

An ERP Investigation of Binding and Coreference

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This study examines the nature of violations in processing one class of binding construction, namely those involving reflexives and their antecedents. When arguments of verbs appear at the point where a syntactic violation is detected, a centro-parietal positivity occurs, peaking at 600 ms after the presentation of the stimulus (P600), as is consistent with other types of syntactic anomalies. However, nonarguments in similar sentences fail to elicit the same response. For example, the reflexive in *John's brothers like himself* is in an argument position and elicits the P600 when compared to its grammatical counterpart. The nonargument, participating in the same type of mismatch, *John's brothers like Bill and himself*, does not elicit the same positivity. This provides evidence that there are two processes involved in parsing this binding construction, one syntactic and another as yet unidentified, perhaps involving meaning or pragmatics. © 2000 Academic Press

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INTRODUCTION

Linguistic theory is primarily concerned with determining the structure for certain phrases and how that structure disallows erroneous permutations while allowing others. The nature of the operations that govern permutations are not specified with respect to the underlying neuronal processes. Yet, for any given linguistic phenomenon, there are a sizable number of plausible

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theories that account for it. It is reasonable that some of these theories are going to be more compatible with the fashion that the brain deals with language than others. Therefore, although it is not the current practice, in principle, physiological evidence could help to choose among theories and may even contribute to the creation of a new theory.

One technique that has shown promise in this regard is event-related brain potentials (ERPs). ERPs are changes in voltage recorded at the scalp which are time-locked to specific stimulus events. When such events fall into one of two conditions that differ along a single factor, it can be surmised that differences in the two patterns of electrical activity is a reflection of a difference along this factor. Using this logic, recent experiments involving ERPs have shown a sensitivity to certain grammatical and semantic processes in spoken and written language (see Osterhout & Holcomb, 1993, for a review). Briefly, it has been shown that a negative-going wave with a peak latency of 400 ms (N400) is larger in amplitude to words that are not supported by a given semantic context. So, for example, words in isolation, words toward the beginnings of sentences, and especially semantically anomalous words (in sentences) all produce large N400s (e.g., Kutas & Hillyard, 1980; Van Petten & Kutas, 1990). One interpretation of this pattern of findings is that the N400 reflects the process of semantic integration—the more difficult this process, the larger the N400 (e.g., Holcomb, 1993). Conversely, a different ERP component, the P600 (a positive-going wave peaking around 600 ms), has been shown to be sensitive to certain syntactic processes (e.g., Osterhout & Holcomb, 1992; Hagoort, Brown, & Groothusen, 1993), its relative amplitude being larger whenever a reader or listener detects a structural violation.

At this point in history, we can begin to apply this tool to map linguistic phenomena to neurological processes. The current study is concerned with the status of certain linguistic elements as *arguments*. The notion of argumenthood in linguistic theory is basic because certain syntactic constraints apply only to arguments and *can* only apply to arguments. A definition of arguments is deferred for the moment. It remains to be seen whether this notion is simply an artifact of theory building or whether it is reflected in neurology.

In the current study, Argument-Based Binding Theory,¹ as described by Reinhart and Reuland (1993), provides the means of exploring this phenomenon. *Binding* relations express a certain kind of dependency among elements of a sentence. The distribution of words like *himself* and *each other* in sentences respects some rather strict constraints. There are a number of proposals that attempt to characterize these restrictions. Argument-Based Binding

¹ Our appellation, not Reinhart and Reuland's, to draw attention to this experimentally crucial feature. With respect to other Binding Theories, it might best be distinguished as "predicate-based."

Theory posits that the restrictions are a combination of both syntactic and pragmatic constraints. The nature of these constraints is not obvious from judgments of well-formedness, on which this proposal is based. There is no one-to-one pairing of judgments to underlying mechanisms; Argument-Based Binding derives the syntactic/pragmatic distinction from theoretical considerations. Since ERPs have been shown to be sensitive to syntactic and nonsyntactic violations of expectancy, they may help determine whether the theory is partitioning English anaphora in the right way.

Before any theoretical considerations can be undertaken, it must be observed whether there is a characteristic ERP response to binding violations, as has been the case for subject–verb agreement (Hagoort, Brown, & Groothusen, 1993), gender/number mismatch (Osterhout & Mobley, 1995), and phrase structure violations (Neville et al., 1991; Osterhout & Holcomb, 1992). This is the first aim of the current study. Given that, what is the nature of the response? Since binding relations are also relations of coreference,² the second purpose of this study is to determine whether such violations are primarily syntactic or meaning-related. Finally, if there are indications of both syntactic and pragmatic violations, are these dependent on the notion of argumenthood? In other words, are the responses to violations distributed along the lines predicted by Argument-Based Binding Theory?

DISTRIBUTION OF ANAPHORA

Binding Theory (Chomsky, 1981; Higginbotham, 1980; Manzini, 1992) is about the distribution of items which do not have inherent reference. For example, certain pronouns³ (e.g., *him*, *her*) and reflexives (e.g., *himself*, *herself*) are not meaningful without being bound to something with reference, whereas *John* or *book* alone pick out entities in the world. As is discussed in greater detail below, pronouns and reflexives usually occur in complementary distribution. An asterisk indicates an ungrammatical utterance. Noun phrases bearing the same index are coreferential.

- (1a). Mary_i forgave herself_i.
- (1b). *Mary_i forgave her_i.
- (1c). *Mary_i forgave herself_j.
- (1d). Mary_i forgave her_j.

When *Mary* and the direct object refer to the same person, a reflexive pronoun is permissible as direct object (1a), but a pronoun is not (1b). When *Mary* and the direct object refer to different people, only a pronoun is permis-

² When two linguistic elements corefer, they pick out the same real-world entity. Notice that coindexed elements needn't pick out real-world entities: "No one saw himself in the mirror" (Alec Marantz, personal communication).

³ Pronouns here refer to pronouns with nonanaphoric reference.

sible as a direct object (1d). This complementarity of pronoun and reflexive is observed in all but a few notable cases, such as the following.

(2a). John_i kept the gun near him_i/himself_i at all times.

(2b). John_i knew no one liked Bill and him_i/himself_i after what had happened.

If the general rule is that a reflexive cannot appear where a pronoun can appear, what is it about the sentences in (2) that allows either to appear in object position? The proposal by Reinhart and Reuland (1993) casts the reflexives in (1) as arguments of the verbs they follow, whereas in (2), they are not arguments. What constitutes an argument is described shortly. The key idea is that the syntactic constraint governing the distribution of these reflexives applies only to arguments. Thus, complementary distribution of such pronouns holds in examples like (1), but is not necessarily observed in sentences like (2).

The proposed argument/nonargument distinction provides an opportunity to investigate cases in which reflexives either violate or respect syntactic constraints and cases in which they are free of such constraints. In the following sections, we trace an outline of this view of Binding Theory. We then review some of the relevant ERP literature to assess the known types of electrophysiological responses to linguistic stimuli. Using this information, we arrive at a methodology for asking about the types of violations evoked by illicit binding constructions.

BINDING THEORY

A theory of binding describes the syntactic restrictions on when pronouns in a sentence can refer to the same person or thing. Below is a brief description of the aspects relevant to the current experiment and the terminology used.

An anaphor is a referentially dependent noun phrase (NP). This class, by definition, includes reflexives (3a) and reciprocals (3b). An anaphor bearing the same index as an NP (and in a certain configuration with the NP) is said to be *bound* (to the NP). In (3a), the reflexive *himself* is bound to the NP *John* and in (3b) the reciprocal *each other* is bound to the NP *John and Mary*.

(3a). John_i likes himself_i.

(3b). [John and Mary]_i like [each other]_i.

Condition A

Condition A of Binding Theory says that reflexive arguments must have a coindexed coargument in their predicates.⁴ The examples that follow use brackets to indicate the relevant predicate.

⁴ See Appendix A for a more formal definition.

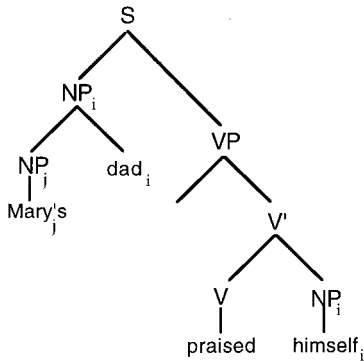


FIG. 1. (5a). *Mary's dad_i praised himself_i.*
 (5b). **Mary's_s dad praised herself_i.*

- (4a). *John_i said that [he_i saw himself_i].*
- (4b). **John_i said that [Mary saw himself_i].*
- (4c). *John said that [Mary_i saw herself_i].*

Sentence (4a) is an acceptable construction because in the relevant domain for *himself*, there is a coargument, namely *he*. Sentence (4b) is ungrammatical because *Mary* cannot serve as any such coargument and *John* is not in the local domain. In (4c), where *Mary* agrees in gender with *herself*, the anaphor is properly bound.

There are structural conditions which can have an effect here as well as the domain-specific type just seen. Consider (5) in Fig. 1.

