

Object Attraction in Subject–Verb Agreement Construction

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Three experiments in which errors of subject–verb agreement were elicited assessed the effects of syntactic function and part of speech of the constituent appearing immediately before the verb. Bock and Miller (1991) have shown that constituents modifying the subject exert an “attraction effect,” an increased rate of agreement errors when that constituent has a grammatical number different from that of the subject head noun. Experiment 1a, conducted in Dutch, showed that such an attraction effect is not restricted to sentences in which the number mismatching information is embedded within the subject: Direct-object noun phrases exert an attraction effect as well, although a smaller one than subject modifier noun phrases. Experiment 1b replicated this effect with new materials, excluding a possible confound with plausibility of the sentences. Experiment 2 showed that direct-object *pronouns* exert an attraction effect about as strong as that observed with nouns, unless the pronoun is explicitly case-marked. In such circumstances no attraction effect obtains. These results are interpreted within the hypothesis that the number of phrasal nodes intervening between “attractor” and subject head noun determines the strength of attraction effects. © 2001 Academic Press

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A central problem that faces a speaker is that elements in a sentence she is about to formulate are often contingent upon other elements appearing earlier or later in the sentence. Syntactic rules constrain what constituents can legally fol-

low another constituent. Likewise, the speaker faces dependencies across a certain distance in the sentence, with respect to morphosyntactic features such as gender, case, and number. A prime example of the latter type of dependency is that in many languages of the world the verb has to agree in number with the subject. Thus, whereas sentence (1) is correct, (2) contains a subject–verb agreement error.

The road to the mountains was long. (1)

*The road to the mountains were long. (2)

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Interestingly, in these examples the subject head noun (road) is separated from the verb (was/were) by a different constituent, the prepositional phrase (“to the mountains”). That makes (2) a rather typical instance of what Quirk and Greenbaum (1973) called “proximity concord” and what Zandvoort (1961) referred to as an

“attraction error,” a sentence in which the verb agrees with the number of the “local” noun directly preceding it, instead of with the number of the head noun. In the remainder of this article, we will use the term “attraction error.” Such errors of attraction have often been observed in experimental studies of subject–verb agreement elicitation in language production (e.g., Bock & Miller, 1991; Bock & Cutting, 1992; Bock & Eberhard, 1993; Eberhard, 1997; Fayol, Largy, & Lemaire, 1994; Vigliocco, Butterworth, & Semenza, 1995). In those experiments, the usual procedure is that the experimenter presents a sentence preamble such as “the road to the mountains.” The participant is requested to repeat this preamble and complete it to a full sentence. This naturally leads to the elicitation of a verb. The dependent variable is the number of verbs that are wrongly inflected for number.

A main finding from this line of research is that agreement errors are more frequent when the numbers of local noun and subject noun mismatch than when these numbers match. However, there is also an asymmetry, especially in the studies conducted in English (Bock & Miller, 1991; Bock & Cutting, 1993; Bock & Eberhard, 1993) and Spanish (Antón-Méndez, 1996; Vigliocco, Butterworth, & Garrett, 1996): If the local noun is plural, there are more agreement errors than when the local noun is singular. Bock and Eberhard (1993) and later Eberhard (1997) accounted for this finding by assuming that a determinant of attraction is linguistic “marking” of the nouns. The feature value “singular” would be the unmarked, default value. Because of that, it would be less likely to strongly interfere with a marked value, i.e., a plural.

A second important finding in research on attraction effects concerns the phrasal structure of the modifying constituent. Bock and Cutting (1992) showed that the attraction effect was stronger when the local noun occurred in a phrase (3) than when it occurred in a clause (4).

The editor of the history books (3)

The editor who rejected the books (4)

This finding with relative clauses and similar findings using preambles with noun-phrase com-

plement clauses led Bock and Cutting (1992) to propose a hierarchical account of agreement computation. That account entails that the unit size on which the mechanism that computes subject–verb agreement operates be the clause. Therefore, information within a certain clause is more likely to interfere with subject–verb agreement computation in that clause. The account assumes that a clause boundary “protects” a subject from the interference of a local noun. However, it is important to note that Bock and Cutting (1992) did report a substantial number of agreement errors in the clause conditions.

A more general hypothesis was proposed by Vigliocco and Nicol (1998). Their hypothesis entails that the mechanism that specifies agreement be sensitive to syntactic relations in the phrasal structure that is being constructed. In particular, the distance, in terms of intervening phrasal nodes between subject head noun, local noun, and verb, would be of relevance. Consider again the items Bock and Cutting (1992) used. In items such as (4), where the subject noun is separated from the verb by a clause, the syntactic path from local noun to highest NP-projection of the subject (and also from local noun to verb) is longer than in phrasal items such as (3). This increased syntactic distance, rather than insulation because of clause boundaries, would be responsible for the higher error rate in items with phrasal modifiers, as exemplified in Fig. 1.

This can be taken to mean that agreement errors arise because of a feature migration emanating from the local noun that interferes with correct number specification (a similar proposal with respect to comprehension was made by Nicol, Forster, & Veres, 1997). A possible mechanism for such an effect, cast in the terminology of spreading activation models (e.g., Dell, 1986) would be that the number information spreads upward from the local noun but loses some of its activation with every step along the way. Thus, the more steps the number information travels, the less activation remains to interfere.

In the linguistic literature on subject–verb agreement, one can distinguish at least two approaches that account for number specification on the verb. One approach (e.g., Gazdar, Klein,

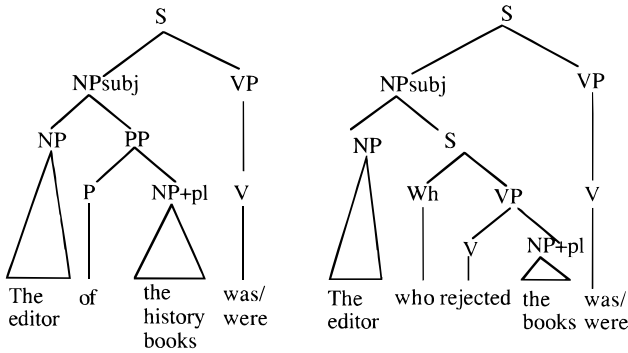


FIG. 1. Partial syntactic tree structures of a sentence with a prepositional phrase modifying the subject (left) and with a relative clause modifying the subject (right). It can be seen that the syntactic distance from local noun to subject NP (and to verb) is larger in the sentence with a clausal modifier (right).

Pullum, & Sag, 1985) assumes that there is a copying process from a controller (the subject) to a target (the verb). Number information would be fully specified in the subject noun phrase and then copied to the verb. An argument for assuming that the subject is the controller and the verb is the target is the fact that the verb is specified for characteristics of the subject (e.g., number or person), but subjects are not specified for characteristics of the verb (such as tense). Another approach assumes merging of features (e.g., Kaplan & Bresnan, 1982) that are partially specified on different constituents (e.g., the subject and the verb). Merging takes place through a process called unification, which ensures that merged constituents share the same syntactic features. An important implication of such an approach for a processing model of agreement is the assumption that number information can be independently specified on subject and on verb. Indeed, Vigliocco et al. (1995) proposed such an independent number specification in order to account for certain conceptual effects on agreement. In their proposal the number of the verb would be independently specified by the conceptual representation. But if conceptual forces can independently specify the number of the verb, then why wouldn't syntactic forces be able to do so as well? A likely syntactic force would be a mismatching number feature on a constituent that is close to the verb in the syntactic tree (i.e., when the syntactic path, defined by the number of intervening nodes that separate the two, is short).

Both a feature-copying approach and a unification approach are compatible with the notion of feature migration through a syntactic tree. However, the approaches potentially differ on *which* final destination of the percolating features is most important. If agreement is taken to be a feature-copying process from subject to verb, the locus at which intruding features exert an effect is the highest subject NP projection. That node is the source from which number will be copied to the verb. On the other hand, suppose that the verb can be independently specified for number. Then, if syntactic features percolate through the syntactic tree, activated number information on other constituents may occasionally introduce a spurious number specification on the verb. Such erroneous number specification would be particularly likely if the constituent from which these features emanate is syntactically close to the verb. In sum, agreement errors may arise because of erroneous number specification appearing on the subject node, or because the number of the verb can be directly influenced by a syntactically proximal constituent.

Thus, there are two possible syntactic distances that are of relevance to agreement computation, distance between subject NP and local noun (on a feature-copying account) and distance between verb and local noun (given an approach in which the verb can be independently specified). In previous studies (e.g., Bock & Cutting, 1992; Bock & Miller, 1991; Vigliocco

& Nicol, 1998), these two syntactic distances were confounded, because the constituent carrying mismatching number information was always embedded within the subject noun phrase (3, 4). Thus, in the conditions where there was a larger distance between subject and local noun, there was also a larger distance between verb and local noun.¹ However, in the present study we present a case in which these alternative distances can be separated.

How do we achieve this separation? We contrast sentences in which the local noun is embedded in either a subject-modifier or a direct object. This is illustrated in Fig. 2. The tree on the left side exemplifies the situation in which the plural local noun (NP + pl) is embedded in a subject-modifier phrase. The syntactic tree on the right side exemplifies the situation in which the local noun is the direct-object NP. Syntactic distance between local noun and subject is shorter in subject-modifier sentences than in direct-object sentences. On the other hand, syntactic distance between local noun and verb is shorter in direct-object sentences. Thus, the hypothesis that the syntactic distance between local noun and highest NP projection of the subject (the node labeled NPsubj in Fig. 1) determines error rate predicts more errors in the subject-modifier condition than in the direct-object condition. The hypothesis that distance between local noun and verb is a determinant of error rate would predict the reverse, more agreement errors in the direct-object situation than in the subject-modifier situation.

The present study thus allows us to disentangle the two alternative routes of feature migration, by manipulating the syntactic function of the local constituent. In the next section, we will discuss another possible role of syntactic function with respect to the computation of number agreement. This leads to the formulation of a third hypothesis, in addition to the two variants of the syntactic distance hypothesis. We will briefly review the experimental literature on agreement production in which syntactic function was manipulated. Next, we turn to the possible role of part of

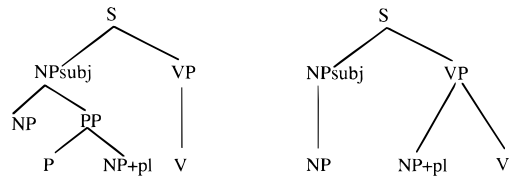


FIG. 2. Partial syntactic tree structures of two (Dutch) subordinate clauses. These correspond to the subject-modifier condition (left) and the direct-object condition (right) tested in Experiment 1A. For reasons of simplicity, the matrix clause and the terminal nodes are omitted. The distance of relevance is the number of nodes between the node labeled NPsubj (highest NP projection for the subject) and NP + pl, the local noun, and the node labeled V and the local noun. It can be seen that the distance from local noun to NPsubj is larger for the direct-object condition (right); the distance from local noun to V is larger in the subject-modifier condition (left).

speech of the local element, in particular with respect to lexical representations of syntactic information. Finally, we describe the plan of the present study in more detail.

