

Research Report

Ambiguous Pronoun Resolution

Contrasting the First-Mention and Subject-Preference Accounts

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ABSTRACT—A visual-world eye-tracking experiment investigated the influence of order of mention and grammatical role on resolution of ambiguous pronouns in Finnish. According to the first-mention account, general cognitive structure-building processes make the first-mentioned noun phrase the preferred antecedent of an ambiguous pronoun. According to the subject-preference account, the preferred antecedent is the grammatical subject of the preceding clause or sentence. Participants listened to sentences in either subject-verb-object or object-verb-subject order; each was followed by a sentence containing an ambiguous pronoun that referred to either the subject or the object. Participants' eye movements were monitored while they looked at pictures representing the two possible antecedents of each pronoun. Analyses of the fixations on the pictures showed that listeners used both order-of-mention and grammatical-role information to resolve ambiguous pronouns.

An essential feature of understanding texts is the ability to resolve co-reference relations. However, such relations, especially between pronouns and their antecedents, are often ambiguous. For example, when hearing the following pair of sentences, how do listeners determine to which person the pronoun *he* refers?

(1) *Tony Blair shook hands with George Bush in the White House. He wanted to discuss the situation in Iraq.*

Various factors have been shown to affect pronoun resolution at some stage during the comprehension process (e.g., Garnham, 2001). Considerable attention has been paid to *heuristic strategies*, especially to whether co-reference resolution is

guided by language-independent, general cognitive processes or by specific linguistic factors.

On the one hand, Gernsbacher (Gernsbacher & Hargreaves, 1988; Gernsbacher, Hargreaves, & Beeman, 1989) has proposed that the first-mentioned noun phrase in a sentence has a privileged status over other potential antecedents. According to the *structure-building* framework, the first-mentioned entity forms a foundation onto which further information is mapped when the mental representation of a sentence is built. As a result, the first-mentioned entity is the preferred antecedent of an ambiguous pronoun. The first-mention advantage is attributed to general cognitive processes that are independent of linguistic factors, such as the antecedent's grammatical role. Evidence for the first-mention preference comes mainly from probe recognition experiments. Gernsbacher and Hargreaves (1988) investigated sentences containing two noun phrases and showed that probe recognition was faster when the probe word was the first-mentioned noun phrase. Moreover, Gernsbacher and Hargreaves (1988) and Carreiras, Gernsbacher, and Villa (1995) observed this advantage even when the first-mentioned noun phrase was not a grammatical subject. However, neither study investigated the processing of pronouns. Furthermore, Gordon, Hendrick, and Foster (2000) have argued that probe recognition reflects the use of special strategies specific to probe recognition rather than processes of language comprehension. Thus, it is uncertain whether the observed first-mention advantage generalizes to on-line pronoun resolution.

On the other hand, preferences in pronoun resolution have been attributed to specific linguistic factors, especially to grammatical-role information. First, the *subject-preference* account claims that the preferred antecedent of an ambiguous pronoun is the grammatical subject of the preceding clause (Crawley, Stevenson, & Kleinman, 1990; Frederiksen, 1981). Frederiksen found that reading times for sentences beginning with a pronoun were faster when the pronoun referred to the subject of the preceding sentence rather than the object. Crawley et al. observed a similar preference. However, in both

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studies, the subject was also the first noun phrase in the clause (as is usually the case in English), so the preference may also have been due to a first-mention advantage.

Second, the proponents of the *parallelism* account argue that a pronoun is preferentially interpreted as co-referent with a noun phrase that has the same grammatical role (e.g., Sheldon, 1974; Smyth, 1994). Smyth (1994); Stevenson, Nelson, and Stenning (1995); and Chambers and Smyth (1998) observed that readers preferred antecedents that had the same grammatical role as the pronoun. The preferred antecedent for an object pronoun was the (second-mentioned) object in the preceding clause, a finding that cast doubt on the generality of the first-mention account. However, in all these studies, the clauses containing the pronoun and the potential antecedents were semantically almost identical, raising the possibility that semantic factors contributed to the preferences.