In (5), the whole sentence seems to be the relevant domain, yet in (5b) the necessary antecedent is unavailable. This is because the subject NP receives its index (or identity) from its head, which is *dad*. The coargument of *herself* is therefore *dad* and not *Mary*. In other words, Condition A does not “see” *Mary*.⁵

In summary, example (5) shows that there is a structural requirement at work in the syntax, which exists in addition to the locality requirement seen in (4).

Argument/Nonargument Distinction

All of the preceding examples have had the anaphor in an argument position. This was done purposefully because our Condition A only applies to arguments. An argument position is one which is licensed by the verb. Its

⁵ Readers familiar with Binding Theory may note that this characterization does not rely on the notion of c-command, although what has been presented so far is compatible with it (Reinhart, 1976; Aoun & Sportiche, 1983; Chomsky, 1981).

appearance is mandatory. For example, in (6) and (7), “the book” is an argument of both “put” and “saw” (cf. **John put* and **John saw*).

- (6). John put the book on the table.
 (7). John saw the book on the table.

The locative phrase *on the table*, however, is an argument only for *put*, as can be seen by its optional deletion only with *saw*.

- (8). *John put the book.
 (9). John saw the book.

Similarly, an object may be omitted after the verb *eat* (12), but cannot be omitted after the verb *kissed* (13).

- (10). John ate.
 (11). *John kissed.

This is an aspect of language use which does not follow from discourse considerations. Sentence (10) is taken to mean John ate something, but that something need not be mentioned. Similarly, in principle (11) could be taken to mean John kissed someone, but in fact, *kissed* is not used in this way. The surface argument structure (e.g., syntactically required objects) of a verb is not determined solely by semantics.

The syntactic dichotomy between arguments and nonarguments is stressed here because this notion is the real focus of investigation in this article, while Argument Based Binding Theory is only the means.

Logophoricity

We now turn to examining reflexives in nonargument positions. Below is a minimal pair in which both a reflexive and a pronoun are in argument positions.

- (12a). Max likes jokes about him.
 (12b). Max likes jokes about himself.

In (12a), the reflexive is an object of a preposition, not a verb. *Jokes about him* is the object of the verb. *About him/himself* is predicated of *jokes* and not *likes*. Reflexives like the one in (12a), which are not arguments of their predicates,⁶ are called *logophors*, and they are interchangeable with appropriate pronouns.⁷

Another way in which an anaphor escapes being the argument of a verb

⁶ For our purposes, predicates must contain verbs.

⁷ “Appropriate” means only that such a logophor and the pronoun will share gender and number features, because those are among the semantic features of the shared referent.

is by being in a conjoined argument phrase, as in (13b). The conjoined phrase is the object (argument) of the predicate; neither of its constituents is the object (argument).

(13a). *Max said the queen invited [himself] to tea.

(13b). Max said the queen invited [Lucie and himself] to tea.

(13c). Max said the queen invited [Lucie and him] to tea.

In (13a), *himself* is an argument of *invited* but does not have a co-indexed coargument in its syntactic domain. That is, although *Max* could be co-indexed with *himself*, *Max* is not in the local domain of *himself*. Thus (13a) is ruled out by Condition A. In (13b), [Lucie and himself] is an argument of *invited*, not [Lucie] and [himself] as individual elements. *Himself* is not a syntactic argument and is free to vary with the pronoun *him*, as in (13c).

(14). The pilot's_i mechanics browbeat Max and himself_i after the race.

The conjoined reflexive (logophor) is subject to some constraint, however, since (14) is not acceptable, according to Reinhart and Reuland. There is an intuition that *pilot* isn't really who the sentence is about and that it isn't a proper antecedent for the logophor. This is a kind of discourse constraint that works independent of the syntax. For present purposes, we avoid attempting a formalization of this [see Kuno (1987) and Zribi-Hertz (1989)]. There seems to be some variability in speakers' judgments of this type of construction. The only important fact here is that whatever constrains the logophor, it is not Binding Theory or any other syntactic constraint. Any violation involving a logophor should therefore be extrasyntactic.

THE CURRENT STUDY

This discussion leaves us in a position to make some hypotheses about the electrophysiological responses that might arise from binding violations.

(15a). John likes himself.

(15b). John likes *him.

In (15b) *him* ought to elicit a posterior positivity with respect to (15a). However, any difference observed may be due to the difference in lexical items alone. It seems that we must use reflexives:

(16a). John likes himself.

(16b). John likes *herself/*themselves.

There are two problems here. One is differing lexical items,⁸ the other arises from the possibility that the violation is due to gender or number mismatch

⁸ A difference in ERPs can be expected simply because the stimuli are different and not due to experimental manipulation. This would potentially increase Type II error.

and not to Condition A alone. In fact, Osterhout and Mobley (1995) report an experiment which used sentences like (17):

(17a). The actress served herself/*themselves at the luncheon.

(17b). The actresses served *herself/themselves at the luncheon.

This construction eliminates the problem of measuring across different lexical items since the singular and plural reflexive appear an equal number of times in both grammatical and ungrammatical sentences. The violation arises due to an intended coreference between the reflexive and the subject. However, it does not eliminate the possibility of a second (unnamed) referent which the experimental subject assumes to be the antecedent for the reflexive. Depending on the subject's interpretation, either a feature mismatch or a binding violation may be responsible for any ungrammaticality. Indeed, fixing the referent may have been a crucial element in this task, which was grammaticality judgment. When subjects in a second experiment were asked to simply read the stimuli for comprehension, the mismatch sentences did not elicit a P600. Subject-verb mismatches in the same experiment did. Thus, agreement mismatches alone may not be sufficient to elicit a P600 in antecedent reflexive constructions. Failing to find a referent or co-indexing with the wrong referent may be what is required [see Osterhout & Mobley, 1995, for discussion].

What is needed is a comparison in which two possible referents are made explicit and one is ungrammatically linked to the reflexive [see (18)]. The task for the subjects must be to determine whether the subject or the possessive modifier is receiving the action of the sentence, using number agreement as the relevant clue. This will increase the likelihood that the subjects make the intended coreference and experience a Condition A violation in (18a).⁹

(18a). *John's_i brothers like [himself_i].

(18b). John's brothers_i like [themselves_i].

This provides the needed comparison of syntactic arguments. Next, we need a similar comparison using logophors. Where the anaphor in argument position is bad, the coargument ought to be good or bad for nonsyntactic reasons.

(19a). #John's_i brothers like [Bill and himself_i].

(19b). John's brothers_i like [Bill and themselves_i].

In (18a), Condition A rules this out. It requires *himself* to have a coargument in its predicate, but the only possible antecedent, *John*, is not an argument of the predicate. In (19a), Binding Theory does not play a role here.¹⁰ Condi-

⁹ If subjects nevertheless experience an agreement violation, then we should expect no difference in the evoked potentials from (18) and (19).

¹⁰ Condition B applies only to reflexive predicates, and the indexing indicates that the arguments of the predicate are not coreferential. Condition B does not apply here.

tion A only applies to reflexive-marked predicates, and the logophor does not do this, at least at a syntactic level. If this sentence is awkward, it is due, supposedly, to the fact that the pragmatic center of the sentence (the subject) is not coreferential with the logophor. This sort of discourse requirement is outside the domain of syntactic considerations.

Therefore, the prediction is that the brain potentials elicited by the reflexives in (18) will be different from those of (19). Drawing further on the ERP literature, it seems reasonable to assume that Binding Theory violations (18) will elicit a pattern similar to those resulting from other syntactic violations, namely the P600. The waveform predicted to arise from a pragmatic violation (19) is trickier. Without a formal characterization of the pragmatic requirements on anaphora (and without a relevant body of ERP experimentation), it is difficult to know what to expect. Perhaps since pragmatics are related to meaning and discourse integration, some N400 type of effect might be predicted. However, if there are idiosyncratic variations in evaluating pragmatic constraints, or if there is individual variation in localization of function, we would expect that any effect would wash out in averaging.

METHODS

Subjects

Forty volunteers participated in this study (22 female). Ages ranged from 18 to 29 ($M = 20$). All were right-handed, native speakers of English with normal or corrected-to-normal vision. Subjects either participated for course credit or were paid.

Materials

One hundred twenty quadruplet sets of sentences were constructed after the fashion of (20), for a total of 480 sentences.

- (20a). The pilot's mechanics brow-beat themselves after the race.
- (20b). The pilot's mechanics brow-beat himself after the race.
- (20c). The pilot's mechanics brow-beat Paxton and themselves after the race.
- (20d). The pilot's mechanics brow-beat Paxton and himself after the race.

A possessive noun preceded the subject. One was singular and one was plural. The grammatical number of these items were counterbalanced. The third word was the verb. The verbs were chosen to be optionally transitive or reflexive, but subcategorization frequencies were not controlled. The fifth word was either a disagreeing/agreeing anaphor or a conjoined phrase consisting of a proper noun and disagreeing/agreeing logophor. Following was a prepositional phrase. The prepositional phrases varied in length and content across quadruplets, but not within quadruplets.