The Role of Syntactic Function

In this article, we address the question of whether number information contained in constituents with a different syntactic function than subject can influence the process of agreement computation. The role of syntactic function with respect to specification of agreement has received little attention in the past. However, there may be an important role for syntactic function in constraining the information taken into account by the agreement mechanism. Information from outside the subject phrase is never relevant for the computation of subject-verb agreement. Therefore, the mechanism might decide to ignore number information on the basis of the syntactic function of the containing constituents.

The local elements that are known to trigger agreement errors have a different syntactic function (subject modifier) than the head noun, but critically, they are part of the subject phrase. In fact, it does seem a (tacit) assumption in some of the literature that only information contained within the subject phrase can interfere with the production of subject-verb agreement. For example, Eberhard (1997) proposed a sketch of

¹ It should be noted that Vigliocco and Nicol (1998) assume that it is the distance to the subject head that is relevant.

the process of agreement computation (through feature copying) in which syntactic features have activations but lose some of this activation with each copying step. She then lists the factors that influence the occurrence of agreement errors. She first mentions decay over time, but then continues “the second and more influential factor is whether other phrasal nodes *within the subject phrase* possess an activated number feature” (p.161, our italics).²

A theory that assigns a special role for syntactic function, encapsulating the subject from syntactic features from outside the phrase, has implications for our experiments. Such a theory would predict no errors in the direct-object situation but a “normal” attraction effect (many more errors with number mismatch between subject and local noun than with number match) in the subject-modifier situation. Thus, if we find that objects exert no attraction effect, we would have strong evidence for the view that the mechanism that computes subject–verb agreement utilizes syntactic function in order to restrict very strongly which information to consider and which information to ignore. However, if we show that there is an attraction effect with objects, questions arise about the way in which the mechanism does its indexing: if information from nonsubject constituents can influence agreement computation, how does the mechanism “know” which information to use?

What evidence do we have for attraction effects from objects? We know of some reports of speech errors in which the attracting element was in the direct-object position (De Smedt, personal communication, 2/17/1998), such as in (5) and (6) in Dutch (followed here by glosses and by English translations).

Ik wist dat de heer In 't Veld nevenwerkzaamheden hadden, eh, had.

I knew that Mr. In 't Veld additional jobs had[plural], uh, had [sing.]. (5)

I knew that Mr. In 't Veld had additional jobs.

Ik weet dat tijd wonden helen.

I know that time wounds heal[plural]. (6)

I know that time heal all wounds.

Notice that in (5, 6) the errors occur in a subordinate clause. The word order subject–object–verb is not only the canonical word order (Bennis & Hoekstra, 1989; Koster, 1974) but is also the only possible word order in Dutch subordinate clauses.

There are also some experimental studies in which attraction errors were elicited using local elements with different kinds of syntactic function. One study, testing spoken language production in Spanish, was reported by Antón-Méndez (1996).³ She presented participants with triplets such as (7) and (8). Participants were instructed to turn each triplet into a sentence including a subject-modifier PP, as in (7a), or with a pronominal, preverbal direct object, as in (8a). The participants then completed these sentence beginnings, by inflecting the infinitive verb.

El delegado, las agencias internacionales, llegar (7)

The delegate, the international agencies, to arrive

La jardinera, ARBOLES, plantar (8)

The gardener, TREES, to plant

El delegado de las agencias internacionales llega hoy. (7A)

The delegate of the international agencies arrives today.

La jardinera los planta.

The gardener them plants. (8A)

(The gardener plants them.)

In (7a), the interfering prepositional phrase is embedded within the subject, similar to the English equivalents tested in earlier experiments. That condition yielded a normal attraction effect. In the second condition (8a), the NP had to be replaced with a preverbal pronoun (“los”) inflected for number. That pronoun is not part of

² Note that Eberhard (1997) assigned an influential role to constituents within the subject phrase but left the potential role of constituents outside the subject phrase unspecified.

³ This study, the second author’s masters thesis, is available upon request.

the subject phrase, but it is the direct object. It is important to note that the canonical word order in Spanish is SVO, but the accusative pronoun must necessarily be preverbal (Green, 1987). In the pronoun condition, no attraction effect was observed. In fact, that condition yielded almost no agreement errors at all. These results thus seem to argue for the theory that the subject has a privileged status, blocking interference from objects.

The Role of Part of Speech

The Spanish findings suggest that syntactic function determines the flow of information during agreement computation in speaking, by blocking interference from objects. However, there is a plausible alternative explanation. That explanation follows from the fact that the conditions differ in another important way: In the direct-object condition, the mismatching number information is attached to a pronoun, but in the subject-modifier condition it is attached to a noun. There are two reasons why this difference in part-of-speech could have consequences for the production of subject-verb agreement.

First, in languages such as Spanish, English, and Dutch, pronouns as opposed to nouns are specified for case. For instance, in these three languages the masculine, singular pronouns are, respectively, “él,” “he,” and “hij” when the case is nominative, but “lo,” “him,” and “hem” in the accusative case. It is conceivable that there are repercussions for the specification of agreement relations, since this case marking signals the syntactic function of an element.

Second, there may be differences in which information sources guide production of nouns and pronouns. In a theory of lexical access proposed by Levelt, Roelofs, and Meyer (1999), content words like nouns are retrieved in two stages. First, an abstract lexical representation, which is specified syntactically (a “lemma”) is retrieved. Second, the word form is determined. At the lemma level, syntactic feature nodes for number and gender will be activated. Thus, the syntactic feature nodes connected to a nonsubject noun can interfere with agreement production. It is unclear, however, how *pronouns* are produced within such a framework (cf. Meyer &

Bock, 1999). It is possible that the form of pronouns is determined by access to the lexical representation of the antecedent. Thus, the syntactic feature nodes connected to that lemma would become activated and would interfere with agreement computation. But another possibility is that pronoun production is largely under conceptual control (Bock, Nicol, & Cutting, 1999). In principle, the conceptual representation may be sufficiently specified (e.g., for number and gender) to directly determine the right form of the pronoun. If that were the case, there would be no activation of syntactic feature nodes and thus no interference with agreement production.

Plan of the Present Study

The study in Spanish by Antón-Méndez (1996) showed no attraction effect with preverbal, pronominal direct objects. However, it is unclear whether this is an effect of syntactic function or an effect of the part of speech of the preverbal constituent. In the present paper we further explore the role of syntactic function and separate it from the issue of the noun/pronoun distinction. We contrast three hypotheses: (1) the syntactic function of subject encapsulates the subject from interfering number information in other phrases; (2) interference depends on the syntactic distance between local noun and verb; (3) interference depends on the syntactic distance between local noun and subject NP. With respect to the noun/pronoun distinction, we test whether there is feature migration from pronouns at all, and if so, whether it matters if the case of the pronoun is morphophonologically transparent.

We report three experiments that manipulated the syntactic function and part-of-speech status of local elements. The experiments were conducted in Dutch, which has a number of important advantages. First of all, in subordinate clauses in Dutch, the word order is subject-object-verb. This allows us to construct preambles with preverbal direct objects, which are very similar to corresponding preambles with a modifying PP. We can thus contrast two conditions with a minimal difference. Second, in Dutch, it is grammatically correct to replace the direct-object NP with a pronoun. This again allows a test with a minimal contrast. In Experiments 1A

TABLE 1
Examples of Experimental Items in Experiment 1A

| Condition | Main clause | Subordinate clause (sng. pl.) | Verb stem |
|------------------|-----------------|-------------------------------|-----------|
| Subject-modifier | Karin zegt dat | het meisje met de krans en | WIN |
| | Karen says that | the girl with the garland s | WIN |
| Direct-object | Karin zegt dat | het meisje de krans en | WIN |
| | Karen says that | the girl the garland s | WIN |

and 1B, we compare direct objects with subject modifiers. In Experiment 2 we restrict ourselves to direct objects and contrast a full NP condition with a pronoun condition.

EXPERIMENT 1A: DIRECT OBJECTS VS SUBJECT MODIFIERS

Method

Participants. Thirty-two undergraduate students at the University of Nijmegen participated in the experiment, six males and twenty-six females. All were native speakers of Dutch, and one was bilingual (Dutch-German). Three participants were excluded because they reported having dyslexia. They were replaced by three new participants. Ages ranged from 19–31 with a mean of 23.

Materials. Experimental materials consisted of a main clause and a subordinate clause. An example of a set of experimental items is provided in Table 1. Main clauses were all very simple and consisted of a subject (a proper noun) and a verb. Subordinate clauses all had a singular head noun and either a singular or a plural local noun. There were two syntactic function conditions. In the subject-modifier condition, the local noun was embedded in a prepositional phrase (PP) modifying the subject head noun of the subordinate clause. In the direct-object condition the local noun was the head of a noun phrase (NP) that was the direct object of the subordinate clause.

For each sentence, there was one variant in the direct-object condition and one variant in the subject-modifier condition. The verb was used transitively in the former case and intransitively in the latter. Furthermore, the factor syntactic function was crossed orthogonally with the

number of the local noun (the number of subject noun was always singular). In half of the cases the local noun was singular (number match condition), and in the other half it was plural (number mismatch condition). Finally, we selected a verb to be used in the completion of each preamble. We only presented the stem of each verb during the experiment.⁴

We constructed 36 such sets of experimental items, each set comprising the four versions derived from crossing the factors syntactic function and local noun number. These items were selected from a larger item pool containing 50 sets. Those 50 sets were presented to 24 participants, none of whom took part in any of the three main experiments reported in this article. Each version of each sentence set was evaluated for plausibility by 6 participants on a 7-point rating scale. The most plausible 36 sentence sets were kept. Unfortunately, there still remained some differences with respect to plausibility between the items in the four conditions. Mean plausibility ratings, followed by standard deviations in parentheses, were subject-modifier match 5.4 (1.0), subject-modifier mismatch 5.3 (0.9), direct-object match 6.0 (1.1), direct-object mismatch 5.8 (1.0). A repeated measures analysis of variance on the plausibility ratings showed that there was a significant difference between the items in the subject-modifier and direct-object conditions [$F(1,35) = 10.16$; $MSE = 1.25$].

In addition, we constructed 60 filler preambles. Forty of these had structures similar to that of the experimental preambles: In 20 items the subordinate clause consisted of a subject NP

⁴ We did not want to provide participants with the infinitive forms, because these forms are identical to the plural forms of verbs in Dutch.

and a modifier PP, and in 20 items the clause contained a subject NP and a direct-object NP. All of these items had a plural head noun, and the local noun was singular in half of the items and plural in the remaining half. There were also 20 filler items in which the subordinate clause consisted of a subject noun phrase only (10 singular and 10 plural).

