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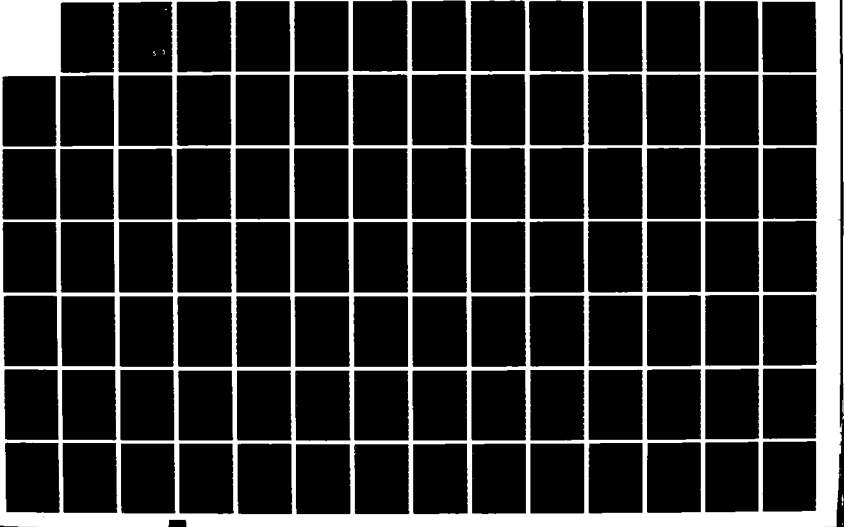

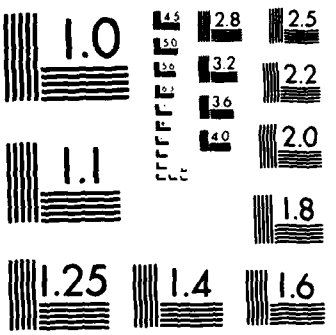

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Aspects of Skill in Understanding High-Order Semantic Relations

Beth Warren

July 1986

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An essential element in text comprehension is the reader's ability to integrate newly encountered propositions with those previously encoded into a coherent model of text meaning. Two bases for propositional integration may be: (a) the network of abstract semantic relations, represented linguistically through conjunctions, verbs and other connectives, and (b) the semantic content of related propositions, represented in, for example, argument repetition, collocation and semantic entailment. The purpose of this research was to develop an understanding of the nature of expertise in using information from these sources in integrating semantically related propositions and to identify sources of comprehension difficulty for the less skilled reader.

The influence of two types of relations (causal and adversative) and two types of connectives (conjunctions and verbs) on readers' comprehension and on-line integration of related propositions was examined. Contextual influences were examined by comparing readers'

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Thirty-two high school students of varying levels of reading ability read 96 passages (64 semantically consistent passages, 32 semantically anomalous). Subjects read each passage, clause by clause (presented via microcomputer) and, at the time they read the final clause, indicated by a key press whether the passage was semantically consisent or anomalous. Accuracy on this task and reading times for each clause were recorded.

The results showed that comprehension and on-line integration of semantic relations were strongly influenced by contextual constraints and by readers' skill in using such constraints. Type of relation also exerted an influence. Adversative relations were more difficult than causal relations. Comprehension of both types of relations also appeared to depend upon reader skill. Readers differed as well in skill in using connectives. Skilled readers were unaffected by connective type whereas less skilled readers' comprehension appeared to depend upon conjunctions. Finally, skilled readers were equally accurate in comprehending consistent and anomalous passages. Less skilled readers were highly inaccurate in judging anomalous passages, although they took longer to read anomalous passages than consistent passages. A framework for understanding process interactions among components of text comprehension is presented. Implications for instruction are also discussed.

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1. LITERATURE REVIEW

1.1 Introduction

Current theories of text comprehension assume that a reader encodes a text as a structured set of propositions representing the meaning of the text (Just & Carpenter, 1980, Kieras, 1981a, Kintsch & van Dijk, 1978). An important element in the construction of a coherent propositional model is the reader's ability to integrate newly encoded propositions with those already encoded. This means that the reader must analyze the semantic content and structure of text propositions in order to identify relationships among the elements of those propositions or between the meanings of those propositions.

One way in which text propositions may be related is through the network of abstract semantic relations, represented linguistically through conjunctions and other connective expressions. Conjunction contributes to the coherence of text by establishing explicit, systematic relations between the meanings of text propositions, leading to the formation of more complex units of meaning. The range of semantic relations that can be conveyed through conjunction includes causal, temporal, additive and adversative relations as well as their subtypes (cf. Halliday & Hasan, 1976). When propositions are conjoined semantically through conjunction, the interpretation of one propositional unit will depend on the particular relation in which it stands to the other. As a feature of coherent text, therefore, conjunction represents a basis for integrating one proposition or set of propositions with another into a unified representation of a text's meaning.

