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Information structure expectations in sentence comprehension

Katy Carlson,

Morehead State University, Morehead, KY, USA

Michael Walsh Dickey,

University of Pittsburgh, Pittsburgh, PA, USA

Lyn Frazier, and

University of Massachusetts, Amherst, MA, USA

Charles Clifton Jr.

University of Massachusetts, Amherst, MA, USA

Abstract

In English, new information typically appears late in the sentence, as does primary accent. Because of this tendency, perceivers might expect the final constituent or constituents of a sentence to contain informational focus. This expectation should in turn affect how they comprehend focus-sensitive constructions such as ellipsis sentences. Results from four experiments on sluicing sentences (e.g., *The mobster implicated the thug, but we can't find out who else*) suggest that perceivers do prefer to place focus late in the sentence, though that preference can be mitigated by prosodic information (pitch accents, Experiment 2) or syntactic information (clefted sentences, Experiment 3) indicating that focus is located elsewhere. Furthermore, it is not necessarily the direct object, but the informationally-focused constituent that is the preferred antecedent (Experiment 4). Expectations regarding the information structure of a sentence, which are only partly cancelable by means of overt focus markers, may explain persistent biases in ellipsis resolution.

Focus is a grammatical property, signaled prosodically or syntactically, which characterizes the element that is the most informationally important one in a sentence. For example, in (1), the prosodically prominent *MARY* bears focus.

(1) John introduced *MARY*.

MARY is intuitively the piece of information that is at issue in (1). In uttering (1), a speaker takes as given or background the information that John introduced someone, and adds as either new information or as a contrast to previously-stated information the fact that the person who was introduced is Mary (Jackendoff, 1972; Krifka, 1992; Rooth, 1992; Schwarzschild, 1999; Vallduví & Engdahl, 1996). Similarly, the clefted constituent *Mary* is the piece of information at issue in (2), while the rest of the sentence is backgrounded:

(2) It was *Mary* who John introduced.

While (1) uses prosodic prominence and (2) uses syntactic means to highlight the focused constituent, both sentences signal that Mary bears focus and should be distinguished from the other non-focused material in the sentence.

Because of its importance in marking what is new or contrastive in a sentence, focus affects how a sentence is related to its context, such as other sentences or common ground in a conversation. For example, (1) and (2) are appropriate in the context of a question like (3a), but not in the context of a question like (3b):

(3)

- a. Who did John introduce?
- b. Who introduced Mary?

The question in (3a) establishes that John introduced someone and asks about who was introduced, a question that (1) or (2) then answers; the question in (3b) establishes as given that someone introduced Mary and asks about who that was, which makes (1–2) infelicitous.

As the discussion above notes, the focused element in a sentence may be informative in at least two different ways. First, it may introduce new, non-presupposed information. We will call this type of focus *informational focus* (see Kiss, 1998; Rochemont, 1986). This type of focus is commonly found in question-answer pairs like (3a). Second, it may introduce information which contrasts with other, previously-stated information. We will call this type of focus *contrastive focus*. This type of focus is commonly found in contexts like that in (4):

(4)

- A: John introduced Sally.
- B: (No,) John introduced MARY.
- B': (No,) it was Mary who John introduced.

In both informational and contrastive focus, the focused element is more informative and salient than the non-focused material in the sentence.

It is widely recognized that all languages use some prosodic or syntactic means to distinguish focused from non-focused material (Ladd, 1990; Lambrecht, 1994; Rooth, 1992; Selkirk, 1984, 1995; Vallduvi, 1992; Vallduvi & Engdahl, 1996). English primarily uses prosody to mark focus, but also uses the syntactic clefting structure in (2) and focus particles like *only* (see Paterson et al. (2007) for recent research on *only*, for example). These devices have been argued to mark different kinds of focus: for example, clefting and the focus particle *only* have been argued to mark contrastive focus uniquely (Kiss, 1998), while prosody has been argued to mark either contrastive or informational focus, depending on the accent type used (Pierrehumbert & Hirschberg, 1990). There is also controversy regarding whether contrastive and informational focus are truly different notions (see Kadmon, 2001; Kiss, 1998; Kratzer, 2004), as well as whether the same prosodic markers may be used to mark the two kinds of focus. In the research we present here, our materials use contrastive focus. However, we will proceed under the working assumption that the conclusions will also apply to informational focus. We will return to the potential differences between these types of focus in the General Discussion.

Ample psycholinguistic evidence exists that focus affects the processing of sentences. Focused constituents are recognized faster in speech (Cutler & Fodor, 1979) and fixated longer in reading (Birch & Rayner, 1997). Furthermore, focused elements appear to be especially salient in memory (Birch & Garnsey, 1995; Foraker & McElree, 2007; Sturt, Sanford, Stewart, & Dawydiak, 2004), and to have an advantage as antecedents in anaphora resolution (Almor, 1999, Cowles & Garnham, 2005; see also Grosz, Joshi & Weinstein, 1995). Listeners and readers use focus marking to determine the information structure of sentences and connect them to previous discourse (Cowles, Kluender, Kutas, & Polinsky,

2007; Stolterfoht, Friederici, Alter, & Streube, 2007). Utterances in which new or contrastive information is marked as focused using accents (and given material is not accented) are rated as more acceptable than utterances with inappropriate focus structure (Birch & Clifton, 1995, 2002; Bock & Mazella, 1983). One line of research has investigated whether the focus marker *only* may influence the resolution of the main clause/reduced relative ambiguity (Filik, Paterson, & Liversedge, 2005; Liversedge et al., 2002; Ni, Crain, & Shankweiler, 1996; Paterson, Liversedge, & Underwood, 1999; Sedivy 2002; but see Clifton, Bock, & Rado, 2000). The focus conveyed by pitch accents can also affect the interpretation of several types of ambiguous sentences (Carlson, 2001, 2002; Schafer, Carlson, Clifton, & Frazier, 2000; Schafer, Carter, Clifton, & Frazier, 1996). In the present paper, we explore how two focus markers, pitch accents and clefts, interact with expectations about where focus will appear in the interpretation of ambiguous ellipsis sentences.

The particular ambiguous sentence type being studied is called sluicing (Chung, Ladusaw, & McCloskey, 1995; Merchant, 2001; Ross, 1967; Romero, 1999). In sluicing, a wh-question following a complete clause is partially elided.

(5) The doctor treated someone yesterday, but I don't recall who.

The wh-element (*who* in (5)) appears alone in its clause, and the material that would normally follow it is left unpronounced. This 'wh-remnant' corresponds to a structurally parallel element, known as the inner antecedent, in the preceding clause (Chung et al., 1995). The inner antecedent is often an indefinite noun phrase such as *someone*, which lends itself to the uncertainty expressed by the wh-question. Like other ellipsis sentences, a sluicing sentence is then interpreted by filling in the elided material, using a proposition derived from the antecedent clause by abstracting over the inner antecedent. In (5), the final clause is thus interpreted as *I don't recall who the doctor treated*.

Frazier and Clifton (1998) examined ambiguous indefinite sluicing sentences like (6) in an auditory questionnaire:

(6) Some tourist suspected that the hotelkeeper was hiding someone. Guess who?

Participants were presented with auditory versions of (6), accenting the matrix subject or the object, and were asked to choose between two written answers. Choosing the matrix subject (*some tourist*) as the inner antecedent for *who* makes the sluiced clause *Guess who [t suspected the hotelkeeper was hiding someone]*, which fits with an answer like *The tourist who suspected the hotelkeeper was hiding someone was Don Knotts*. If the embedded object (*someone*) is the inner antecedent, the sluicing clause is instead *Guess who [the hotelkeeper was hiding t]* which fits best with an answer like *The person who the tourist suspected the hotelkeeper was hiding was Don Knotts*. Frazier and Clifton (1998) found that the choice between answers (and antecedents) was affected by the position of pitch accents. When the embedded object bore a pitch accent, participants chose the object antecedent answer 72% of the time. However, when the matrix subject was accented, participants chose the subject antecedent answer 52% of the time (and the object antecedent answer only 48% of the time). This result shows two things. First, accenting a constituent increases the probability that the constituent is chosen as the antecedent of the wh-remnant, *who*, by a significant but modest 24%. Second, there is also a tendency to take the object as antecedent.