Procedure. Participants were tested individually. They first received written instructions. Participants were requested to read aloud and complete sentence fragments that would be presented on the computer screen. The stem of a verb that had to be used was presented along with the preamble. It was requested that completions be in the (past or present) perfect tense. This was done by providing examples of how to complete and how not to complete the sentences. A correct completion of an experimental trial would contain the inflected verb *hebben* (“to have”) and a past participle. Some of the filler items required the verb *zijn* (“to be”) and a participle. The auxiliary is specified for number (i.e., *heeft* in the singular, *hebben* in the plural), but the participle is not. A participle in Dutch is formed by adding the prefix *ge-* to the stem and adding a suffix, which is *-d*, *-t*, or *-en* (depending on the particular verb). The ending *-en* is homophonous with the plural marker on the finite verb. Some verbs also require a vowel change of the stem, e.g., *wīn-gewonnen* (win–won).

A trial was initiated by the participant pressing a button, which started the following sequence of events: (1) at 0 ms a fixation cross appeared and remained on the screen for 900 ms; (2) at 900 ms the fixation cross disappeared and the screen remained blank for 100 ms; (3) at 1000 ms the first part of the sentence (main clause and complementizer—e.g., “Peter roept dat,” “Peter shouts that”) appeared on the screen and remained the only thing on the screen for 500 ms; (4) at 1500 ms the second part of the sentence (the subordinate clause and the verb stem, which was presented in a different color, i.e. red, and in a larger font, e.g., “de baas de monteurs BEL,” “the boss the mechanics CAÏ.L[stem]”) appeared below the first part and both parts were simultaneously visible on the screen for 1000 ms; (5) at 2500 ms the first part

of the sentence disappeared, leaving only the second part visible on the screen for 1200 ms more; (6) at 3700 ms the screen appeared blank for 100 ms; (7) at 3800 ms a deadline window appeared which consisted of an unfilled bar that was filled from bottom to top in 500 ms at which moment a tone sounded to indicate the deadline.

Participants were supposed to start reading the first part of the sentence aloud immediately after it appeared. The second part appeared while they were still uttering the first words, so they kept uttering the sentence in a fluent manner until the deadline signal. Presentation of the different sentence parts proceeded so fast that there was no time to pause in between. Putting time pressure on the participants by using a deadline window is a technique that has been employed before in subject–verb agreement experiments (e.g. Vigliocco, Hartsuiker, Jarema, & Kolk, 1996) with results comparable to that of other experiments reported in the literature.

Scoring. The experimental sessions were all recorded on tape. They were first transcribed and the experimental items were scored by two independent raters. The scores were then compared and the two raters discussed the cases in which their scores differed, until they reached a decision (they disagreed on less than 5% of the items). All sentences were assigned to one of the scoring categories listed below. In order to be scored in any of these scoring categories, except for the category “miscellaneous responses,” it was necessary for the uttering of the auxiliary to be initiated before the deadline signal. Examples of responses in each scoring category are presented in Table 2.

Responses were scored as *Correct* if the participant read the preamble correctly and produced a correct completion. An *Agreement error* was scored if the preamble was read correctly and there was a completion in which the auxiliary verb disagreed in number with the subject head noun. A response was scored as a *Number repetition error* if the participant read the preamble, changed the number of the subject head noun, and produced an auxiliary that agreed in number with the produced subject head noun. A *Number repetition plus agreement error* was a number repetition error, but the verb disagreed

TABLE 2

Examples of Responses in the Different Scoring Categories and their English Translations, Given the Target Phrase
Peter roept dat de baas van de monteurs . . . (Peter shouts that the boss of the mechanics . . .)

| Category | Item |
|--|--|
| Correct | Peter roept dat de baas van de monteurs heeft gebeld. (Peter shouts that the boss of the mechanics has called.) |
| Agreement error | Peter roept dat de baas van de monteurs hebben gebeld. (Peter shouts that the boss of the mechanics have called.) |
| Number repetition error | Peter roept dat de bazen van de monteurs hebben gebeld. (Peter shouts that the bosses of the mechanics have called.) |
| Number repetition and agreement error | Peter roept dat de bazen van de monteurs heeft gebeld. (Peter shouts that the bosses of the mechanics has called.) |
| Structure error | Peter roept dat de baas de monteurs heeft gebeld. (Peter shouts that the boss the mechanics has called.) |
| Structure and agreement error | Peter roept dat de baas de monteurs hebben gebeld. (Peter shouts that the boss the mechanics have called.) |
| Tense error | Peter roept dat de baas van de monteurs is gebeld. (Peter shouts that the boss of the mechanics is called.) |
| Tense and agreement error | Peter roept dat de baas van de monteurs zijn gebeld. (Peter shouts that the boss of the mechanics are called.) |
| Tense and indistinctive number marking | Peter roept dat de baas van de monteurs belde. (Peter shouts that the boss of the mechanics called.) |
| Miscellaneous | Peter roept dat de baas van de . . . van de monteurs . . . (Peter shouts that the boss of the . . . of the mechanics . . .) |

in number with the produced subject. In a (*Syntactic*) *structure error*, the participant changed the condition by either adding a preposition such as “van” (“of”) or “met” (“with”) or omitting the preposition that was there. In the completion, the auxiliary agreed in number with the subject head noun. In a (*Syntactic*) *structure plus agreement error* a preposition was omitted or added and the auxiliary disagreed in number with the subject head noun. In *Tense or auxiliary change*, the preamble was read correctly, but either the completion had a different tense than the present perfect or past perfect or it contained an incorrect auxiliary. A combination of both was also possible. The verb in the completion agreed in number with the subject head noun. In *Tense or auxiliary change and agreement errors*, tense or auxiliary verb was changed and the verb did not agree in number with the subject head noun. In *Tense or auxiliary change and indistinct number marking*, the tense or auxiliary verb was changed and the verb had no distinct number marking (e.g., the finite, past-tense form of “bellen,” “to call,” is

“belde” in the singular and “belden” in the plural. Many speakers of Dutch do not articulate the final /n/ in “belden”). In *miscellaneous responses* the participant failed to read the preamble, omitted or substituted part of the preamble, changed the number of the local noun, added an object in the subject modifier condition, corrected himself or herself in the repetition of the preamble, or did not produce a finite verb before the deadline signal.

If two different completions were made in succession before the deadline signal, only the first was scored, including those cases in which an agreement error was produced and immediately corrected.

Design and analysis. There were 36 experimental item sets, each containing four possible conditions. We constructed four different lists. Each list contained 36 items, 9 items per condition. Across the four lists, all four versions of a given item set were each presented once. The lists were all individually randomized. Furthermore there were six warm-up trials. Each participant was presented with one list.

Repeated measures analyses of variance were performed on the number of responses in each of the scoring categories, one with participants as a random factor and one with items as a random factor. The orthogonally crossed factors were the syntactic function of the constituent containing the local noun (subject modifier or direct object) and the number of the local noun (singular or plural). All factors were within-subjects and within-items. An effect was considered significant if it was reliable at or beyond the .05 level. The test statistics for participants and items are designated F_1 and F_2 , respectively.

Results

Of the 1152 experimental responses scored, there were 912 (79.2%) correct responses, 48 (4.2%) agreement errors, and 137 (11.9%) miscellaneous responses. An overview of the numbers of responses in the different scoring categories is reported in Table 3.

Agreement errors were most common in the subject-modifier condition with a plural local noun (11.5% of all the responses in that condition). In the object condition with a plural local noun, the percentage of agreement errors was 4.9%. The analysis of variance contrasted just these two conditions because there was only one agreement error (0.3%) in the subject-modifier condition with a singular local noun, and there were no agreement errors in the object condition with a singular local noun. The effect of syntactic

function was reliable by subjects and by items: $F_1(1,31) = 7.33$; $MSE = 0.77$; $F_2(1,35) = 8.57$; $MSE = 0.59$.

Correct responses occurred more often in the direct-object condition and more often in the number-match conditions. Indeed, for the correct responses, the analysis of variance showed a significant effect of syntactic function, both by subjects and by items: $F_1(1,31) = 7.47$; $MSE = 1.85$; $F_2(1,35) = 15.45$; $MSE = 0.79$. There was also a significant effect of number of local noun: $F_1(1,31) = 24.80$; $MSE = 1.29$; $F_2(1,35) = 15.42$; $MSE = 1.84$. The interaction between syntactic function condition and number of local noun was not significant: (F_1 and $F_2 < 1$).

Miscellaneous responses occurred most frequently in the subject-modifier conditions. In the analysis of variance for the miscellaneous responses, there was a significant effect of syntactic function, both by subjects and by items: $F_1(1,31) = 5.18$; $MSE = 2.07$; $F_2(1,35) = 15.30$; $MSE = 0.62$. The effect of the number of the local noun was not significant: $F_1(1,31) = 2.15$; $MSE = 1.05$; $F_2(1,35) = 1.40$; $MSE = 1.44$. The interaction was also not significant: $F_1 < 1$; $F_2 < 1$. In the remaining scoring categories we observed only a few responses. These scoring categories were not analyzed.

Recall that there were some differences with respect to the plausibility of items in the different conditions. To see if this variable had any ef-

TABLE 3
Distribution of Responses by Scoring Category in Experiment 1A

| Experimental condition | Correct | Agr. error | Rep. | Rep. + agr. | Syn. fun. | Syn. fun + agr. | Tense error | Tense + agr. | Tense + ind. | Misc. |
|------------------------|--------------|-------------|-----------|-------------|-----------|-----------------|-------------|--------------|--------------|-------------|
| SM, match | 236 81.9% | 1 0.3% | 4 1.4% | 0 0.0% | 1 0.3% | 0 0.0% | 5 1.7% | 1 0.3% | 1 0.3% | 39 13.5% |
| SM, mismatch | 199 69.1% | 33 11.5% | 3 1.0% | 1 0.3% | 1 0.3% | 0 0.0% | 3 1.0% | 0 0.0% | 0 0.0% | 48 16.7% |
| DO, match | 252 87.5% | 0 0.0% | 0 0.0% | 2 0.7% | 7 2.4% | 0 0.0% | 6 2.1% | 0 0.0% | 0 0.0% | 21 7.3% |
| DO, mismatch | 225 78.1% | 14 4.9% | 7 2.4% | 1 0.3% | 7 2.4% | 2 0.7% | 3 2.4% | 0 0.0% | 0 0.0% | 29 10.1% |

Note. Experimental conditions: SM, match (subject-modifier, number match); SM, mismatch (subject-modifier, number mismatch); DO, match (direct-object, number match); DO, mismatch (direct-object, number mismatch). *Scoring categories:* Correct; Agr. error (agreement error); Rep. (repetition error); Rep. + agr. (repetition + agreement error); Syn. fun. (syntactic function error); Syn. fun. + agr. (syntactic function + agreement error); Tense error; Tense + agr. (Tense + agreement error); Tense + ind. (tense + indistinct number marking); Misc. (miscellaneous responses).

fect on the number of agreement errors, we compared error rates between the 36 least plausible items (a quarter of the total number of items, ranging in plausibility from 2.2 to 4.8) and the 36 most plausible items, ranging in plausibility from 6.5 to 7). The mean error rate of the 36 most plausible items was 0.31 and the mean error rate of the 36 least plausible items was 0.36. A two-tailed *t*-test showed no statistically reliable difference between the groups ($t = 0.38$; $df = 70$).

