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Understanding Anaphora: Rules Used by Readers in Assigning Pronominal Referents

John R. Frederiksen

July 1981

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addition to reading the text, subjects were occasionally asked to report the correct referent for a pronoun that had appeared in the sentence they have just completed. With this probe task motivating them to analyze carefully reference problems as they were encountered, subjects' reading times were found to be closely related to structural properties of the text. Text variables of importance included the number of potential referents available, topicalization of the correct referent, staging of references to the correct or to alternative noun phrases, and the degree of ambiguity of the semantic constraints within the target sentence used in selecting the proper referent. The results support a reinstatement theory in which a number of available, potential referents are brought forward into working memory at the time a pronoun is encountered. The selection of a single referent from the set of potential referents is based upon a set of prioritizing rules that are sensitive to the staging of ideas within text and to features of surface syntactic structure as well as to propositional content.

UNDERSTANDING ANAPHORA: RULES USED BY READERS IN ASSIGNING PRONOMINAL REFERENTS

John R. Frederiksen

Bolt Beranek and Newman Inc.

Report No. 4462

Technical Report No. 3

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Abstract

The focus in this experiment was on the analysis of cohesive elements within a text and on the difficulty of their resolution within a particular text structure. The cohesive form we selected was a particular type of anaphoric reference -- pronominal reference. The subjects' task was to read a text sentence by sentence. The texts presented contained pronouns, and referents for the pronouns. In addition to reading the text, subjects were occasionally asked to report the correct referent for a pronoun that had appeared in the sentence they had just completed. With this probe task motivating them to analyze reference problems carefully as they were encountered, subjects' reading times were found to be closely related to structural properties of the text. Text variables of importance included the number of potential referents available, topicalization of the correct referent, staging of references to the correct or to alternative noun phrases, and the degree of ambiguity of the semantic constraints within the target sentence used in selecting the proper referent. The results support a reinstatement theory in which a number of available, potential referents are brought forward into working memory at the time a pronoun is encountered. The selection of a single referent from the set of potential referents is based upon a set of prioritizing rules that are sensitive to the staging of ideas within a text and to features

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Understanding Anaphora: Rules used by Readers in Assigning Pronominal Referents

Pronouns are referential terms; rather than having their own semantic interpretations, they are words that make reference to something else for their interpretation (Halliday & Hasan, 1976). In reading, that something else is generally knowledge derived from prior text, and encoded in the reader's discourse model. The problem at issue here is how readers develop interpretations for pronouns in the light of their understanding of a text. The purpose of this study is to identify text characteristics that influence a reader's difficulty in resolving problems of pronominal reference. In the process, we hope to draw inferences about the rules used by readers in searching for and selecting referents from prior text at the time a pronoun is encountered.

Process models for solving problems of anaphoric reference must deal explicitly with a set of questions regarding possible strategies for the interpretation of pronouns in a text.

Reinstatement of Potential Referents

Pronouns differ from other forms of reference, such as lexical reference (which includes synonyms, superordinates, properties, collocative expressions, etc.; cf. Halliday & Hasan, 1976), in that the need for a referent is immediately evident

when the pronoun is perceived. A pronoun thus serves a pointer function, and communicates to the reader that a referent having specified gender and number must be sought in earlier text. According to a reinstatement theory, readers reinstate into active memory, or reconsider, the set of noun phrases (potential referents) that are available in the prior text at the moment the pronoun is encountered. The set of reinstated nouns (or noun phrases) might include all those agreeing in gender and number with the pronoun, that received some emphasis in prior discourse, or that occurred recently in the text. Such a reinstatement search (Kintsch & van Dijk, 1978) would then be followed by the selection of a single referent from among these reinstated potential referents, as soon as semantic constraints within the sentence will allow such a selection.

The alternative to a reinstatement theory would be to conceive of a process in which an empty pointer or slot is set up at the time the pronoun occurs, to be later filled when semantic constraints will permit. Here, the pronoun merely serves the marking function, with retrieval of the appropriate referent awaiting the occurrence of adequate semantic constraints within the sentence containing the referent noun phrase. The empty slot thus acts like a blank in a CLOZE test item (Taylor, 1953). Evidence supporting the reinstatement theory at the expense of the "pure pointer" theory would consist in a demonstration that

the presence of alternative noun phrases that agree in gender and number with the pronoun will increase processing difficulty in finding referents for pronouns, even when they are semantically inappropriate within the sentential context of the pronoun.

Dominance by a Prior Referent

Since pronouns in a text are typically used repeatedly to refer to the same referent, an efficient processing strategy might be to allow the pronoun to be "dominated" by the referent it has just been assigned. Then when the pronoun is next encountered, the last used referent can be substituted and verified on the basis of intrasentential semantic constraints. If it is not verified, a new process of referencing will be undertaken, but with the advantage that semantic constraints will reduce the set of reinstated noun phrases to, in all likelihood, a single item. The alternative to this view is to regard pronouns as serving a momentary reference function, so that following a particular use they are free to be assigned new referents. Consider, for example, the sentence:

> When the environmentalists petitioned the members of the board of directors, they saw that they were adamantly opposed to any change in the construction schedule.

The fact that the second they in this sentence is free to be assigned to either referent (environmentalists, members of the board) is driven home if we consider the following alternative ending for the sentence:

> they saw that they had little hope of realizing their goals.

While it is possible to construct examples of the re-use of pronouns to refer to separate referents, it remains possible that the processing required is more difficult when a switch in referents has taken place. Such a result would constitute evidence for the dominance of a pronoun by its prior referent.

Establishing Priorities in Selecting Referents

An author can manipulate the degree of emphasis or topicalization accorded a particular referent noun phrase through the use of stylistic devices that emphasize one or another noun phrase (Grimes, 1975). Topicalized noun phrases will be more readily assignable as referents than will noun phrases that are relegated to the background. Gruber, Beardsley, and Caramazza (1978), for example, have shown that a noun that is the subject of the first clause of a sentence is preferred over a noun occurring in the predicate, as a referent for a pronoun occurring in a second because or but clause. And Lesgold, Roth, and Curtis

(1979) have shown that, when a sentence refers to earlier material in a discourse, it takes longer to understand when the material referred to has been "backgrounded" than when the material has foreground status.

The list of text characteristics that can accord foreground or background status to a particular noun phrase may be fairly long. One source of possible text variables can be found in the rich characterization of cohesive forms developed by Halliday and Hasan (1976). While their analysis provides no general principle for classifying particular forms as to their difficulty with respect to pronominal reference, it does suggest a number of text variables that are prime candidates for further study. These are illustrated in Table 1. The first variable in Table 1 bears on the issue of reinstatement of potential referents, discussed earlier. In the first sentence set (a), the number of potential referents for a pronoun has been varied. Sentence one contains two antecedent noun phrases that are compatible with the pronoun it: the nineteenth century and America. The alternative to sentence one contains only a single such antecedent. In (b), we have manipulated the distance in the text between referent and pronoun. A sentence intervenes between the pronoun it in the final sentence and its referent, St. Mark's Square, in the initial sentence of the set. In (c), we have a set where an intervening sentence uses the pronoun he in the same way as does

Table 1
Text Variables

(a) Number of Potential Referents

The nineteenth century was a period in which numerous immigrants came to America.

It closed with a second wave, stemming from Italy, Poland, Russia, and the other Slavic countries.

Alternative to sentence one:
The nineteenth century was an era of immigrations.

(b) Number of Intervening Sentences

The great square of St. Mark's in Venice is constantly alive with activity.

Cathedral bells toll, and children frolic, amidst a swirl of greedy pigeons.

It is, as Napoleon once remarked, "the most magnificent drawing room in Europe."

(c) Mediated versus Nonmediated Intervening Sentences

The judge passes up the letter to the defendent's lawyer, who studies it.

He is finally ready, it now becomes clear, to address the court and pass sentence upon William Crawford.

He says: "William Crawford, you have made a proper mess of your life, and I have no choice except to send you to prison."

Alternative intervening sentence:
The clerk rises, calls the proceedings to order, and turns, rather stiffly, toward the prisoner's dock.

(d) Referent in Subject Position

Modern advertising does not, as a rule, seek to demonstrate the superior quality of the product.

It plays up to the desire of Americans to conform, to be like the Joneses.

Alternative to sentence one:
The superior quality of the product is not, as a rule, what modern advertising seeks to demonstrate.

(e) Foregrounding an Incorrect Referent

The congressman's early struggles were a subject he reminisced about, in two candid interviews.

The interviews were filmed in the spacious corner office which he had occupied for the past thirty years.

They were pieces of a past that was still clearly alive, and very much part of the current picture.

(f) Ambiguous Selection of a Referent

Seeing Japan had always been his life-long dream.

The mere mention of the East had brought visions of strange new lands, and thrilling adventures.