Notice that in (20b), for example, the subject must accept some kind of grammatical error upon reading the reflexive, either preserving the subject as argument and violating number agreement (*mechanics* as antecedent) or violating the subject-as-argument restriction and preserving number agreement (*pilot* as antecedent). Subjects were instructed to rely on number agreement to determine who received the action of each sentence. (See Appendix A for instructions given.) In short, the subjects were told that each subject contained a singular noun and

a plural noun. The reflexive would be either singular or plural. The task is to determine who received the action of the sentence based on number agreement. Since the options in the subsequent question were always the two nouns in the subject and presented in the same order, experimental subjects were encouraged to anticipate the question and response. It was hoped that by encouraging subjects to make this determination at the time of reading the reflexive, the intended coreference would be made, regardless of whether there were a binding theory violation. Indeed, it was part of the design that subjects who did not make the intended coreference, as revealed by their accuracy in answering questions (to all conditions), would not be included in the final analyses.

Four lists of stimuli were used, and each contained exactly one member of each quadruplet set. Each subject saw only one list. Therefore, a given subject read 60 sentences containing anaphors. Half of these anaphors disagreed in number with the subjects. Half (30) of the subjects were plural. The same counterbalancing existed in the logophor sentences.

There were also 30 filler sentences per list. These were sentences from an unrelated experiment, and one-third of these were followed by questions, as in the main experiment. All of these items were grammatical, although half were designed to elicit some mild processing difficulty.

Procedure

The subject was seated in an arm chair before a computer screen. Each trial began with a fixation point in the center of the screen, which lasted 500 ms. It was followed by the first word of the trial sentence. Each word appeared centered on the screen for 300 ms, followed by a blank screen for 350 ms. The screen was blank 1350 ms following the last word, which was indicated by a period following the last letter. In one-third of the trials, immediately following were a comprehension question and two possible answers, which appeared in their entirety. The presentation of a question was pseudorandomized.

(21a). The pilot's mechanics brow-beat himself after the race.

(21b). Who was brow-beaten after the race? pilot(s)/mechanic(s).

The task was to push either the left or the right button on a button box held in the lap. The question remained on-screen until the subject responded. In this example, the answer to (21b) would be the depression of the left button, since *pilot(s)* is the leftmost of the two choices. The number of the two choices was made ambiguous, as in (21b), in order to force the subjects to match the reflexive to the antecedents and not to simply match number features. In other words, it wasn't enough to remember that the subject was plural and match it to the plural choice of answers. In order to reduce the difficulty of the task, the noun answers were always presented in the same order as the nouns had appeared in the sentence.

A 10-trial practice session preceded the experimental run. The stimuli had the same structure as the experimental run, except that half of the reflexives did not agree with their subjects' genders instead of number. Subjects were given feedback regarding their accuracy. Any subject making two or more mistakes repeated all practice trials.

Data Acquisition

The International 10-20 System was used for scalp sites including midline sites (Fz, Cz, and Pz) and four lateral sites (F7, F8, O1, and O2). Six nonstandard placements were also used. WL and WR: left and right temporoparietal cortex (30% of the interaural distance lateral to a point 13% of the nasion-inion distance posterior to Cz); TR and TL: left and right temporal cortex (33% of the interaural distance lateral to Cz; ATR and ATL: one-half the distance between F7-F8 and T3-T4). Eye movements and blinks were monitored by means of an electrode beneath the left eye and one to the right of the right eye. The reference electrode

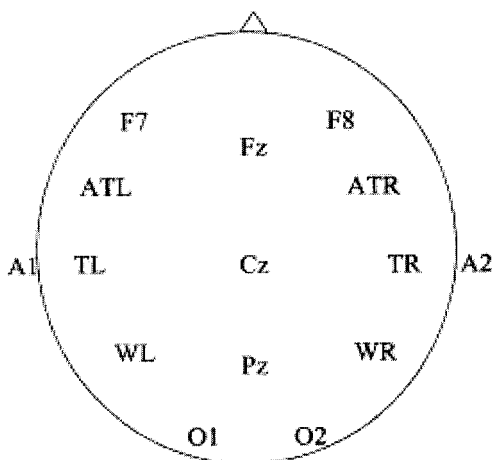


FIG. 2. Electrode deployment.

was placed on the left mastoid bone. A second electrode on the right mastoid was used to determine whether lateral asymmetries arose due to the use of the single reference electrode. Electrode potentials were amplified by a Grass Model 12 amplifier with a bandpass of 0.01 to 100 Hz (3-db cutoff).

Data Analysis

Because our hypotheses concerned the P600 and the N400, our comparisons were based on measurements taken only in windows surrounding those peaks. For N400 effects, we measured between 350 and 450 ms. For P600 effects, which are slow waves, we used a larger window, 550 to 750 ms. Because of possible component overlap, we did not attempt to use larger windows. The comparisons are based on average amplitude within those windows.

A two-way repeated-measures ANOVA was conducted for all sites (29 levels of electrode position) and then separately for midline sites (3 levels of electrode position: frontal, central, and parietal) with two levels for agreement. Lateral sites were examined using a three-way repeated-measures ANOVA involving two levels for agreement, two levels of hemisphere, and five electrode positions. The Huynh-Feldt correction was applied to effects involving more than one degree of freedom. Nonsignificant results are not reported unless specifically predicted.

RESULTS

Data were processed from 40 subjects. Performance in answering questions ranged from 57 to 97% accuracy. Subjects with the lowest accuracy scores obviously failed to perform the task. They were removed from analysis. In order to avoid a gratuitous acceptance criterion, only the top half of subjects were evaluated. King and Kutas (1996) have shown that interpretable effects seen in the data of good comprehenders are absent from poor

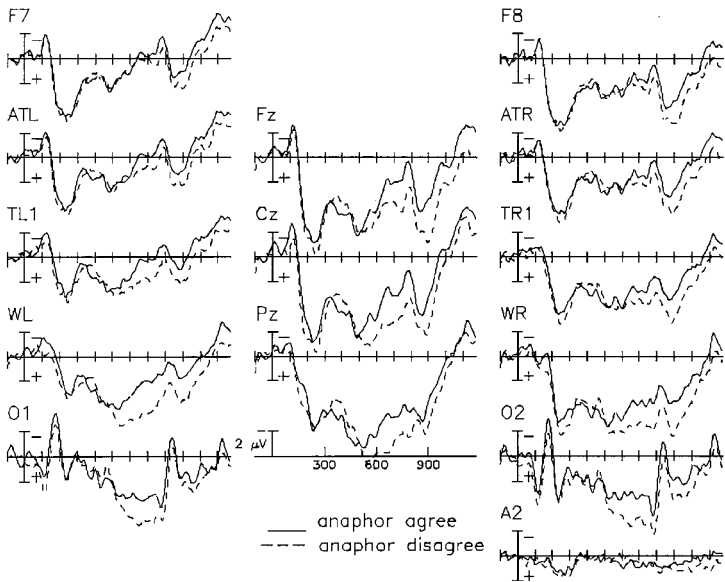


FIG. 3. ERPs from anaphor-agree vs anaphor-disagree comparison, good comprehenders. The 0 mark corresponds to presentation of the anaphor.

comprehenders' data. The good comprehenders in this study had accuracy scores at or above 84%.

Within-Reflexive-Type Comparisons (Agree vs Disagree)

Anaphor-Agree vs Anaphor-Disagree Comparison

P600 window (550–750 ms). Plotted in Fig. 3 are the ERPs following the presentation of the anaphor from the disagreeing and agreeing conditions. This would be “John’s brothers fed *himself*” vs “John’s brothers fed *themselves*.” The prediction was a positivity peaking at 600 ms. Repeated-measures ANOVA over all cortical sites showed an effect for condition (more positivity when the reflexive disagreed with the sentential subject than when it agreed) [$F(1, 19) = 4.46, p < .05$]. There was an interaction of condition and electrode site [$F(12, 228) = 2.77, p = .002$]. An ANOVA for 10 lateral sites showed an effect for hemisphere [$F(1, 19) = 11.33, p < .01$]. While the difference between conditions for left sites was greater than those for the right (1.06 vs 0.56) there was no condition by hemisphere interaction [$F(1, 19) = 1.19, p = .289$]. A MANOVA for midline sites (Fz, Cz, and Pz) showed an effect of condition [$F(1, 19) = 6.78, p = .017$].

N400 window (350–450 ms). As can be seen in Fig. 3, differences between the conditions in this epoch were small or nonexistent. They were not statistically reliable ($p < .157$).

