NP inside the minimal governing category containing the pronoun; however, they tend to accept as grammatical (and in fact guess), ungrammatical sentences containing a local antecedent which is a referential NP.

These results are consistent with previous findings and add a new important dimension—they point to a distinction children make between bound variable anaphora and other pronouns. Indeed, both Wexler and his colleagues (Wexler & Chien, 1985; Chien & Wexler, 1990; Montalbetti & Wexler, 1985), and Grodzinsky and Reinhart (1993) have taken these findings, coupled with others, as providing evidence for the claim that the binding conditions are true of bound anaphora only and that other cases of coreference are governed by another, independent module of the grammar, presented above as Rule-i.

With these two contrasting theoretical approaches in mind, and with the findings of Chien & Wexler, we set out to test the aphasic patients to see whether the distinctions commended by either approach to binding would be reflected in their breakdown patterns. If such distinctions were indeed apparent, favoring one theoretical framework, then we would get yet another neurologically based constraint on the theory of syntax.

In the study, we tested both agrammatic and Wernicke's aphasics, with two additional goals in mind: (1) To see whether the hypothesized deficit could be related to one group of patients or rather to any aphasic deficit. (2) To compare the abilities of two language-deficient populations—children and aphasics.

THE EXPERIMENT

Materials and Procedure

Our experiment used the same materials devised for children by Chien and Wexler (1990, see experiment 4, pp. 260–275), using the following sentence types:

- (13) a. Is Mama Bear touching herself?
b. Is Mama Bear touching her?
- (14) a. Is every bear touching herself?
b. Is every bear touching her?
- (15) a. Are all the bears touching her?
b. Is Mama Bear touching Goldilocks?
c. Is every bear touching Donald Duck?

The logic behind this experimental setup was dictated by the binding theory in its various formulations: Sentences containing reflexives—(13a), (14a)—are governed by condition A of the binding theory. Sentences containing pronouns (13b) and (14b) are governed by condition B of the standard BT, yet they split according to Reinhart: (14b) is governed by condition B only (since quantified antecedents do not permit coreference interpretation), whereas (13b) is ruled out twice: since the pronoun has a c-commanding local antecedent, binding is ruled out by condition B, but since this antecedent is referential, coreference should be (and indeed is) ruled out by Rule-i. Thus, we tested the patients on both reflexives and pronouns, with both quantified antecedents (falling under condition B only) and referential antecedents (falling under both condition B and Rule-i, according to Reinhart), to see whether the aphasics would distinguish the types. The sentences in (15) represented control conditions of several types: (15a) was a quantifier-control used to ensure that no effects were due to the particular choice of quantifier; (15b) was used as a control for the structure to guarantee that failures in the task are not due to some peculiar property of sentence structure; (15c) was used to show that the quantifier in question was known.

A Yes/No judgment task was used to invoke the patients' grammaticality judgments to sentences with anaphora. The patients were presented with a cartoon picture, an introductory (context building) sentence, followed by a question concerning the picture. Each question among those seen in (13)–(15) was prefaced, then, by sentences like, "This is Mama Bear. This is Goldilocks," to set up the context from which reference could be picked by the pronouns or reflexives. The aphasic was expected to answer "yes" or "no" by pointing to either a smiling face or a frowning face drawn on a sheet of paper in front of him (this is done due to severe speech production problems some of these patients suffer). We thus made minimal changes in the task Chien and Wexler devised to fit the special characteristics of the population we tested.

Each sentence type was presented in two varieties: one where the grammatical reading, i.e., intrasentential coreference for sentences containing reflexives and noncoreference for pronouns, matched the scene depicted (the Match), and another for an ungrammatical reading (the Mis-

match), where the pictures were reversed (i.e., noncoreference for reflexives, coreference for pronouns). The pictures showed one cartoon character (or more for sentences with quantifiers) performing some action either on itself or on another. In the quantifier control conditions, the picture for the Mismatch had only two of three characters doing the right thing. Each sentence type had 6 tokens for each reading. In each condition in (13)–(15), then, there were 12 sentences, half requiring a positive answer and half a negative answer, bringing the total to 84 sentences for the whole experiment presented to the patients in a random order.

After a short training session, where the experimenter made sure that the subjects understood the task, they were presented with the test items. They saw one picture and heard one sentence at a time, and they were asked to say “yes” if the sentence accurately described the picture and “no” if it did not.