It was finally becoming a reality for him.

Alternative to sentence three:
It was all that he had hoped it would be, and that was saying a great deal.

the final sentence, to refer to the judge. (This would not be the case had the alternative intervening sentence been used.) The sentences in set (d) allow us to study the topicalizing effect of placing a referent noun phrase in the subject position. In (d), both the referent modern advertising and pronoun it are subjects of their respective sentences. If the paraphrase of the first sentence printed at the bottom were used instead, this would not have been the case. And in (e), we illustrate how texts can be constructed to manipulate the staging of references to alternative noun phrases. There is, following the initial sentence, an intervening sentence that brings to the foreground an "incorrect" potential referent (interviews), and thus places the correct referent for the target pronoun -- struggles -- in the background. Finally, in (f) we see how the effect of semantic ambiguity on selection of a referent can be studied. In the final sentence of the paragraph, it can refer either to seeing Japan or to life-long dream. In contrast, it in the alternative sentence can refer only to seeing Japan.

Each of these text variables may have an important bearing on the problem of text reference. A careful study of such text variables and their effect on performance may allow us to develop a set of prioritization rules or principles that account for the influence of such structures on the selection of referents for pronouns. At the same time, something will be learned of the

nature of text representations built in reading for comprehension. In the research to be reported, we have sought to develop a data base that will allow us to select from among the alternative forms of theory we have discussed a reasonable set of initial specifications for a process theory of text reference. We have in addition been interested in exploring the differences among skilled and less skilled readers in their sensitivity to text structure as it is related to difficulty in resolving problems of text reference.

Method

Subjects

Subjects were 44 high school students in grades 10-12, chosen to represent a wide range of reading ability levels. Their reading skill was assessed using the Nelson-Denny Reading Test. Subjects were grouped into four levels, with eleven subjects in each group. Subjects at the bottom level were below the 50th percentile on that test. Those at the second level had scores above the 50th and below the 80th percentile, while those in the third level had scores above the 80th but below the 98th percentile and those in the top category had scores in the 98th or 99th percentiles.

Procedure

In the experimental task, subjects were presented a series of paragraphs of text to read, a sentence at a time. They could control their rate of progress in reading each text by pressing a button when they were ready for the next text segment. This method of presenting text permitted us to measure reading time for each presented unit. In addition, we have developed a technique for marking a particular word in a preceding segment so that we could probe the reader's understanding of the forms that were so marked. The probed forms were, of course, pronouns. For

example, the subject might be shown the following series of displays (indicated by numbered lines):

1. Violence has been, all too often, a frank goal of much of humanity.

2. Have we not had enough wars and disasters on this planet of ours?

3. Will people not tire of dreaming up reasons to see each other as enemies?

4. It is something that we must instead, of necessity, work to control and to prevent.

The underscore beneath it in display 4 appears at the moment the subject requests a new line, after he has finished reading the sentence in 4. The underscore remains until the subject identifies the referent. Measures obtained include reading times for each sentence, as well as the reaction time from the onset of the underscore in line 4 to the subject's vocal report in supplying the referent, which is in this instance "violence" or some clear synonym for that word.

Sentences were presented on the screen of an Imlac PDS-1 display computer. Characters used were highly legible, drawn using vector-stroke graphics, and twice the size of the standard

Imlac characters. Capital letters subtended .67 degrees of visual angle at the subject's viewing distance of 72 cm. Sentences occupied 2, 3, or 4 lines, each line having no more than 45 characters, with a typical line containing 5 or 6 words. A telegraph key was furnished for the subject to use when requesting the next sentence of a text. When the key was depressed, the screen would go blank and, after a brief interval, the next sentence would appear. At times (as explained above), the previous sentence would instead reappear with a pronoun underscored, and the subject's task at that moment was to "say to what or to whom the pronoun refers." Vocal RTs were measured from the re-appearance of the target sentence to the onset of vocalization, using a Grason-Stadler Model E7300A-1 voice operated relay. Subjects were generally instructed to "spend a long enough time with each sentence to understand it." They were motivated to comprehend each sentence and pronoun fully by the possibility of a probe occurring whenever they requested a new sentence.

Textual Materials and Design

The textual materials employed were carefully crafted to meet a set of design requirements. Fifty sets of 11 sentences were written following the model shown in Table 2. The test essays were constructed by assembling subsets of these 11

Table 2
A Sample Set of Sentences
Used in Generating Test Passages

Classification	Form	Example
Initial Sentences		
Two Possible Referents		
1. Subject = Ref.	NP ...NP ... 1 2	Education is, above all, supposed to produce a well-trained mind.
2. Subject ≠ Ref.	NP ...NP ... 2 1	A well-trained mind is supposed to be the foremost goal of education.
One Referent		
3. Subject = Ref.	NP ... 1	Education, we are reminded, is above all supposed to enlighten.
Intervening Sentences		
Non-Mediating or Neutral		
4. No Direct Ref.		Too often, the emphasis in our schools has been on immediate practical goals, such as personal success, or wealth.
5. No Direct Ref.		This has been at the expense of true learning, and of simple, general knowledge.

Foregrounding Incorrect Referent		
6. Incorrect Ref. (lexical) repetition	NP_2 ...	A well-trained mind possesses more than the ability to turn on a TV knob, fly an airplane, or make a good living.
7. Incorrect Ref. (pronominal)	$Pron_{NP_2}$ ...	It possesses more than the ability to turn on a TV knob, fly an airplane, or make a good living.
Mediating		
8. Pronoun = Subject	$Pron_{NP_1}$ ...	It should emphasize more drill in the three R's, and put more stress on such subjects as geography.
9. Pronoun ≠ Subject	...$Pron_{NP_1}$ ...	More drill in the three R's, and such subjects as geography should become essential aspects of it.
Final (Target) Sentences		
10. Unambiguous	$Pron_{NP_1}$ ...	It should concern itself with developing the high ability to read, learn, and understand what men of intelligence have said about this world.

11. Ambiguous	$Pron_{NP_1}$ or $_{NP_2}$...	It involves a high ability to read, learn and understand what men of intelligence have said about this world.

sentences in specified orders. Each test essay has an initial sentence containing one or two potential referents for a pronoun that occurs in the final, target sentence. Following the initial sentence, an essay may have one or more intervening sentences, followed by the target sentence. The subject's task was to pronounce the proper referent for a designated pronoun whenever an underscore appeared beneath it on the screen. As not every pronoun was tested this way (only pronouns occurring in the target sentences were probed), and the test essays varied in length from two to four sentences, the subject could never be certain that a particular pronoun would or would not be a test item.

It can be seen from Table 2 that there are three types of initial sentences, depending upon whether they contain one or two potential referents, and whether they foreground the correct referent or the alternative potential referent. The intervening sentences are of five types, depending upon whether or not (a) they avoid direct references to either of the potential referents in sentence 1, (b) they foreground the alternative (incorrect) referent by using it as the subject, (c) they refer pronominally to the alternative referent, or (d) they refer pronominally to the correct referent, with the referring pronoun appearing as a subject or nonsubject (that is, the referring pronoun is or is not foregrounded). Finally, there are two types of final

sentences: one in which the pronominal reference is unambiguous and the other in which it is ambiguous and can refer to either of two noun phrases in sentence 1.

Ten one-paragraph "essays" were constructed from each of these 50 sets of 11 sentences, following the prescriptions given in Table 3. One complete set of essays, constructed following these assembly rules using the 11 sentences in Table 2, is printed in Table 4. In all, 500 test essays were thus generated. No subject was shown two essays constructed from the same sentence base. Each subject was presented with a total of 50 test essays, five of each type. The assignment of essay types generated from the different sentence sets to individual subjects was counterbalanced so that approximately equal numbers of subjects were tested on each combination of sentence set and essay type.

Comparisons of performance among the various essay types enabled us to evaluate the extent to which the text characteristics described earlier influence the difficulty subjects have in resolving problems of text reference. For example, to study the effects of foregrounding the alternative (incorrect) referent, we would compare performance for the final sentence of essay type six with that for essay type five. These essays are matched on other variables, and differ only on the

Table 3

Assemblages of Sentences Forming the Texts Used for the Study of Pronominal Reference*

Essay Type	Sentence 1	Sentence 2	Sentence 3	Sentence 4
1	1 Potential Referent; (3) NP_1 is Subject	Unambiguous (10) Target	-	-
2	2 Potential Referents; (1) NP_1 is Subject	Unambiguous (10) Target	-	-
3	2 Potential Referents; (2) NP_2 is Subject	Unambiguous (10) Target	-	-
4	2 Potential Referents; (1) NP_1 is Subject	Neutral (4) Intervening	Unambiguous (10) Target	-
5	2 Potential Referents; (1) NP_1 is Subject	Neutral (4) Intervening	Neutral (5) Intervening	Unambiguous (10) Target
6	2 Potential Referents; (1) NP_1 is Subject	Lexical (6) Repetition of Incorrect Referent	Neutral (4) Intervening	Unambiguous (10) Target
7	2 Potential Referents; (1) NP_1 is Subject	Pronominal (7) Reference to Incorrect Referent	Neutral (4) Intervening	Unambiguous (10) Target
8	2 Potential Referents; (1) NP_1 is Subject	Pronominal (8) Reference to Correct Referent (Pronoun is Subject)	Unambiguous (10) Target	-
9	2 Potential Referents; (1) NP_1 is Subject	Pronominal (9) Reference to Correct Referent (Pronoun is in Predicate)	Unambiguous (10) Target	-
10	2 Potential Referents; (1) NP_1 is Subject	Neutral (4) Intervening	Ambiguous (11) Target	-

* Number in parentheses are sentence numbers from Table 2.