The fact that accents affect the interpretation of this kind of elliptical sentence fits well with focus-sensitive analyses of ellipsis sentences (Merchant, 2001; Sag, 1980). These theories claim that elided material is always non-focused, or treated as background or given information (Merchant, 2001; Schwarzschild, 1999). In such theories, the inner antecedent

of a wh-remnant in a sluicing sentence is chosen on the basis of its being focused within the antecedent clause. But when the matrix subject is marked as focused instead of the object, these analyses predict that the object should seldom if ever be taken as the antecedent. Nonetheless, it was chosen almost half the time, and the object interpretation was also dominant in the written experiments reported by Frazier and Clifton (1998).

We suggest that this pattern reflects the tendency of speakers of English to place new constituents, which receive informational focus, late in the clause. Objects and other constituents that occur late in the clause are tempting antecedents for ellipsis resolution, then, since they are likely to be focused. A good deal of linguistic work on focus and information structure supports the claim that elements low in the sentence's syntax are the preferred bearers of informational focus in English. For example, objects are more likely to describe new rather than given information, while subjects are more likely to be given than new (Birner & Ward, 1998; Haviland & Clark, 1974), and new information tends to bear focus (Rooth, 1992; Selkirk, 1984). Jaeger (2005) suggests that the salience of objects, as likely bearers of the main focus of a sentence, accounts for their frequent involvement in anticipatory slips of the tongue. Discussions of the usual position of primary stress in English have also suggested that such stress, expressed through a pitch accent, appears preferentially on the right (e.g., Cinque, 1993; Selkirk, 1984). We do not want to suggest that focus must appear late in a sentence, or that late focus has any necessary grammatical status, but it is a general tendency. In processing, perceivers could exploit this tendency by expecting focus to be late. This expectation about the likely placement of informational focus might not be abandoned even when specific information in the sentence indicates the presence of another, possibly more prominent, focus position.

One reason that this is plausible is that pitch accents are not unambiguous markers of focus. For example, an utterance with focus on a late constituent may be produced with some earlier element(s) accented as well, simply due to phonological well-formedness requirements such as the need for an accent in each intermediate or intonational phrase, or in order to achieve rhythmic alternation (Cohan, 2000; Ladd, 1996; Selkirk, 2000; Shattuck-Hufnagel, Ostendorf, & Ross, 1994). These earlier pitch accents do not signal focus. Similarly, when all sentence constituents are given and none needs focus-marking, a pitch accent still appears within the VP (Schwarzschild, 1999).

Thus, we suggest that listeners do not rely solely on pitch accents in determining focus structure and information structure. They may also utilize regularities of the language, such as the tendency for rightmost constituents to be new and focused, and these regularities may even override the effects of pitch accent in determining focus.

In the present paper, we explore the possibility that an expectation for focus to occur late in a sentence is partly responsible for both the observed tendency to favor object antecedent interpretations of sluicing sentences over subject antecedent interpretations and the relatively small size of the effect of placement of pitch accent observed by Frazier and Clifton (1998). In order to support our claims, we conducted experiments examining different focus mechanisms in the comprehension of written and auditory sluicing sentences. The first experiment reported below is a written questionnaire, designed to explore the possibility that an object preference in sluicing simply reflects a preference for a recent and highly accessible antecedent. Experiment 2 uses auditory sluicing sentences to probe the mechanism by which pitch accents confirm or override the expectation of focus late in a sentence. Experiment 3 is a self-paced reading experiment in which sentences were followed by interpretation questions, designed to explore the effect of syntactically-conveyed focus on sluicing preferences, using clefted sentences. Finally, Experiment 4 is an auditory questionnaire examining whether the general preference for object antecedents is really a

preference for the syntactic object (or semantic theme or patient) or simply for the final constituent of a sentence.

EXPERIMENT 1

Earlier experiments have shown a preference for object antecedents over subject antecedents in sluices (Frazier & Clifton, 1998). However, there are possible alternative factors that could explain this bias besides focus. First, recency might be responsible for the preference for sentence-final constituents as sluicing antecedents, especially in the two-clause sentences they studied. Second, since subject and object nouns were not counterbalanced in these earlier experiments, intrinsic lexical biases of verbs or their interaction with particular lexical arguments might have affected the results.

In the current experiment, each sentence appeared with the subjects and objects in the antecedent clause counterbalanced, so that any effects of the plausibility of particular NPs as the object or subject of a verb could be identified. In addition, the length and position of material between the remnant and its possible antecedents was manipulated, to explore whether increased distance would affect interpretation. We assume that the final few words of a clause are especially privileged in memory, as indicated by the classic serial position effect in free recall (Glanzer & Cunitz, 1966) and suggested in sentence parsing by the sharp reduction in the effect of recency or “late closure” when several words are added to the end of a sentence (Altmann, van Nice, Garnham, & Henstra, 1998). If the relative recency of the object was responsible for its being chosen more often as an antecedent for the *wh*-remnant, then adding material between the object and the remnant should make the subject and object more comparable in their recency or accessibility and decrease the strength of the object preference.

Methods

Materials—For this experiment, eighteen sluicing sentences as in (7) were created.

(7)

- a. The lawyer insulted the witness, but I don't remember who else. (short)
- b. The lawyer insulted the witness in the aftermath of the trial, but I don't remember who else. (long, early)
- c. The lawyer insulted the witness, but in the aftermath of the trial I don't remember who else. (long, late)
- d. The witness insulted the lawyer, but I don't remember who else. (short reversed)
- e. The witness insulted the lawyer in the aftermath of the trial, but I don't remember who else. (long, early reversed)
- f. The witness insulted the lawyer, but in the aftermath of the trial I don't remember who else. (long, late reversed)

In contrast to Frazier and Clifton (1998), who used indefinite sluices like (6), the sentences were definite sluices with all definite noun phrases (introduced by *the*).¹ The *wh*-remnant was the phrase *who else*, signaling a contrast with one of the animate definite phrases. The sentences appeared in the three length conditions and two argument order conditions shown

¹The change from indefinite to definite sluice was made for several reasons: to explore the generality of the Frazier and Clifton (1998) findings, to permit more flexibility in identifying the inner antecedent of a sluice (since definite NPs can serve that function), and to begin to explore the possibility that the effect of focus and accent would be more substantial in definite sluices, which can be considered to be contrastive.

in (7). The full set of materials is found in Appendix A. Conditions (a) and (d) were short conditions, differing only in the order of arguments. The entity that appeared as a subject in condition (a) appeared as an object in condition (d), and vice versa. Conditions (b) and (e) had an additional phrase (underlined) added to the end of the earlier clause, and conditions (c) and (f) had the same phrase added to the beginning of the sluicing (later) clause. The additional phrase never contained another definite animate phrase which could serve as the antecedent for *who else*.

The late position of the added phrase in conditions (c) and (f) allowed the object to retain its position at the end of the first clause, as in the short conditions (a) and (d). If this position is preferentially focused, then we would expect the added phrase to have less effect in conditions (c) and (f) than in the early conditions, (b) and (e). In all the lengthened conditions, though, the subject and object were more comparable in their relative recency/accessibility with respect to *who* than they were in the short conditions. If recency is behind the object preference, this lengthening should reduce the preference for the object antecedent in all of the lengthened conditions.

Procedure—This experiment was a written questionnaire. Participants read the sentences in this questionnaire and then answered either an acceptability rating question (for some non-experimental items) or an interpretation question as in (8), shown in the version for condition (a) with explanatory labels not provided to participants.

(8) I don't remember who else...

- a. the lawyer insulted. (object answer)
- b. insulted the witness. (subject answer)

In colloquial American English, at least, the alternate wording *whom else* for object antecedents is vanishingly rare, so we considered (8) to be fully ambiguous between the two answers. The conditions were counterbalanced so that each participant saw the same number of items in each condition, but no more than one condition of a particular item. The experiment as a whole contained the 18 sluicing sentences, along with 91 sentences with a variety of structures, including VP ellipsis sentences and sentences with ambiguous pronouns.

Participants—There were 48 participants in this experiment. All were undergraduate students at the University of Massachusetts Amherst taking psychology classes. They participated in this experiment in exchange for course credit.

Results

The results of this experiment are shown in Table 1. There was an overall preference for the object antecedent in this experiment: across all conditions, the object interpretation (as in (8a)) was chosen 72% of the time (with a 95% between-subjects confidence interval of 6%). This preference was not affected by situation-specific plausibility biases, as the main effect of argument order (a-c vs. d-f) was not significant by participants or items (p 's > .1). Nor were preferences affected by additional length separating the *wh*-remnant and the antecedents, as the main effect of length was also not significant by participants or items (F s < 1). An interaction between argument order and length was marginally significant only by participants ($F(1,2,94) = 3.06$, $p = .06$, but $F(2,34) = 1.96$, $p > .10$; $\text{min}F'(2,79) = 1.19$). If this effect is real, it probably reflects some subtle effect of the material added to the end of the sentence on the relative plausibility of the two argument orders, and, if so, is of little interest.