There was a significant correlation between the number of miscellaneous responses and plausibility [$r = -.253$; $n = 144$]. This relation is negative; thus the more implausible items tended to elicit more miscellaneous responses. Separate correlation coefficients for the items in each of the four conditions showed that there were negative and significant correlations in both of the mismatch conditions.

Discussion

This experiment clearly showed an effect of syntactic function: there were significantly more agreement errors in the subject-modifier mismatch condition than in the direct-object mismatch condition. However, attraction errors were not restricted to the case in which the attracting element is located within the subject phrase: We observed a fair number of agreement errors in the direct-object mismatch condition. Thus, the results seem to argue in favor of the version of the syntactic distance hypothesis in which the syntactic proximity between subject and local noun determines the probability of interference from the local noun.

However, before we accept this conclusion, we have to address the concern that this difference may be the result of differences in the plausibility of the items. A post hoc analysis showed that this is unlikely, since the 36 least plausible and the 36 most plausible items yielded comparable numbers of agreement errors. But a stronger test of our claim would be a replication of the experiment with materials that are balanced for plausibility. Experiment 1B constituted such a replication. We defer further discussion of the present results until after we report that experiment.

EXPERIMENT 1B

Experiment 1B was a replication of Experiment 1A with a new set of materials and new participants. The new items were carefully selected so that the items in the subject-modifier conditions and those in the direct-object conditions were equally plausible. If we replicate the findings of Experiment 1A, we can exclude the possibility that they are the result of a confound with plausibility.

Method

Participants. Thirty-six undergraduate students at the University of Nijmegen participated in the experiment, 24 females and 12 males. Ages ranged from 18 to 26, with a mean of 21. All were native speakers of Dutch, and two were bilingual (Dutch-German). None of the participants had taken part in Experiment 1A.

Materials. The sets of items were composed in the same way as in Experiment 1A. We selected 28 sets of items to include in the experiment (see Appendix B). These 28 sets were selected from a larger pool of 72 sets on the basis of a plausibility pretest. In this pretest, the 72 sets were presented to 40 participants, none of whom took part in the experiments. Each version of an item was presented to 10 participants, and each participant judged 18 items in each of the four conditions (subject-modifier match; subject-modifier mismatch; direct-object match; direct-object mismatch). Plausibility judgments were provided on a 7-point rating scale, where 1 meant "very implausible" and 7 meant "very plausible." A selection of 28 sets was based on the results of this plausibility test. Mean plausibilities, followed by standard deviations, were subject-modifier match 5.8 (0.9), subject-modifier mismatch 6.0 (0.6), direct-object match 6.2 (0.8), direct-object mismatch 6.0 (0.9). The mean plausibility in the two mismatch conditions was equal, and there was no difference between the overall plausibility in the subject-modifier conditions and the direct-object conditions [$F(1,27) = 1.47$; $MSE = 0.54$].

Furthermore, forty-two filler items were randomly selected from the materials of Experiment 1A. Twenty-eight of these had structures

parallel to the experimental items, but they had plural subject nouns. Fourteen items contained a simple noun phrase as the subordinate clause (seven singular and seven plural).

Procedure and scoring. The procedure was identical to that in Experiment 1A. The responses were transcribed and scored by nine raters (a group of students, under the supervision of the first author). Transcription and scoring was subsequently checked and corrected by the first author.

Design and analysis. There were 28 experimental item sets, each containing four conditions. We constructed four lists, each containing 7 items per condition. Across the lists, all four versions of a given item occurred once. Each list was given to 9 participants. The order of items was individually randomized. Similar analyses were performed as in Experiment 1A. All effects that achieved significance were reliable at or beyond the .05 level.

Results

Of the 1008 experimental responses, there were 781 correct responses (77.5%), 55 agreement errors (5.5%), and 115 miscellaneous responses (11.4%). An overview of the numbers of responses in each of the scoring categories is reported in Table 4.

Agreement errors were most common in the subject-modifier condition with a mismatched

plural local noun (13.5% of all the responses in that condition). In the direct-object condition with a mismatched plural local noun, the percentage of agreement errors was 7.1%. Hardly any errors were made in the conditions with matched singular local nouns (0.8% for the subject-modifier condition; 0.4% for the direct object condition). We conducted a repeated measures analysis of variance on the number of agreement errors, crossing the factors syntactic function and number of local noun. There were significant main effects of syntactic function [$F_1(1,35) = 5.98$; $MSE = 0.34$; $F_2(1,27) = 5.29$; $MSE = 0.49$] and of the number of the local noun [$F_1(1,35) = 41.46$; $MSE = 0.40$; $F_2(1,27) = 43.48$; $MSE = 0.49$]. Importantly, there was a significant interaction between the two factors [$F_1(1,35) = 4.49$; $MSE = 0.35$; $F_2(1,27) = 4.26$; $MSE = 0.47$]. To qualify this interaction, we conducted a test of simple effects, contrasting the two conditions with plural local nouns. The effect of syntactic function was significant [$F_1(1,35) = 5.54$; $MSE = 0.6$; $F_2(1,27) = 5.05$; $MSE = 0.90$].

Correct responses occurred more often in the direct-object conditions than in the subject-modifier conditions, and they occurred more often in conditions with singular local nouns than in conditions with plural local nouns. Indeed, the analysis of variance on the number of correct responses revealed main effects of syn-

TABLE 4
Distribution of Responses by Scoring Category in Experiment 1B

| Experimental condition | Correct | Agr. error | Rep. | Rep. + agr. | Syn. fun. | Syn. fun + agr. | Tense error | Tense + agr. | Tense + ind. | Misc. |
|------------------------|--------------|-------------|-----------|-------------|-----------|-----------------|-------------|--------------|--------------|-------------|
| SM, match | 199 79.0% | 2 0.8% | 0 0% | 0 0% | 0 0% | 0 0% | 18 7.1% | 0 0% | 0 0% | 33 13.1% |
| SM, mismatch | 167 66.3% | 34 13.5% | 3 1.2% | 0 0% | 1 0.4% | 0 0% | 6 2.4% | 7 2.8% | 0 0% | 34 13.5% |
| DO, match | 218 86.5% | 1 0.4% | 0 0% | 0 0% | 7 2.8% | 0 0% | 3 1.2% | 0 0% | 0 0% | 23 9.2% |
| DO, mismatch | 197 78.2% | 18 7.1% | 4 1.6% | 4 1.6% | 3 1.2% | 1 0.4% | 0 0% | 0 0% | 0 0% | 25 9.9% |

Note. *Experimental conditions:* SM, match (subject-modifier, number match); SM, mismatch (subject-modifier, number mismatch); DO, match (direct-object, number match); DO, mismatch (direct-object, number mismatch). *Scoring categories:* Correct; Agr. error (agreement error); Rep. (repetition error); Rep. + agr. (repetition + agreement error); Syn. fun. (syntactic function error); Syn. fun. + agr. (syntactic function + agreement error); Tense error; Tense + agr. (tense + agreement error); Tense + ind. (tense + indistinct number marking); Misc. (miscellaneous responses).

tactic function [$F_1(1,35) = 13.39$; $MSE = 1.25$; $F_2(1,27) = 9.29$; $MSE = 2.31$] and of number of local noun [$F_1(1,35) = 18.09$; $MSE = 1.08$; $F_2(1,27) = 11.95$; $MSE = 2.1$]. There was no interaction between these factors (both F_1 and $F_2 < 1$).

Descriptively, there were more miscellaneous responses in the subject-modifier conditions than in the direct-object conditions, and there was no difference between the conditions with plural and singular local nouns. However, the analysis of variance on miscellaneous responses showed that the effect of syntactic function was not significant [$F_1(1,35) = 3.70$; $MSE = 0.68$; $p = .063$; $F_2(1,27) = 3.05$; $MSE = 1.06$; $p = .092$]. There was no effect of number of local noun (F_1 and $F_2 < 1$), and there was no interaction (F_1 and $F_2 < 1$).

In the remaining scoring categories, too few responses occurred to warrant an analysis. Notice though that there were many more tense and tense + agreement errors in the subject-modifier conditions (31) than in the direct-object conditions (3).

Discussion of Experiments 1A and 1B

Experiments 1A and 1B yielded very similar results, both in the overall distribution of the responses and with respect to the effect of the critical conditions. In both experiments an effect of syntactic function was obtained on the number of agreement errors: Agreement errors were more common in the subject-modifier condition than in the direct-object condition. Experiment 1B refuted any explanation of the results based on the plausibility of the items: The effect of syntactic function remained with items that were balanced with respect to this variable.

In Experiment 1A, miscellaneous responses occurred significantly more frequently in the subject-modifier condition than in the direct-object condition. Although descriptively the distribution of miscellaneous responses in Experiment 1B was similar, the syntactic function effect on these responses was not significant in that experiment.

An interesting feature of the data is that, in Experiment 1B, tense errors occurred more frequently in the subject-modifier conditions than

in the direct-object conditions. Quite likely, this is due to the linguistic fact that the choice of the auxiliary “zijn,” instead of “hebben,” results in a grammatical completion for the subject-modifier fragments (i.e., a passive sentence). In the direct-object condition, the choice of that auxiliary results in an ungrammatical completion. In fact, that happened once. The remaining two tense errors in the direct-object conditions were due to the use of the simple present and the future tense.

Let us now return to the interpretation of the results on agreement errors. In the introduction, we listed three different hypotheses about the mechanism specifying agreement and three corresponding predictions: (1) a theory that would assign a special status to the subject, encapsulating it from information from elsewhere in the syntactic tree, would predict no agreement errors in the direct-object condition and many agreement errors in the subject-modifier condition; (2) the hypothesis that syntactic distance between local noun and verb determines agreement error rate predicts more agreement errors in the direct-object condition; (3) the hypothesis that syntactic distance between local noun and highest NP projection of the subject is relevant predicts more agreement errors in the subject-modifier condition.

The results clearly refute the hypothesis that number information from outside the subject NP cannot interfere with the computation of agreement. Quite clearly, it can. This finding calls for a further specification of Eberhard's (1997) sketch of the mechanism that computes subject-verb agreement. Not only activated number features within the subject phrase influence the agreement process. The present results show that information from other parts of the syntactic tree also influence subject-verb agreement computation.

How do the two variants of the syntactic distance hypothesis fare? The first variant of that hypothesis entails that an important factor for the occurrence of agreement errors be the syntactic distance between (number mismatching) local noun and verb. That hypothesis predicts more errors in the direct-object condition. This prediction is clearly refuted by the present data.