Subjects. We tested 15 subjects in this experiment: they were 8 agrammatics and 4 Wernicke’s aphasics, all diagnosed by clinical tests (Goodglass & Kaplan, 1983), radiological information (CT scan) when available, and neurological workup. The remaining subjects were 3 neurologically intact control subjects, matched with the patients for age and educational level. The clinical profiles of the patients are provided in Appendix 1.

Results

The control subjects performed perfectly, with no errors, indicating that this test presents no problems to a linguistically unimpaired subject. The raw scores of the agrammatic patients (in terms of proportion correct) are given in Appendix 2. Two patients were excluded from the analysis: One (FC) was excluded due to a strong response bias that was evident from his scores—the number of “no” responses we recorded for him (50) was 2 SDs from the group mean ($X = 40.5$, $SD = 4.98$). A second patient (MW) was excluded because she was 2 SDs apart from the group mean in more than half of the conditions in the experiment. While the reasons for their deviant performance remain unknown to us, excluding their scores from further analysis, as is normally done, was justified given that our experiment had no descriptive aims but rather was directed at a theoretical question independent of our target patient population. We were thus left with 6 agrammatic and 4 Wernicke’s patients, whose raw scores on the test are given in Appendix 2.

The agrammatic aphasics. An analysis of variance was performed on the results of these patients to detect differences between conditions. No significant differences were found, except in the crucial comparisons between the ungrammatical condition where a pronoun had a local referential antecedent (13b) and two others: first, a comparison between this condition and its grammatical counterpart revealed a significant difference ($F = 12.00$, $df = 5$, $p < .02$); a second comparison, this time with

the ungrammatical part of (14b), where a pronoun had a local quantified NP antecedent, was also significant ($F = 7.47$, $df = 5$, $p < .05$).

Next we compared each of the conditions to chance level to see whether the patients were guessing on any condition. As expected, all conditions were highly significantly above chance, except the ungrammatical part of condition (13b), where patients' performance was at chance levels ($F \ll 1$).³

The Wernicke's aphasics. The results of this group of patients were also subjected to an analysis of variance. Here, too, the relevant conditions to be compared were the ungrammatical condition, where a pronoun had a local referential antecedent (13b), and two others: first, a comparison between this condition and its grammatical counterpart was not significant ($F = 2.40$, $df = 3$, $p < .22$); another comparison, with the ungrammatical part of (14b), where a pronoun had a local quantified NP antecedent, was also significant ($F = 1.27$, $df = 3$, $p < .34$). Another comparison was performed between the "pronoun" and the "reflexive" conditions, in terms of percentage correct (collapsing the Match and Mismatch conditions for each category). A one-tailed t test revealed a marginally significant difference ($t(3) = 2.02$, $p < .068$). This weak effect may be attributed to the small sample size.

Next we compared each of the conditions to chance level to see whether the patients were guessing on any condition. Here, too, the Wernicke's aphasics performed in a manner different from the agrammatics: While being above chance on all the conditions involving reflexives (at the level of at least $p < .01$), they were at chance on virtually all the conditions involving pronouns. These included the grammatical Pronoun-Lexical antecedent condition (13b) ($F = 3.41$, $df = 3$, $p < .16$) and its ungrammatical counterpart ($F \ll 1$). The grammatical Pronoun-Quantified antecedent condition (14b) was marginally above chance ($F = 9.0$, $df = 3$, $p < .06$), while its ungrammatical counterpart was not different from chance ($F = 1.0$, $df = 3$, $p < .4$). These patients were also well above chance on all the control conditions (15a-115c).

Summary of Results

Each of the two patient groups gave a different performance pattern: The agrammatics were virtually normal in every case, except the ungrammatical instance of condition (13b), in which the sentences had a pronoun with a referential antecedent, and the picture associated with it indicated that the antecedent was local. Although the correct response was "no," the agrammatics overaccepted them yet not fully. Their performance on this condition was not different from chance; namely, they were guessing

³ It should be noted that if the results are looked at not in terms of the proportion of correct responses, but, as some would think is appropriate, in terms of the proportion of "yes" responses in each condition, these results would come out the same.

at the grammatical status of these sentences. The Wernicke's aphasics, by contrast, guessed at all the conditions that involved pronouns—whether grammatical or not.