Discussion

Experiment 1 found a preference for an object interpretation of the sluice. The size of the object bias does not appear to have been affected by either the relative recency of the object antecedent, or by situation-specific biases favoring one event participant over another. Adding extraneous material between the object and the *wh*-remnant did not affect interpretation frequency, casting doubt on the suggestion that the relative recency of the object noun phrase is the reason for its preference. There was no significant effect of alternating the object and subject arguments, showing that the bias toward the object argument is not due to either participant in a particular event being inherently more salient or plausible as the inner antecedent of *who else*. Rather, whichever event participant was in the later (object) position was preferred as the antecedent of *who else*.

Since there was no length effect, the position of the added length (early, at the end of the first sentence, or late, at the beginning of the second) also had no significant effect on interpretations. This suggests that the final argument of the sentence (the direct object) was likely to receive focus whether or not it was the final constituent. The object was the last potential antecedent for the *wh*-remnant, of course, which may have contributed to the added phrase's irrelevance to the interpretive decision. It is also true that the subject was always further away from the *wh*-word than the object, regardless of added length, but if recency is a gradient measure, we would have expected the amount of favoring of the object to decrease when it was a long prepositional phrase away from the remnant.

EXPERIMENT 2

Definite sluicing sentences show a strong object bias in their interpretation, independent of the relative plausibility of the event participants in different roles and of the absolute distance from the remnant, judging by the results of Experiment 1. Evidence cited earlier suggests also that the interpretation of sluicing sentences is substantially affected by the placement of overt focus markers. Experiment 2 further explores the mechanism behind the effect of prosody on focus placement by examining several accent conditions: conditions with a pitch accent on both the subject and the object and with an accent just on the verb are compared to conditions with pitch accents separately on the subject or the object.

The prosodic system assumed here is based on Pierrehumbert's analysis of English prosody (Beckman & Pierrehumbert, 1986; Pierrehumbert, 1980; Pierrehumbert & Hirschberg, 1990) and the subsequent ToBI system for labeling (Beckman & Elam, 1997; Silverman et al., 1992). In this system, prominent words receive pitch accents, which can have relatively high (H*) or low (L*) pitch targets aligned with the stressed syllables. Pitch accents can also include preceding or following tonal targets. We follow Pierrehumbert and Hirschberg (1990) in assuming that the L+H* accent type, which involves a swift rise from a low F0 target to a high accented syllable, conveys contrastive focus. There is disagreement in the literature about whether L+H* pitch accents are a distinct accent category with a different contribution to meaning than simple H* accents, or whether both are points on a continuum of accents with high peaks (Bartels & Kingston, 1996; Dainora, 2002; Kraemer & Swerts, 2001; Ladd, 1996; Ladd & Schepman, 2003). However, even if the distinction is a gradient one, accents which are especially steep and immediately preceded by a low pitch target are generally considered to convey special emphasis and are more consistent with contrastive focus than lower, more rounded H* accents or L* accents.

The sentences in this experiment had the form shown in (9). An unpublished written questionnaire found that these sentences, presented with the two answer choices shown (minus the informative labels), received 86% object antecedent answers.

(9) The captain talked with the co-pilot, but we couldn't find out who else.

- a. We couldn't find out who else talked with the co-pilot. (subject antecedent)
- b. We couldn't find out who else the captain talked with. (object antecedent)

We tested definite sluicing sentences like (9) in conditions with contrastive (L+H*) accents on either the subjects or objects. In addition, we tested a condition with both arguments accented, and a condition with the most prominent accent on the verb instead.

L+H*

L-H%

(10)

- a. Subject Accent: The CAPtain talked with the co-pilot, but...

H*

L+H* L-H%

- b. Object Accent: The captain talked with the CO-pilot, but...

L+H*

L+H* L-H%

- c. Both Accent: The CAPtain talked with the CO-pilot, but...

H* L+H*

L-H%

- d. Verb Accent: The captain TALKed with the co-pilot, but...

The Verb Accent condition was expected to produce results similar to the baseline written results, since neither potential antecedent was overtly picked out as being focused. The Subject Accent prosody was predicted to increase subject responses. The Object Accent condition was predicted to show heightening of the usual object preference.

Of particular interest was the Both Accent condition, as it could clarify how focus expectations and overt prosodic marking interact. If listeners expect focus on the object (as the latest argument in the verb phrase), that might guide how they use prosody. For example, a listener might only check to see if the expected argument is accented, and if so, carry on with the usual object-focus analysis. In that case, the Object Accent and Both Accent conditions should receive similar response levels. This result would also be expected if the accent on the subject is taken to be a pre-nuclear accent that does not convey focus. On the other hand, listeners might consider the import of all pitch accents for the overall focus structure of the sentence, without reference to the usual focus status of the arguments they appear on. On that hypothesis, the Both Accent condition should pattern like the Verb Accent condition. Listeners should give fewer object responses than in the Object Accent condition, in which the object carries the most prominent accent, and fewer subject responses than in the Subject Accent condition.

Methods

Materials—Sixteen definite sluicing sentences (cf. Appendix B) were produced in four prosodic conditions for this experiment (10). The *wh*-remnant was always accented (on the word *else*), and contrastive accents (L+H*s) were placed on the subject, the object, both the subject and the object, or the verb. When the subject NP was not contrastively accented, it

was given a H* accent in order to produce a natural-sounding contour. Representative pitch tracks for one item are shown in Figure 1.

The pitch tracks show that the accents labeled as L+H* in this experiment were steep and prominent, dwarfing any subsidiary H* accents.

The sentences were recorded by the first author, a native speaker of American English from California with training in prosody, following the ToBI analyses shown above. Recordings were made in a sound-proof booth to a minidisc recorder and sampled at 22050 Hz. All recordings were analyzed and viewed in Praat (Boersma & Weenink, 2003) and any non-conforming sentences were re-recorded. Acoustic measurements of the duration and peak F0 values of the relevant arguments are summarized in Table 2, showing that contrastively accented arguments were consistently longer and higher than their unaccented or non-contrastively accented counterparts. Durations of noun phrases excluded the determiner *the*.

Procedure—This experiment was an auditory questionnaire with a forced-choice task. Participants were seated in front of a computer and wore headphones. They pressed a button to hear each sentence and then looked at a written answer sheet. This showed two paraphrases of the sluiced material, as in (9), one with the subject antecedent (e.g., *We couldn't find out who else talked with the co-pilot*) and one with the object antecedent (e.g., *We couldn't find out who else the captain talked with*). Participants circled the letter of their chosen answer and continued on to the next item. The order of answers was varied so that subject and object answers appeared equally often in first position. Participants completed a short practice session before beginning the actual experiment to familiarize themselves with the procedure.

The experiment included a variety of other sentence types including VP Ellipsis sentences, gapping sentences, sentences with ambiguous pronouns, and other fillers, for a total of 81 items. Each participant heard only one prosodic version of a particular item, but heard equal numbers of each prosodic condition over the experiment. Items were presented by the computer in one of four pseudo-randomized orders, such that consecutive items were not of the same type or condition. The experiment lasted approximately half an hour.

Participants—Twenty-eight undergraduate students at Northwestern University who were native speakers of English and taking introductory-level linguistics classes participated in this experiment in exchange for course credit.

Results

There was an overall bias towards interpreting the object as the antecedent of the wh-remnant, which was only overcome in the Subject Accent condition. That condition received less than 50% object responses. The position of accents in all of the conditions had a strong effect on interpretation responses, as seen in Figure 2.

A four-level within-subjects and within-items ANOVA revealed that there were significant differences between conditions ($F(3,81) = 24.93, p < .001$; $F(3,45) = 26.77, p < .001$; $\text{min}F^*(3,117) = 12.91, p < .001$). There was a difference of 46% between the Object Accent and Subject Accent conditions (95% confidence interval of the difference = 8%), with the subject accent pulling object responses below 50% and the Object Accent condition having the highest level of object responses. This difference was significant ($t(27) = 7.58, p < .001$; $t(15) = 8.33, p < .001$). The Verb Accent condition had results intermediate between the two other single-accent conditions, as expected, though the level of object responses here was slightly (but not significantly) lower than the 86% found for the unpublished written baseline questionnaire. The Both Accent condition turned out to have results similar to the

Verb Accent condition, rather than patterning fully with the Object Accent condition. This suggests that listeners were aware of and used both of the accents in their interpretive decisions. The Subject Accent condition differed significantly from the Verb Accent and Both Accent conditions (subject vs. verb: $t(27) = 5.86, p < .001$; $t(15) = 5.35, p < .001$; subject vs. both: $t(27) = 5.06, p < .001$; $t(15) = 6.17, p < .001$). The Object Accent condition also showed differences from these baselines (object vs. verb: $t(27) = 2.46, p < .05$; $t(15) = 2.54, p < .05$; object vs. both, $t(27) = 2.39, p < .05$; $t(15) = 2.56, p < .05$).