In a language like English, it is very difficult to distinguish among the accounts—and, in particular, between the first-mention and subject-preference accounts—because the grammatical subject is usually also the first-mentioned referent. Thus, all of the accounts we have mentioned predict that *Blair* is the preferred antecedent in example (1). Therefore, in the present study, we used Finnish, a language with free word order and a gender-neutral third-person singular pronoun, *hän* (“he/she”). In Finnish, grammatical roles are indicated through morphosyntactic marking, with the subject typically in nominative and the object in partitive, as in example (2):

(2) *Tony Blair kätteli George Bushia valkoisessa talossa. Hän halusi keskustella Irakin tilanteesta.*

Tony Blair (subject) shook hands with George Bush (object) in the White House. He wanted to discuss the situation in Iraq.

In this sentence, the subject noun phrase, *Tony Blair*, is in the nominative singular case, and the object noun phrase, *George Bush*, is in the partitive singular, indicated by the suffix *-ia*. *Kätteli* is a third-person singular past-tense form of the verb *kätellä* (“to shake hands with”), which, unlike in English, is a simplex verb taking a direct (partitive) object.

In (2), the word order of the first sentence is subject-verb-object (SVO). However, in Finnish, the word order can be reversed (OVS) without any change in the inflectional marking, as shown in (3):

(3) *George Bushia kätteli Tony Blair valkoisessa talossa. Hän halusi keskustella Irakin tilanteesta.*

George Bush (object) shook hands with Tony Blair (subject) in the White House. He wanted to discuss the situation in Iraq.

SVO is the basic word order in Finnish, whereas OVS is less common, but is nevertheless used frequently (Hakulinen & Karlsson, 1979). OVS is pragmatically the least marked non-

canonical order and has a variety of uses. The main syntactic function of this word order is to present the object as given information and the subject as new (e.g., Kaiser & Trueswell, 2004). Therefore, without accompanying prosodic marking, the object is not automatically topicalized. In other words, with a neutral intonation (no contrastive stress), the information structure in (3) is similar to “Tony Blair shook hands with George Bush,” rather than “it was George Bush that Tony Blair shook hands with.”

For example (2), both the first-mention and the grammatical-role accounts predict that *Tony Blair* should be the preferred antecedent for *hän*. For example (3), however, the accounts make differing predictions: The subject-preference and parallelism accounts predict that *Tony Blair* is the preferred antecedent, whereas the first-mention account predicts that *George Bush* is preferred. Therefore, (3) provides a strong test of the generality of the first-mention advantage, because both subjecthood and grammatical-role parallelism conspire against it. However, a preference for the object would be consistent with the first-mention account, but might also be due to a preference for the noun phrase in the topic position.

On the basis of a visual-world eye movement study of Finnish pronoun resolution, Kaiser and Trueswell (2003) argued for a preference to interpret *hän* as co-referent with the subject of the preceding clause regardless of word order. However, a closer look shows that in the SVO condition, there were more looks to the object than to the subject 800 to 1,200 ms after onset of the pronoun, but this pattern reversed 1,400 ms after pronoun onset. In the OVS condition, the pattern was the opposite, with initial looks to the subject, followed by more looks to the object. These results seem to go against both the subject-preference and the first-mention accounts. Instead, they suggest that there is an initial *recency* preference for the second-mentioned character, followed by a later preference for the first-mentioned character (cf. Gernsbacher et al., 1989). Thus, contrary to Kaiser and Trueswell’s claim, it seems that order of mention affected online comprehension. However, the interpretation of their study is hampered by the fact that the first sentence always ended with either the subject or the object. This may explain the observed initial recency preference: When participants heard the pronoun, they may still have been fixating the second-mentioned character. To avoid a similar problem, in the present study we included a location (e.g., *in the park*) as the last phrase in the first sentence, so that at the onset of the pronoun, participants were usually fixated on the picture of the location.