These results can be summarized in the following table, where the above experimental conditions are reproduced and the scores for each condition are divided into the grammatical half—the Match (where the picture described a scene that matched the grammatical reading of the sentence)—and the ungrammatical half—the Mismatch. The results are listed in terms of their relation to chance performance, where “+” indicates correct, above-chance performance and “?” indicates a performance that was marginally above chance:

Condition	Agrammatics		Wernicke's	
	Match	Mismatch	Match	Mismatch
(13') a. Is Mama Bear touching herself?	+	+	+	+
b. Is Mama Bear touching her?	+	Chance	Chance	Chance
(14') a. Is every bear touching herself?	+	+	+	+
b. Is every bear touching her?	+	+	?	Chance
(15') a. Are all the bears touching her?	+	+	+	+
b. Is Mama Bear touching Goldilocks?	+	+	+	+
c. Is every bear touching Donald Duck?	+	+	+	+

The only condition where chance performance was recorded for the agrammatic aphasics, then, was the ungrammatical, Mismatch part of (13'b), which also turned out to be very significantly different from the other relevant conditions; namely, its grammatical counterpart—the Match condition of (13'b)—and its quantified counterpart—the Mismatch condition of (14'b).

The Wernicke's aphasics, by contrast, were at chance on all the conditions that involved pronouns (both Matches and Mismatches) and were above chance on all the rest.⁴ The two patient groups thus gave very different performance patterns in the study.

INTERPRETATION AND CONSEQUENCES

The results obtained in this study point to dramatic patterns of selectivity in the aphasics' linguistic abilities; patterns that were different for each patient group. They also indicate that the performance pattern of the agrammatics is surprisingly identical to that obtained by Chien and

⁴ It may be noted that on one condition involving pronouns, namely (15'a)—the quantifier control condition—the Wernicke's aphasics performed well, in apparent contrast to their performance on the other conditions involving pronouns. Yet here the foil was quite different: They had to choose between a picture where all the bears performed the action and one where only some bears did. Knowledge of the pronoun was thus irrelevant to the performance.

Wexler for children. Recall that their finding is that only on (13b) did the children perform poorly—even the older groups (age 5–6) remained at chance levels. In all the other conditions the children quickly developed abilities that brought them to performance levels above chance, indicating mature abilities to process these sentences. The performance of the Wernicke's aphasics, on the other hand, indicated that they suffer a general disruption as far as pronouns are concerned—a problem rather different from (and more severe than) that of the agrammatics, at least in this domain. While it is possible that this (presumably lexical) deficit masked a deficit similar to the agrammatics', this possibility is unlikely for reasons that will become apparent below. This type of deficit is of little interest to us, given that it has nothing to do with binding and thus is orthogonal to the theoretical issue we have focused on. We will therefore proceed with the discussion concentrating mainly on the results of the agrammatic group.

Returning to the surprisingly parallel results for children and agrammatics, several questions arise:

(1) Why did the agrammatics perform as they did, namely, what is their underlying deficit?

(2) Is their performance related to the children's performance in a principled way, and if so, why?

(3) Is their performance related to other deficits observed in agrammatism?

(4) Are these findings relevant to the debate concerning the formulation of the binding conditions?

From a syntactic point of view, it is quite clear at the outset that a distinction between environments containing quantified and nonquantified antecedents is necessary, given the performance pattern of both the children and the agrammatics. But such a distinction is made by both theories, whether through the coreference/variable-binding distinction or through the Bijection Principle. For children it has been argued by Grodzinsky and Reinhart that independent evidence (mainly regarding their performance on condition C structures) indicates that the correct distinction between the structures children know and those where they fail is according to Reinhart's theory. But this does not necessarily hold for the aphasics because the additional evidence existing for children is simply not available for aphasia. If a unified account for both children and agrammatics could be proposed, it would provide strong support for the theory at issue. We will consider two explanations (Grodzinsky & Reinhart, 1993; Chien & Wexler, 1990).

Grodzinsky and Reinhart have proposed one such account, which, in addition to explaining the above finding, also carries over to explain the performance of children and aphasics in other domains. According to this proposal, the deficit observed for both children and agrammatic aphasics

is a processing deficit. On their view, Rule-*i* is known, yet the processing of constructions it governs requires resources that both children and aphasics do not have, and hence, they all fail to apply Rule-*i* properly. Crucially, such resources are not necessary for the processing of binding relations. Since processing claims have sometimes proved to be bogus, one needs strong evidence and detailed reasoning to support them. For that, we now consider what it takes to compute Rule-*i* governed constructions and provide independent evidence that the computational resources necessary for it are indeed lacking for both children and agrammatic aphasics.