The second variant entails that the syntactic distance between local noun and highest projection of the subject NP be important. As shown in Fig. 2, the number of intervening phrasal nodes is two in the direct-object case (VP and S), but it is only one in the subject-modifier case (PP). Thus, that variant predicts more errors in the subject-modifier condition. This prediction is confirmed by the data.

Our results are different from those obtained by Antón-Méndez (1996) in Spanish. Antón-Méndez did not obtain an attraction effect with direct objects, but we did. In addition to the test language, there is an important difference between the two experiments, the part of speech of the local constituents. We tested the effect of local nouns, but, because of the word order restrictions of Spanish, Antón-Méndez was forced to use pronouns. In Experiment 2 we will test whether direct-object pronouns can exert an attraction effect comparable to that of direct-object noun phrases.

EXPERIMENT 2: PRONOUNS VS FULL NOUN PHRASES

In the present experiment the role of part of speech (noun or pronoun) of the attracting constituent is investigated. As mentioned in the Introduction, there are two main reasons that one may expect nouns and pronouns to play a different role in agreement computation.

First, pronouns and nouns differ with respect to being overtly specified for case or not, at least in Spanish, English, and Dutch. For instance, in these three languages the masculine, singular pronouns are, respectively, “él,” “he,” and “hij” in the nominative, but “lo,” “him,” and “hem” in the accusative. It is conceivable that this case marking has repercussions for the specification of agreement relations, because it explicitly indicates the syntactic function of the local constituent as nonnominative.

Second, arguments about the occurrence of number agreement errors are often based on the assumption that number (plural) is a syntactic feature added to a word (Eberhard, 1997). Eberhard assumes that the feature value “singular” is the default and that the value “plural” is marked, in the linguistic sense first proposed by Jakob-

son (1975). This explains the asymmetry in the occurrence of agreement errors: If the subject is singular and the local noun is plural, many more agreement errors occur than in the case where the subject is plural and the local noun is singular (e.g., Bock & Miller, 1991; Vigliocco, Butterworth, et al., 1996). Only if the local noun is plural would there be a feature value which is activated along with the lexical representation of the local noun.

Such an account is consistent with the theory of lexical access proposed by Levelt et al. (1999). In that theory production of a noun implies the retrieval of a lemma and its corresponding syntactic features, such as gender and number. These features are represented by separate nodes, which can be activated to some extent. The markedness effect could be accounted for in this framework, by assuming that the node for the feature value “plural” is generally activated more than the node for “singular.”

But how are pronouns produced? To the best of our knowledge, little attention has been given to this issue. An exception is a recent study by Meyer and Bock (1999). These authors proposed two plausible ways by which production of pronouns is driven, strictly conceptually or indirectly through access of the antecedent’s lemma. Of course, production is always driven by conceptual information, and, in principle, the conceptual representation is specific enough to determine the appropriate form for a pronoun. The conceptual hypothesis claims that this conceptual information is the *only* information source used in pronoun production. If that is the case, syntactic feature nodes for number and gender will not become activated during pronoun production, disallowing feature migration.

Alternatively, according to the lexical hypothesis the speaker accesses the representation of the antecedent’s lemma and its corresponding syntactic features. If that is the case, the syntactic features node will be become active, and they will interfere with agreement. Meyer and Bock (1999) showed that the presence of gender-mismatching local nouns influenced the selection of the gender-marked pronoun. This finding supports a lexical hypothesis, because it suggests a competition at the lemma level. However, the

findings do not exclude the possibility that with respect to number, pronoun selection is more under conceptual than lexical control. In Dutch, grammatical gender is an inherently syntactic feature: For most nouns, there is no conceptual gender corresponding to grammatical gender. But for number this situation is different, because each noun is conceptually specified for number. Therefore the gender of a pronoun can only be decided after consulting the lemma of the antecedent containing the gender information, but its number can be specified according to the conceptual information.

In the present experiment, we presented participants with sentence fragments that were similar to those in Experiments 1A and 1B. All of them were direct-object fragments. They were presented in two part-of-speech conditions, the condition in which the direct object was a full noun phrase and the condition in which the direct object was a pronoun. The first condition was thus comparable to the direct-object condition in Experiment 1A. The second condition added a new manipulation.

Before we can proceed with a description of the experiment, it is necessary to briefly explain the pronominal system of Dutch. We will restrict this digression to the third person pronouns. A subdivision of pronominal forms is provided in Table 5, adapted from Geerts, Haeseryn, de Rooij, & Van den Toorn (1984, p. 167). The basic subdivisions are, according to case, reduction, number, and gender. The first feature, case, has two marked values, nominative and nonnominative. As is obvious, the Dutch pronominal system is rather complex. Many forms can be used in different cells of the table (i.e., are ambiguous), and many cells in the

matrix allow different kinds of pronominal forms. It must be added that many of the clitic forms are archaic (the forms following the semicolons). Furthermore, traditional grammar makes a distinction between the nonnominative forms "hen" and "hun" (both: them). The pronoun "hun" is reserved for indirect objects not following a preposition. In practice, speakers and writers of Dutch seldom use that distinction (Geerts et al., 1984). Essential for the present experiment is the fact that "hen" and "hun" can only refer to persons (Geerts et al., 1984). Nonpersons can only be referred to with the clitic form, "ze." This form is ambiguous with respect to case and number (see Table 5).

Method

Participants. Thirty-two students of the University of Nijmegen, 28 females and 4 males, participated in the experiment. None of them had participated in Experiments 1A and 1B. All participants had Dutch as their native language (one in the Flemish dialect). Ages ranged from 18 to 26, with a mean of 21.

Materials. We constructed 36 experimental sentences which were in many cases adaptations from materials in Experiment 1A. Experimental materials consisted of a noun phrase antecedent, a main clause, and a subordinate clause. An example of a set of experimental items is given in Table 6. Main clauses were all very simple and consisted of a subject (a proper noun) and a verb. Subordinate clauses all had a singular head noun and a plural local element. Subordinate clauses all consisted of a subject noun phrase and a direct-object phrase. That latter phrase consisted of a full NP in one condition and of a pronoun in the other condition. In the full NP

TABLE 5
System of Dutch Third-Person Pronouns

| | | Nominative | | Nonnominative | |
|----------|--------------|------------|---------|----------------|-------------|
| | | Full | Clitic | Full | Clitic |
| Singular | masculine | hij | ie, die | hem | 'm |
| | feminine | zij | ze | haar | 'r, d'r; ze |
| | neuter | | het, 't | | het, 't |
| Plural | masc. neuter | zij | ze | hen, hun | ze |
| | feminine | zij | ze | hen, hun; haar | ze; 'r, d'r |

TABLE 6
Examples of Materials in Experiment 2

| Condition | Antecedent | Preamble (sng. pl.) | Verb stem |
|---|-------------------------------|---|-------------------|
| <i>Animate antecedent</i> (unambiguous pronoun) | | | |
| Full NP | De zeerover s The pirate s | Ed ziet dat de kapitein de zeerover s Ed sees that the captain the pirate s | Val aan Attack |
| Pronoun | De zeerover s The pirate s | Ed ziet dat de kapitein hem hen Ed sees that the captain him them | Val aan Attack |
| <i>Inanimate antecedent</i> (case-ambiguous plural pronoun) | | | |
| Full NP | De auto 's The car s | Tanja zegt dat de verkoper de auto 's Tanja says that the salesman the car s | Rijd Drive |
| Pronoun | De auto 's The car s | Tanja zegt dat de verkoper hem ze Tanja says that the salesman him them | Rijd Drive |

condition, the antecedent was the same as the object noun phrase. In the pronoun condition, the antecedent noun phrase was given as the antecedent for the pronoun. Furthermore, the factor part-of-speech was crossed orthogonally with the number of the direct object (the number of the subject noun was always singular). In half of the cases the direct object was singular (number match condition), and in the other half it was plural (number mismatch condition). Finally, we selected a verb to be used for the completion of each preamble. We presented only the stem of each verb during the experiment.

We constructed 36 such sets of experimental items, each set comprising the four versions derived from crossing the factors part-of-speech and direct-object number. We made sure that the materials were carefully balanced: The antecedent was a person in 18 sentences and a nonperson (inanimate) in the other 18. Thus, the plural direct-object pronoun was "hen" in the former 18 cases and "ze" in the latter 18. Furthermore, the antecedent was masculine in 18 cases and feminine in the remaining 18 cases. Of the antecedents that were persons, nine were masculine and nine were feminine. This was usually accomplished by choosing gender-specific names for professions (e.g., actress, waiter). Of the antecedents that were inanimates, nine were grammatically masculine and nine grammatically feminine. This was done with reference to a dictionary, because the distinction between masculine and feminine gen-

der for inanimates is seldom correctly made by native speakers of Dutch (including the first and third author of this article).

In addition, we constructed 108 filler items. Thirty-six of these had the same structure as the experimental sentences, 18 with a full NP direct object and 18 with a pronominal direct object. All of these had a plural subject noun, but the number of the local noun or pronoun was singular in 18 cases and plural in the remaining 18. Of the nine filler sentences with plural object pronouns, four contained the pronoun "hen" and five "ze." Of the nine fillers with singular object pronouns, three contained the pronoun "hem," three contained "haar," and three contained "het." Furthermore, there were 72 simple fillers. Subordinate clauses just consisted of a simple noun phrase in these items. Thirty-six of these contained a full NP, 18 singular and 18 plural. The remaining 36 contained a subject pronoun (18 singular, 18 plural). Singular subject pronouns were "zij" (she) in nine cases and "hij" (he) in the remaining nine. Plural subject pronouns were all "ze" (they).

Procedure. The procedure was similar to that of the previous experiments, with one important exception: Before the presentation of the sentence fragment, an antecedent was presented. Each trial proceeded as follows. The participant initiated the trial with a button press and the screen remained blank for 400 ms. Then a fixation cross was presented for 900 ms. Following a 100-ms pause, the antecedent was presented,

for 1000 ms, in a different color (blue) than the sentence fragment. Then another 100-ms pause followed, and consecutively the first part of the sentence fragment (the main clause and the complementizer “dat,” *that*) was presented for 1500 ms. The remaining part of the sentence fragment was presented for 2200 ms, and it began 500 ms post-onset of the first part. That part also included the verb stem, which was presented below the sentence fragment, in a larger font and in a different color (red). Finally, after a 100-ms pause, the deadline window appeared, and the bar was filled in 500 ms. When the bar was filled, the warning tone sounded.

Before the experiment commenced there were six practice sentences.

Scoring. The experimental sessions were all recorded on tape. They were first transcribed and the experimental items were scored by two independent raters. Cases where the two scorers disagreed were discussed and settled. This happened in less than 5% of the trials. All sentences were assigned to one of the scoring categories used in Experiments 1A and 1B. The only difference between the scoring systems is that in Experiment 2 we no longer scored “syntactic function errors” (if any were made they were categorized as miscellaneous responses) but included a new category, “part-of-speech errors.” A response was classified as a part-of-speech error if the participant substituted the antecedent

NP for the pronoun, or the pronoun for the full NP. For all other response types, criteria for assigning responses to categories were the same as in the previous experiment.