Table 4
Sample Essays

1. Education, we are reminded, is above all supposed to enlighten. It should concern itself with developing the high ability to read, learn, and understand what men of intelligence have said about this world.

2. Education is, above all, supposed to produce a well-trained mind. It should concern itself with developing the high ability to read, learn, and understand what men of intelligence have said about this world.

3. A well-trained mind is supposed to be the foremost goal of education. It should concern itself with developing the high ability to read, learn, and understand what men of intelligence have said about this world.

4. Education is, above all, supposed to produce a well-trained mind. Too often, the emphasis in our schools has been on immediate practical goals, such as personal success, or wealth. It should concern itself with developing the high ability to read, learn, and understand what men of intelligence have said about this world.

5. Education is, above all, supposed to produce a well-trained mind. Too often, the emphasis in our schools has been on immediate practical goals, such as personal success, or wealth. This has been at the expense of true learning, and of simple, general knowledge. It should concern itself with developing the high ability to read, learn, and understand what men of intelligence have said about this world.

6. Education is, above all, supposed to produce a well-trained mind. A well-trained mind possesses more than the ability to turn on a TV knob, fly an airplane, or make a good living. Too often, the emphasis in our schools has been on immediate practical goals, such as personal success, or wealth. It should concern itself with developing the high ability to read, learn, and understand what men of intelligence have said about this world.

7. Education is, above all, supposed to produce a well-trained mind. It possesses more than the ability to turn on a TV knob, fly an airplane, or make a good living. Too often, the emphasis in our schools has been on immediate practical goals, such as personal success, or wealth. It should concern itself with developing the high ability to read, learn, and understand what men of intelligence have said about this world.

8. Education is, above all, supposed to produce a well-trained mind. It should emphasize more drill in the three R's, and put more stress on such subjects as geography. It should concern itself with developing the high ability to read, learn, and understand what men of intelligence have said about this world.

9. Education is, above all, supposed to produce a well-trained mind. More drill in the three R's, and such subjects as geography should become essential aspects of it. It should concern itself with developing the high ability to read, learn, and understand what men of intelligence have said about this world.

10. Education is, above all, supposed to produce a well-trained mind. It involves a high ability to read, learn, and understand what men of intelligence have said about this world.

variable of interest. Performance measures we have collected include (1) reading times for each sentence, (2) latencies in reporting the correct referent for probed pronouns, and (3) error rates in reporting pronoun referents. Reading times were adjusted for differences in sentence length by dividing by the number of syllables in the sentence. For brevity, reading times per syllable will be referred to as "reading times" as we report our results.

Results

A series of analyses of variance were carried out on selected sets of essay types with reading time per syllable as the dependent variable. Additional analyses were carried out using vocal RT and number correct as the dependent variables. The analyses had two factors: reading ability group (four levels) and essay type (two or three conditions), with subjects nested under groups. The particular essay types under study varied from analysis to analysis. Since the assignment of sentence sets to conditions was counterbalanced, the use of subject variance within groups and variance due to subject by condition interaction as error terms in these analyses amounted to testing each effect against variability due to subjects and textual materials. The significance tests we shall report are thus conservative ones. The results of the analyses of variance are given in Table 5, and will be referred to as we discuss each in turn. In addition, results for planned comparisons among conditions will also be reported for each analysis. Data will be presented for separate groups of readers for those analyses in which significant reader group differences are obtained and in which significant main effects of conditions are also present.

The first analysis was concerned with evaluating the time required to identify the appropriate referent for a pronoun,

Table 5

Summary of Analyses of Variance for Reading Times

ANOVA	Dep. Var. Based On	Conditions and Essay Types (in Parentheses)			Effects		
					Reading Ability	Condition	R x C
I	Second Sentence	Repeated NP_2 (6)	Pron. Ref. to NP_2 (7)	Neutral (4,5,10)	F(3,40)=4.6**	F(2,80)=17.9***	F(6,80)=1.4
II	Final Sentence	1 Pot. Ref. with NP_1=Sub. (1)	2 Pot. Ref. with NP_1=Sub. (2)	2 Pot. Ref. with NP_1 in Pred. (3)	F(3,40)=5.7***	F(2,80)=9.0***	F(6,80)=0.2
III	Final Sentence	Unambiguous Target Pron. (4)	Ambiguous Target Pron. (10)	-	F(3,40)=2.1	F(1,40)=21.4***	F(3,40)=0.7
IV	Second Sentence	Pron. Ref. to NP_1 (NP_1 is Sub.) (8)	Pron. Ref. to NP_2 (NP_2 is Pred.) (7)	-	F(8,40)=3.5*	F(1,40)=6.3*	F(3,40)=2.1+
V	Second Sentence	Pron. Ref. to NP_1 (Pron. is Sub.) (8)	Pron. Ref. to NP_1 (Pron. is Pred.) (9)	-	F(3,40)=2.3+	F(1,40)=2.0	F(3,40)=1.3

\+ Significant at .10 level
* Significant at .05 level
** Significant at .01 level
*** Significant at .005 level or better.

Table 5 (Continued)

ANOVA	Dep. Var. Based On	Conditions and Essay Types (in Parentheses)			Effects: Reading Ability	Effects: Condition	Effects: R x C
VI	Final Sentence	Ø Intervening Sentences (2)	1 Neutral Intervening (4)	2 Neutral Intervening (5)	F(3,40)=4.9**	F(2,80)=0.3	F(6,80)=0.3
VII	Final Sentence	Pron. Ref. to NP_1 (Pron. is Sub.) (4)	Pron. Ref. to NP_1 (Pron. is in Pred.) (8)	Neutral (9)	F(3,40)=4.6**	F(2,80)=3.1+	F(6,80)=0.7
VIII	Final Sentence	Neutral Intervening	Repeated NP_2 as Subject (6)	Pron. Ref. to NP_2 (Pron. is Subject) (7)	F(3,40)=2.7+	F(2,80)=1.9+	F(6,80)=0.1
IX	Second & Third Sentences Respect.	First Neutral Intervening Sentence (4,5,10)	Second Neutral Intervening Sentence (5)	-	F(2,40)=3.7*	F(1,40)=7.2*	F(3,40)=0.9
X	First Sentence	1 Pot. Ref. with NP_1 as Subject (1)	2 Pot. Ref. with NP_1 as Subject (2,4-10)	2 Pot. Ref. with NP_1 in Predicate (3)	F(3,40)=4.6**	F(2,80)=5.1**	F(6,80)=1.2

\+ Significant at .10 level
* Significant at .05 level
** Significant at .01 level
*** Significant at .005 level or better.

among skilled and less skilled readers. The texts we used began with a sentence containing two antecedent noun phrases, one of which was referred to in the following sentence. We compared subjects' reading times for the second sentence, when it had as its subject either a noun phrase repeated from the first sentence or a pronoun substituted for the repeated lexical item. As is shown in Figure 1, there was an increase in reading time when the referential relationship was pronominal compared with that when a lexical category was simply repeated ($t[80]=5.37$, $p<.001$). Comparisons of reading times for these conditions were made for each of the four reader groups. Significant differences were obtained for the first three reader groups, with $t[40]=5.06$, $p<.001$, $t(40)=1.76$, $p=.043$, and $t(40)=2.63$, $p=.006$, respectively. However, the difference was not significant for the fourth group of readers ($t[40]=1.29$, $p=.10$).