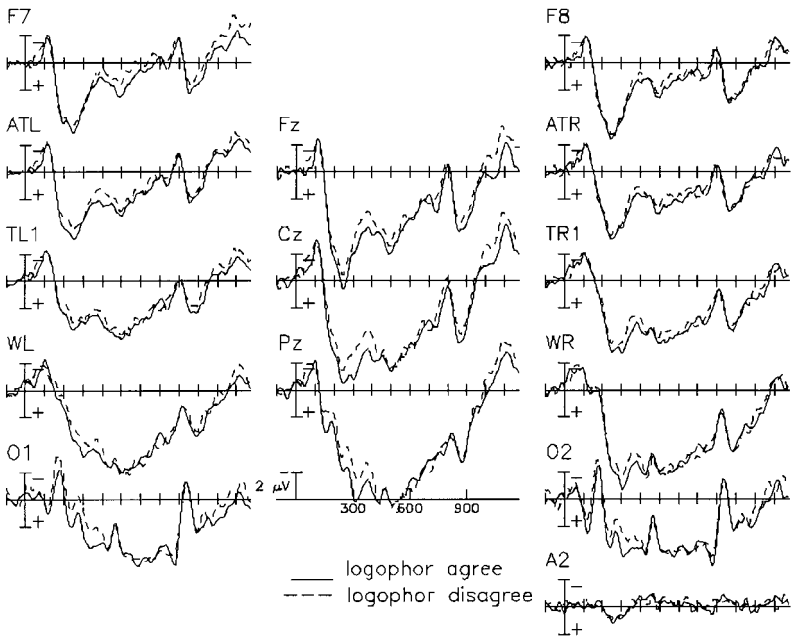


FIG. 4. ERPs from logophor-agree vs logophor-disagree comparison, good comprehenders. The 0 mark corresponds to presentation of the logophor.

Logophor-Agree vs Logophor-Disagree

P600 (550–750 ms). Plotted in Fig. 4 are the ERPs following the presentation of the logophor from the disagreeing and agreeing conditions. This would be “John’s brothers fed Bill and *himself*” vs “John’s brothers fed Bill and *themselves*.” The prediction was no P600 effect and perhaps an N400. As can be seen in Fig. 4 there are few if any differences in this epoch. This observation was borne out in the ANOVA; there were no significant effects involving the condition variable ($p > .57$) other than a marginal effect for hemisphere [$F(1, 19) = 3.85, p = .065$].

N400 (350–450 ms). A repeated-measures ANOVA over all cortical sites showed no effect for condition [$F(1, 19) = .40, p = .53$] and no condition \times site interaction [$F(12, 228) = .25, p = .99$]. An N400 trend appeared to be developing, most prominently manifest at the midline sites. An ANOVA for midline sites (Fz, Cz, and Pz) showed no effect of condition [$F(1, 19) = .54, p = .471$].

Between-Reflexive-Type Comparisons (Anaphors vs Logophors)

Our design created agree–disagree comparisons which involved sentences that were structurally identical; only agreement differences signaled referen-

tial possibilities, and these differences were counterbalanced. In order to make these comparisons possible, this design forfeits the means of making clean between-type (i.e., anaphor vs logophor) comparisons. However, we present them with the following caveats.

Structural Differences

ERP differences may be due simply to whether the reflexive was in a conjoined NP vs a nonconjoined NP.

Baseline Differences

The preceding two words are different for the two types (i.e., the logophor was always preceded by the conjunction *and* and the anaphor was always preceded by a verb). Such differences may carry over into the ERP epoch of the word of interest, making unambiguous interpretation of results difficult.

Cloze Probability

Kutas and Hillyard (1983) report that the negativity elicited by a word is inversely proportional to the predictability of the word given its context. In the current experiment, an anaphor appeared directly after the matrix verb 50% of the time, whereas the logophor appeared after an “and” 100% of the time. Therefore, the logophor might be expected to elicit less negativity¹¹ than the anaphor, due to predictability alone.

Logophor-Agree vs Anaphor-Agree Comparison

P600 window 550–750 ms. Plotted in Fig. 5 are the ERPs following the presentation of the logophor and the anaphor from the agreeing conditions. This would be “John’s brothers fed Bill and *themselves*” vs “John’s brothers fed *themselves*.” The binding theory we studied predicts no P600 here and makes no other predictions. A positivity for the logophor is predicted by Cloze probability considerations (see Discussion). A repeated-measures ANOVA over all cortical sites showed an effect for the interaction of condition \times site [$F(12, 228) = 4.16, p = .004$]. In the lateral analysis, there was an effect for hemisphere [$F(1, 19) = 13.13, p = .002$] and a marginal hemisphere \times condition interaction [$F(1, 19) = 4.1, p = .057$]. Hemispheric differences were stronger (more positive) for the anaphor–agree condition.

¹¹ Or more positivity, as is produced by a P300. Note, however, that the observed positivity is not related to the appearance of a stimulus, but to a type of word, namely any instance of a reflexive—this seems to be a higher level than P3.

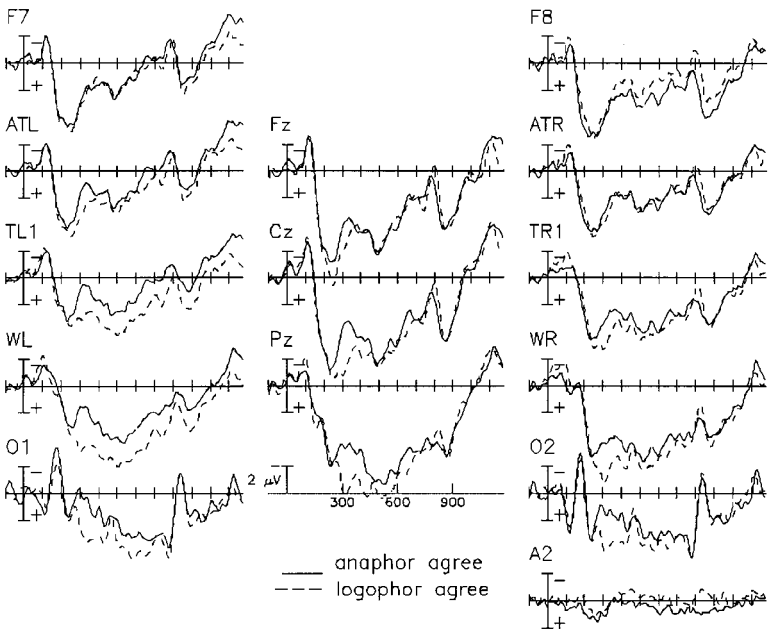


FIG. 5. ERPs from anaphor-agree vs logophor-agree comparison, good comprehenders. The 0 mark corresponds to presentation of the reflexive.

N400 window 350–450 ms. A repeated-measures ANOVA showed an effect for the condition \times site interaction [$F(12, 228) = 6.19, p < .001$] for all cortical sites as well as for the midline [$F(2, 38) = 8.23, p = .008$].

Anaphor-Disagree vs Logophor-Disagree Comparison

P600 window (550–750 ms). Plotted in Fig. 6 are the ERPs following the presentation of the anaphor and the logophor from the disagreeing conditions. This would be “John’s brothers fed Bill and *himself*” vs “John’s brothers fed *himself*.” The prediction would be a P600 for the anaphor because the mismatch for the logophor is not syntactic in nature. A repeated-measures ANOVA over all cortical sites shows no effect for condition (whether the reflexive was an anaphor or logophor) [$F(1, 19) = .01, p = .915$]. [The discussion section suggests that the positivity associated with Cloze probability (logophor condition) masks the effect].

N400 window (350–450 ms). A repeated-measures ANOVA over all cortical sites showed an effect for condition [$F(1, 19) = 5.84, p = .026$] and an effect for the condition \times site interaction [$F(12, 228) = 6.16, p = .001$]. There was also a condition \times site interaction for the midline [$F(2, 38) = 11.03, p = .003$]: In the lateral analyses, there was no effect for hemisphere

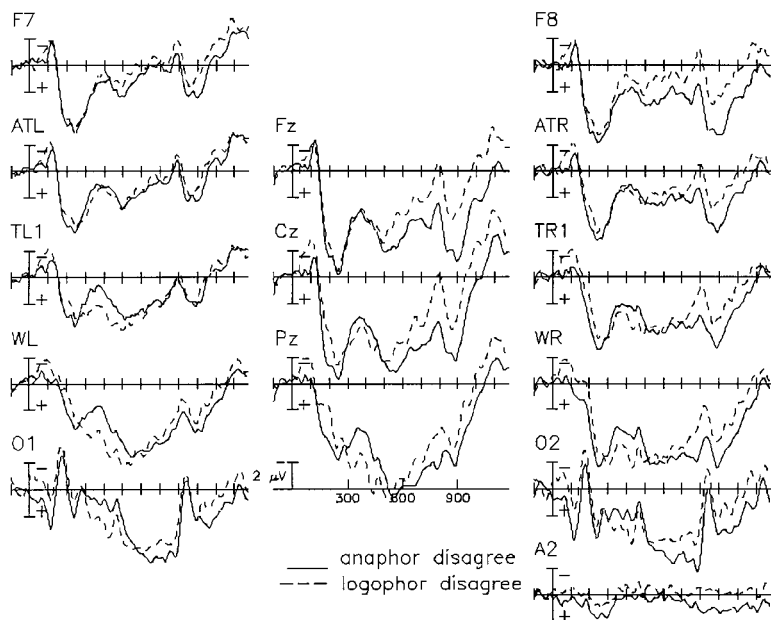


FIG. 6. ERPs from anaphor-disagree vs logophor-disagree comparison, good comprehenders. The 0 mark corresponds to presentation of the reflexive.

[$F(1, 19) = 3.03, p = .098$] and none for the hemisphere \times condition interaction [$F(1, 19) = .40, p = .54$].