*The Computation of Rule-*i* Governed Structures*

Consider again the formulation of Rule-*i*:

(16) *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.

Upon being presented with a sentence containing a pronoun, the hearer must decide whether Rule-*i* allows the pronoun to corefer with an antecedent. That is, he must first determine whether a replacement of the pronoun with a bound element is possible. For that he must attempt to construct an alternative, bound representation. If this is not possible, his task would be over and coreference is allowed. But there are cases in which it is, in fact, possible to obtain an alternative variable binding (as would be the case in the LF representation of this sentence if a reflexive anaphor was used). Rule-*i* now requires the hearer to do the following: While still holding the sentence under processing in memory, he has to construct two representations: one involving the binding option he discovered to be possible and another which is the alternative coreference reading. The two representations have to be compared, relative to their context, in order to decide whether they are distinguishable. If they are, coreference is allowed; if they are not, it is ruled out.

The execution of all these steps puts a much heavier weight on working memory than required by other rules (e.g., than executing the binding conditions). Thus the need to hold and compare two representations surpasses the processing ability of a language-deficient hearer, whether an aphasic or child. If this is so, then facing Rule-*i* governed cases, the child and aphasic know exactly what they are required to do by Rule-*i*, but getting stuck in the execution process, they give up and offer a guess. This is why both children and aphasics perform at chance on (13b) rather than accepting every token as grammatical (as would follow from the assumption that they do not know Rule-*i* at all).

Further Evidence for a Processing Failure

If this is the case, and the failure is due to a processing limitation of this particular kind, then there must be other tasks in which this deficit is reflected: That is, there must be other tasks with similar demand characteristics in which these language-deficient populations will fail, too. Such evidence comes from a surprising source—the performance of children and aphasics (compared to normal subjects) on real-time tasks.

In a well-known experiment, Swinney (1979) demonstrated that normal adults ignore context when accessing a word. He presented his subjects with a sentence containing an ambiguous word, with left context that biased toward one of the readings.

- (17) a. The FBI agent searched the room for BUGS.
- b. He caught spiders, roaches, and other BUGS.

Using a secondary priming task, he demonstrated that people initially access all the meanings of an ambiguous word, regardless of context. He presented the sentence in (17) auditorily and then, right after the ambiguous word had been heard, flashed a sequence of letters on a screen, consisting of either a word related to the contextually relevant meaning (e.g., SPY) or a word related to the other meaning (e.g., ANT) or a control sequence. The subject had to decide whether the sequence of letters was a word, and his decision time was measured. The logic behind this task (called Cross Modal Lexical Priming—CMLP) is that if the subject uses context to preselect the relevant meaning, only the word related to it would be primed. Yet he found the opposite: the subjects showed a priming effect for both meanings. This was taken to indicate that the lexical access mechanism is encapsulated and insensitive to contextual influences. The choice of the appropriate lexical item is made only a few hundred milliseconds later. There, only the contextually relevant meaning gives a priming effect, indicating that other, irrelevant meanings had been suppressed.

Consider, now, what such a task involves. The subject has to access two representations, hold them in memory for a very short period of time, and quickly compare each of them to the context to make the appropriate selection. This is exactly the kind of task for which we have a prediction. From a processing point of view it is analogous to the application of Rule-i. For both tasks to be carried out, space in memory is necessary, in which two representations (whether phrase markers or words) can be stored in parallel temporarily, a scanning device that would be able to compare these representations against a given context, so that a selector would pick the appropriate one. In the case of a pronoun, a representation involving a coreference relation is selected only when it gives way to an interpretation that is distinct from the bound one, relative

to context. In the case of the ambiguous word, the selection among the two meanings is done relative to context, too. We claim that the processing machinery for these two tasks is one and the same. Normal subjects are quite successful in this task, as Swinney's experiment shows, yet in order to demonstrate the identity of processing resources for the two tasks, we turn to aphasics and children.