Discussion

In this experiment, we continued to see both a preference for the object antecedent and effects of overt prosodic marking of an intended focus structure. The overall preference for the object as an antecedent over the subject is plausibly due to listeners' expectations about where focus appears. Focus in English is more likely on an object than a subject (Selkirk, 1984), and so that is where listeners often choose to locate it. However, listeners are not solely guided by their previous expectations; they are also sensitive to prosodic indicators of focus. All auditory experiments so far have shown significant effects of accent placement on the interpretation of sluicing sentences, with an element being chosen more often as an antecedent for the *wh*-remnant when it is accented than when it is not. In this experiment, placing a salient accent on the subject vs. the object caused a 40% swing in interpretive preferences.

In addition, the Both Accent condition in Experiment 2 clarified how listeners use pitch accents in interpretation. Specifically, previous work had not shown whether a pitch accent on the expected position of focus (the object) would be equally effective in the presence of a similar accent on the subject. It could have been the case that listeners would check the prosodic status of their preferred antecedent and then adopt that analysis given consistent information. This hypothesis would have predicted similar response levels for the Object Accent and Both Accent conditions. Indeed, these conditions only differed in the type of accent present on the subject, since the Object Accent prosody had a H* on the subject. Instead, the Both Accent condition received more subject responses than the Object Accent condition (and fewer than the Subject Accent condition), similar to the level in the Verb Accent (baseline) prosodic condition. That shows that both of the accents in the Both Accent condition were noticed and taken into account in perceivers' decisions regarding the sentence's focus structure.

EXPERIMENT 3

Subjects relying on expectations regarding the placement of focus based on information structure regularities should favor sentence-final constituents in most sentences. However, there are structures that conventionally indicate that the distribution of topical, backgrounded, and focused information is different from the typical case. As discussed in the Introduction, one such structure is the *it*-cleft, which indicates that the first constituent (*Lisa* in (11)) is focused, while the rest of the sentence-internal information is backgrounded (Atlas & Levinson, 1981; Foraker & McElree, 2007; Lambrecht, 1994; Vallduvi, 1992;).

(11) It was Lisa who Patty praised at the ceremony.

In clefted sentences, perceivers are provided with explicit syntactic information about the informational status of sentence constituents, such that focus appears in an atypical position. The clefting structure is therefore useful for disentangling the source of the object biases found in previous sluicing experiments. It could still be argued that the usual preference for late antecedents is due to some sort of recency, though not a simple gradient type (cf. Experiment 1), along with or instead of showing the influence of focus structure. But in

clefted sentences, focus is placed on the earliest constituent instead of later ones. If sluicing antecedent preferences still shift to the clefted constituent, this would argue that focus is more central to sluicing interpretation than recency when they are pitted against one another. If, on the other hand, the object bias remains, outweighing the focus marking, this would argue for a recency-based explanation of the preference. Intermediate results would suggest an influence of both factors.

Methods

Materials—Twenty-four definite sluicing sentences were created using clefted sentences, as in (12). The subjects and objects were proper names or definite noun phrases, and one of these phrases was clefted in each condition:

(12)

- a. It was Lisa who Patty praised at the ceremony, / but I don't know who else.
- b. It was Patty who praised Lisa at the ceremony, / but I don't know who else.

Condition (a) was the object cleft, in which *Lisa* was moved from object position after *praised*.

Condition (b) was the subject cleft, with the subject of the verb *praised* having been moved. The rest of each sentence was identical between the conditions.

Experiment 3 was intended to determine how readers use focus to resolve the ambiguity about the antecedent of the sluice. In order to do this in an unbiased fashion, unambiguous sentences expressing the meaning of object and subject sluices should be equally natural. Therefore, the naturalness of the materials in this experiment was tested in a norming questionnaire. Unambiguous unclefted versions of each sentence were created, with complete (non-elided) second clauses, as in (13):

(13)

- a. Patty praised Lisa at the ceremony, but I don't know who else Patty praised.
- b. Patty praised Lisa at the ceremony, but I don't know who else praised Lisa.

Sentence (13a) corresponds to the object antecedent resolution, and (13b) is the subject antecedent version. The questionnaire was designed to determine whether these two sentences are equally natural.

Two groups of 20 University of Massachusetts undergraduates rated the naturalness of the sentences on a 5-point scale, with 5 being “quite natural” and 1 being “quite unnatural.” The sentences were presented in an individually-randomized order on computer terminals using an Internet-based questionnaire program, together with 81 other sentences, most of which were ambiguous and required participants to indicate their preferred interpretation. The raters received extra course credit for their participation. One group of participants rated the object antecedent version of half the sentences and the subject antecedent version of the other half; the other group rated the other versions of the sentences. The object antecedent sentences received a mean rating of 3.16 and the subject antecedent versions, 3.08. The difference between these ratings was small and non-significant, suggesting that subjects did not find one contrast more natural or plausible than the other. In other words, in unambiguous sentences, the naturalness rating of subject antecedent and object antecedent sentences was comparable.

Procedure—Experiment 3 was a self-paced reading experiment with questions after each item. The ambiguous test sentences were presented visually on a computer screen in two large segments, as indicated by the slashes in (12). Participants pressed a button to see an underscore preview of the sentence (underscores indicated the number of letters in each word in the sentence), pressed it again to see the first part of each sentence, pressed it again to see the second part, and pressed it again when they were done reading the sentence.

After each item, two possible completed versions of the sluiced portion of the sentence, as in (14), were presented on the screen, one on each side (without the informative labels in parentheses).

(14)

- a. I don't know who else Patty praised. (object antecedent)
- b. I don't know who else praised Lisa. (subject antecedent)

Participants pressed a button under the version they felt best captured the interpretation of the sentence, thus indicating what they had taken as the antecedent of the sluice.

The experiment included the 24 sentences of Experiment 3 plus 114 other sentences of a variety of constructions. Each participant saw only one version of each particular item, but read equal numbers of each condition over the experiment. Items were presented using E-Prime (Psychology Software Tools, www.pstnet.com) in individually randomized orders, with the constraint that consecutive items were not of the same type or condition. The experiment lasted approximately half an hour.

Participants—Forty-eight native English-speaking undergraduate students at the University of Massachusetts Amherst taking psychology classes participated in this experiment in exchange for course credit.

Results and Discussion

Reading times for the first and second segment of the sentences were recorded (they are of secondary interest in the present experiment, serving primarily to show that readers read and understood the sentences reasonably quickly without pondering over the sentences). Times for the second segment, the sluicing clause, did not differ significantly between conditions (p 's > .2). But the first segment, containing the clefted constituent and the clause it came from, did show a pattern. Participants were an average of 530 ms slower reading the object cleft condition (12a) than the subject clefts (12b) (2991 vs. 2461 ms; $t(47) = 3.69$, $p < .001$; $t(23) = 3.56$, $p < .005$; $\min F'(1,60) = 6.56$, $p < .02$). This result is expected, given that other researchers have found object clefts to be more difficult than subject clefted sentences (cf. Gordon, Hendrick, & Johnson, 2001; Warren & Gibson, 2005). But the difficulty seemed to be over by the time of the second segment of the sentences.

Responses to the choice of interpretations showed a strong effect of clefting, with 75% object answers for the object cleft sentences and 39% object answers for the subject clefts (95% confidence interval of the difference = 17%). This difference was significant ($t(47) = 8.25$, $p < .001$; $t(23) = 9.14$, $p < .001$; $\min F'(1,65) = 37.5$, $p < .001$). This result can also be expressed as showing that when the object was clefted, 75% of responses chose the clefted antecedent, while 61% of responses chose the clefted antecedent when the subject was clefted. This difference was significant as well ($t(47) = 3.93$, $p < .01$; $t(23) = 3.18$, $p < .01$), showing a slight preference for the object argument. But in either case, the majority of responses clearly chose the clefted constituent.