Reading times for reading "neutral" second sentences, sentences that contained no direct references to antecedent noun phrases occurring in the first sentence, were included in the analysis of variance. While these sentences did not contain pronouns or repeat lexical items, they did contain examples of what Halliday and Hasan (1976) have termed lexical reference. Of the 50 "neutral" sentences used as second sentences in this study, 2 contained superordinate terms (e.g., environments for deserts), 41 contained examples of collocation, usually by

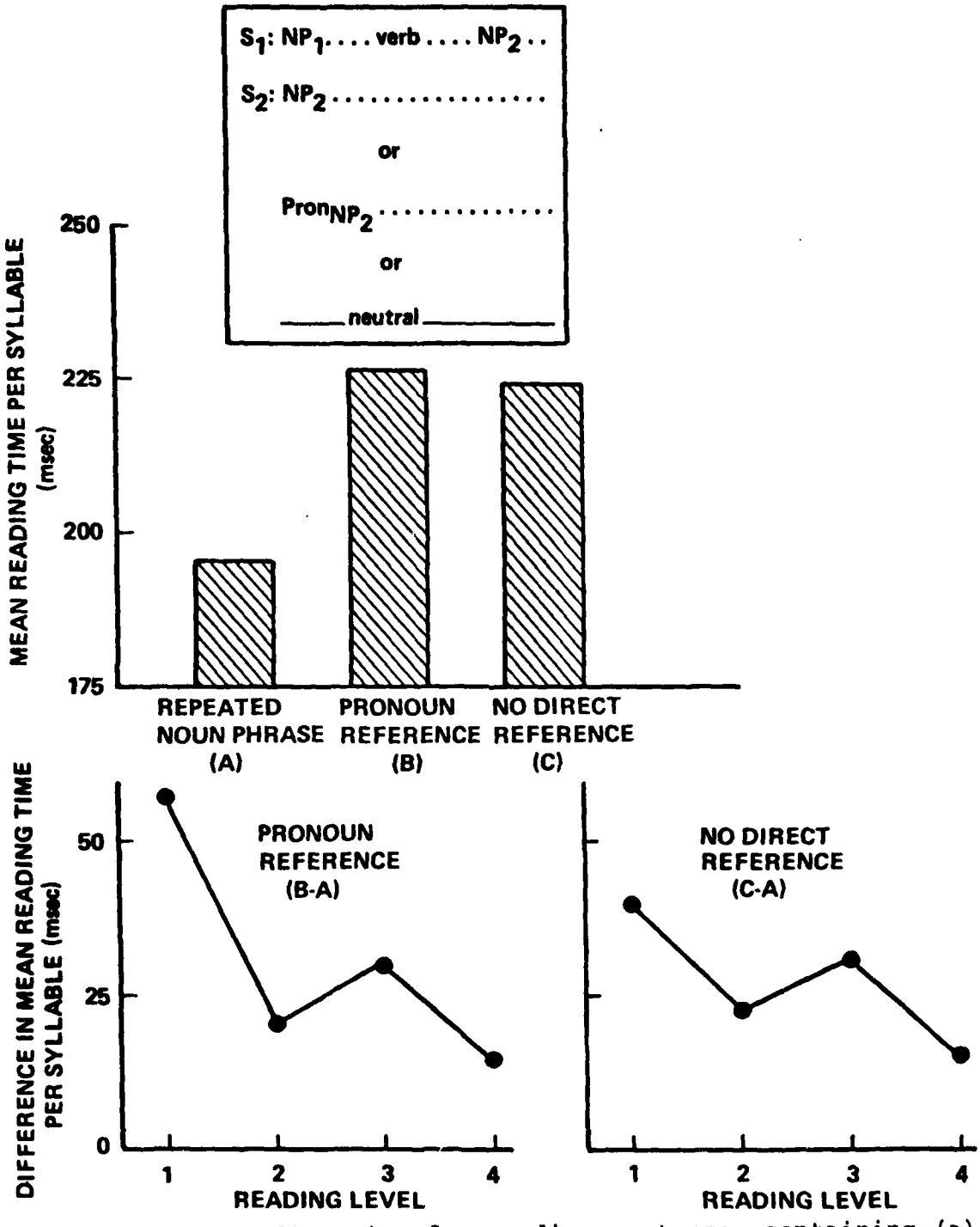

Figure 1. Mean reading time for reading sentences containing (a) a repeated noun phrase, (b) a pronoun substituted for the repeated noun phrase, and (c) no direct reference, but containing lexical references. Differences among reading ability groups for selected contrasts are shown at the bottom of the figure.

association (e.g., oil consumed associated with energy crisis, piece of bone with Anthropologists, etc.), and there were only 7 sentences which contained no example of lexical cohesion. (Of these 7, 2 contained examples of association, not between lexical terms alone, but between a lexical item in one sentence and propositions presented in the other sentence taken as a whole.) Of the 43 cases of lexical reference, 23 make reference to NP1, 7 make reference to NP2, 6 make reference to both NP1 and NP2, and the remaining 6 make reference to other noun phrases. Reading times for these "neutral" sentences were as large as those for reading sentences that contained pronominal references, and they also differed significantly from reading times for sentences containing repeated lexical items, with $t[80]=4.98$, $p<.001$. There were significant differences between these two conditions for each of the four reader groups. Values of these comparisons were, respectively, $t(40)=3.50$, $p=.001$; $t(40)=1.96$, $p=.038$; $t(40)=2.71$, $p=.005$; and $t(40)=1.79$, $p=.041$. Results of the analysis of variance carried out for all three conditions are given at the top of Table 5, Analysis I.

These analyses show that readers at all ability levels analyze the coherent features of a text. They require greater time in processing sentences within a text when a reference problem must be solved. When reference is by pronoun, a search of memory for previous text and selection of a referent noun

phrase is involved. When reference is by lexical collocation, semantic distinctions must be evaluated to establish referential relationships. Note that the pattern of reader differences for these two cohesive forms was highly similar, despite the processing differences that are likely to differentiate the two forms.

The second question we dealt with concerned the nature of processing that takes place when a pronoun is encountered. A pronoun, as we have seen, serves at the least a marking function, signaling to the reader that a reference to earlier text is intended. Beyond this marking function, processing may involve a reinstatement of those prior referents that agree in gender and number with the pronoun when the pronoun is encountered. Selection of a single antecedent noun phrase as the correct referent then takes place on the basis of intrasentential semantic features. Results bearing on this hypothesized process are presented in Figure 2, and the relevant analysis of variance is summarized in the second line (II) of Table 5. Of interest here are the first two conditions included in the analysis, which represent variation in the number of antecedent noun phrases that are consistent in gender and number with the pronoun. There was a significant overall increase in reading time for reading a target sentence when the number of potential referents in the initial sentence was increased from one to two ($t[80]=4.24$,

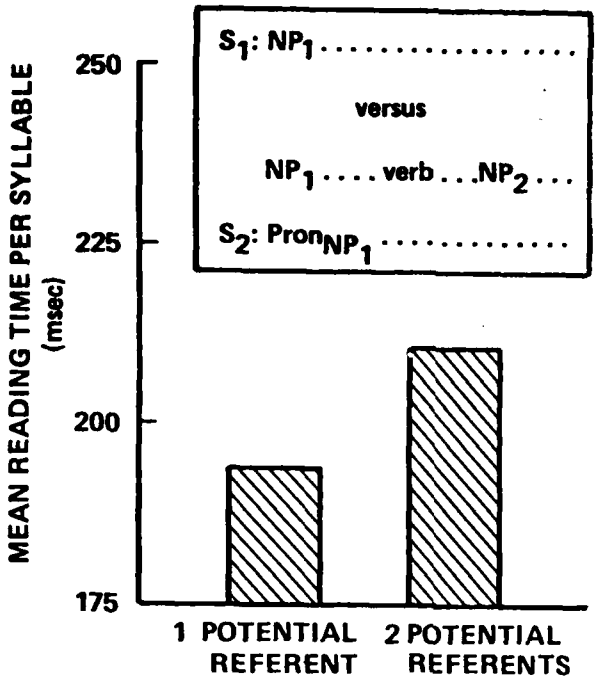

Figure 2. Effect on reading time for sentences containing a pronoun brought about by varying the number of available, potential referent noun phrases in the initial sentence of a two-sentence paragraph.

p<.001). However, there was no evidence for an interaction between the effect of adding a second potential referent and the ability level of the reader. These results support a reinstatement theory. At the time the pronoun occurs in sentence two, there are (by design) no semantic constraints to allow a selection among potential referents occurring in the first sentence. When the remainder of sentence two is processed, semantic constraints unambiguously rule out noun phrase two (NP2) as the referent. Note that, if the subjects had withheld their search of prior text until they had processed the entire second sentence, they would have reinstated only NP1, the only referent in sentence one that was semantically compatible with the pronoun.