EXPERIMENT

In the present experiment, we investigated the processing of subject pronouns in Finnish. Participants were presented with spoken ministories such as (2) and (3), and at the same time, their eye movements were monitored while they looked at pictures of the two characters and the location in each story (cf.

Arnold, Eisenband, Brown-Schmidt, & Trueswell, 2000; Tanenhaus, Spivey-Knowlton, Eberhard, & Sedivy, 1995).

Method

Participants

Twenty-eight students at the University of Turku, Finland, participated. All were native speakers of Finnish and had normal or corrected-to-normal vision.

Apparatus

An SR Research EYELINK II eyetracker was used. The eyetracker is an infrared video-based system with two cameras mounted on a headband. A monocular registration with a 500-Hz sampling rate was used. The spatial accuracy was better than 0.5°.

Materials

Forty ministories consisting of two sentences were constructed. The stories appeared in two versions, with the first sentence in either SVO or OVS order. In each story, the first sentence mentioned two well-known persons or cartoon characters and a location, as in (2) and (3). The second sentence always began with the gender-neutral subject pronoun *hän*. This sentence was constructed so that the words immediately following the pronoun did not bias the pronoun toward one of the potential antecedents. The grammatical roles filled by the characters were counterbalanced so that across the stories, all characters acted as both the grammatical subject and the grammatical object. Hence, there were 40 experimental items, each having two word orders in two counterbalancing conditions. The resulting four versions were counterbalanced across four experimental lists. In addition, each list contained 40 filler stories. Seven participants were randomly assigned to each list.

In order to avoid verbs that had a strong implicit causality bias for interpreting the pronoun as co-referent with either the subject or the object (e.g., Garvey & Caramazza, 1974), we selected the experimental verbs using a sentence-completion task. Ninety verbs were embedded in sentence fragments of the form *[Noun Phrase 1][Verb][Noun Phrase 2], because. . .* None of the 20 selected verbs had more than 62.5% completions favoring either subject or object.

The materials were read aloud by a male native speaker and recorded onto a computer hard disk. A 1,000-ms pause was inserted between the offset of the first sentence and the onset of the second. In order to keep the information structure in SVO and OVS versions as similar as possible, all stimuli bore neutral sentence intonation, and neither the noun phrases in the first sentence nor the pronouns were stressed.

The subject, object, and location were presented as separate pictures. The pictures were facial photographs of well-known persons or cartoon characters and clearly identifiable locations.

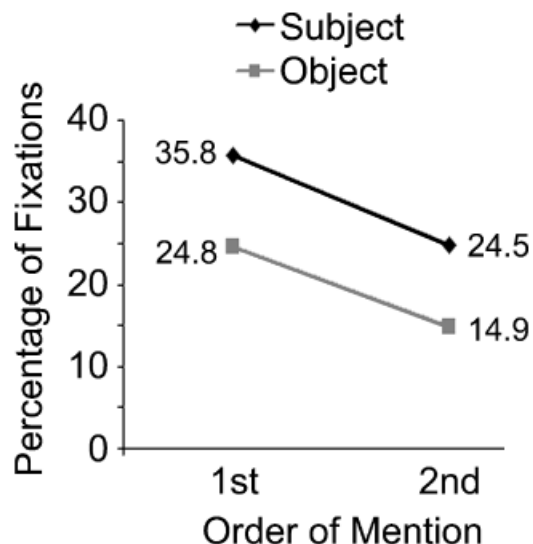


Fig. 1. Percentage of first visits to the subject and object by order of mention.

The position of the pictures was counterbalanced within conditions.

Procedure

On each trial, after the participant had fixated on the fixation point, the experimental pictures appeared on the computer screen. The sound file started 50 ms later and lasted for 9.5 to 11 s. Participants were instructed to follow the pictures while listening to the ministories for comprehension. The experimenter occasionally asked participants to continue a ministory using the presented characters and the location. Each participant produced approximately 10 continuations.

