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The effect of the discourse center on the local coherence of a discourse¹

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This paper presents two experiments that test the notion of a discourse center introduced by Grosz, Joshi, and Weinstein (1983). The discourse center is a central component of a larger theory of discourse structure being developed by Grosz and Sidner (1985).

Grosz et al. (1983) have defined two levels of discourse coherence. Large segments of a discourse are related to one another by a process, namely focusing, which maintains the global coherence. Centering is an additional process which aids in the local coherence of a discourse. Local coherence is defined as the coherence between adjacent utterances. A forward-looking center provides entities to which the remaining discourse may be tied. A backward-looking center (hereafter the center) connects the current sentence with the immediately preceding discourse. The center is that element from all the focused elements that the utterance is about.

Grosz et al. suggest different roles played by pronouns and nouns in discourse coherence. Pronouns most often serve in identifying the single entity the discourse is about. Noun phrases, on the other hand, are most often used to shift the focus of the discourse and as such they are related to the global coherence of the discourse. Thus the use of a noun phrase rather than a pronoun to refer to the center is somewhat unnatural as seen in the fact that sentence (1b) more naturally follows (1a) than (1c).

- (1) a. Who did Max see yesterday?
b. He saw Rosa.
c. Max saw Rosa.

We tested two predictions generated from the discourse center hypothesis. First, an ambiguous pronoun, e.g., the pronoun "she" when there are two female antecedents in the discourse will be interpreted immediately with the antecedent of the pronoun assumed to be the discourse center. If the correct antecedent later turns out not to be the center, the pronoun will have to be reinterpreted resulting in increased processing time. The second prediction is that a pronoun will be more rapidly understood than a noun phrase when both refer to the center of the preceding sentence.

The materials were two-sentence discourses in which the first sentence, hereafter the context sentence, introduced two possible antecedents and the second sentence, hereafter the target sentence, began with either a pronoun or a proper noun which

referred to either the centered or noncentered entity in the context sentence. The subject of the context sentence was established as the discourse center by using verbs in which the subject was likely to be the perceived cause of the event described by the verb (Brown and Fish, 1983; Newman, 1984). Implicit causality of verbs has been shown to control antecedent assignment in sentences with ambiguous pronouns in studies by Caramazza and colleagues (Garvey & Caramazza, 1974; Garvey, Caramazza, & Yates, 1975; Caramazza, Grober, Garvey, & Yates, 1977) and more recently by Newman (1984).

Example materials are presented in (2). The context sentence is given in (2a). Target sentences beginning with a pronoun and noun that refer to the centered entity are given in (2b) and (2c), respectively, and target sentences beginning with a pronoun and noun that refer to the noncentered entity are given in (2d) and (2e), respectively.

- (2) a. Jack apologized profusely to Josh.
- b. He had been rude to Josh yesterday.
- c. Jack had been rude to Josh yesterday.
- d. He had been offended by Jack's comment.
- e. Josh had been offended by Jack's comment.

Twenty sets of materials similar to those given in (2) were used in Experiment 1. The four target sentences for each context sentence were counterbalanced across four presentation lists. The test sentences were intermixed with sensible and nonsensible fillers. An example of a nonsensible filler context and continuation sentence is presented in (3a) and (3b), respectively.

- (3) a. John couldn't mail Tim a check.
- b. He was proud that Tim was able to.

Twenty University of Rochester volunteers served as subjects. Their task was to read each sentence carefully and, when cued, to indicate whether or not the two-sentence texts were comprehensible. The sentences were presented visually on a CRT. On each trial the context sentence was displayed. Upon reading the context sentence the subject pressed a button. The context sentence was removed from the screen and the target sentence was immediately presented. Upon reading the target sentence the subject again pressed the button. The target sentence then disappeared from the screen, and a question mark appeared. The subject then judged whether or not the text made sense by pressing one of the two response buttons.

The results are presented in Table 1. The conditions are labeled according to whether a pronoun or noun was used as an anaphor and whether the pronoun or noun referred to the centered or noncentered discourse entity. The percentage of sentences judged to make sense are in parentheses. Reading times are for

target sentences judged to make sense.

A 2X2 ANOVA with Type of Antecedent and Type of Anaphor as factors was conducted on both the reading times for the target sentences and the percentage of cases in which the texts were judged "sensible." For the judgment data, there was a significant interaction both by subjects ($F(1,15)=17, p<.001$) and by items ($F(1,18)=8.69, p<.008$), and for the reaction data, there was a significant interaction by subjects ($F(1,15)=5.643, p<.03$) and a nearly significant interaction by items ($F(1,18)=3.69, p<.08$).

There were two primary hypotheses. The first was that the initial phase of the target sentence would be read more rapidly when it began with a pronoun than when it began with a noun, because the pronoun's antecedent would be immediately interpreted as the discourse center. Second, if the pronoun's antecedent turns out not to be the center, readers will have been led down the "garden path" and they will be forced to reprocess the sentence. Thus we expect that in these cases subjects will either judge these sentences to be nonsensical or will take a relatively longer time to determine that the sentences do make sense.