In Figure 3, additional results are presented which bear on the problem of selection of a referent from the set of reinstated noun phrases. We compared reading times for ambiguous target sentences that allow either referent with those for unambiguous target sentences in which only a single meaning was correct. Reading times were greater when the target sentence was semantically compatible with either of two prior text referents than when only one referent was sensible--even though both referents in principle constituted a correct response. The analysis of variance (III) showed that these effects were highly significant, with $F(1,40)=21.4$, $p<.001$. However, there were no

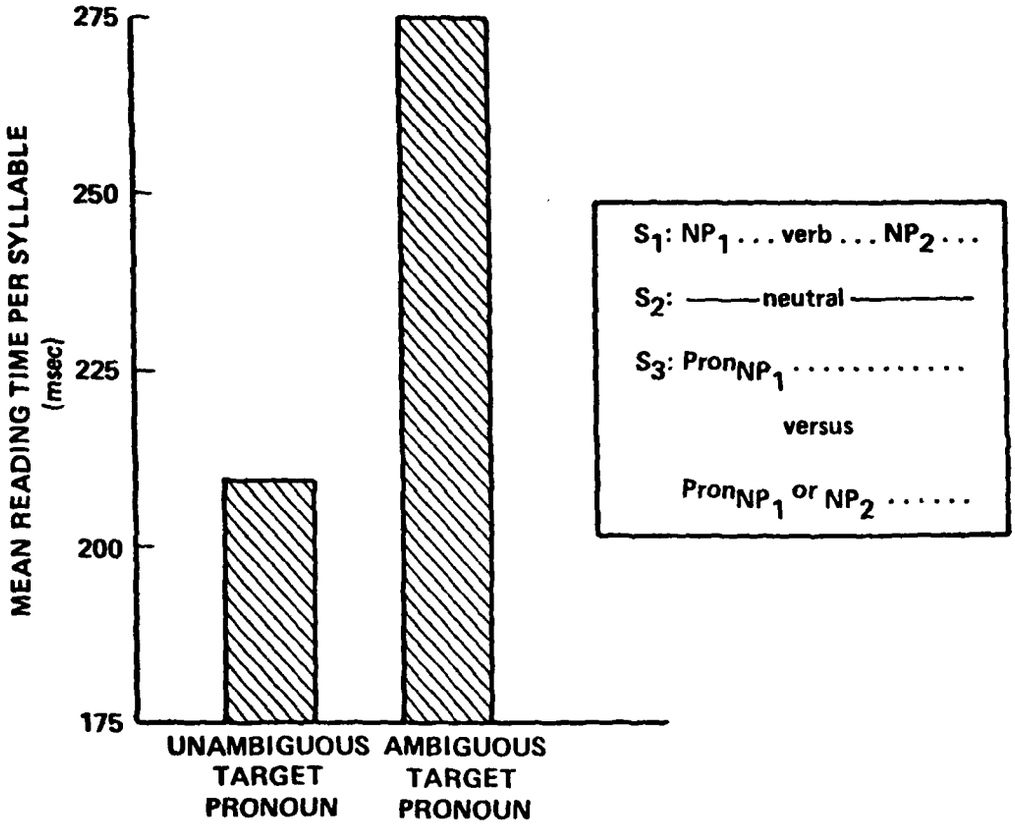

Figure 3. Fffects on reading times for sentences containing a pronoun brought about by varying the degree of semantic ambiguity in the final sentence of a 3-sentence paragraph.

significant differences among groups of readers in reading times for the two types of target sentences ($F[3,40]=.7$, $p=.56$).

When we performed analyses of variance on subjects' vocalization latencies in reporting the referents for pronouns when they were probed, the only text condition that yielded any significant effects on report latencies dealt with the ambiguity of the target sentence. The mean vocalization latency for unambiguous target sentences was 1356 msec, while it was 1735 msec for the ambiguous target sentences ($F[1,40]=9.7$, $p=.002$). This result suggests that subjects complete their reading of ambiguous target sentences without selecting a single referent for the pronoun. Then, when they are probed to give a referent for that pronoun, they make a selection before responding. Indeed, subjects occasionally would respond with both referent noun phrases. Our general conclusion, based upon results for reading times and latencies in reporting pronominal referents is that, when pronouns are encountered, good and poor readers alike appear to retrieve the set of alternative referents that are available for a pronoun and then select from among them the referent that fits the semantic constraints of the sentence in which it occurred.

Let us turn our attention now to the effects of text characteristics on rules or priorities used by subjects in

assigning referents to pronouns. The notion here is that noun phrases which are emphasized or topicalized will be more readily assignable as referents than will noun phrases that are relegated to a background status. One device used to establish a topic is the placement of a noun phrase in the subject position of an initial sentence of a paragraph. The results shown in Figure 4 support the idea that readers, particularly less skilled readers, use a strategy of selecting the grammatical subject of an initial sentence as the preferred referent for a pronoun occurring in a following sentence. The two comparisons in Figure 4 bearing on this conclusion are supported by results of analyses of variance II and IV in Table 5. Reading times were in each case significantly faster when the referent for a pronoun in the target sentence was the topicalized noun phrase in the initial sentence of the paragraph. In analysis II, the relevant contrast yielded $t(80)=2.32$, $p=.011$. In analysis IV, the effect of topicalizing the referent noun phrase was also significant with $F(1,40)=6.3$, $p=.008$. There was some evidence for an interaction in analysis IV ($F[3,40]=2.1$, $p=.12$). Significant effects of topicalization were present for readers in group 1 ($t[40]=3.32$, $p=.001$), but not for readers in any of the other three groups. It is the least skilled readers who appear to be most dependent upon the topical status of a noun phrase in selecting a referent for a pronoun.

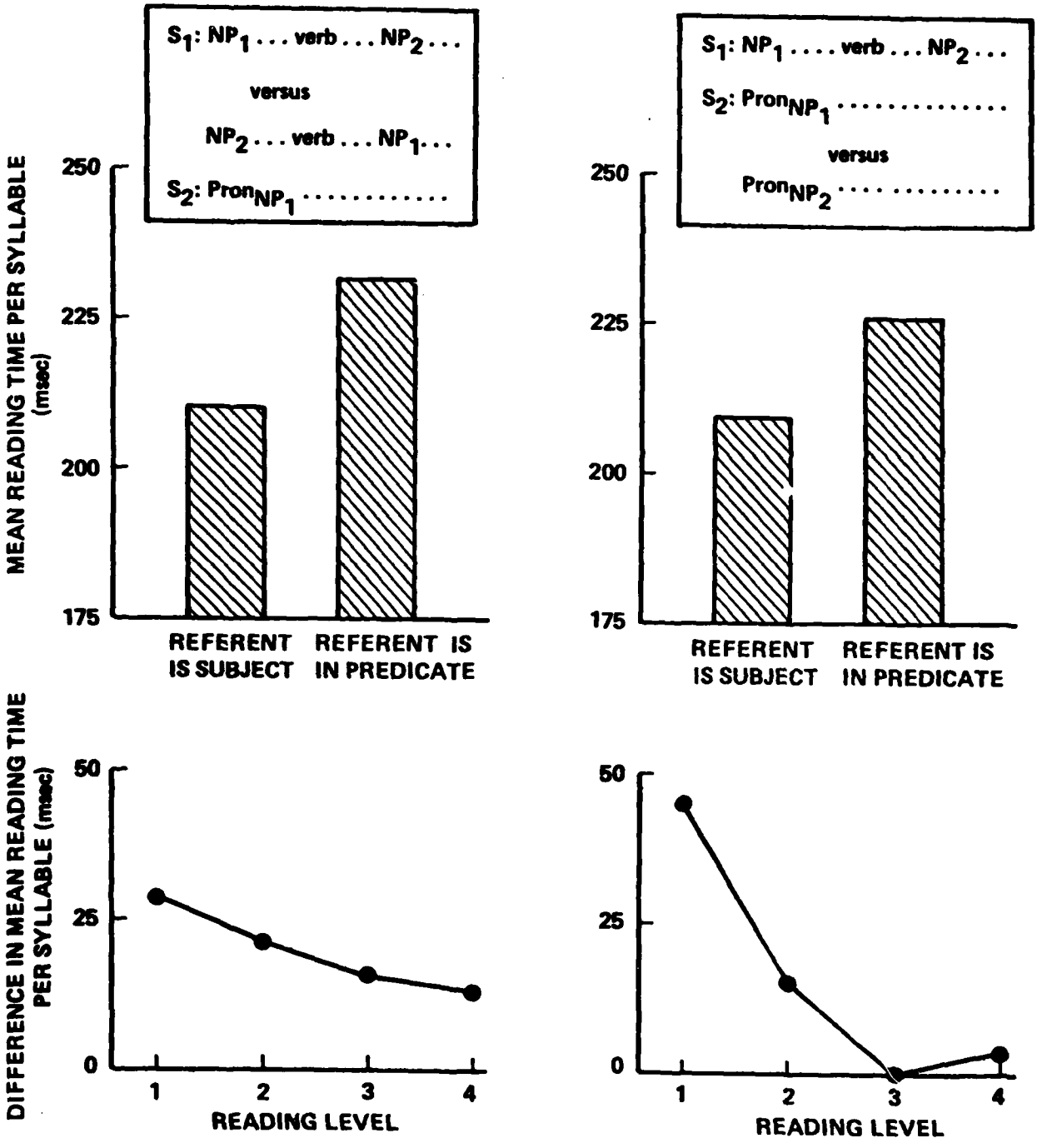

Figure 4. Effects on reading times for sentences containing pronouns brought about by foregrounding the referent noun phrase (making it the subject of the initial sentence). Differences among reader groups are shown at the bottom of the figure.