Swinney et al. (1989) tested agrammatic and Wernicke's aphasics on exactly this task, and Swinney and Prather (1989) tested children on a similar task. The results of both studies were remarkably similar: Both children and agrammatic aphasics primed only one of the meanings, yet surprisingly, it was not necessarily the one determined by context, but rather the one with the higher frequency of occurrence. If context were to have any effect at all, we would expect it to force the selection of the proper meaning, but here a completely irrelevant factor—frequency—surfaced and dictated which meaning would be primed.⁵ The same study also tested Wernicke's aphasics, whose performance was very slow, but with similar response times for the related and unrelated meanings, regardless of context, akin to the normal subjects. Swinney et al. take this to indicate that the accessing mechanism for Wernicke's aphasics is virtually normal.⁶

Surprising as they are, these findings are perfectly consistent with our interpretation of the experimental results in children and agrammatics regarding Rule-i. First, if they are unable to hold two representations in memory in order to match them with context, then a priming effect for both meanings should not be expected because this is exactly what these

⁵ One could argue (see below) that if our account is correct, then the agrammatics did not understand the stimulus sentences properly because they were unable to access the related meaning of the ambiguous word. Indeed, there is no evidence that they understood those sentences. Although a comprehension test was conducted by the experimenters, in order to make sure that the subjects understood the stimulus sentence, this test was not reliable—each subject was requested after 2 trials (out of 48) to paraphrase the stimulus sentence, and no criteria were set for successful paraphrasing.

⁶ The performance of the Wernicke's aphasics was far from normal, in our view, for several reasons. First, all the subjects in the Swinney et al. experiment were tested twice. The normal controls and the agrammatic Broca's aphasics performed similarly in both testing sessions, yet the Wernicke's aphasics made so many errors (about 50% of the items in each condition, indicating that they were simply guessing, not knowing whether a string of letters presented to them was a word or not) in the first experimental session that their scores in it had to be ignored in the statistical analysis. Second, although on the face of it the Wernicke's aphasics showed exhaustive access to both meanings of the word, as evidenced by the difference between the RT for a related target word (for both meanings of the ambiguous probe) and an unrelated, control word, the time differences that served as basis for Swinney et al.'s interpretation were of a lower magnitude than those of the normal controls, despite the fact that their response times were much higher. Third, the fluctuations in their RTs were vast. The normals and agrammatics, by contrast, maintained a similar difference between different conditions—about 300 msec. Yet the Wernicke's aphasics showed differences in RT between conditions that were twice as big. Moreover, the direction of the difference was, at times, opposite to that shown by the two other groups.

subjects cannot do. Second, a priming effect for the contextually relevant meaning should certainly not be observed because this would mean that the subject had already made a choice, based on context, an operation which we claim he is incapable of. Third, if there is an independent factor that affects priming generally, it is most likely to surface here. When normal adults are faced with Swinney's task, their mature, unimpaired language processing device is capable of carrying out the full task, thereby masking any frequency effects. But in children and aphasics the system is deficient. They cannot keep both representations in memory for the purpose of comparing them with prior context, and thus, the experimental situation is reduced to the simplest form of a priming experiment. With limited processing capacity, the task becomes one that just requires priming between an ambiguous word and a target (that is, between a word like *BUG* as the prime and targets such as *ANT* and *SPY*) without any context at all. Under such conditions it is not at all surprising that the only factor at play would be the one that always is, namely frequency, because in such a task—when an ambiguous word is used for priming—it is well known that the more frequent meaning prevails. Finally, the Wernicke's aphasics, who gave a different pattern of errors in our binding test, also performed in a manner different from both the children and the agrammatics in the Swinney task.

Our processing claim is thus independently supported, and the (otherwise mysterious) parallelism between children and agrammatic aphasics (as well as the difference between these groups and the Wernicke aphasics on both tests) gets a natural explanation, thereby providing a strong argument for a formulation of the binding conditions in Reinhart's narrow sense and for Rule-i.

The account in question has several interesting predictions, none of which have been investigated so far. Consider ambiguous words first. Swinney's claim regarding lexical access has the consequence that both the children and the agrammatics should be unable to integrate an ambiguous word into sentential context, if the contextually relevant meaning is the less frequent one. This should be so because these populations access only the more frequent meaning of the ambiguous word. If a test can be devised that probes their abilities to integrate the less frequent meaning of an ambiguous word into sentential context, the prediction of our account is that both the children and the aphasics would fail.