This result is consistent with the pitch accent results in Experiment 2, showing that either syntactic or prosodic means of focusing an argument lead to more choices of that argument as the antecedent. The clefted sentences did not show a bias toward the unclefted argument, even though the clefted argument was the least recent possible antecedent in the sentences, nor did they show a weakened effect of focus compared to the accented sentences. These facts suggest that recency is less important than focus in determining the antecedent of a sluicing remnant.

EXPERIMENT 4

The final experiment returned to indefinite sluices similar to those used by Frazier & Clifton (1998). It was designed to explore the nature of the object bias observed in the present studies. In particular, it was intended to examine the possibility that the observed bias is due to some property specific to objects, such as their semantic role as patient or theme, or was due instead to more general properties of focus placement, such as the preference discussed earlier to place focus on the syntactically lowest position within the VP. It used spoken materials with two VP-internal constituents, a direct object and a following prepositional phrase, as illustrated in (15).

(15) Lucy bought some present for some occasion, but I don't know what.

Methods

Materials—There were 16 sentences similar to (15) in this experiment (see Appendix D). The sentences all had proper name subjects, and the VP contained an indefinite direct object and a prepositional phrase (PP) with an indefinite noun phrase inside it. Because the sluicing *wh*-remnant was *what*, and the sentential subjects were animate, the subject was not a potential antecedent for the remnant. Instead, the two indefinite inanimate phrases in the predicate were the only possible options. In a previous unpublished written questionnaire with 25 participants, these sentences had received 63% prepositional object responses, suggesting a baseline bias toward the lower potential antecedent.

The experimental sentences were recorded with four prosodic contours, one contrastively accenting the object, one accenting the PP-internal argument, and two baseline conditions which accented other constituents (see (16)).

H* L+H* L-H%

(16)

- a. Object Accent: Lucy bought some PREsent for some occasion, but ...

H* L+H* L-H%

- b. PP Accent: Lucy bought some present for some oCCASion, but ...

H* L+H* L-H%

- c. Verb Accent: Lucy BOUGHT some present for some occasion, but ...

L+H* L-H%

d. Subject Accent: LUCY bought some present for some occasion, but ...

The subject NPs in conditions (c-d) were given non-contrastive H* pitch accents for naturalness. The accents placed on intended antecedents were high and steeply rising (L+H*, in the ToBI system), a pitch contour most characteristic of contrastive accents, while other arguments were deaccented. The pitch tracks shown in Figure 3 exemplify the resulting prosodies.

The sentences were recorded by the first author, as in Experiment 2. All recorded sentences were viewed in Praat (Boersma & Weenink, 2003) and analyzed to ensure consistent renditions of the desired prosody. Any anomalous sentences were re-recorded. Acoustic measurements are shown in Table 3.

Procedure—This experiment was an auditory questionnaire with a forced-choice task. Participants were seated in front of a computer and two speakers. They pressed a lever to hear each sentence, and pressed it again when the sentence was finished. This caused a question and two answers to appear on the screen in front of them. The answers clarified whether the sluice had been interpreted as *I don't know which present* (the object answer) or *I don't know which occasion* (the PP answer). Participants pressed the right or left lever to choose the correspondingly-positioned answer. The order of answers was varied so that object and PP-internal answers appeared equally often on each side of the screen. Participants completed a short practice session before beginning the actual experiment so that they would be familiar with the procedure.

The experiment included a variety of other sentence types including VP Ellipsis sentences, replacive sentences, sentences with ambiguously attached adverbial phrases, and other fillers, for a total of 122 items. Each participant heard only one prosodic version of a particular item, but heard equal numbers of each prosodic condition over the experiment. Items were presented in an individually randomized order by the computer. The experiment lasted approximately half an hour.

Participants—There were 72 participants in this experiment. They were native English-speaking undergraduate students in the Psychology Department at the University of Massachusetts Amherst. Participants received course credit for their participation in the experiment.

Results and Discussion

The percentages of PP-internal argument choices (and their complements, the percentages of direct object choices) appear in Table 4. The main effect of prosody showed significant differences across the four levels ($F(1,3,213) = 2.79, p < .05$; $F(2,3,42) = 3.04, p < .05$). In the specific comparison of the two conditions with accented antecedents, listeners chose the PP-internal argument as the antecedent of the remnant 72% of the time when it was accented, and 60% of the time when the direct object was accented. This difference of 12 percentage points was significant ($t(71) = 2.94, p = .01$; $t(14) = 2.62, p = .02$), while other contrasts between conditions were not. The two conditions which did not accent potential antecedents had intermediate results. We suspect that the smaller effect of pitch accent here than in Experiment 2 is associated with the difference between definite and indefinite sluices, but we will not explore this possibility further here.

Of particular interest in this experiment is the fact that there was an overall preference of 64% (across the four accent conditions) to take the final PP constituent, not the direct object, as the antecedent of the sluice's remnant. This strongly suggests that the preference for a direct object antecedent observed in the other experiments (and in Frazier and Clifton

(1998)) is not due to a preference for object (or theme, or patient) antecedents, *per se*, but rather to a preference for the final argument, which we have argued is the default location of focus in English.

GENERAL DISCUSSION

The results of the studies above point to several conclusions regarding how perceivers interpret ellipsis sentences. Pitch accent placement and other means of conveying focus affect the choice of antecedents for the *wh*-remnant in sluicing sentences, and thus the interpretation of the sentences. Accentuation of an argument consistently led to its being chosen as the antecedent more often than when it was not accented. Similarly, the syntactic manipulation of clefting increased the number of responses choosing the clefted argument as the antecedent.

The present results thus support the view that the object bias observed for ambiguous sluice sentences by Frazier and Clifton (1998), as well as similar object biases observed for other types of ellipsis sentences by Carlson (2002), is due to focus. Neither recency nor inherent plausibility biases favoring a particular event participant can account for the whole pattern of results presented here. This was shown by Experiment 1, which specifically manipulated both distance and which event participant appeared as the subject or object antecedent. Similarly, the norming questionnaire for Experiment 3 ensured that the two possible interpretations were equally natural. In both experiments, a robust object bias for ambiguous sluice sentences emerged.

Furthermore, the results of the current experiments indicate that readers and listeners retained a bias toward interpreting the last argument as the focus of the first clause, even when overt focus markers did not support that preference. Evidence for this comes from Experiments 2, 3, and 4. Listeners chose the last argument as the antecedent for the *wh*-remnant on a fairly high proportion of trials, despite pitch accents or clefting conveying a different position of focus. We attribute this to the effect of expectations about where informational focus occurs.

The limited effects of prosodic marking of focus may not be surprising, given the potential ambiguity of pitch accents. Pitch accents need not always indicate focus. For example, phonological well-formedness requirements may cause an utterance with focus on a late constituent to be produced with an earlier element accented as well (Ladd, 1996; Selkirk, 2000; Shattuck-Hufnagel, Ostendorf, & Ross, 1994; Welby, 2003). Cohan (2000)'s production study found that sentences with contextually-supplied focus structures were produced with 34% of pitch accents outside the focused constituent (often in addition to accents placed within the focused constituent, so these were not infelicitous or anomalous productions).² Also, various types of focus may overlap. For instance, a contrastive pitch accent that is also the last and most prominent accent in a prosodic phrase may represent both contrastive and informational focus (Cohan, 2000). Thus listeners must choose between several interpretive options when faced with a particular pitch accent, since it may indicate informational or contrastive focus, or both, or neither. The absence of a fully grammaticized mapping between a particular accent and a focus interpretation makes choices possible for listeners. It also makes the role of syntactically-governed expectations regarding the appearance of focus even more important.

²The sentences in this study contained direct objects and following PPs, as in the indefinite sluicing sentences of Experiment 4. Interestingly, another finding was that sentences with focus on the object were produced 38% of the time with nuclear pitch accents within the PP (while in the PP-focus condition, 94% of sentences had nuclear accent within the PP). This supports our contention that there may be a preference to assign focus or pitch accents to the lowest/latest constituents in a sentence, though Cohan suggests it is a phonological constraint.

The current results thus suggest that syntactic factors help determine focus placement even in a language like English. Natural languages differ markedly in how they express focus: by syntactic position, as in Hungarian or Catalan, or with a morphological marker, or primarily through intonational means (see Kiss, 1998; Vallduvi & Engdahl, 1996). Our data suggest that in English, syntactic position affects the assignment of focus not only in reading, in the absence of intonational information, but also when prominent contrastive pitch accents are present, even though English is not a language with obligatory syntactic marking of focus. In fact, acoustic manifestations of focus like pitch accents appear to have significant but in many cases rather weak effects on interpretation, both in sluicing and in a range of other ellipsis constructions (Carlson, 2001, 2002; Carlson, Dickey & Kennedy, 2005; Stolterfoht, 2005; Stolterfoht et al., 2007), while syntactic position is surprisingly influential. In all these cases, syntactic distinctions appear to inform the language processor's decisions regarding how to interpret ambiguous prosodic information that could be used to mark focus.