When analyses of variance were carried out on the number of correct referents supplied for pronouns occurring in the final sentences of our test paragraphs, significant treatment effects were obtained in only one analysis (that corresponding to analysis II in Table 5), with $F(3,80)=20.0$, $p<.001$. Referents were reported correctly more often when they were subjects of the initial sentences than when they were not subjects. In sentences containing two antecedent noun phrases, the mean percentage correct was 91% when the referent noun phrase was in subject position, but only 71% when the referent was not the subject of the initial sentence. Comparison of these two conditions yielded $t(80)=5.08$, $p<.001$. When comparisons were made of effects of topicalization for each reader group, significant differences were found for all groups but the fourth. The differences were 24% for group 1 ($t[40]=3.07$, $p=.002$), 22% for group 2 ($t[40]=2.54$, $p=.008$), 24% for group 3 ($t[40]=3.07$, $p=.002$), but only 9% for subjects in group 4 ($t[40]=1.18$, $p=.12$). Thus, rates of success in supplying referents also indicate that high ability readers are less dependent upon the topical status of a referent.

The sentence patterns in Figure 4 have the property that, in either case, the pronoun occurring in the second sentence is itself in the subject position, and is thus awarded topical status within that sentence. In Figure 5, we have a comparison of the case where the pronoun and its referent are in parallel

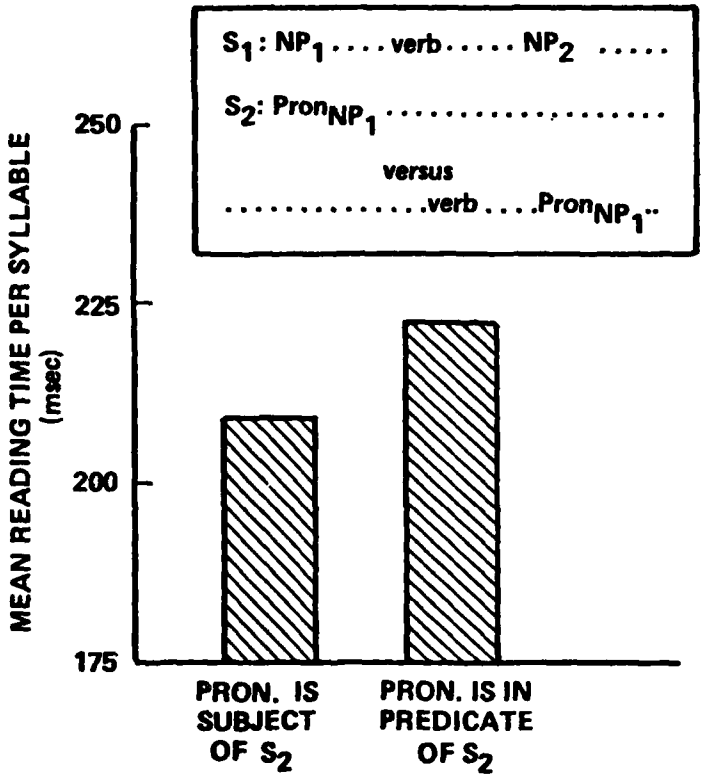

Figure 7. Effect on reading times for sentences containing pronouns brought about by varying the position of the pronoun in the sentence.

(subject) positions in their respective sentences with a case where the pronoun has been demoted to a non-subject position in the second sentence. The corresponding analysis of variance is presented in line V of Table 5. There are no significant differences for these two conditions. Our initial interpretation was to conclude that parallel syntactic structure, despite its generally being regarded as good writing practice, has little effect on performance in understanding anaphoric references. However, a second consideration probably renders these conclusions somewhat premature. When a pronoun occurs late in an unambiguous target sentence (such as the one employed here), semantic constraints within the sentence can rule out all but a single referent for reinstatement at the time the pronoun is encountered, and the problem of selecting among referents will be obviated. For this reason, a definitive conclusion concerning the role of parallel syntactic structure cannot be reached without further research.

The topicalizing effect of placing a noun phrase in the subject position has been demonstrated on reading times for sentences occurring immediately following the initial sentence. The next question we addressed considered the effect of interposing additional "neutral" intervening sentences between the referent and pronoun on reading times for sentences that refer pronominally to the topicalized noun phrase. These results

are shown in Figure 6, and the supporting analysis of variance is presented in line VI of Table 5. These data indicate that topicalized noun phrases retain their special availability as referents for pronouns when the distance between referent and pronoun is increased by introducing one or more intervening sentences between the initial sentence containing the referent and the sentence containing the pronoun. As shown in Figure 6, there was little effect of increasing the distance between referent and pronoun when the referent noun phrase was the subject of the initial sentence of the paragraph.

While the availability of a topicalized antecedent noun phrase as a referent for a pronoun is not strongly related to text distance per se, there are manipulations within an intervening text segment that might be expected to influence availability of a referent. These manipulations include text features that change or alter the topical status of the referent for the target pronoun. For example, referring to the referent noun phrase pronominally within an intervening sentence might serve to augment its topical status. Results bearing on this first possibility are shown in Figure 7, with the supporting analysis of variance given in line VII of Table 5. There was an effect of a prior pronominal reference within an intervening sentence on reading times for sentences containing a second use of the pronoun to refer to the same referent noun phrase in

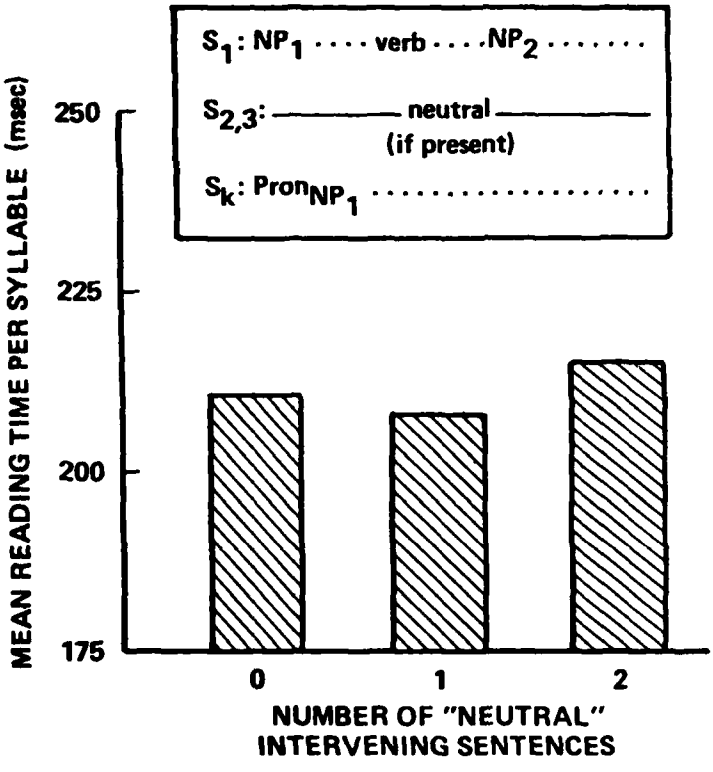

Figure 6. Effect on reading times for sentences containing pronouns brought about by varying the distance between pronoun and referent through the insertion of "neutral" intervening sentences.