Results

Two eye movement measures are reported: (a) the percentage of first visits to subject or object after the onset of the pronoun and (b) the number of fixations on the subject and object at different points in time after the onset of the pronoun, showing the time course of the effects. Trials on which the participant fixated either of the critical characters at the onset of the pronoun were excluded (19.5% of trials, equally distributed between the subject and object characters in both word-order conditions).

Analyses of variance (ANOVAs) were conducted with grammatical role (subject vs. object) and order of mention (first vs. second mention) as within-participants and within-items factors. Omitted from the analyses were the data from 1 participant who failed to fixate on either character on 70% of the trials. Another participant did not have any fixations to the grammatical object in the SVO word order. Therefore, the means for the number of first visits to the object for this participant in the SVO condition were taken to be 0.

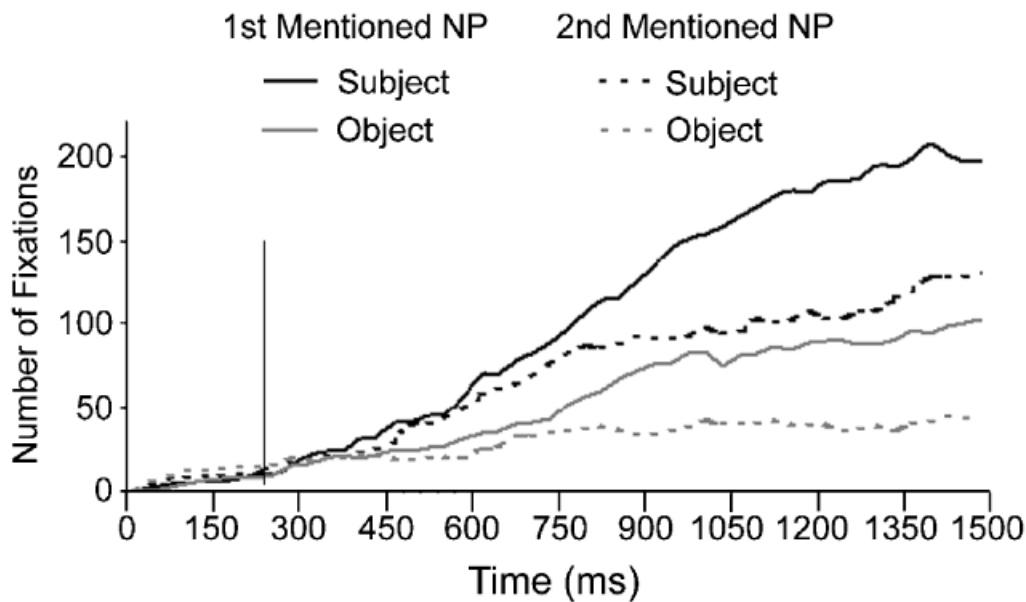


Fig. 2. Number of visits to the subject and object by order of mention within the first 1,500 ms from pronoun onset, pooled in 30-ms time frames. The vertical line indicates the average offset of the pronoun (270 ms). NP = noun phrase.

Percentage of First Visits

Figure 1 shows the percentage of first visits. ANOVAs revealed a significant effect of grammatical role, $F_1(1, 26) = 19.47, p < .001, \eta_p^2 = .428$, and $F_2(1, 39) = 45.86, p < .001, \eta_p^2 = .540$, with more first visits to subjects than to objects. In addition, there was a significant effect of order of mention, $F_1(1, 26) = 17.77, p < .001, \eta_p^2 = .406$, and $F_2(1, 39) = 39.35, p < .001, \eta_p^2 = .502$, with more first visits to first- than to second-mentioned characters. There was no significant Grammatical Role \times Order of Mention interaction ($F_s < 1$). Analyses of simple effects showed no difference between first visits to the subject and object when the first sentence was in OVS order ($F_s < 1$), indicating that there was no advantage for the first-mentioned noun phrase.