Recent German results by Stolterfoht support the idea that syntactic focus position expectations affect processing, showing revision processes when such expectations are violated. ERP studies were conducted on German ellipsis sentences which were disambiguated by the case of the final phrase, such as (the translation of) *On Friday the father insulted the uncle, and not the nephew_{NOM/ACC}* (Stolterfoht, 2005; Stolterfoht, et al., 2007). These sentences appeared with and without the focus particle *only* to mark the position of contrastive focus. When the remnant *nephew* contrasted with the subject (*father*), there was an extra negativity, showing perceivers having to move the assumed position of focus away from the object. (See also Johnson, Clifton, Breen & Morris, 2003, for related results in English.) Given that prosodic information does not map one-to-one onto focus (and vice versa), and that focus structure must be assigned to written sentences as well as auditory ones, it is perhaps not surprising that listeners should choose to rely in part on syntactically-based assumptions regarding the placement of focus.

We turn now to the question of whether our findings are specific to English or whether they might hold more generally. As discussed above (see also Vallduvi & Engdahl, 1996), languages vary considerably in the way they mark focus. Languages can also differ greatly in their intonational properties, such as the inventory of specific prosodic contours and how those prosodic contours interact with other properties of the language's phonological system (see Beckman, Hirschberg, & Shattuck-Hufnagel, 2006). Given this cross-linguistic variation, we do not wish to make claims beyond English in terms of the precise information-structure expectations that may be brought to bear during sentence processing (though the German results found by Stolterfoht et al. suggest some similarity with English focus structure). However, we would be surprised if whatever information-structure regularities or expectations exist in a given language did not influence how ambiguous ellipsis sentences were comprehended in that language.

Another question raised in the Introduction is whether the focus effects found here are specific to contrastive focus (as marked by clefting or L+H* accenting). Across the four experiments here, contrastive focus was consistently used. We assumed as a starting point that similar effects should be found for informational focus, especially if what is most important for ellipsis interpretation is the non-focused, backgrounded material, as in recent analyses of ellipsis (Merchant, 2001; Romero, 1998). Contrastive and informational focus may differ with respect to the exact information status of the focused element, but they are similar in treating the non-focused material as background or given information (see Rooth, 1992; Vallduvi & Engdahl, 1996). However, this is an open question requiring further investigation, which we will not attempt to answer definitively here.

The robust effect of clefting on which constituent was chosen as the antecedent of the wh-remnant in Experiment 3 provides further evidence that syntactic manipulation of focus structure can affect perceivers' decisions regarding sentence interpretation. The clefting results also reinforce the conclusion that perceivers are responding to information structure and focus more than recency when choosing an antecedent for the wh-remnant in sluicing sentences. However, even clefting an argument did not guarantee that it would be chosen as an antecedent, and the non-clefted antecedent was chosen slightly more often when it was the object. Assuming that clefting sentences unambiguously mark the clefted constituent as focused (Kiss, 1998), this may mean that participants were able to entertain the idea of another focus within the rest of the clause. Or this result could indicate that a factor like the salience of recent material in memory accounts for some part of the object bias. But the results of the studies presented here suggest that recency alone cannot explain the object bias.

Additional work is needed to explore the exact nature of the expectations in focus interpretation. Experiment 1–3 found consistent evidence of an object bias for focus, but Experiment 4 suggested that this was not due to a preference for a particular syntactic role or a particular thematic role (e.g., direct objects, or themes/patients) but instead was due to an expectation based on information-structure, in particular, the expectation that the final constituent will be focused.

The existing evidence that focus is expected late in a sentence has used ellipsis interpretation as a probe for focus placement in the antecedent clause. It would be useful to have converging evidence from other domains not involving ellipsis to complement this body of results. In addition, it is possible that the role of syntax in conditioning listeners' expectations regarding the position of focus and new information could be reduced in context, where what is given and new in an utterance may be inferred from preceding discourse. Placing potentially ambiguous sentences like the ones examined here in discourse contexts should help illuminate this issue. Nevertheless, the current results suggest that perceivers have surprisingly robust expectations regarding the information structure of an utterance, even when other sources of information are inconsistent with them.

In sum, we submit that the present results shed new light on the role of information structure in comprehension, which has become increasingly central in accounts of language processing in recent years (e.g., Lee, Lee, & Gordon, 2007; Stolterfoht et al., 2007). We have argued that the pervasive final-constituent bias in the resolution of ambiguous ellipsis sentences should be related to information-structure expectations, namely the expectation that informational focus will appear late in a clause or sentence. This account of the observed preference makes sense of the fact that overt indicators of focus, such as pitch accents or syntactic clefting, and expectations about where informationally-focused phrases typically appear, both influence the choice of antecedent.

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Appendix A

Experiment 1 Materials. Note: Each item was tested in six conditions, with the arguments exchanged and length varied as shown for Item 1.

1.
 - a. The lawyer insulted the witness, but I don't remember who else.
 - b. The lawyer insulted the witness in the aftermath of the trial, but I don't remember who else.
 - c. The lawyer insulted the witness, but in the aftermath of the trial I don't remember who else.

___ I don't remember who else the lawyer insulted

___ I don't remember who else insulted the witness

- d. The witness insulted the lawyer, but I don't remember who else.
- e. The witness insulted the lawyer in the aftermath of the trial, but I don't remember who else.
- f. The witness insulted the lawyer, but in the aftermath of the trial I don't remember who else.

___ I don't remember who else insulted the lawyer.

___ I don't remember who else the witness insulted.

2. The sculptor chatted with the painter (according to the papers), but (according to the papers) it's unclear who else.

___ It's unclear { who else the sculptor chatted with./ who else chatted with the painter. }
3. The electrician recommended the plumber (according to reports), but (according to reports) no one is sure who else.

___ No one is sure { who else the electrician recommended./who else recommended the plumber. }
4. The mobster implicated the thug (despite a number of threats), but (despite a number of threats) we can't find out who else.

___ We can't find out { who else the mobster implicated./who else implicated the thug. }
5. The swimmer attacked the runner (in the middle of the closing ceremony), but (in the middle of the closing ceremony) no one could see who else.

___ No one could see { who else the swimmer attacked./who else attacked the runner }
6. The radiologist complimented the nurse (from behind the desk), but (from behind the desk) I couldn't hear who else.

___ I couldn't see { who else the radiologist complimented./who else complimented the nurse. }
7. The gardener punched the hotel porter (in the chaos of the holiday party), but (in the chaos of the holiday party) we couldn't say who else.

___ We couldn't say { who else the gardener punched./who else punched the hotel porter. }
8. The cheerleader dated the football player (despite the unsavory rumors), but (despite the unsavory rumors) no one remembers who else.

___ No one remembers { who else the cheerleader dated./who else dated the football player. }
9. The salesman recognized the secretary (through all the hubbub), but (through all the hubbub) it's not clear who else.

___ It's not clear { who else the salesman recognized./who else recognized the secretary. }
10. The teacher defended the administrator (despite a great deal of pressure), but (despite a great deal of pressure) we can't find out who else.

__ We can't find out {who else the teacher defended./who else defended the administrator.}

11. The new kid fought the bully (despite the teacher's hints), but (despite the teacher's hints) I don't know who else.

__ I don't know {who else the new kid fought./who else fought the bully.}

12. The mailboy supported the manager (during the investigation), but (during the investigation) we couldn't tell who else.

__ We couldn't tell {who else the mailboy supported./who else supported the manager.}

13. The passenger talked with the flight attendant (over the engine noise), but (over the engine noise) we couldn't tell who else.

__ We couldn't tell {who else the passenger talked with./who else talked with the flight attendant.}

14. The executive informed on the banker (thanks to the prosecution's careful investigation), but (thanks to the prosecution's careful investigation) no one knows who else.

__ No one knows {who else the executive informed on./ who else informed on the banker.}

15. The reporter sympathized with the detective (because of the poor press coverage), but (because of the poor press coverage) I'm not sure who else.

__ I'm not sure {who else the reporter sympathized with./who else sympathized with the detective.}

16. The oncologist consulted the surgeon (amid the drama of the ER), but (amid the drama of the ER) we didn't see who else.