Design and analysis. There were 36 experimental item sets, each containing four possible conditions. We constructed four different lists. Each list contained 36 items, 9 items per condition. Across the four lists, all four versions of a given item set were each presented once. The lists were all individually randomized. Each participant was presented with one list.

A repeated measures ANOVA was performed on the number of responses in each of the scoring categories, first with participants as a random factor and then with items as a random factor. The orthogonally crossed factors were part-of-speech of direct object (full NP or pronoun) and the number of the local element (singular or plural). These factors were within-subject and within-item factors. An effect was considered significant if it was reliable at or beyond the .05 level. The test statistics for participants and items are designated F_1 and F_2 , respectively.

Results

The experiment yielded a total of 1152 responses, which were divided into the nine scoring categories. There were 1033 correct responses (89.7%), 31 agreement errors (2.7%),

TABLE 7
Distribution of Responses by Scoring Category in Experiment 2

| Experimental condition | Correct | Agr. error | Rep. | Rep. + agr. | Gram. cat. | Gram. cat. + agr. | Tense error | Tense + agr. | Tense + ind. | Misc. |
|------------------------|--------------|------------|-----------|-------------|------------|-------------------|-------------|--------------|--------------|------------|
| NP, match | 274 95.1% | 0 0.0% | 0 0.0% | 0 0.0% | 0 0.0% | 0 0.0% | 1 0.3% | 0 0.0% | 0 0.0% | 13 4.5% |
| NP, mismatch | 240 83.3% | 22 7.6% | 3 1.0% | 1 0.3% | 1 0.3% | 0 0.0% | 4 1.4% | 0 0.0% | 0 0.0% | 17 5.9% |
| PN, match | 270 93.8% | 0 0.0% | 2 0.7% | 0 0.0% | 0 0.0% | 0 0.0% | 2 0.7% | 0 0.0% | 0 0.0% | 14 4.9% |
| PN, mismatch | 249 86.5% | 9 3.1% | 1 0.3% | 0 0.0% | 0 0.0% | 0 0.0% | 2 0.7% | 0 0.0% | 0 0.0% | 27 9.4% |

Note. Experimental conditions: NP, match, (full NP, number match); NP, mismatch (full NP, number mismatch); PN, match (pronoun, number match); PN, mismatch (pronoun, number mismatch). *Scoring categories:* Correct; Agr. error (agreement error); Rep. (repetition error); Rep. + agr. (repetition + agreement error); Gram. cat (part of speech error); Gram. cat. + agr. (part of speech + agreement error); Tense error; Tense + agr. (tense + agreement error); Tense + ind. (tense + indistinct number marking); Misc. (miscellaneous responses).

71 miscellaneous responses (6.2%), and 17 responses in the other categories (1.5%). An overview of the distribution of responses in the conditions of the experiment is provided in Table 7. Only in the conditions with number mismatch were any agreement errors observed. Therefore, in the analysis we conducted on the number of agreement errors, we only considered the latter two conditions. There were more agreement errors in the condition with full noun phrases (7.6%) than in the condition with pronouns (3.1%). The effect of part of speech was significant [$F_1(1,31) = 5.51$; $MSE = 0.48$; $F_2(1,35) = 4.29$; $MSE = 0.55$].

In Table 8, we have divided the number of agreement errors according to pronoun ambiguity and part-of-speech of the direct object. Because items in the full NP condition and the corresponding pronoun condition comprised a minimal contrast, we can consider the NP items a control condition for the pronoun condition. The division in Table 8 shows that items with ambiguous pronouns elicited exactly as many errors as their control items with full NPs (both 5.6%). However, items with unambiguous pronouns elicited far fewer errors (0.7%) than their control items with full NPs (9.7%). Thus, when case was unambiguously marked as nonnominative (i.e., in the unambiguous pronoun condition), the attraction effect disappeared.

We conducted an analysis over the items in the number mismatch conditions, with animacy of referent (animate, inanimate) as a between-item variable and part-of-speech (pronoun, full NP) as a within-item variable. Note that in the inanimate referent condition, the pronoun was ambiguous for case. There was a significant

main effect of part of speech [$F_2(1,34) = 4.75$; $MSE = 0.49$], no significant main effect of animacy [$F_2(1,34) < 1$], and a significant interaction between animacy and part-of-speech [$F_2(1,34) = 4.75$; $MSE = 0.49$]. To qualify the interaction, we determined the effect of animacy within each part-of-speech condition, using the Wilcoxon–Mann–Whitney test, with correction for ties. This showed that the effect of animacy was significant in the pronoun condition [$Z = -2.1122$] but not significant in the full NP condition [$Z = -1.1078$].

In the ANOVA on the number of correct responses, there was a significant main effect of number [$F_1(1,31) = 14.92$; $MSE = 1.58$; $F_2(1,35) = 27.49$; $MSE = 0.76$]. There was no effect of part of speech [$F_1 < 1$; $F_2 < 1$], and no significant interaction [$F_1(1,31) = 1.39$; $F_2(1,35) = 2.34$; $MSE = 0.50$]. In the ANOVA on miscellaneous responses, there was no significant effect of number in the subject analysis [$F_1(1,31) = 3.42$; $MSE = 0.66$], but the effect was significant in the item analysis [$F_2(1,35) = 4.32$; $MSE = 0.45$]. The effect of part of speech was not significant [$F_1(1,31) = 2.48$; $MSE = 0.38$; $F_2(1,35) = 1.91$; $MSE = 0.44$] and neither was the interaction [$F_1(1,31) = 1.22$; $MSE = 0.52$; $F_2(1,35) = 1.11$; $MSE = 0.51$].

Discussion

What have we established? First, this experiment demonstrated, once again, that mismatching information embedded in a nonsubject NP is capable of eliciting attraction errors. Thus, we can now safely reject the strong hypothesis that the mechanism that computes verb agreement is sensitive only to number information within the subject noun phrase. Second, we have shown that object attraction is not reserved for those objects that consist of a determiner and a noun: Pronominal objects are capable of attraction as well. This finding is in agreement with the lexical hypothesis of pronoun production proposed by Meyer and Bock (1999). Third, that latter conclusion should be qualified by the statement that apparently not all pronouns are equal; pronominal objects that were ambiguously case-marked (“ze,” “them” for inanimate objects) induced more agreement errors than pronouns that

TABLE 8

Agreement Errors by Part of Speech and Animacy of Referent

| | Full NP, mismatch | Pronoun, mismatch |
|--------------------|-------------------|-------------------|
| Inanimate referent | 8 (5.6%) | 8 (5.6%) |
| Animate referent | 14 (9.7%) | 1 (0.7%) |

Note. Pronouns in the inanimate referent condition were ambiguous for case, but pronouns in the animate referent condition were transparently marked as nonnominative.

were unambiguously marked for nonnominative case (i.e., “hen,” “them” for animate objects). In fact, the ambiguously case-marked pronouns resulted in as many agreement errors as the corresponding full NPs.

Notice, however, that the animate and inanimate pronouns also differ with respect to number marking. The animate pronoun, “hen,” is unambiguously plural. The inanimate accusative pronoun, “ze,” however, is ambiguous with respect to number as well as case. It can be nominative singular or plural, or even an accusative singular clitic in archaic speech (see Table 6). That seems to open the possibility that the differences in error pattern elicited by the two pronouns is due to the number ambiguity instead of the case ambiguity. However, there are two reasons that we think the effect is one of case ambiguity rather than number ambiguity. First, other studies that manipulated number ambiguity of the local noun found no effect of this variable (Bock & Eberhard, 1993; Vigliocco et al., 1995). Second, even if number marking ambiguity of the pronoun has an effect on the number of agreement errors, one should expect fewer agreement errors in the ambiguous condition, since speakers would sometimes consider the number of the pronoun to be singular instead of plural. This is clearly disconfirmed by the data (see Table 7).

It is worth noting here that the pattern of results obtained in this experiment offers an argument against a possible effect of length on attraction errors (see also Bock & Miller, 1991). The argument follows from the results with case-ambiguous pronouns: For those items, there was an equal number of errors in the pronoun condition as in the full NP condition, although the full NP items were all longer than the pronoun items. If a length-explanation were to hold, we would have expected more agreement errors in the full NP condition.

GENERAL DISCUSSION

The most important contribution of the present results is that they further specify and constrain the list of factors that interfere with agreement computation, and that can thus be thought to play a role in normal computation of agree-

ment. In particular, they elucidate the role of syntactic function and part of speech. Let us recapitulate the main findings. First, number information in the subject phrase is not encapsulated from conflicting information elsewhere in the sentence. The existence of object attraction, obtained in all three experiments, refutes such a hypothesis. Second, we obtained an effect of syntactic function: There were more agreement errors when the local noun was embedded in a subject modifier than when it was the direct object. Third, the present data demonstrate that pronominal objects exert an attraction effect, and the data clarify the conditions under which this attraction occurs. At first glance, nouns appear to be stronger “attractors” than pronouns. However, a closer inspection of the data reveals that pronouns that are unambiguously marked for nonnominative case are weak attractors, but ambiguous pronouns attracted as many agreement errors as the corresponding items with nouns (which are not case marked). The data thus seem to argue for a role of morphophonological ambiguity of case.

In the remainder of this section, we will discuss how our results regarding syntactic function constrain theories of agreement computation. We will then return to the notion of morphophonological ambiguity and discuss that finding from a cross-linguistic viewpoint. We will conclude by mentioning some reservations that arise as a consequence of the chosen methodology.

Toward a Theory of Agreement Computation

The present data provide a number of constraints that theories of agreement production will have to take into account. In this section, we will discuss the implications of these constraints and propose a sketch of the mechanism that computes agreement.

First, the consistent finding of attraction effects from direct objects argues against the strong hypothesis that the mechanism that implements agreement is sensitive only to mismatching information *within* the subject NP. Quite clearly, that mechanism is influenced by local constituents outside the subject phrase. The implication is that prior to the implementa-

tion of agreement, number information can be transmitted from any part of the syntactic tree.

Second, the finding of a syntactic function effect in Experiments 1A and 1B supports the syntactic distance hypothesis proposed by Vigliocco and Nicol (1998) and further restricts it. The experiments that Vigliocco and Nicol report do not distinguish between two alternative versions of that hypothesis: (1) attraction effects are stronger if the attracting constituent is syntactically closer to the verb; (2) attraction effects are stronger if the attracting constituent is syntactically closer to the highest projection of the subject NP. Hypothesis (1) predicted more agreement errors in the direct-object condition than in the subject-modifier condition (see Fig. 2). Hypothesis (2) predicted more errors in the subject-modifier condition. Our results clearly confirm the second hypothesis.