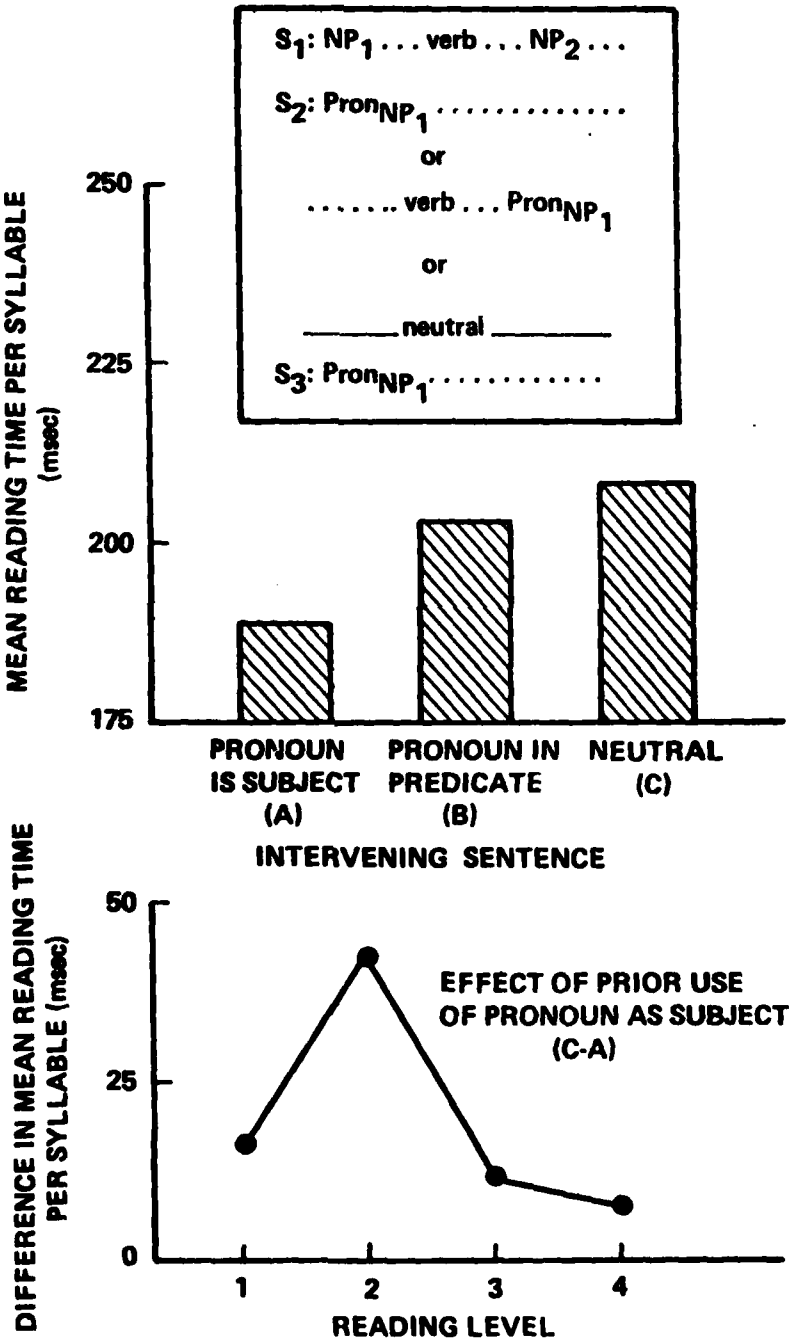

Figure 7. Effect on reading times for sentences containing pronouns brought about by prior use of the same pronoun within a mediating sentence, in subject or predicate position. Results for the four reading groups are shown at the bottom of the figure.

sentence one. However, interestingly, this effect was restricted to that case where the pronoun in the intervening sentence occurs in the subject position. When the pronoun occurs as the subject of the intervening sentence, availability of the referent is enhanced when compared with the case where a neutral sentence occurs as the intervening sentence ($t[80]=2.36$, $p=.01$). This effect is larger for the less skilled readers, but only reaches significance for the second reader group (for the first group, $t[40]=1.16$, $p=.13$, while for the second group, $t[40]=2.50$, $p=.008$). When the pronoun occurs within the predicate of the intervening sentence, availability of the referent is not enhanced ($t[80]=.53$, $p=.30$). Referring pronominally to the target noun phrase with a pronoun in non-subject position thus has the effect of reducing the topical status of the referent, which in turn offsets any effect of prior consistent use of the pronouns on availability of the referent. Note that this result bears on the dominance theory discussed earlier. In condition B of Figure 7, a pronoun is occurring near or at the end of sentence two and again at the beginning of the following sentence three. Despite the close proximity of the two pronouns in the text, the prior use of the pronoun to refer to the same referent had less of a "priming" effect on reading times than did the same use of the pronoun when it occurred a substantial textual distance away, at the beginning of the intervening sentence. We

conclude that the dominance idea is incorrect, and that pronouns are "cleared" and are free to refer to alternative referents in their subsequent use.

To summarize these findings, we found that pronominal reference to the target noun phrase reduces the time needed to find the appropriate referent for a similar pronoun occurring in a subsequent sentence, but this facilitating effect of an earlier reference is only found when the pronoun occurs as the subject of the intervening sentence and thus maintains the topical status of the referent noun phrase.

This observation led us to investigate some other staging features of text that could influence the topical status of the antecedent noun phrase and therefore the reader's priorities in assigning referents for pronouns. These results are summarized in Figure 8, and the relevant analysis of variance is analysis VIII in Table 5. The first staging procedure involved bringing an incorrect but compatible (i.e., agreeing in gender and number) antecedent noun phrase to the foreground (i.e., subject position) within the intervening sentence. This had an effect of lengthening the time for finding the correct referent for a pronoun occurring subsequently, although the effect was not statistically significant ($t[80]=1.10$, $p=.14$). Foregrounding the incorrect referent (condition B in Figure 8) presumably reduces

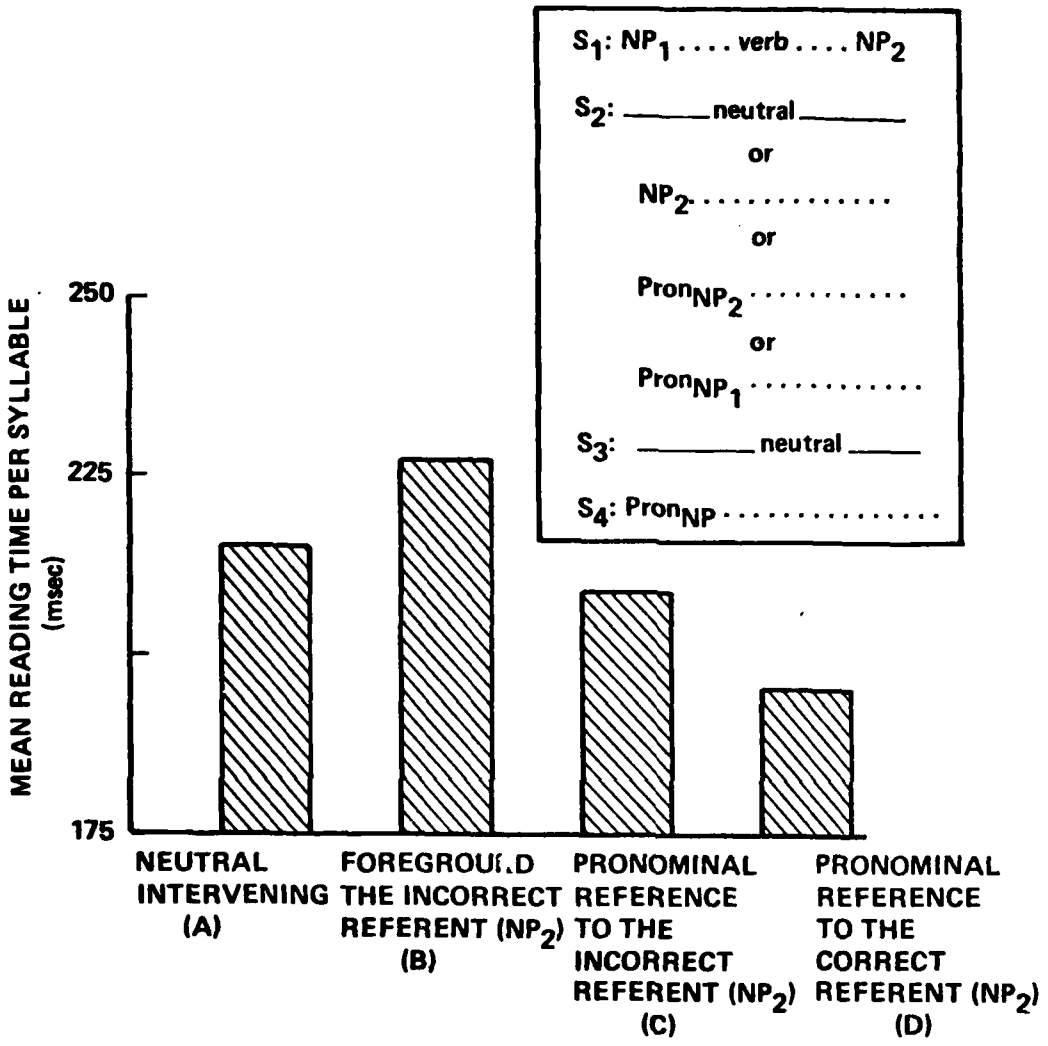

Figure 8. Effect on reading times for sentences containing pronouns brought about by foregrounding an incorrect referent by (b) lexcial repetition, or (c) pronominal reference. The reading times for the case where an intervening sentence refers pronominally to the correct referent is shown for comparison. (This value, taken from the previous figure, has been increased by 8 msec to adjust for the effect of adding an additional neutral intervening sentence.)