__ We didn't see {who else the oncologist consulted./who else consulted the surgeon.}

17. The busboy hit on the waitress (despite the company policy), but (despite the company policy) I couldn't find out who else.

__ I couldn't find out {who else the busboy hit on./who else hit on the waitress.}

18. The agent hugged the model (amid the bustle of the party), but (amid the bustle of the party) we couldn't see who else.

__ We couldn't see {who else the agent hugged./who else hugged the model.}

Appendix B

Experiment 2 Materials. Each item was followed by a two-choice question, as illustrated for the first item.

1. Alice insulted Bill, but I don't know who else.
 - __ I don't know who else Alice insulted.
 - __ I don't know who else insulted Bill.
2. Frank interviewed Mark, but it's unclear who else.
3. Wendy recommended Ursula, but no one is sure who else.

4. Ray implicated Gino, but we can't find out who else.
5. Ervin attacked Michael, but no one could see who else.
6. Ruby admired Shelly, but I don't know who else.
7. Brendan punched Tony, but we couldn't say who else.
8. Annette dated Aaron, but no one remembers who else.
9. The secretary recognized the salesman, but it's not clear who else.
10. The principal defended the teacher, but we can't find out who else.
11. The bully teased the new kid, but I don't know who else.
12. The manager supported the mailboy, but it's not clear who else.
13. The Captain talked with the co-pilot, but we couldn't tell who else.
14. The banker informed on the CEO, but no one knows who else.
15. The detective sympathized with the thief, but I'm not sure who else.
16. The surgeon consulted the oncologist, but we didn't see who else.

Appendix C

Experiment 3 Materials. / indicates division into presentation segments. Each sentence was followed by a two-choice question, as illustrated for Item 1.

1. It was Lisa who Patty praised at the ceremony, / but I don't know who else.
It was Patty who praised Lisa at the ceremony, /but I don't know who else.
I don't know who else Patty praised (object);
I don't know who else praised Lisa (subject)
2. It was Richard who Patrick insulted during the meeting, /but no one would say who else.
It was Patrick who insulted Richard during the meeting, /but no one would say who else.
3. It was the famous skier who the German tourist photographed, /but it wasn't clear who else.
It was the German tourist who photographed the famous skier, /but it wasn't clear who else.
4. It was the detective who the police chief reprimanded regarding the situation, /but I don't know who else.
It was the police chief who reprimanded the detective regarding the situation, /but I don't know who else.
5. It was Larry who Melissa mocked at the party, /but we didn't see who else.
It was Melissa who mocked Larry at the party, /but we didn't see who else.
6. It was the judge who the reporter accused of fraud, /but I'm not sure who else.
It was the reporter who accused the judge of fraud, /but I'm not sure who else.
7. It was Sammy who William defended, /but we didn't hear who else.

It was William who defended Sammy, /but we didn't hear who else.

8. It was the secretary who the boss greeted this morning, /but no one remembers who else.

It was the boss who greeted the secretary this morning, /but no one remembers who else.

9. It was Dr. Green who the dean nominated for an award, /but we couldn't find out who else.

It was the dean who nominated Dr. Green for an award, /but we couldn't find out who else.

10. It was the senior accountant who the CEO asked to lie, /but I don't know who else.

It was the CEO who asked the senior accountant to lie, /but I don't know who else.

11. It was the butcher who the manager placated, /but no one knows who else.

It was the manager who placated the butcher, /but no one knows who else.

12. It was the head chef who the food critic annoyed, /but I forget who else.

It was the food critic who annoyed the head chef, /but I forget who else.

13. It was Rachel who criticized Barbara for no reason, /but no one would say who else.

It was Barbara who Rachel criticized for no reason, /but no one would say who else.

14. It was Madonna who hugged Bono on stage, /but I didn't see who else.

It was Bono who Madonna hugged on stage, /but I didn't see who else.

15. It was the music department chair who recommended the trombonist for the job, /but I never heard who else.

It was the trombonist who the music department chair recommended for the job, /but I never heard who else.

16. It was Marta who forgot to pay the pharmacist, /but it's not clear who else.

It was the pharmacist who Marta forgot to pay, /but it's not clear who else.

17. It was Tina who teased Billy, /but I don't know who else.

It was Billy who Tina teased, /but I don't know who else.

18. It was the politician who blamed the announcer for the scandal, /but no one remembered who else.

It was the announcer who the politician blamed for the scandal, /but no one remembered who else.

19. It was Josh who serenaded Annie, /but I wasn't sure who else.

It was Annie who Josh serenaded, /but I wasn't sure who else.

20. It was Ryan who admired Jessica, /but I forget who else.

It was Jessica who Ryan admired, /but I forget who else.

21. It was Jason who amused Dana, /but I don't know who else.

It was Dana who Jason amused, /but I don't know who else.

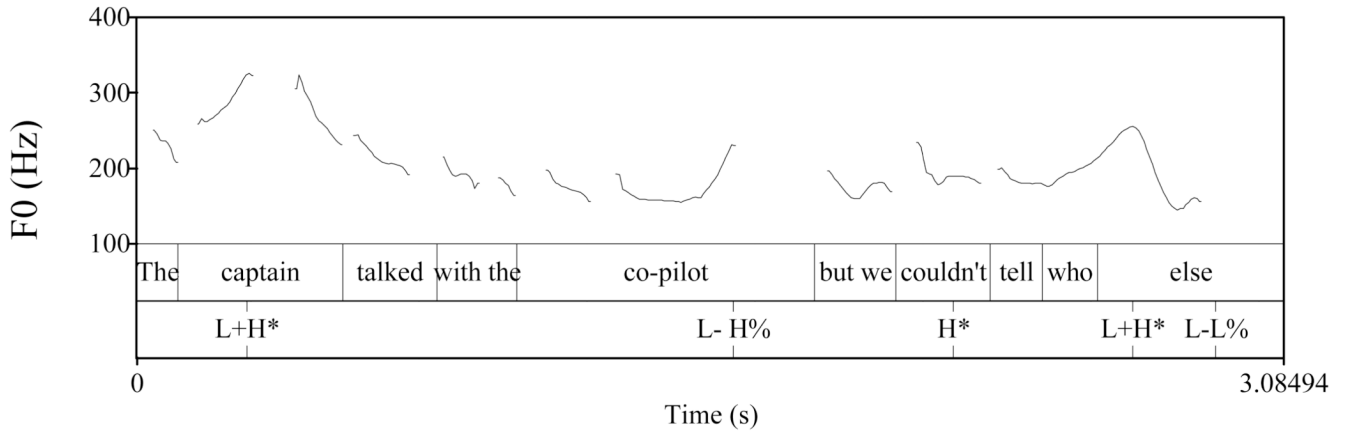
22. It was Elizabeth who told Peggy about the meeting, /but no one knows who else.
It was Peggy who Elizabeth told about the meeting, /but no one knows who else.
23. It was Whitney who danced with Phil at the prom, /but no one recalled who else.
It was Phil who Whitney danced with at the prom, /but no one recalled who else.
24. It was Beth who disliked Melinda, /but I don't know who else.
It was Melinda who Beth disliked, /but I don't know who else.

Appendix D

Experiment 4 Materials. Each item was pronounced in 4 prosodic conditions as shown for the first item.

1. Gary received some PAMPhlet from some organization but I don't know which
Gary received some pamphlet from some organiZAtion but I don't know which
Gary reCEIVED some pamphlet from some organization but I don't know which
GARy received some pamphet from some organization but I don't know which
2. Tom assigned some difficult projects to some undergraduate class but the secretary didn't know which
3. Tina organized some outing for some upcoming holiday but I couldn't tell you what
4. Melissa picked some odd color from some weird paint chips but Sue didn't say which
5. Roger put up a poster with some permanent glue but nobody knows which
6. Richard wrote a satirical e-mail about a recent incident but I've forgotten what
7. Caitlin asked a pointed question about an administrative policy but she failed to mention which
8. Theo fixed an old car with an unusual tool but he didn't say which one
9. The cleaning lady scratched a piece of furniture with a cleaning implement but she didn't say which one
10. Ian posted a notice for a rally but he didn't say which one
11. Mary dates a boy in some nearby town but she didn't tell us which one
12. Anne worked on a project for some big company but I can't remember which one
13. Sam gave a book to some girl but he didn't say which one
14. Kate received some new regulation from some branch office but she didn't tell us which
15. John stir-fried some vegetables with some implement but I don't know what
16. Lucy bought some present for some occasion but I don't know what