That finding has a number of implications. It disconfirms the idea that the number of the verb is sometimes erroneously specified as a result of feature copying from constituents that are syntactically close to the verb (i.e., for which there are relatively few nodes in the syntactic tree that separate the constituent and the verb). Rather, it supports the idea that the subject is the “controller” of the agreement relation, and number is subsequently copied to the verb.⁵ Furthermore, the effect of syntactic distance confirms the hypothesis that agreement is specified with respect to the syntactic structure of the sentence (Vigliocco & Nicol, 1998). The shorter the distance in the syntactic tree between local constituent and subject, the fewer the steps the mismatching number feature has to migrate, and the more agreement errors one observes. Importantly, number features outside the subject NP participate in this feature migration and even traverse the S-constituent. This latter finding is not unprecedented though. Bock and Cutting (1992) observed that local nouns embedded in a relative clause or complement clause elicited fair numbers of agreement errors (although less than local nouns in prepositional phrases).

⁵ Notice, though, that this does not exclude the possibility that the verb is sometimes independently specified for number on *semantic* grounds.

Third, Experiment 2 further clarifies which constituents can serve as a source of feature migration. This includes pronouns as well as nouns. That finding has implications for theories of pronoun production. In fact, it is consistent with the hypothesis that the antecedent’s lemma and its syntactic features (partially) control the production of pronouns (Meyer & Bock, 1999). Furthermore, we observed a difference between pronouns that were ambiguously and unambiguously specified for case. We will turn to that issue in the next section.

In sum, our results argue for a two-step process of agreement computation in production. First a syntactic tree is constructed and number features migrate throughout this tree. In the case of Dutch (and English), the features would ultimately mark the subject NP of the syntactic tree, which is the controller of the subject–verb agreement relation. The initial sources of these number features are syntactic feature nodes connected to the lemmas of local nouns or to lemmas of the antecedents of local pronouns. The number specified on the subject NP can be influenced by plural features other than the ones on which this subject number should depend, and the shorter the syntactic distance from the source of the number mismatching features to the subject, the larger the probability that the number of the subject will be incorrectly specified. In the second step, the verb is made to agree with the subject, by copying number from subject to verb.

The Case for Morphophonological Ambiguity: Evidence from Spanish, German, and French

The data in Experiment 2 suggested a role of morphophonological ambiguity since explicit marking of nonnominative case diminished the attraction effect. How do the results obtained in other languages bear upon the hypothesis that such an ambiguity interacts with agreement computation? First of all, the null-effect found in Spanish, where the local elements were clitic accusative pronouns (Antón-Méndez, 1996), can also be explained in these terms, since accusative pronouns differ in form from nominative pronouns. Spanish nominative pronouns are “él,” “ella,” “ellos,” and “ellas.” Equivalent accusative pronouns are “lo,” “la,” “los,” and “las.”

Thus, in the direct-object conditions, the pronouns were unambiguously accusative.

Recently, Hartsuiker, Schriefers, Bock, and Kikstra (2000, and submitted manuscript) presented evidence that confirmed the role of morphophonological ambiguity for case. These authors elicited agreement errors in German phrases that consisted of a subject head noun and a subject modifier, e.g., *die Stellungnahme gegen die Demonstrationen* (the comment on the demonstrations). Depending on the preposition in the subject modifier, the local noun takes either the accusative case (as in this example) or the dative case. Importantly, case marking for the *accusative* is morphophonologically ambiguous: it cannot be distinguished from the nominative case (for local nouns of feminine or neuter gender). Case marking for *dative* is transparent and cannot be confused with nominative case. The authors obtained a significantly stronger attraction effect in the ambiguous (accusative) condition than in the unambiguous (dative) condition. These results thus parallel our findings with ambiguous (“ze”) and unambiguous (“hen”) pronouns.

However, there is also a series of experiments in which agreement errors following clitic pronoun direct objects were elicited in French, in a writing-to-dictation task (Chanquoy & Negro, 1996; Fayol, Largy, & Lemaire, 1994). Importantly, attraction effects were found in conditions with pronominal direct objects such as (9).

*Il les promènt.

*He them walk[plural]. (9)

(*He walk them).

These results seem to be at odds with our findings: the accusative pronouns (“le,” “la,” and “les”) are morphophonologically distinct from nominative pronouns. Note, however, that there was no direct comparison with morphophonologically ambiguous pronouns or nouns. Furthermore, in addition to the obvious differences in conditions, task, and output modality, there is also a linguistic difference that could possibly account for the different results in French. In French, the accusative pronoun is sometimes relevant for agreement between object and past

participle (Harris, 1990). Object–verb agreement is required when the past participle is used with the auxiliary “avoir” (“to have”) and when the direct object precedes the verb (just as in Spanish, it is an obligatory object-clitic then). An example is provided in (10).

les pommes (fem, pl), je les (object-clitic) ai mangées (fem, pl) (10)

the apples, I them have eaten

It is thus conceivable that the finding of agreement errors in French with object clitics as local attractors is related to the fact that French sometimes *requires* verbs to agree in number (and gender) with these elements.

A Reservation

Although our conclusions are straightforward, a reservation is in order in view of the specific task we used. We assume that the effects of syntactic function and morphophonological ambiguity are localized within the production system. However, the task used in most studies on subject–verb agreement contains a comprehension part as well, since participants first need to read or listen to a sentence preamble before performing the production task. This introduces the possibility that some of the effects we tend to ascribe to the grammatical encoding system could be (partly) attributed to the sentence parsing system. Consistent with this story, Nicol et al. (1997) obtained effects in comprehension of variables that also affected agreement error rates in production.

There are three reasons that one may argue that this alternative applies in particular to our experiments.⁶ First, we presented the sentences visually, and they remained on the screen for a relatively long time (the subordinate clause remained visible for 2200 ms). Thus, the participants could read aloud at least part of the sentence, instead of relying on short-term memory only, as would have been the case with auditory presentation. As a consequence, participants may have been uncertain about the intended syntactic functions until they encountered the

⁶This was pointed out to us by an anonymous reviewer.

verb.⁷ Second, we imposed time pressure on the participants. This may have aggravated any tendency to misidentify syntactic functions. Third, in Experiments 1A and 1B, there was a parallelism between the syntactic structures in the filler items and the experimental items. Thus there were many sentences with a subject modifier (either filler or experimental), and this may have induced a strategy by which participants expected a subject modifier. As a result, even though the direct-object sentences contained no preposition, participants may have misinterpreted them as subject-modifier sentences.

The most obvious effect to be attributed to comprehension factors is that of morphophonological ambiguity. Clearly, unambiguous case-marking is beneficial to the comprehension system in determining syntactic function (McDonald, 1987). A misidentification of syntactic function thus seems more likely when case-marking is ambiguous. However, we found converging evidence for effects of morphophonological ambiguity, with respect to case and also with respect to number, in a series of studies that tested agreement in German (Hartsuiker et al., 2000, and submitted manuscript). Crucially, these experiments employed a procedure to which none of the potential problems noted above apply. First, the preambles were presented auditorily instead of visually. Second, no time limit was imposed on the participants for the duration of their completions. Third, the filler materials in those experiments comprised a wide range of constructions, making it unlikely that participants developed a strategy to expect a particular type of construction.

We also do not think that the syntactic function effect can be considered an artifact of comprehension processes (in particular, as the result of a tendency to mistake the direct object for a subject modifier). It may be true that conditions were favorable in Experiments 1A and 1B for inducing a strategy in which participants expect subject-modifier sentences, because subject-modifier sentences occurred there quite often. However, conditions were *not* favorable for mistaking direct

objects for subject modifiers in Experiment 2, since no subject-modifier sentences were presented there. A comprehension account would predict overall fewer agreement errors for direct-object NPs in Experiment 2 than in Experiment 1A or 1B, because confusion of object and subject modifier would be more likely in Experiments 1A and 1B than in Experiment 2. On the contrary, errors for mismatched direct-object sentences occurred fairly constantly in the three experiments (4.9, 7.1, and 7.6%, respectively).

In sum, it is important to realize that the comprehension component may have some specific influences in the subject–verb agreement paradigm. However, we do not believe that this undermines our conclusions. First, we found converging evidence for the effects that can be most obviously attributed to comprehension (morphophonological ambiguity effects) in experiments that minimized the potential influence of comprehension. Second, the observation of similar rates of object attraction in experiments that were relatively likely to elicit syntactic function confusion (Experiments 1A and 1B) and those that were unlikely to do so (Experiment 2) is inconsistent with the comprehension account.

Conclusion

Our data show that any theory of agreement computation needs to take into account three important constraints. First and foremost, number specification on constituents located outside the subject can interfere with subject–verb agreement computation. Second, the data support the hypothesis that the farther away from the highest projection of the subject NP an attractor element is, the weaker its attraction effect. Together, these constraints argue for the viewpoint that the subject indeed plays an integral role in the computation of agreement, but that it is not encapsulated from number information that occurs elsewhere in the clause. The data argue for a two-step process of agreement computation, in which first number is transmitted through the syntactic tree, and subsequently the number marked on the subject NP node regulates the specification of number on the verb. Third, the results argue for the notion of morphophonological ambiguity. If a constituent's case-marking clearly signals it is not the subject, then the attracting effect of that constituent diminishes.

⁷ But notice that word order provides very strong cues here. If a Dutch subordinate clause contains two noun phrases (as in our experiments), the word order is obligatorily subject–object. Further, a pronoun occurring after a noun phrase (as in Experiment 2) is never the subject (Geerts et al., 1984).

APPENDIX A: ITEMS IN EXPERIMENT 1A

We list here each item and its literal English translation, the matrix clause, the subordinate clause in the prepositional phrase condition, and the verb stem. The object condition is derived by deleting each preposition.