DISCUSSION

The responses given by poor comprehenders indicated that they did not parse the sentences with the intended coreference. Thus their data are not meaningful with respect to the experimental hypotheses. In addition, there was a significant effect of the group factor in two comparisons when both groups were examined together. We conclude therefore that only the data from the good comprehenders bear on the hypotheses under consideration, and we center our discussion on their results.

Agree-Disagree Comparisons

The argument/nonargument distinction presented in Reinhart and Reuland (1993), coupled with evidence from the ERP literature, suggests that a P600 should be expected in the anaphor-agree/-disagree conditions. This was borne out. This alone is of significance in that this is the first observation of the effect of a Binding Theory violation, and it seems to pattern after the effect observed in agreement violations (Hagoort, Brown, & Groothusen,

1993), phrase-structure violations (Osterhout & Holcomb, 1992), and ECP and subadjacency violations (McKinnon & Osterhout, 1996). The present finding further supports the theoretical assumption that binding violations of this type are syntactic violations. They are not bad simply due to problems fixing coreference.

Following Reinhart and Reuland, if the logophor violations are pragmatic and not syntactic, then there should be no P600 observed between the logophor-agree/-disagree conditions. This prediction was also borne out here.

The fact that there was no N400 effect for the anaphor-agree/-disagree comparison is consistent with earlier findings that grammatical violations don't yield an N400, which is associated more with "semantic processing." It is interesting, however, that there is no N400 effect between the logophor conditions. Apparently, the type of pragmatic violation imputed to these sentences is not the same as other types of semantic violations reported in previous studies (Kutas & Hillyard, 1980; Nigam et al., 1992; Van Petten & Kutas, 1990; Van Petten, Kutas, Kluender, & Mitchener, 1991).

Between-Type Comparisons (Logophor vs Anaphor)

This study was designed to give clean comparisons only within the reflexive type. However, the argument presented thus far makes two implicit between-type predictions. The first is that while some difference ought to be expected for the processing of the different types of reflexives, there ought to be no P600 for the agree-agree comparison. Neither is ungrammatical. However, there ought to be some indication of a P600 between the two "disagree" conditions, as only one of them is syntactically malformed. This latter prediction is surprising without the invocation of binding theory. Without the notion of violations arising from improper coreference, these sentences are simply examples of number-agreement violations, which is present in both conditions.

These comparisons were not included in the design of the study because of the possibility of an ERP response to reflexive type alone, which would increase Type II error. Nevertheless, the results of these comparisons are compatible with the two weak predictions.

Logophor-Anaphor-Agree Comparison

A comparison of the two agreeing conditions revealed that there is no overall effect of type of reflexive (logophor versus anaphor). There is, however, an effect observed at Wernicke's area, in which the logophor is more positive than the anaphor. The fact that it is a slow-going positive wave makes it a potential P600.

The observed effect is most likely not a P600 for the following reasons.

Distribution. The late positivity is highly localized to WL. Previous reports of P600 effects (Osterhout & Holcomb, 1992; Hagoort, Brown, & Groothusen, 1993) note that the distribution is more widespread. In fact, the P600 we report for the anaphor comparison has a wider distribution than this positivity. This observation is confirmed by the fact that there was a main effect of condition in the anaphor agree/disagree comparison but not in the current comparison.

Latency. The classic P600 effect shows the onset of the positive shift occurring between 400 and 500 ms. This same latency was observed in the anaphor-agree/-disagree comparison. In the current comparison, the shift is seen starting at 250 ms. Kutas and Hillyard (1980) report that differences due to frequency/context (Cloze probability) begin as early as 200 ms, and this seems concordant with our observations here.¹²

Logophor–Anaphor–Disagree Comparison

The logophor–anaphor–disagree comparison is interesting because the theory predicts a P600 for the anaphor and not the logophor, even though each is coreferential with an impossible antecedent. By hypothesis, the violation for the anaphor condition is syntactic and the violation for the logophor is pragmatic.

We suggest the positivity at the logophor is due to its greater relative predictability (as in logophor–anaphor–agree comparison) and that there is a P600 for the anaphor (as in the anaphor–agree/-disagree comparison). The positivities predicted in both conditions are consistent with the hypothesis that both conditions elicit a P600. However, the “predictability” hypothesis predicts an earlier onset for the logophor positivity than that seen in a typical P600. In Fig. 4, it is evident that a positivity begins around 300 ms. That positivity becomes weaker as the epoch progresses. In fact, around 600 ms, it crosses over the anaphor wave and becomes less positive, significantly so at the midline sites. In summary, the positivity for the logophors is strongest in the early portion of the epoch, while the positivity for the anaphor occurs later in the epoch. This is consistent with the hypothesis that a probability-induced positivity exists for the logophor, while a P600 is elicited by the anaphor.

¹² This so-called predictability hypothesis predicts that an early negativity ought to also be present in the poor comprehenders. While the P600 is dependent on successful performance in the experimental task (cf. between group differences in the anaphor–agree/-disagree comparison), predictability is orthogonal to coreference. We therefore expect that the difference observed in the current (logophor–anaphor agree) comparison to also be present in the data from poor comprehenders. This means that they will show differences for type (logophor–anaphor) but not for agreement match/mismatch. This is borne out in the data (which for brevity’s sake are not reported here). Logophors are more positive than anaphors in both the agreeing and disagreeing conditions in the poor comprehenders’ data.

CONCLUSION

There were two main predicted effects: first, that there should be a P600 for the anaphor-agree/-disagree comparison and, second, that there should be no P600 for the logophor-agree/-disagree comparison. Both of these predictions were confirmed in the data from the good comprehenders. By hypothesis, the first comparison contains a syntactic violation and the second a nonsyntactic violation. The results, taken with other experiments involving the P600, suggests that the comparisons involving arguments are mediated by processes sensitive to syntactic constraints, while the processes for nonarguments are either insensitive to those constraints or sensitive in a very different way.

Two further comparisons (anaphor-agree vs logophor-agree and anaphor-disagree vs logophor-disagree) seem to be consistent with the predictions that there ought to be no indication of ungrammaticality for the agree-agree comparison and that one ought to exist for the disagree-disagree comparison. The agree-agree comparison appears not to show a P600, but rather an earlier positivity most likely sensitive to between-type probabilistic differences in this experiment. Furthermore, the results for the disagree comparison were consistent with the hypothesis that the anaphor-disagree sentences had syntactic violations and the logophor-disagree sentences did not.

Why is this interesting? There now seems to be evidence that language processing is sensitive to the environments that arguments appear in. Yet the notion of argumenthood is not superficially derived from the speech stream. For example, reflexives in conjoined NPs, like those appearing in this study, are in the same distribution as single NPs. Some tip-off to the parser might be available if the conjoined noun phrases in which logophors appear did not themselves have to appear in argument positions. In other words, if CNPs sometimes appeared in nonargument positions, it might be surmised that reflexives they contained are nonarguments in that configuration and perhaps in all configurations. In fact, a survey of the 1989 AP newswire releases reveals no CNPs containing reflexives (himself, herself, themselves) in nonargument positions. This is surprising, since sentences like *John erected a fence around Mary and himself* are neither implausible nor difficult to understand. In sum, there is a mysterious lack of distributional evidence regarding the argument status of reflexives in CNPs.¹³

In summary, we believe that our results show that (a) Condition A is a syntactic constraint; (b) constraints on logophor antecedents are not syntactic; (c) the structural property of argumenthood is crucially involved in computation; and (d) there is good reason to expect that electrophysiological

¹³ Only 70% of these reflexives had local antecedents, which could be argued to be the kind of distributional evidence we are looking for. However, this is begging the question, since it is not orthogonal to the predicted consequence of nonargumenthood for reflexives.

investigations can play an important role in the establishment and testing of theories concerning the nature of language and how it is represented in the brain.

APPENDIX A

Instructions Given to Subjects

You will be reading a number of sentences on a computer screen. The sentences are presented one word at a time; one word flashes on, then it flashes off. Some of the sentences have questions attached to them. The questions are only related to the action in the sentence, and who is doing it. For example, if you see a sentence, "John kissed Mary under a tree," the question would be, "who was kissed under a tree?" The question simply ensures comprehension of the sentence.

Some of the sentences will be normal sentences, and some will sound strange. Your job will be to overcome that strangeness and answer the question anyway. For example, if you saw the sentence, "Mary said John likes her," the question would be, "Who was liked?" And your answer would be . . .? However, you may see a sentence like, "Mary said John likes him," and the question would be, "Who was liked?" The answer would be John, because even though the sentence sounds strange, *John* is the only "him" around.

Ten practice sentences were given in the experimental situation; five agreeing (i) and five disagreeing (ii) with the matrix subject. If more than one question was answered incorrectly, the entire list was repeated.

- (i) Marcie's boyfriend E-mailed her by mistake.
Who was E-mailed? Marcie/boyfriend
- (ii) Debbie's data analyst corrected him after discovering a mistake.
Who was corrected? Debbie/data analyst

The sentences that you'll be reading in the experiment will not be exactly the same as the practice sentences, but the same strategy for answering the questions will apply. One thing that they have in common, however, is that you cannot figure out the answer by context, by who is most likely to be doing something. All the sentences are reversible. You may see a sentence in one form where the answer is on the left. Another person will see the same sentence in a different form where the answer is on the right.