A. Subject accent



B. Object accent

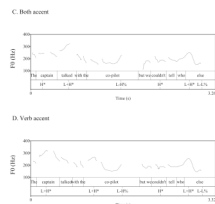
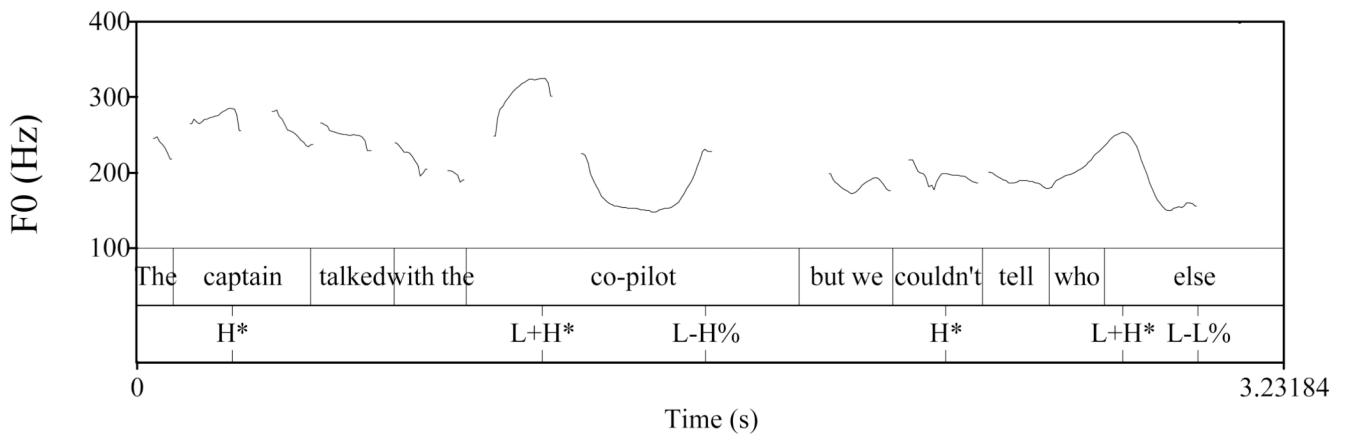


Figure 1. Representative pitch tracks, Experiment 2. Panel A: Subject Accent. Panel B: Object Accent. Panel C: Both Accent. Panel D: Verb Accent.

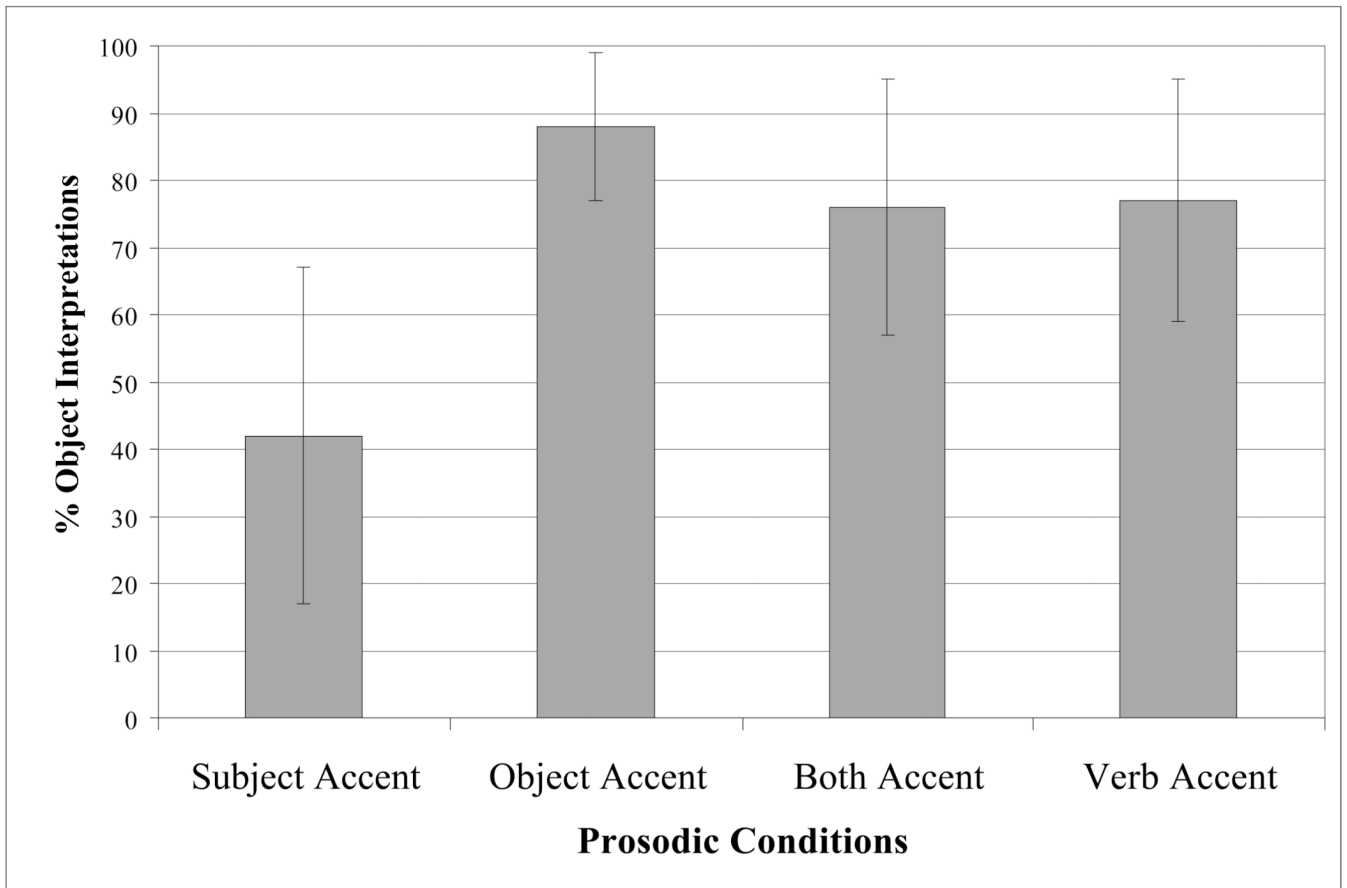


Figure 2.
Percentages of object antecedent interpretations, Experiment 2

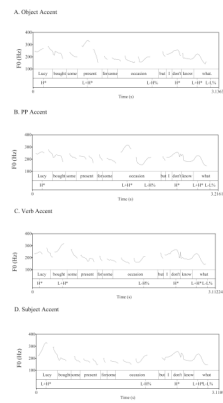


Figure 3. Representative pitch tracks, Experiment 4. Panel A: Object Accent. Panel B: PP Accent. Panel C: Subject Accent. Panel D: Verb Accent.

Table 1

Proportions of Object Antecedent Choices, Experiment 1

Order	Short	Lengthened Clause 1	Lengthened Clause 2
1	.76	.71	.77
2	.64	.74	.71
Mean	.70	.73	.74

Note—95% CI of a difference between means = 0.064

Table 2

Mean Acoustic Properties of Stimuli (SDs in parentheses), Experiment 2

Condition	Durations in ms		Fundamental Frequency Peaks in Hz		
	Subject	Object	Subject	Verb	Object
Subject Accent	425 (87)	552 (118)	359 (23)	204 (21)	172 (15)
Object Accent	341 (97)	668 (119)	252 (24)	235 (18)	340 (16)
Both Accent	382 (86)	590 (153)	357 (22)	242 (17)	298 (24)
Verb Accent	317 (81)	550 (125)	255 (16)	348 (12)	194 (13)

Table 3

Mean Acoustic Properties of Stimuli (SDs in parentheses), Experiment 4

Condition	Durations in ms		Fundamental Frequency Peaks in Hz					
	Subject	Object	PP Object	Subject	Verb	Object	PP Object	
Object Accent	295 (91)	473 (109)	547 (130)	302 (28)	264 (14)	335 (12)	176 (10)	
PP Accent	268 (88)	369 (101)	640 (139)	284 (24)	259 (14)	225 (9)	323 (14)	
Verb Accent	279 (81)	357 (101)	557 (131)	265 (12)	313 (18)	202 (12)	175 (10)	
Subject Accent	369 (75)	348 (95)	549 (132)	334 (14)	200 (12)	181 (7)	168 (9)	

Table 4

Mean Percentages of Choice of Inner Antecedent, Experiment 4

Condition	Percentage Direct Object	Percentage Final NP (PP object)
Object Accent	40	60
PP Accent	28	72
Verb Accent	33	67
Subject Accent	33	67