Time-Course Analyses

Figure 2 presents the time course of the effects. ANOVAs were conducted on the number of fixations in four 210-ms time slices

after offset of the pronoun (at 270 ms; see Table 1). There were no significant effects within the first time slice. In the second, there was an effect of grammatical role only. There were effects of both grammatical role and order of mention in the third and fourth time slices. There were no reliable interactions.

GENERAL DISCUSSION

The eye movement measures showed clear effects of both grammatical role and order of mention. The first-visit measure showed that after hearing the pronoun, participants fixated more often on pictures of the subject character in the antecedent sentence than on pictures of the object character. This suggests that participants preferentially interpreted the pronoun as co-referent with the subject rather than the object. Participants also fixated more often on the first-mentioned than the second-mentioned character in the antecedent sentence, suggesting that they also had a preference to interpret the pronoun as referring to the first-mentioned character rather than the second-

TABLE 1
Time-Course Analyses: Effects of Grammatical Role and Order of Mention on Number of Fixations

Time segment	Grammatical role		Order of mention	
	$F_1 (\eta_p^2)$	$F_2 (\eta_p^2)$	$F_1 (\eta_p^2)$	$F_2 (\eta_p^2)$
270–480 ms	<1	<1	<1	<1
480–690 ms	7.54 (.225)*	23.28 (.374)**	1.31 (.048)	1.74 (.043)
690–900 ms	16.97 (.395)**	36.19 (.481)**	4.81 (.156)*	8.74 (.183)*
900–1,110 ms	21.17 (.449)**	55.37 (.587)**	11.71 (.310)**	49.96 (.562)**

Note. The 270-ms segment containing the pronoun was not analyzed because of the low number of fixations on either the subject or the object picture.
* $p < .05$. ** $p < .001$.

mentioned. There was no interaction between grammatical role and order of mention, indicating that they had independent effects on resolution of the ambiguous pronouns. More important, there was no preference for the first-mentioned character in OVS sentences. This finding is inconsistent with Gernsbacher's (Gernsbacher & Hargreaves, 1988; Gernsbacher et al., 1989) first-mention account and with accounts that claim the object in OVS sentences is preferred because it is the topic.

Consistent with the first-visit analyses, the time-course analyses showed effects of both grammatical role and order of mention. The grammatical-role effect first emerged in the 480- to 690-ms time segment. However, the effect of order of mention emerged later, in the 690- to 900-ms segment. In addition, Figure 2 shows no evidence for a first-mention preference in the OVS sentences; if anything, there were more looks to the subject than to the object character.

The overall subject preference and the early subject preference in the time-course analysis are most likely due to a combination of strategies. First, listeners may have a strategy to interpret pronouns as co-referent with the grammatical subject (e.g., Crawley et al., 1990; Frederiksen, 1981). Second, listeners may prefer co-reference with a noun phrase that has the same grammatical role as the pronoun (e.g., Sheldon, 1974; Smyth, 1994). In this study, this parallelism effect may have been enhanced by the fact that in Finnish, parallel grammatical roles are signaled by overt case marking on both the pronoun and the antecedent noun phrase. However, the structure of the second sentence differed from that of the first, and it has been suggested that this may weaken the parallelism effect (Smyth, 1994).

The results from our experiment are clearly incompatible with Gernsbacher's first-mention account, which claims that general cognitive processes favor co-reference with the first-mentioned noun phrase (Carreiras et al., 1995; Gernsbacher & Hargreaves, 1988). This account does not assign any role to linguistically driven strategies. Similarly, our results provide evidence against approaches suggesting that the subject-preference strategy is the only strategy in pronoun resolution (Crawley et al., 1990; Frederiksen, 1981). Rather, our experiment indicates that both factors have an effect (e.g., Gordon & Chan, 1995; Gordon, Grosz, & Gilliom, 1993). Therefore, our results make clear that one-factor models are inadequate, and that pronoun resolution is determined by a delicate interplay of several factors.

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