The purpose of the research reported here is to develop an understanding of the nature of expertise in analyzing high order semantic relations among text

propositions. Implicit in this purpose is the view that expertise in this aspect of text comprehension is not a unitary skill, but one which involves use of multiple sources of information to constrain analysis of the meanings of relations among propositions. *Information about the ways in which text propositions are related is derivable from* at least two sources: the vocabulary of connectives (e.g., conjunctions) representing different types of high order semantic relations, and the semantic content of the related text propositions themselves. Effective use of these information sources, in theory, enables the reader to analyze the meaning of particular relations among propositions and to integrate propositions with their related antecedents into a coherent representation of the meaning of a text.

The primary goals of this research are: (1) to investigate the relative influence of connectives and semantic context on the ease with which high-school age readers integrate semantically related propositions, (2) to explore possible interdependencies in the ways that readers use these sources of information, and (3) to develop an understanding of the kinds of difficulties less skilled readers may have in this component of text comprehension. Research of this kind is important on several counts. It is important on theoretical grounds because of its emphasis on an aspect of text comprehension that is not well understood (cf. Kintsch & van Dijk, 1978). It is important on practical grounds as well because it investigates sources of potential *comprehension difficulty for the less skilled reader*, and thus may have important implications for comprehension instruction. An outline of the major issues addressed through this research follows directly; a more detailed rationale is provided in the main body of this section.

1.1.1 Semantic relations

Within the English language, relations among text propositions can be expressed through a number of linguistic forms, the most obvious of which is conjunction. Some of the alternative means for conveying semantic relations include verbs, adverbs and prepositions. Relations between the meanings of text propositions are not always marked by an explicit connective term, however. Semantic relations may also be communicated to varying degrees through features of the semantic content of text propositions, as when one event strongly presupposes the occurrence of a second event. In this study, the efficacy of conjunctions and verbs in conveying particular types of semantic relations is compared, and semantic or contextual influences on difficulty in integrating related propositions are also examined.

In addition, while the types of semantic relations can be grouped into rather general, or abstract, categories of meaning (i.e., causality, temporal priority, antithesis, etc.), certain of these categories appear more stable in meaning than others. For example, the adversative relation (i.e., conveyed through connectives like "but" and "yet") covers a range of subtle connotations of meaning, from simple contrast to violation of expectation. Because of this, the precise connotation conveyed by a particular usage will depend not only on the mutability of the connective itself (i.e., to what degree it conveys a particular meaning as opposed to multiple meanings), but also on the semantic content of the context in which it occurs (i.e., the surrounding context may to a greater or lesser degree determine the meaning of a particular connective). In the present study, the influence of two types of relations, one stable in meaning (the causal relation) and the other mutable (the adversative relation), on difficulty in integrating related propositions is also examined as a potentially critical dimension of skill in this domain.

1.1.2 Process interactions

The observation above that semantic relations among text propositions can be conveyed without explicit marking of the relation through a connective leads to a question of theoretical interest. How is skill in analyzing the semantic information in a context frame related to skill in analyzing high order semantic relations among propositions? Frederiksen & Warren (in press) have proposed a theory of process interaction in text comprehension that focuses on the implications that skill in analyzing context frames to activate concepts in semantic memory may have for processes involved in interpreting some of the cohesive features of text, including conjunctive relations among propositions. By examining contextual influences on difficulty in constructing semantic relations among propositions, this study addresses one aspect of a theory of process interaction in text comprehension.

1.1.3 Skill differences among readers

Skilled and less skilled readers have been shown to differ in the efficiency and accuracy of their performance on tasks which tap particular component skills in reading (Curtis, 1980, Frederiksen, 1981a,b, Perfetti & Hogaboam, 1975, Perfetti & Lesgold, 1977, Stanovich, 1980). A principal aim of this research is to develop an understanding of the kinds of difficulties that high-school age readers of varying levels of tested reading ability may have in processing high order semantic relations in text. For instance, what is the nature of contextual influence on readers' ability to analyze high order semantic relations among text propositions? And, are conjunctions and verbs, as two kinds of connective expressions, equally effective in communicating these relations for skilled and less skilled readers alike? Finally, it is possible that readers may have difficulty in comprehending particular types of relations, and that this difficulty is related to reading ability. Demonstrated reader differences in sensitivity to these aspects of skill would have important implications for the diagnosis

and remediation of comprehension-based reading difficulties, providing valuable information for the design of instructional programs for directly improving readers' skill in analyzing coherent text features.