Second, as Avrutin and Wexler (1991) have pointed out, the account predicts that for cases like those in (11), where an ungrammatical sentence is made grammatical by context through the application of Rule-i (or, equivalently, Chien and Wexler's Principle P which allows coreference between conjoined NPs if context so indicates), both children and aphasics would respond at chance when asked to make grammaticality judgments. This should be so because Rule-i must apply to these cases, and a comparison of two representations made. Since the assump-

tion of the Grodzinsky and Reinhart account is that children and agrammatics are unable to carry out this computation and thus give up and guess, they should do so on the sentences in (11) as well. So, upon being faced with sentences like those in (18), for instance, we predict them to guess as to the identity of the antecedent:

- (18) a. Donald Duck and Mickey Mouse play a lot together. Mickey is usually good, but sometimes Donald Duck is so bad, even he doesn't like him.
 b. Popeye really loves himself, and Olive loves him, too.
 So they have a lot in common: She thinks Popeye is great, and he thinks Popeye is great.

This prediction is a consequence of the claim that coreference between the pronouns is made possible by Rule-i and that it is this rule that both the agrammatic aphasics and the children are unable to execute. Once designed carefully (with appropriate foils, etc.), we should expect this prediction to come true. The outcome of these experiments is crucial for the processing account to hold.

An alternative account, appealing to lack of knowledge, was proposed by Chien and Wexler (1990; Wexler & Chien, 1985), who attempted to find an explanation for the children's performance on the condition B cases.⁷ The "knowledge account" follows the formulation of Chien and Wexler (1990). They argue that the relevant principle governing coreference (what they call Principle P and Grodzinsky and Reinhart call Rule-i) is not known to the children—namely, it is either learned later, or it is innate but has not yet matured (Principle P says that two noncoindexed NPs are noncoreferential unless context indicates otherwise). This claim would then be extendable to the agrammatic aphasics, for whom it would be said that they are not aware of Principle P anymore, hence their poor performance on the cases this principle governs. As Avrutin and Wexler (1991) point out, this account has a prediction that is opposite to the Grodzinsky and Reinhart account concerning the discourse cases like (18). While Grodzinsky and Reinhart predict that the children and the agrammatics would make guesses regarding the identity of the antecedents to the pronouns in (18), Chien and Wexler predict that both populations would correctly accept (18) and assign the correct antecedents, as adults do.

⁷ The Chien and Wexler proposal does not necessarily assume the Reinhart hypothesis that binding and coreference are represented distinctly in the grammar, that is, that c-command is necessary for coindexation. Chien and Wexler's proposal acknowledges that both syntactic and pragmatic principles govern binding constructions, as any binding theory must that has a chance of being empirically adequate. Thus the poor performance of children on cases where a pronoun is locally c-commanded by a NP antecedent is due to lack of pragmatic knowledge. On this view, the acquisition evidence itself does not distinguish between a Reinhart-style theory and classical binding theory, in which c-command is not necessary for coindexing. See Avrutin and Wexler (1991) for discussion.

Maintaining the Chien and Wexler account, though, would restrict the scope of the explanation only to the condition B cases. The processing results for both children and agrammatic aphasics (on the Swinney test) would not follow and would have to be attributed to a separate source.

Our Results in Relation to Other Deficits in Aphasia

Syntactic movement. The finding regarding a new pattern of selective impairment in aphasia and agrammatism, in particular, immediately raises questions concerning its relation to previously discovered deficits. The relation between the present result and claims concerning agrammatic deficits on structures containing moved constituents immediately comes to mind. One of us (Grodzinsky, 1986, 1990) has argued that the deficient comprehension abilities of agrammatic aphasics in such structures lead to the postulation of a deficit in S-structure representation, according to which traces are deleted. As a result, the assignment of thematic roles to moved constituents is incomplete, leading to representations with NPs that lack a thematic role. These NPs are then assigned a role by a cognitive strategy. A question that was explicitly left open in that account was whether the deficit resulted in the deletion of traces or could rather be attributed to a failure to link positions (especially nonadjacent ones) via a coindexing mechanism. In fact, one idea that was considered (Grodzinsky, 1986) was that the observed deficit is a result of a processing disruption, leading to an inability to link such positions. This would explain not only the comprehension failures that agrammatics suffer, but also violations of agreement attested in their speech patterns.