In the last set of sentences, the difference was between him and her. In the upcoming sentences, the difference will be between himself and themselves. An example would be, John's brothers like themselves. The question would be, "Who is liked? And you'd answer . . .? Right. The strange version would be, John's brothers like himself. The question would be, "Who is liked? And the answer would be . . .? Right, because *himself* is singular and *John* is singular.

In the two possible answers, there is always one singular noun and one plural, but you won't know which is receiving the action of the sentence until you read the *himself/themselves*.

Try to answer each question as quickly as possible. You'll notice that all the questions are of the same form. This will enable you to decide on your answer as soon

as you see the *himself/themselves*. Try to snap off an answer as soon as you see the question.

APPENDIX B

Stimuli

Coargument, Agree Condition

- The agencies' representative inculcated Jones and himself by accident.
 The cover girls' photographer reassured Felix and himself about the lighting.
 The infants' nanny dressed Dorothy and herself carefully for the outing.
 The artists' patron served Brad and herself at the opening. Who was served? artists/patron
 The athletes' sponsor withdrew Nichols and itself from the meet. Who was withdrawn?
 athletes/sponsor
 The buyers' agent pleased Cummings and himself with his purchases.
 The cabbies' dispatcher startled Oscar and himself with sudden radio feed-back.
 The refugees' medic inoculated Jenkins and himself against dysentery. Who was inoculated?
 refugees/medic
 The sailors' captain trusted Lieutenant Pollock and himself in the worst seas.
 The boys' cousin introduced Suzie and himself at the wedding.
 The sorority sisters' housekeeper calmed Mary and herself after the break-in. Who was
 calmed? sorority sisters/housekeeper
 The children's father excused Estelle and himself from the table.
 The Johnsons' butler held Smithers and himself in high regard.
 The labs' overseer evaluated Kenrick and himself for accurate reporting of data. Who was
 evaluated? labs/overseer
 The lepers' aide-worker examined Alison and herself for signs of infection.
 The lions' tamer frightened Stupich and himself with the unpredictable pistol. Who was fright-
 ened? lions/tamer
 The litigants' arbitrator satisfied Fleischer and himself with the final arrangement.
 The gang members' mastermind disguised Hogarty and himself before the heist.
 Who was disguised? gang members/mastermind
 The accountants' firm committed Saphier and itself to the new contract.
 The schoolgirls' teacher asked Erin and herself themselves about the solution in the text book.
 The sharecroppers' landowner freed Sharon and himself from manual labor.
 The Benson's waiter short-changed Gordon and himself at the restaurant. Who was short-
 changed? Bensons/waiter
 The board members' ad exec scolded Stromquist and himself for loss of market share.
 The hunters' guide disoriented Payette and himself in a ravine. Who was disoriented? hunters/
 guide
 The industrialists' spin doctor saw Nordstrom and himself as a benefit to the public.
 The corpses' mortician prepared Stevens and himself for the embalming.
 The insurgents' leader camouflaged Juarez and himself along the road.
 The musicians' conductor worked Heinrich and himself to death before the concert.
 The activists' spokesman heard Linda and himself on the radio. Who was heard? activists/
 spokesman
 The girls' uncle treated Betty and himself to ice cream.
 The design teams' director promoted Ferguson and himself to a better project.
 The post-docs' advisor relieved Kim and himself of responsibility on the project.
 The twins' babysitter covered Nora and herself with a blanket. Who was covered? twins/
 babysitter
 The vacationers' tour guide registered Sawyer and himself at the cheapest hotel.

Who was registered? vacationers/tour guide

The contractors' supplier deceived Hudson and himself about the real costs.

The reformers' opposition drew Stockbridge and itself into the controversy.

The addicts' counselor employed Bob and himself everyday in busy work.

The advertisers' PR-man sold Mr. Davidson and himself on the idea.

The natives' chief lauded Batu and himself before his rivals. Who was lauded? natives/chief

The pensioners' stock broker betrayed VanDorn and himself with sloppy record keeping. Who was betrayed? pensioners/stock broker

The stuntmen's coordinator moved Lewis and himself to a better vantage point.

The survivors' rescuer strapped McKensie and himself into the helicopter. Who was strapped? survivors/rescuer

The proofreaders' redactor pushed Schafer and himself to the limit.

The puppies' mother hid Ozzie and herself from the dog-catcher.

The climbers' radio-man comforted Gail and himself after the tragic mishap.

The conspirators' hitman sacrificed Scavito and himself during the botched mission.

Who was sacrificed? hitman/conspirators

The delegates' translator recognized Moselsky and himself as relatively unimportant.

The swimmers' trainer exhausted Danny and himself before the big meet.

The technicians' supervisor doubted Cartman and himself after the last mistake.

The teenagers' dentist rattled Denise and himself after a painful mistake.

The spys' control agent identified Weisman and himself in the photograph. Who was identified? spys/control agent

The Stewarts' handyman limited Jeff and himself to rear-door entry during renovations.

The employees' manager trained Tracy and himself on the job. Who was trained? employees/manager

The ward members' nurse fooled Dr. Conley and herself with her cheerfulness.

The women's boss exonerated Novak and himself in court. Who was exonerated? women/boss

The playwrights' producer included Dana and himself in the cast of a running show.

The newscasters' intern reminded Amy and himself of the new air date.

The entrepreneurs' bank insured Computron and itself against catastrophic loss.

The policemen's sergeant informed Finnigan and himself of new policy directives.

Who was informed? policemen/sergeant

The tenants' landlord educated Travers and himself on lease law.

The governor's appointees injured Nelson and themselves with an untimely press leak. Who was injured? governor/appointees

The anchorman's cameramen amused Kelly and themselves during a commercial.

The despot's bodyguards hurried Piantes and themselves to the helipad.

The loudmouth's friends quoted Marsha and themselves for ironic effect. Who was quoted? loudmouth/friends

The manufacturer's consultants submitted Ramani and themselves to questioning.

The foundation's proponents forced Goldman and themselves into the spotlight.

The congressman's speech-writers disengaged Anderson and themselves from the fray.

The contract's bidders portrayed Uptown Architects and themselves as extremely desirable.

The senator's constituents compromised Donham and themselves over farm subsidies. Who was compromised? senator/constituents

The sorcerer's rivals changed Marek and themselves into a cloud of smoke. Who was changed? sorcerer/rivals

The crooked cop's informants implicated Pearson and themselves during the interrogation.

The defendant's lawyers described Kevin and themselves as hard-working.

The fugitive's pursuers persuaded Knapp and themselves of the futility of the chase.

The diver's teammates congratulated Rick and themselves on the discovery. Who was congratulated? diver/teammates

The editor's reporters vindicated Levenson and themselves after the sensationalism charges.
 The executive's secretaries organized Ms. Cordman and themselves for greater efficiency.
 The king's noblemen restored Hamilton and themselves to power.
 The nitpicker's office-mates defended Larry and themselves against unjust criticism.
 Who was defended? nitpicker/office-mates
 The designer's models recommended Michelle and themselves for the new project.
 The bear's cubs washed Miffy and themselves behind the ears. Who was washed? bear/cubs
 The pilot's mechanics brow-beat Gould and themselves after the race.
 The boycott's targets hurt the government and themselves with bad publicity. Who was hurt?
 boycott/targets
 The knight's squires placed Lady Chilton and themselves on horseback.
 The jeweler's salesmen cursed Kaminsky and themselves for the slow business.
 The author's publishers inconvenienced Helen and themselves with the new deadline. Who
 was inconvenienced? author/publishers
 The president's biographers praised Larsen and themselves for a job well done.
 The businessman's blackmailers frustrated Pawly and themselves with the long waiting game.
 The bus driver's passengers commended Jackie and themselves for their role in the wreck.
 The surgeon's patients distracted Marjorie and themselves in the waiting room.
 Who was distracted? surgeon/patients
 The mobster's henchmen maneuvered Janick and themselves into the new territory.
 The groom's ushers rushed Tammy and themselves to the church.
 The dictator's cronies proclaimed Ramirez and themselves as the winners of the staged elec-
 tions.
 The candidate's supporters cheered Rufkin and themselves after the victory.
 The consortium's retailers protected Vance, Inc. and themselves from suit. Who was protected?
 consortium/retailers
 The nation's soldiers guarded General Carthas and themselves from attack.
 The princess' handmaidens anointed Anna and themselves with scented oils. Who was an-
 ointed? princess/handmaidens
 The carpenter's apprentices burdened Tom and themselves with the fate of the shop.
 The heretic's accusers contradicted Chartrand and themselves in the mock trial. Who was
 contradicted? heretic/accusers
 The insurrection's advocates touted Chavez and themselves as the sole means of liberation.
 The stranger's hosts sat Judy and themselves at the dinner table.
 The city's inhabitants love Mario and themselves more than anyone else.
 The workaholic's relatives outdid Jaimie and themselves in planning the trip.
 The ambassador's staff personnel immersed Comerford and themselves in the new language.
 The coach's worst players surprised Difabio and themselves with their performance.
 Who was surprised? coach/worst players
 The company's investors drove Ekerton and themselves into bankruptcy.
 The program's administrators cheated Gibson and themselves out of much needed funds.
 The prophet's disciples criticized Kalled and themselves for minor sins. Who was criticized?
 prophet/disciples
 The psychiatrist's colleagues villified Carol and themselves at the inquiry.
 The queen's ministers presented Lord Belmore and themselves to the Viceroy.
 The programmer's coworkers teased Ron and themselves about the playboy calendar.
 Who was teased? programmer/coworkers
 The scientist's detractors questioned Eastly and themselves after the startling finding.
 The traitor's captors found Bicknell and themselves alone in an old building.
 The vintner's chemists blamed Harding and themselves for the poor year. Who was blamed?
 vintner/chemists
 The prosecutor's investigators convinced Judge Andrews and themselves beyond a doubt.
 Who was convinced? prosecutor/investigators
 The millionaire's daughters distanced Simon and themselves from racist statements.