Theo denkt dat de knecht van de jagers roep.
Theo thinks that the servant of the hunters call.
 Els vermoedt dat de moeder van de baby's sla.
Els suspects that the mother of the babies hit.
 Thea zegt dat de kweker van de planten snoei.
Thea says that the nurseryman of the plants cut.
 Pieter denkt dat de acteur in de tragedies speel.
Peter thinks that the actor in the tragedies play.
 Els schrijft dat de schilder van de prenten teken.
Els writes that the painter of the pictures draw.
 Piet verneemt dat de docent van de lessen staak.
Pete learns that the teacher of the classes strike/stop.
 Ed ziet dat de kapitein van de zeerovers valaan.
Ed sees that the captain of the pirates attack.
 Herman hoort dat de secretaresse van de bedrijfsleiders bel.
Herman hears that the secretary of the company managers call.
 Tanja zegt dat de verkoper van de auto's rijd.
Tanja says that the salesman of the cars drive.
 Bert zegt dat de stoker van de ovens stook.
Bert says that the stoker of the ovens stoke.
 Karin zegt dat de vrouw met de kransen win.
Karen says that the woman with the garlands win.
 Johan hoopt dat de koper van de woningen betaal.
John hopes that the buyer of the dwellings pay.
 Frank zegt dat de tante van de jongens bel-op.
Frank says that the aunt of the boys phone-up.
 Esther zegt dat de hond van de zussen bijt.
Esther says that the dog of the sisters bite.
 Iemand zei dat de vader van de jongens geloof.
Someone said that the father of the boys believe.
 Kim beweert dat de man met de gitaren stem.
Kim asserts that the man with the guitars tune.
 John zegt dat de aanlegger van de snelwegen steek-over.
John says that the constructor of the highways cross.
 Joost begreep dat de bewoner van de kamers schilder.
Joost understood that the occupant of the rooms paint.
 Paul schrijft dat de fokker van de katten win.
Paul writes that the breeder of the cats win.
 Jan ziet dat de ontwikkelaar van de spoorbanen steek-over.
John sees that the developer of the railroads cross.
 Yvonne hoort dat de oom van de jongens schrijf.
Yvonne hears that the uncle of the boys write.
 Marieke denkt dat de kater van de buurvrouwen krab.
Marieke thinks that the tomcat of the neighbors scratch.
 Eva zegt dat de oppas van de jongens schop.
Eva says that the babysitter of the boys kick.
 Gerard gilt dat de hamster van de vriendinnen bijt.
Gerald screams that the hamster of the girlfriends bite.
 Arend roept dat de baas van de monteurs bel.
Arend shouts that the boss of the mechanics call.
 Gerda denkt dat de maker van de vazen steel.
Gerda thinks that the creator of the vases steal.
 Julia zegt dat de opa van de jongens roep.
Julia says that the granddad of the boys call/shout.

Andre zegt dat de begeleider van de studenten bel-op.
Andre says that the supervisor of the students call.
 Ilse schreeuwde dat de vrouw met de katten verdrink.
Ilse shouted that the woman with the cats drown.
 Harold verzint dat de aannemer van de winkels saboteer.
Harold makes up that the contractor of the shops sabotage.
 Karel zegt dat de teler van de appels betaal.
Carl says the breeder of the apples pay.
 Koos weet dat de directeur van de instellingen adviseer.
Koos knows that the director of the institutes advise.
 Arjan hoort dat de schrijver van de teksten vertaal.
Arjan hears that the writer of the texts translate.
 Cor zegt dat de monteur van de verwarmingen schilder.
Cor says that the mechanic of the heatings paint.
 Corine leest dat de moeder van de welpen val-aan.
Corine reads that the mother of the cubs attack.
 Claudia zegt dat de presentator van de shows betaal.
Claudia says that the presenter of the shows pay.

APPENDIX B: ITEMS IN EXPERIMENT 1B

We list here each item and its literal English translation in italics, the matrix clause, the subordinate clause in the prepositional phrase condition, and the verb stem. The object condition is derived by deleting each preposition.

Pieter denkt dat de spits van de tegenstanders spuug.
Peter thinks that the forward of the opponents spit.
 Esther zegt dat de uitvinder van de computers programmeer.
Esther thinks that the inventor of the computers program.
 Herman denkt dat de moeder van de jongens bel.
Herman thinks that the mother of the boys call.
 Yvonne beweert dat de directeur van de instellingen adviseer.
Yvonne states that the director of the institutions advice.
 Theo denkt dat de dame met de honden wenk.
Theo thinks that the lady with the dogs beckon.
 Harold hoort dat de secretaresse van de bedrijfsleiders bel.
Harold hears that the secretary of the managers call.
 Paul beweert dat de tante van de jongens belop.
Paul states that the aunt of the boys ringup.
 Koos hoort dat de jongen met de knikkers win.
Koos hears that the boy with the marbles win.
 Thea denkt dat de fokker van de katten win.
Thea thinks that the breeder of the cats win.
 Els denkt dat de baas de honden fluit.
Els thinks that the master of the dogs whistle.
 Andre hoort dat de verslaafde aan de drugs spuit.
Andre hears that the addict to the drugs shootout.
 Karin denkt dat de stoker van de ovens stook.
Karen thinks that the stoker of the ovens stoke.
 Jan beweert dat de hamster van de vriendinnen bijt.
John states that the hamster of the friends bite.
 Kim zegt dat de baas van de monteurs bel.
Kim says the boss of the mechanics call.
 Marieke beweert dat de beheerder van de zalen ruimop.
Marieke states that the caretaker of the halls cleanup.
 Ilse hoort dat de man met de gouden ringen steel.
Ilse hears that the man with the golden rings steal.
 Eva beweert dat de man met de honden train.
Eve states that the man with the dogs train.
 Frank zegt dat de koper van de woningen betaal.

Franks says that the buyer of the dwellings pay.
 Gerda hoort dat de vrouw met de kransen win.
Gerda hears that the woman with the garlands win.
 Bert zegt dat de hond van de zussen bijt.
Bert says the dog of the sisters bite.
 Tanja zegt dat de verkoper van de auto's rijdt.
Tanja says that the salesman of the cars drive.
 Julia hoort dat de liefhebber van de dranken bestel.
Julia hears that the connoisseur of the drinks order.
 Joost zegt dat de opa van de buurjongens roep.
Joost says that the grandfather of the boys next door call.
 Arend beweert dat de pastoor van de dorpelingen groet.
Arend states that the priest of the villagers greet.
 Johan zegt dat de oppas van de jongens leesvoer.
John says that the baby sitter of the boys readto.
 Arjan hoort dat de leeuwin met de welpen val/aan.
Arjan hears that the lioness with the cubs attack.
 Gerard beweert dat de medeplichtige aan de misdaden beken.
Gerald states that the accomplice to the crimes confess.
 Ed denkt dat de opsteller van de verklaringen lieg.
Ed thinks that the drafter of the declarations lie.

APPENDIX C: ITEMS IN EXPERIMENT 2

We present here the antecedent, the preamble in the plural, object condition, and the verb. In the full NP-condition the pronominal object is replaced by the antecedent.

| | |
|----------------------|---|
| De jagers | Theo denkt dat de knecht hen roep. |
| <i>The hunters</i> | <i>Theo thinks that the servant them call.</i> |
| De baby's | Els vermoedt dat de moeder hen sla. |
| <i>The babies</i> | <i>Els suspects that the mother them hit.</i> |
| De planten | Thea zegt dat de kweker ze snoei. |
| <i>The plants</i> | <i>Thea says that the nurseryman them cut.</i> |
| De tragedies | Pieter denkt dat de acteur ze speel. |
| <i>The tragedies</i> | <i>Peter thinks that the actor them play.</i> |
| De prenten | Els schrijft dat de schilder ze teken. |
| <i>The pictures</i> | <i>Els writes that the painter them draw.</i> |
| De lessen | Piet verneemt dat de docent ze staak. |
| <i>The lessons</i> | <i>Pete learns that the teacher them strike/stop.</i> |
| De zeerovers | Ed ziet dat de kapitein hen valaan. |
| <i>The pirates</i> | <i>Ed sees that the captain them attack.</i> |
| De bedrijfsleidsters | Herman hoort dat de secretaresse hen bel. |
| <i>The managers</i> | <i>Herman hears that the secretary them phone.</i> |
| De auto's | Tanja zegt dat de verkoper ze rijdt. |
| <i>The cars</i> | <i>Tanja says that the salesman them drive.</i> |
| De ovens | Bert zegt dat de stoker ze stook. |
| <i>The ovens</i> | <i>Bert says that the stoker them stoke.</i> |
| De kransen | Karin zegt dat de vrouw ze win. |
| <i>The garlands</i> | <i>Karen says that the woman them win.</i> |
| De woningen | Johan hoopt dat de koper ze betaal. |
| <i>The dwellings</i> | <i>John hopes that the buyer them pay.</i> |
| De dames | Frank zegt dat de tante hen bel-op. |
| <i>The ladies</i> | <i>Frank says that the aunt them phone-up.</i> |
| De zussen | Esther zegt dat de hond hen bijt. |
| <i>The sisters</i> | <i>Esther says that the dog them bite.</i> |
| De jongens | Iemand zei dat de vader hen geloof. |
| <i>The boys</i> | <i>Someone said that father them believe.</i> |
| De gitaren | Kim beweert dat de man ze stem. |
| <i>The guitars</i> | <i>Kim asserts that the man them tune.</i> |

| | |
|--|--|
| De snelwegen <i>The highways</i> | John zegt dat de aanlegger ze steekover. <i>John says that the constructor them cross.</i> |
| De woningen <i>The dwellings</i> | Joost begreep dat de bewoner ze schilder. <i>Joost understood that the occupant them paint.</i> |
| De katten <i>The cats</i> | Paul schrijft dat de fokker hen win. <i>Paul writes that the breeder them win.</i> |
| De spoorbanen <i>The railroads</i> | Jan ziet dat de ontwikkelaar ze steekover. <i>John sees that the developer them cross.</i> |
| De jongens <i>The boys</i> | Yvonne hoort dat de oom hen schrijf. <i>Yvonne hears that the uncle them write.</i> |
| De buurvrouwen <i>The neighbors</i> | Marieke denkt dat de kater hen krab. <i>Marieke thinks that the tomcat them scratch.</i> |
| De jongens <i>The boys</i> | Eva zegt dat de oppas hen schop. <i>Eva says that the babysitter them kick.</i> |
| De vriendinnen <i>The girlfriends</i> | Gerard gilt dat de hamster hen bijt. <i>Gerald screams that the hamster them bite.</i> |
| De typistes <i>The typists</i> | Arend roept dat de baas hen bel. <i>Arend shouts that the boss them phone.</i> |
| De vazen <i>The vases</i> | Gerda denkt dat de maker ze steel. <i>Gerda thinks that the creator them steal.</i> |
| De leraresen <i>The teachers</i> | Julia zegt dat de opa hen roep. <i>Julia says that the granddad them call.</i> |
| De studenten <i>The students</i> | Andre zegt dat de begeleider hen bel-op. <i>Andre says that the supervisor them phone-up.</i> |
| De katten <i>The cats</i> | Ilse schreeuwde dat de vrouw hen verdrink. <i>Ilse shouted that the woman them drown.</i> |
| De garages <i>The garages</i> | Harold verzint dat de aannemer ze saboteer. <i>Harold makes up that the contractor them sabotage.</i> |
| De appels <i>The apples</i> | Karel zegt dat de teler ze betaal. <i>Charles says that the breeder them pay.</i> |
| De actrices <i>The actresses</i> | Koos weet dat de directeur hen adviseer. <i>Koos knows that the director them advise.</i> |
| De discussies <i>The discussions</i> | Arjan hoort dat de schrijver ze vertaal. <i>Arjan hears that the writer them translate.</i> |
| De verwarmingen <i>The heatings</i> | Cor zegt dat de monteur ze schilder. <i>Cor says that the mechanics them paint.</i> |
| De kapsters <i>The hairdressers</i> | Corine leest dat de moeder hen valaan. <i>Corine reads that the mother them attack.</i> |
| De shows <i>The shows</i> | Claudia zegt dat de presentator ze betaal. <i>Claudia says that the presenter them pay.</i> |

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