The current results show that the scope of this claim is both too wide and too narrow. If the patients could not link positions, one would not expect them to be able to handle any coreference phenomena at all. Yet we found that on bound variables (both reflexives and bound pronouns) their performance was virtually normal. They failed on unbound pronouns only, and these do not fall under the same generalization as cases of syntactic movement. Thus, while the above processing account predicts they would fail on sentences involving binding and succeed in those involving coreference, we found the opposite. The conclusion, then, is that the best account for their performance on movement cases is indeed one that assumes the deletion of traces from S-structure representations, that an assumption of a general processing failure to link positions makes the wrong predictions, and, most importantly for the present result, the deficit discovered in this study is an independent one. Agrammatic aphasics, on this view, suffer a deficit in more than one aspect of their syntactic abilities. With respect to syntactic movement, the nature of the structural deficit remains unknown, the Trace-Deletion Hypothesis (Grodzinsky, 1986) being a descriptive generalization over the observed patterns of selectivity. As for the impairment this study documented,

the processing account given by Grodzinsky and Reinhart serves as an explanation of the underlying deficit.

Automatic access. Swinney and his colleagues account for their findings in aphasics and children as "a disruption at the stage of exhaustive access of word meanings" (Swinney et al., 1989, pp. 31–32). This is to account for the finding that while normal subjects first access all the meanings of an ambiguous word and then check them against context to select the appropriate one, agrammatics fail to do so. Yet from the present perspective, the failure can be seen as much broader in scope. If the generalization we propose is correct, then the failure has little to do with lexical access per se, but rather results from an inability to hold two representations in memory and compare them to context. Swinney et al., in fact, consider an even more radical possibility. They suggest that "the agrammatic patients' failure to exhaustively engage meaning representations might be indicative of an even wider based disruption of information access—of a disruption that extends even beyond language . . . It might well be the case that the agrammatics' inability to access lexical items in the normally exhaustive manner is but one reflection . . . of a failure to show exhaustive computation in any domain" (p. 32). While the present claim differs from theirs in that it focuses on comparisons of representations to context rather than on access, the data we present can be seen as yet another instance of the same failure, reflected outside the domain of the mental lexicon.

Cerebral localization and the acquisition/breakdown parallelism. Among the aphasics we tested, the deficit we have documented and accounted for is limited to agrammatics. This brings the issue of cerebral localization to mind. If our generalization is indeed correct, then its consequence is that the disabled component—whether a processing component (presumably a part of working memory) or a pragmatic/interpretive one—resides in the frontal portion of the left cerebral hemisphere. Since developing children show identical patterns of performance, it is tempting to speculate that the neural substrate underlying this part of working memory is not fully developed in children. Thus, functional similarities between children and aphasics may lead to the exploration of the postnatal neuroanatomy of the language areas. Differences in neuroanatomical structure between children and normal adults are predicted to be found in at least some of the cerebral areas that are lesioned in agrammatism. This may bring back to life old ideas concerning the relation between children and aphasics (cf. Jakobson, 1941/1969; Grodzinsky, 1990, Chap. 6). While it is not clear to us how such a speculation can be substantiated, we are confident that detailed behavioral studies such as ours should be taken seriously by students of brain function, in that they provide new directions for research. We hope, then, that our study will be followed up by neuroanatomists who study the development of the central nervous system after birth.

CONCLUDING REMARKS

Three general points emerge from this study: First, studies of linguistic deficits—whether in children or adult aphasics—provide important clues concerning the formulation of grammatical theories. Second, linguistic theory provides a powerful and necessary descriptive tool for neuropsychology. Third, statements regarding functional impairment in aphasia may have important consequences for our understanding of brain/language relations. Studies such as ours underscore the importance of the interaction between linguistics and neuropsychology: They should each serve as a source of constraints for the other. Only in this way can the study of language and the brain make progress.