- The winner's collaborators rewarded Severin and themselves with a party. Who was rewarded?
winner/collaborators
- The sharpshooter's competitors measured Tomlinson and themselves by the strictest criteria.
- The heroine's companions locked Julian and themselves in the dungeon by accident.
- The mercenary's enemies judged Kimball and themselves as the most dangerous element in the battle.
- The environmentalist's sympathizers placed Clifton and themselves behind the barricade.

Coargument, Disagree Condition

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 The stranger's hosts sat Judy and himself at the dinner table.
 The city's inhabitants love Mario and itself more than anyone else.
 The workaholic's relatives outdid Jaimie and himself in planning the trip.
 The ambassador's staff personnel immersed Comerford and himself in the new language.
 The coach's worst players surprised Difabio and himself with their performance.
 Who was surprised? coach/worst players
 The company's investors drove Ekerton and itself into bankruptcy.
 The program's administrators cheated Gibson and itself out of much needed funds.
 The prophet's disciples criticized Kalled and himself for minor sins. Who was criticized? prophet/disciples
 The psychiatrist's colleagues villified Carol and himself at the inquiry.
 The queen's ministers presented Lord Belmore and herself to the Viceroy.
 The programmer's coworkers teased Ron and himself about the playboy calendar.
 Who was teased? programmer/coworkers
 The scientist's detractors questioned Eastly and himself after the startling finding.

The traitor's captors found Bicknell and himself alone in an old building.
 The vintner's chemists blamed Harding and himself for the poor year. Who was blamed?
 vintner/chemists
 The prosecutor's investigators convinced Judge Andrews and himself beyond a doubt. Who
 was convinced? prosecutor/investigators
 The millionaire's daughters distanced Simon and himself from racist statements.
 The winner's collaborators rewarded Severin and himself with a party. Who was rewarded?
 winner/collaborators
 The sharpshooter's competitors measured Tomlinson and himself by the strictest criteria.
 The heroine's companions locked Julian and herself in the dungeon by accident.
 The mercenary's enemies judged Kimball and himself as the most dangerous element in the
 battle.
 The environmentalist's sympathizers placed Clifton and himself behind the barricade.

Noncoargument, Agree Condition

The agencies' representative inculcated himself by accident.
 The cover girls' photographer reassured himself about the lighting.
 The infants' nanny dressed herself carefully for the outing.
 The artists' patron served herself at the opening. Who was served? artists/patron
 The athletes' sponsor withdrew itself from the meet. Who was withdrawn? athletes/sponsor
 The buyers' agent pleased himself with his purchases.
 The cabbies' dispatcher startled himself with sudden radio feed-back.
 The refugees' medic inoculated himself against dysentery. Who was inoculated? refugees/
 medic
 The sailors' captain trusted himself in the worst seas.
 The boys' cousin introduced himself at the wedding.
 The sorority sisters' housekeeper calmed herself after the break-in. Who was calmed? sorority
 sisters/housekeeper
 The children's father excused himself from the table.
 The Johnsons' butler held himself in high regard.
 The labs' overseer evaluated himself for accurate reporting of data. Who was evaluated? labs/
 overseer
 The lepers' aide-worker examined herself for signs of infection.
 The lions' tamer frightened himself with the unpredictable pistol. Who was frightened? lions/
 tamer
 The litigants' arbitrator satisfied himself with the final arrangement.
 The gang members' mastermind disguised himself before the heist. Who was disguised? gang
 members/mastermind
 The accountants' firm committed itself to the new contract.
 The schoolgirls' teacher asked herself themselves about the solution in the text book.
 The sharecroppers' landowner freed himself from manual labor.
 The Benson's waiter short-changed himself at the restaurant. Who was short-changed?
 Bensons/waiter
 The board members' ad exec scolded himself for loss of market share.
 The hunters' guide disoriented himself in a ravine. Who was disoriented? hunters/guide
 The industrialists' spin doctor saw himself as a benefit to the public.
 The corpses' mortician prepared himself for the embalming.
 The insurgents' leader camouflaged himself along the road.
 The musicians' conductor worked himself to death before the concert.
 The activists' spokesman heard himself on the radio. Who was heard? activists/spokesman

- The girls' uncle treated himself to ice cream.
- The design teams' director promoted himself to a better project.
- The post-docs' advisor relieved himself of responsibility on the project.
- The twins' babysitter covered herself with a blanket. Who was covered? twins/babysitter
- The vacationers' tour guide registered himself at the cheapest hotel. Who was registered?
vacationers/tour guide
- The contractors' supplier deceived himself about the real costs.
- The reformers' opposition drew itself into the controversy.
- The addicts' counselor employed himself everyday in busy work.
- The advertisers' PR-man sold himself on the idea.
- The natives' chief lauded himself before his rivals. Who was lauded? natives/chief
- The pensioners' stock broker betrayed himself with sloppy record keeping. Who was betrayed?
pensioners/stock broker
- The stuntmen's coordinator moved himself to a better vantage point.
- The survivors' rescuer strapped himself into the helicopter. Who was strapped? survivors/
rescuer
- The proofreaders' redactor pushed himself to the limit.
- The puppies' mother hid herself from the dog-catcher.
- The climbers' radio-man comforted himself after the tragic mishap.
- The conspirators' hitman sacrificed himself during the botched mission. Who was sacrificed?
hitman/conspirators
- The delegates' translator recognized himself as relatively unimportant.
- The swimmers' trainer exhausted himself before the big meet.
- The technicians' supervisor doubted himself after the last mistake.
- The teenagers' dentist rattled himself after a painful mistake.
- The spys' control agent identified himself in the photograph. Who was identified? spys/control
agent
- The Stewarts' handyman limited himself to rear-door entry during renovations.
- The employees' manager trained himself on the job. Who was trained? employees/manager
- The ward members' nurse fooled herself with her cheerfulness.
- The women's boss exonerated himself in court. Who was exonerated? women/boss
- The playwrights' producer included himself in the cast of a running show.
- The newscasters' intern reminded himself of the new air date.
- The entrepreneurs' bank insured itself against catastrophic loss.
- The policemen's sergeant informed himself of new policy directives. Who was informed?
policemen/sergeant
- The tenants' landlord educated himself on lease law.
- The governor's appointees injured themselves with an untimely press leak. Who was injured?
governor/appointees
- The anchorman's cameramen amused themselves during a commercial.
- The despot's bodyguards hurried themselves to the helipad.
- The loudmouth's friends quoted themselves for ironic effect. Who was quoted? loudmouth/
friends
- The manufacturer's consultants submitted themselves to questioning.
- The foundation's proponents forced themselves into the spotlight.
- The congressman's speech-writers disengaged themselves from the fray.
- The contract's bidders portrayed themselves as extremely desirable.
- The senator's constituents compromised themselves over farm subsidies. Who was compro-
mised? senator/constituents
- The sorcerer's rivals changed themselves into a cloud of smoke. Who was changed? sorcerer/
rivals