the topical status of (backgrounds) the formerly topicalized noun phrase that occurred in the subject position of sentence one, and increases reading times for the final sentence containing a reference to the originally topicalized noun phrase. Interestingly, when a pronoun is substituted for the lexically repeated NP2 in the second sentence (condition C in Figure 8), there is not only no increase in time needed to process the final sentence, but actually a small decrease in reading time below that obtained when a neutral sentence has replaced the referencing intervening sentence. Moreover, the mean reading time for condition C is only 11 msec longer than that found when the pronoun in the intervening sentence refers to the same referent as the pronoun in the final sentence (condition D in Figure 8). The effect of substituting a pronoun for the incorrect antecedent noun phrase in sentence two was statistically significant, with $t(80)=1.96$, $p=.027$. We can conclude from this rather surprising set of findings that (1) referring to an incorrect potential referent pronominally in the subject position does not have the same effect of reducing topical status as does the repetition of the alternative noun phrase as the subject of the intervening sentence; and (2) use of a pronoun to refer to a different referent in an intervening sentence does not increase difficulty in later using the pronoun to refer to the alternative potential referent; it actually may

have a small priming effect. This result is consistent with a reinstatement theory, since processing of the pronoun in sentence two reinstates both NP1 and NP2 to working memory until the point at which a selection can be made of NP2 on semantic grounds. Thus, paradoxically, the non-referenced NP1 has been "primed" as well as the noun phrase actually referred to.

There are two final results that are worthy of mention, even though they do not bear directly on the theory of pronominal reference. The first result concerns a comparison of reading times for neutral intervening sentences, when they occur as the first or second such intervening sentences in a test essay. The relevant analysis of variance is reported in line IX of Table 5. For a neutral sentence following the initial, topic sentence of a paragraph, the mean reading time was 224 msec. For a second neutral sentence, the mean reading time was 211 msec, and the difference in reading times was significant with $F(1,40)=7.2$, $p=.006$. These times include time to analyze cohesive relations between the neutral sentence and the initial sentence that are largely due to the presence of collocative expressions. The reduction in reading time for a second such sentence suggests that the generation of collocative associations in analyzing the first neutral sentence has primed associated lexical categories that may occur subsequently in the following neutral sentence.

The final result to be reported derives from an analysis of reading times obtained for the three types of initial sentences we have used in our test essays, which were represented schematically in Table 2. The last analysis of variance (X) in Table 5 gives the pertinent results. While reading times for sentences containing one and two noun phrases (NP1.... and NP1...NP2..., respectively) did not differ significantly (they were 299 and 293 msec with $t[80]=.46$, $p=.32$), rewriting the sentences containing two referent noun phrases in order to place NP2 -- the former predicate noun phrase -- in the subject position produced a significant change in reading time. The mean reading time for the paraphrases (NP2...NP1...) was 335 msec, compared with 293 msec for the original sentences, and this comparison yielded $t(80)=2.96$, $p=.002$. The increases in reading time were largest for the first three reading groups; they were 66 ($t[40]=2.32$, $p=.01$), 34 ($t[40]=1.20$, $p=.12$), and 78 msec ($t[40]=2.74$, $p=.005$), respectively. However, there was no increase for the fourth group (-9 msec). The increase in reading time for paraphrase sentences suggests that these alternative initial sentences are syntactically more complex. While a proper exploration of the effects of syntactic transformations (e.g., passivization) on reading time will be the subject of future research, our conclusion here is that, for sentences that empirically differ in difficulty of syntactic analysis, there are

differences among groups of good and poor readers in their ability to analyze propositional content as syntactic structure is varied.

Discussion

In this experiment we have manipulated a number of text variables thought to alter difficulty of resolving problems of anaphoric reference in a text. The selection of these variables was motivated by a set of questions concerning the form a process theory of text reference should take. First, we were concerned with the process by which referential relations are established between antecedent noun phrases occurring in the initial sentence of a text, and pronouns occurring in later text. The results support a reinstatement theory in which a set of prior potential referents (i.e., antecedent noun phrases agreeing in gender and number with a pronoun and which meet existing semantic constraints) are reconsidered at the time a pronoun is encountered. Selection of a single, "best" referent follows when intrasentential semantic constraints will allow such a selection. The investigation of the referential relation signalled by the pronoun begins immediately, and does not appear to be put off until after further disambiguating semantic constraints have become available within the sentence. Finally, we found no difference between good and poor readers in the nature of the evidence for such a reinstatement process, and we therefore conclude that in this respect, good and poor readers are alike.

The second question with which we began this study dealt with the independence -- or lack of independence -- in processing a pronoun when it is used repeatedly within a text. The weight of evidence here did not favor a dominance theory, wherein a pronoun, once assigned a referent, is automatically given the same referent in its future use. Rather, it appears that a pronoun, once it has served its referencing function, is cleared and free to be assigned alternative referents on future occasions.

Finally, we have explored the set of prioritizing principles used by readers in selecting referents for pronouns. We have found that readers are influenced by surface syntactic features of text that serve to communicate to the reader the topical value of noun phrases, as they are presented. Devices for establishing topical value include presentation of the noun phrase in subject position within the initial sentence and in intervening sentences, and maintaining a continuity of reference to the topic throughout the paragraph. Staging of references to other noun phrases also has an effect on the availability of a referent noun phrase. Presentation of an alternative noun phrase as the topicalized element in an intervening sentence has the effect of reducing the topical value of an initially topicalized referent. Results such as these are at variance with proposals suggesting that while subjects develop a propositional base for each sentence as

they progress through a text (cf. Kintsch and van Dijk, 1978), they do not evaluate referential relationships among elements of sentences solely on the basis of a stored set of abstract propositions. Our results indicate that the internal representation of a sentence must be sensitive to the topical status of sentence elements as well as being faithful to the propositional content. Furthermore, the topical status accorded one or another propositional element must be capable of re-definition as subsequent text is processed. Conceptually, this might best be accomplished by postulating a separate list of topicalized categories that can serve to facilitate the reinstatement of such categories within the reader's text model in searching for potential referent noun phrases, as in Kieras' system (1981).

The generality of many of the effects we have investigated remains to be demonstrated. The probe task has clearly performed its function in motivating subjects to make sure they have understood the referents of pronouns before going on to request the following sentence. This is clear from the finding that, except for the case of ambiguous target sentences, none of the text variables that influenced reading times for sentences containing pronouns had any effect on subjects' latencies in reporting referents for pronouns. In more typical reading situations, subjects probably give less close attention to

pronouns, and may tolerate a degree of ambiguity in reference that has been ruled out in the present reading task. However, it should be pointed out that text variables pertaining to the staging of topics within a text have been shown to influence patterns of eye movements (Carpenter & Just, 1977), and staging manipulations have been shown to have effects that are independent of propositional content in studies of recall (Clements, 1975; Marshall & Glock, 1978).

With regard to differences among readers, the evidence suggests that less skilled readers are more dependent upon the relative topical status of noun phrases for the successful retrieval of pronoun referents. This result is consistent with findings of Marshall and Glock (1978). Analogous to the automaticity differences among good and poor readers in word decoding that have been stressed by Lesgold and Perfetti (1978), we must begin to entertain the possibility that skilled and less skilled readers may also differ in relative automaticity of processes involved in the analysis of discourse structures. The characterization of these processes and of the differences between automatic and controlled forms of those processes will be the subject of future research.

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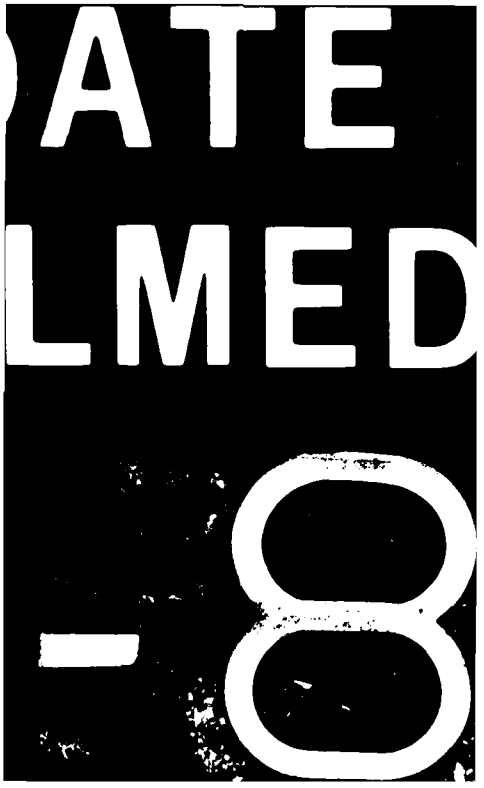
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