The main predictions were confirmed. Target sentences that began with a pronoun were read more rapidly and judged to be sensible more often when the antecedent was not the center. Sentences in which the subject of the target sentence referred to the centered entity were read more rapidly when the sentence began with a pronoun than when the sentence began with a noun.

The second experiment was conducted to replicate the first experiment and to provide more local information about the pronoun assignment. We used materials similar to those in the first experiment but divided the target sentence into two phrases so that the disambiguating information always came in the second phrase. Example materials are presented in (4). The context sentence is presented in (4a). Target sentences were either consistent or inconsistent with the centered agent in (4b-c) and (4d-e), respectively. Target sentences beginning with a pronoun are presented in (4b) and (4d) and target sentences beginning with a proper name are presented in (4c) and (4e). The slash mark indicates where the sentences were broken into phrases.

- (4) a. Jack apologized to Josh.
b. He hadn't even/ noticed Josh.
c. Jack hadn't even/ noticed Josh.
d. He hadn't even/ noticed Jack.
e. Josh hadn't even/ noticed Jack.

The experimental materials were counterbalanced over four presentation lists. The test sentences were intermixed with sensible and nonsensible fillers. Twenty-four University of Rochester volunteers served as subjects. The context sentence was

displayed on a CRT followed by a target sentence. When the first phrase of the target sentence was displayed subjects pressed a button which resulted in the presentation of the second phrase. The subject then decided whether or not the entire target sentence was comprehensible with respect to the context sentence. This judgment was indicated by a YES or NO response.

Table 2 presents the proportion of sentences judged to make sense and the reading times to those sentences. A 2X2 ANOVA with Type of Anaphor and Type of Antecedent as factors was conducted on the reading time data for the first phrase and both the judgment and reading time data for the second phrases.

The reading time data for the first phrase support the first prediction from the center hypothesis. Sentences with pronouns were read faster than sentences beginning with nouns. This was reflected in a significant effect of Type of Anaphor ($F(1,19)=7.615$, $p<.01$ by subjects and $F(1,19)=5.738$, $p<.03$ by items). Somewhat surprisingly, the reading times to the noncentered noun were faster than the centered noun, suggesting that beginning the target sentence with the noncentered noun violated reader's expectations. The comparison between centered pronouns and nouns was in the right direction, with phrases beginning with centered nouns taking longer to read, but the difference did not reach significance ($F(1,19)=2.573$, $p<.12$ by subjects and $F(1,19)=2.79$, $p<.11$ by items).

The second phrase judgment data strongly support the second prediction. There was a robust interaction between Type of Anaphor and Type of Antecedent in the subject and item analyses ($F(1,19)=19.54$, $p<.0004$ by subjects and $F(1,19)=38.94$, $p<.00003$ by items). As in the first experiment, subjects frequently rejected sentences with pronouns that referred to the noncentered entity. The reading time data are less clear. As expected, reading times were longest when the second phrase indicated that the pronoun in the first phrase referred to the noncentered entity. However, contrary to our expectations, the fastest second phrase reading times obtained when the first phrase contained a centered noun. Overall, there was a significant effect of centeredness, ($F(1,19)=7.77$, $p<.01$ by subjects only), indicating that having a noncentered entity as the subject of the sentence interfered with processing, even when the noncenter was unambiguously introduced as a noun.

Conclusion

The results of both experiments lend strong support to the discourse center hypothesis proposed by Grosz et al (1981). When readers encounter an ambiguous pronoun, they immediately assume that its antecedent will be the discourse center of the previous sentence. Moreover, sentences which continue with the same center as the preceding sentence are read more rapidly and judged to be

more comprehensible when the center is mentioned as a pronoun than when the center is mentioned as a noun. However, the mechanics of center shifting remain unclear, and our future research will focus on these issues.

TABLE 1

Type of Anaphor	Type of Antecedent	
	<u>Center</u>	<u>Noncenter</u>
Pronoun	2158 (97%)	2644 (78%)
Noun	2475 (94%)	2422 (95%)

Reading times for the target sentences in Experiment 1 with the percentage of sentences judged to be sensible in parentheses.

TABLE 2

Type of Anaphor	Type of Antecedent	
	Center	
	<u>Phrase 1</u>	<u>Phrase 2</u>
Pronoun	He hadn't even 961	noticed Josh. 2026 (85%)
Noun	Jack hadn't even 1075	noticed Josh. 1687 (75%)
	Noncenter	
	<u>Phrase 1</u>	<u>Phrase 2</u>
Pronoun	He hadn't even 970	noticed Jack. 2368 (60%)
Noun	Josh hadn't even 1187	noticed Jack. 2019 (80%)

Reading times for the first and second phrases of the target sentences in Experiment 2. The percentage of sentences judged to make sense is in parentheses after the second phrase reading times.

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