(Continued on following page)

APPENDIX 1
Broca's

Patient	Sex	Hand	Age	Onset	Lesion site	Clinical signs	Speech
RBA	M	R	59	1985	Large L lesion in Broca's area w/deep extn invlv subcallosal fasciculus; lesion in insular struct. across temp isthmus; some super exten to supermarg gyrus and angular gyrus	R hemiparesis	Agrammatic Telegraphic Nonfluent Dysarthric
RBL	M	R	62	1977	Part of Broca's area with deep exten—all of subcallos fascic, putamen, head of caudate, ant limb, intern capsule, part of temporal isthmus	R hemiparesis	Nonfluent Agrammatic Telegraphic Paraphasias Neologisms
FC	M	R	58	1973	Left CVA—occlusion of left MCA no more available—no CT scan	R hemiparesis	Dyspraxia Nonfluent Agrammatism
LD	M	R	60	1977	L frontal parietal region w/ extension into temp lobe; l ventricle enlarge. Most of B's area w/deep exten to border of frontal horn, incl subcallos fascic; temp isthmus, super temp gyrus (W's area); insul struct, putamen, ant limb intern capsule, obus pallidus, head of caudate; lowest 2/5 sens and motor cortex, ant supermarg gyrus, perivent white matter	R hemiparesis	Nonfluent Telegraphic Dysphonic Dysarthric Agrammatic

RD	M	R	71	1976 and 1977	Two left frontal—Broca's area w/deep exten to left frontal horn—lower motor cortex; l temp lobe incl < 1/2 W's area	Mild r side weakness	Nonfluent Telegraphic
EM	M	R	71	1976	Decreased density in posterior region of left frontal lobe; patchy decrs density in mid temp region; focal enlarge of ant horn to body of left lat ventricle	R hemiparesis	Nonfluent Dysarthric Dysprosodic Paraphasic Agrammatic
MR	M	R	68	1988	Left hem—all Broca's area w/ deep exten to white matter, some invlv of subcallos fascic; > 1/2 W's area, temp isthmus; Insul struct, lat putamen, ant limb of intern capsule; super exten invlv lower 2/3 of motor and sensory cortex, ant and post supermarg gyrus and part of ang gyrus; small infarct in right hemis in ant limb of intern cap	R side weakness—minor	Nonfluent Dysarthric
MW	F	R	62	1990 two incid	Left hem—all Broca's area, > 1/2 medial subcallos fascic; < 1/2 temp isthmus, < 1/2 W's area; perivent white matter; insular struc, putamen, glob pallidus, ant limb of intern capsule; super lesion invlv Premotor, motor and sensory cortex, ant supermarg gyrus; supplem motor area, cingulate gyrus area 24	R hemiparesis	Nonfluent Stereotypes

APPENDIX 1—Continued
Wernicke's

Patient	Sex	Hand	Age	Onset	Lesion site	Clinical signs	Speech
CC	M	R	64	1984	Left hem—portion of poster temp lobe w/super exten into supermarg and angular gyrus areas and large occip lobe lesion	R homonymous hemianopsia	Fluent Anomic
WD	M	R	67	1991	Left hem posterior part of infer section of MCA; 1/4 W's; deep to supermarg gyrus		Fluent Anomic
RL	M	R	67	1978	Left posterior in W's area extending into parietal lobe		Fluent Anomic
JM	M	R	54	1986	Patchy left hem lesion invlv temporal isthmus and poster portion of putamen and insular area; poster supermarg and ang gyrus areas w/deep exten to border of body of l lateral ventricle	R hemiparesis R hemisensory deficit R field cut	Fluent Anomic Paraphasic

APPENDIX 2: NUMBER OF ERRORS

Subject	13a		13b		14a		14b		15a		15b		15c	
	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
Broca's														
RBa	0	2	2	3	2	1	3	0	0	0	0	0	0	0
RBI	0	0	0	2	0	0	0	0	0	0	0	0	0	0
LD	2	0	1	5	1	0	1	2	0	0	0	0	2	0
RD	0	0	2	5	1	1	0	0	0	0	0	0	1	0
EM	1	0	2	4	0	1	0	4	0	0	0	0	0	1
MR	4	1	1	1	0	2	0	1	1	0	0	0	2	0
FC	2	0	5	0	0	0	2	1	0	0	0	0	1	0
MW	1	2	3	3	3	3	3	5	1	0	0	0	4	3
Wernicke's														
CC	0	0	0	5	0	0	0	1	0	2	0	0	0	0
WD	2	0	4	5	0	0	3	5	0	0	0	0	2	1
RL	0	0	0	3	0	1	0	1	0	0	0	0	0	0
JM	1	0	1	0	0	0	0	1	0	0	0	0	1	0

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