- The crooked cop's informants implicated themselves during the interrogation.
- The defendant's lawyers described themselves as hard-working.
- The fugitive's pursuers persuaded themselves of the futility of the chase.
- The diver's teammates congratulated themselves on the discovery. Who was congratulated?
diver/teammates
- The editor's reporters vindicated themselves after the sensationalism charges.
- The executive's secretaries organized themselves for greater efficiency.
- The king's noblemen restored themselves to power.
- The nitpicker's office-mates defended themselves against unjust criticism. Who was defended?
nitpicker/office-mates
- The designer's models recommended themselves for the new project.
- The bear's cubs washed themselves behind the ears. Who was washed? bear/cubs
- The pilot's mechanics brow-beat themselves after the race.
- The boycott's targets hurt themselves with bad publicity. Who was hurt? boycott/targets
- The knight's squires placed themselves on horseback.
- The jeweler's salesmen cursed themselves for the slow business.
- The author's publishers inconvenienced themselves with the new deadline. Who was inconvenienced? author/publishers
- The president's biographers praised themselves for a job well done.
- The businessman's blackmailers frustrated themselves with the long waiting game.
- The bus driver's passengers commended themselves for their role in the wreck.
- The surgeon's patients distracted themselves in the waiting room. Who was distracted? surgeon/patients
- The mobster's henchmen maneuvered themselves into the new territory.
- The groom's ushers rushed themselves to the church.
- The dictator's cronies proclaimed themselves as the winners of the staged elections.
- The candidate's supporters cheered themselves after the victory.
- The consortium's retailers protected themselves from suit. Who was protected? consortium/retailers
- The nation's soldiers guarded themselves from attack.
- The princess' handmaidens anointed themselves with scented oils. Who was anointed?
princess/handmaidens
- The carpenter's apprentices burdened themselves with the fate of the shop.
- The heretic's accusers contradicted themselves in the mock trial. Who was contradicted?
heretic/accusers
- The insurrection's advocates touted themselves as the sole means of liberation.
- The stranger's hosts sat themselves at the dinner table.
- The city's inhabitants love themselves more than anyone else.
- The workaholic's relatives outdid themselves in planning the trip.
- The ambassador's staff personnel immersed themselves in the new language.
- The coach's worst players surprised themselves with their performance. Who was surprised?
coach/worst players
- The company's investors drove themselves into bankruptcy.
- The program's administrators cheated themselves out of much needed funds.
- The prophet's disciples criticized themselves for minor sins. Who was criticized? prophet/disciples
- The psychiatrist's colleagues villified themselves at the inquiry.
- The queen's ministers presented themselves to the Viceroy.
- The programmer's coworkers teased themselves about the playboy calendar. Who was teased?
programmer/coworkers
- The scientist's detractors questioned themselves after the startling finding.
- The traitor's captors found themselves alone in an old building.

- The vintner's chemists blamed themselves for the poor year. Who was blamed? vintner/chemists
- The prosecutor's investigators convinced themselves beyond a doubt. Who was convinced? prosecutor/investigators
- The millionaire's daughters distanced themselves from racist statements.
- The winner's collaborators rewarded themselves with a party. Who was rewarded? winner/collaborators
- The sharpshooter's competitors measured themselves by the strictest criteria.
- The heroine's companions locked themselves in the dungeon by accident.
- The mercenary's enemies judged themselves as the most dangerous element in the battle.
- The environmentalist's sympathizers stationed themselves behind the barricade.

Noncoargument, Disagree Condition

- The agencies' representative inculcated themselves by accident.
- The cover girls' photographer reassured themselves about the lighting.
- The infants' nanny dressed themselves carefully for the outing.
- The artists' patron served themselves at the opening. Who was served? artists/patron
- The athletes' sponsor withdrew themselves from the meet. Who was withdrawn? athletes/sponsor
- The buyers' agent pleased themselves with his purchases.
- The cabbies' dispatcher startled themselves with sudden radio feed-back.
- The refugees' medic inoculated themselves against dysentery. Who was inoculated? refugees/medic
- The sailors' captain trusted themselves in the worst seas.
- The boys' cousin introduced themselves at the wedding.
- The sorority sisters' housekeeper calmed themselves after the break-in. Who was calmed? sorority sisters/housekeeper
- The children's father excused themselves from the table.
- The Johnsons' butler held themselves in high regard.
- The labs' overseer evaluated themselves for accurate reporting of data. Who was evaluated? labs/overseer
- The lepers' aide-worker examined themselves for signs of infection.
- The lions' tamer frightened themselves with the unpredictable pistol. Who was frightened? lions/tamer
- The litigants' arbitrator satisfied themselves with the final arrangement.
- The gang members' mastermind disguised themselves before the heist. Who was disguised? gang members/mastermind
- The accountants' firm committed themselves to the new contract.
- The schoolgirls' teacher asked themselves about the solution in the text book.
- The sharecroppers' landowner freed themselves from manual labor.
- The Benson's waiter short-changed themselves at the restaurant. Who was short-changed? Bensons/waiter
- The board members' ad exec scolded themselves for loss of market share.
- The hunters' guide disoriented themselves in a ravine. Who was disoriented? hunters/guide
- The industrialists' spin doctor saw themselves as a benefit to the public.
- The corpses' mortician prepared themselves for the embalming.
- The insurgents' leader camouflaged themselves along the road.
- The musicians' conductor worked themselves to death before the concert.
- The activists' spokesman heard themselves on the radio. Who was heard? activists/spokesman
- The girls' uncle treated themselves to ice cream.
- The design teams' director promoted themselves to a better project.

- The post-docs' advisor relieved themselves of responsibility on the project.
- The twins' babysitter covered themselves with a blanket. Who was covered? twins/babysitter
- The vacationers' tour guide registered themselves at the cheapest hotel. Who was registered? vacationers/tour guide
- The contractors' supplier deceived themselves about the real costs.
- The reformers' opposition drew themselves into the controversy.
- The addicts' counselor employed themselves everyday in busy work.
- The advertisers' PR-man sold themselves on the idea.
- The natives' chief lauded themselves before his rivals. Who was lauded? natives/chief
- The pensioners' stock broker betrayed themselves with sloppy record keeping. Who was betrayed? pensioners/stock broker
- The stuntmen's coordinator moved themselves to a better vantage point.
- The survivors' rescuer strapped themselves into the helicopter. Who was strapped? survivors/rescuer
- The proofreaders' redactor pushed themselves to the limit.
- The puppies' mother hid themselves from the dog-catcher.
- The climbers' radio-man comforted themselves after the tragic mishap.
- The conspirators' hitman sacrificed themselves during the botched mission. Who was sacrificed? hitman/conspirators
- The delegates' translator recognized themselves as relatively unimportant.
- The swimmers' trainer exhausted themselves before the big meet.
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- The teenagers' dentist rattled themselves after a painful mistake.
- The spys' control agent identified themselves in the photograph. Who was identified? spys/control agent
- The Stewarts' handyman limited themselves to rear-door entry during renovations.
- The employees' manager trained themselves on the job. Who was trained? employees/manager
- The ward members' nurse fooled themselves with her cheerfulness.
- The women's boss exonerated themselves in court. Who was exonerated? women/boss
- The playwrights' producer included themselves in the cast of a running show.
- The newscasters' intern reminded themselves of the new air date.
- The entrepreneurs' bank insured themselves against catastrophic loss.
- The policemen's sergeant informed themselves of new policy directives. Who was informed? policemen/sergeant
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- The defendant's lawyers described himself as hard-working.
- The fugitive's pursuers persuaded himself of the futility of the chase.

- The diver's teammates congratulated himself on the discovery. Who was congratulated? diver/
teammates
- The editor's reporters vindicated himself after the sensationalism charges.
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- The pilot's mechanics brow-beat himself after the race.
- The boycott's targets hurt itself with bad publicity. Who was hurt? boycott/targets
- The knight's squires placed himself on horseback.
- The jeweler's salesmen cursed himself for the slow business.
- The author's publishers inconvenienced himself with the new deadline. Who was inconvenienced?
author/publishers
- The president's biographers praised himself for a job well done.
- The businessman's blackmailers frustrated himself with the long waiting game.
- The bus driver's passengers commended himself for their role in the wreck.
- The surgeon's patients distracted himself in the waiting room. Who was distracted? surgeon/
patients
- The mobster's henchmen maneuvered himself into the new territory.
- The groom's ushers rushed himself to the church.
- The dictator's cronies proclaimed himself as the winners of the staged elections.
- The candidate's supporters cheered himself after the victory.
- The consortium's retailers protected itself from suit. Who was protected? consortium/retailers
- The nation's soldiers guarded itself from attack.
- The princess' handmaidens anointed herself with scented oils. Who was anointed? princess/
handmaidens
- The carpenter's apprentices burdened himself with the fate of the shop.
- The heretic's accusers contradicted himself in the mock trial. Who was contradicted? heretic/
accusers
- The insurrection's advocates touted itself as the sole means of liberation.
- The stranger's hosts sat himself at the dinner table.
- The city's inhabitants love itself more than anyone else.
- The workaholic's relatives outdid himself in planning the trip.
- The ambassador's staff personnel immersed himself in the new language.
- The coach's worst players surprised himself with their performance. Who was surprised?
coach/worst players
- The company's investors drove itself into bankruptcy.
- The program's administrators cheated itself out of much needed funds.
- The prophet's disciples criticized himself for minor sins. Who was criticized? prophet/disci-
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- The queen's ministers presented herself to the Viceroy.
- The programmer's coworkers teased himself about the playboy calendar. Who was teased?
programmer/coworkers
- The scientist's detractors questioned himself after the startling finding.
- The traitor's captors found himself alone in an old building.
- The vintner's chemists blamed himself for the poor year. Who was blamed? vintner/chemists
- The prosecutor's investigators convinced himself beyond a doubt. Who was convinced?
prosecutor/investigators
- The millionaire's daughters distanced himself from racist statements.
- The winner's collaborators rewarded himself with a party. Who was rewarded? winner/collab-
orators

The sharpshooter's competitors measured himself by the strictest criteria.
 The heroine's companions locked herself in the dungeon by accident.
 The mercenary's enemies judged himself as the most dangerous element in the battle.
 The environmentalist's sympathizers stationed himself behind the barricade.

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