The remainder of this section is organized according to the following plan. First, existing evidence on the influence of connective expressions on text comprehensibility and processes of semantic integration is examined. Contextual influences on text comprehensibility are then discussed. Studies of skill differences in knowledge and use of connectives representing particular types of relations and in sensitivity to contextual constraints are then examined, and their implications for high order integrative processing in skilled and less skilled readers are explored.

1.2 Influence of Explicit Connectives

High order semantic relations among propositions may be conveyed through a variety of forms within the English language. Consider, for example, one such relation, the causal relation. Table 1 illustrates a number of ways in which the causal relation between two sentences can be expressed. First note that in the absence of any explicit marking of the relation (1), there is a line of plausible inference linking the two sentences, namely, that the first sentence describes the condition of an eclipse of the sun. Explicit connectives such as verbs may also be used to communicate semantic relations, as shown in example (2). Yet another vehicle for conveying relational meaning is the conjunction (3). Finally, although not shown, semantic linkages among propositions may also be expressed through adverbs and prepositions (cf. Halliday & Hasan, 1976). Three important observations may be made about the nature of the vocabulary used to represent high order semantic relations. First, both verbs and conjunctions are effective in communicating semantic relations among propositions. Second, both verbs and conjunctions can serve as alternative realizations

of the same relation, each preserving the meaning of the relation as well as that of the elements participating in it; and third, context can contribute substantially to the effective communication of the relation connecting two base sentences.

1.2.1 Connective vocabulary

Verbs would appear, however, to have a major advantage over conjunctions. There is a large vocabulary of them and they can express with precision the relations that hold between text propositions (see Table 2 for sample sets of conjunctions and verbs for different types of relations). Indeed, a number of theorists from linguistics, cognitive psychology and artificial intelligence have proposed that verb meanings act as central frames for integrating the meanings and, in some cases, perhaps guiding the selection of elements within sentence propositions (Fillmore, 1968; Gentner, 1981; Kaplan & Bresnan, 1982; Rosebery, 1983; Schank, 1975).

For example, Gentner (1981) has investigated some of the processes by which individual sentence meanings may combine to form a unified representation of meaning. Subjects read stories containing general verbs (e.g., "give") along with biasing semantic material which, if integrated with the meaning of the general verb, would produce a representation for the meaning of a more specific verb (e.g., "pay"). With the inclusion of the biasing information, subjects were more likely to recall the specific verb than when no additional semantic information was provided. This finding suggests that verbs have an important integrative function in language processing which perhaps derives from the richness of their underlying representations. In particular, these representations may include some specification of the semantic relationships that hold among elements within sentence propositions.

In contrast to verbs, the vocabulary of conjunctions is relatively small and

imprecise. In Table 3, the set of conjunctions as tabulated by Halliday & Hasan (1976) is reproduced, although it should be noted that neither their tabulation nor their classification of relational types is necessarily exhaustive. As Halliday & Hasan point out, conjunctions "represent the generalized types of connection that we recognize as holding between sentences" (1976, p.238). Their generality aside, conjunctions appear to *serve at least two functions within a discourse: they serve to mark semantic* relations between, for example, narrated events and they serve to coordinate the stages or modulate the rhetorical force of a discourse.

By way of illustrating some of the ways in which conjunctions may function textually, consider the following example.

1. Mrs. Verrant had avoided Basil for three months. (.....) she treated him during their meeting as if those three months had made him an old friend.

2. Mrs. Verrant had avoided Basil for three months. Yet she treated him during their meeting as if those three months had made him an old friend.

3. Mrs. Verrant had avoided Basil for three months. As a result, she treated him during their meeting as if those three months had made him an old friend.

Without explicit marking of the connection, as in (1), it is possible to infer a linkage of the type shown in (2) on the basis of the relationship of violated expectation that naturally holds between avoidance and friendship. The relationship is thus neatly captured in the juxtaposition of these two antagonistic concepts. In this case, then, the effect of the conjunction "yet" is to mark or emphasize the meaning of the relation between the propositions containing those concepts, it is, in some fundamental sense, redundant with the meaning contained in the arguments of the surrounding context. The conjunction of the two facts of avoidance and friendship leads further to the inference that Mrs. Verrant's motives in treating Basil as an old friend after months of avoidance should be viewed with some suspicion. Compare this with the text

as written in (3). The force of the conjunctions in these two cases is markedly different. In (3), the conjunction "as a result" actually alters the relation between the meanings of the sentence propositions, leading to a different set of inferences from those in (2) regarding Mrs. Verrant's psychology: more guilt perhaps than calculation in the former case. It would appear, then, that connectives, despite the generality of the meanings they represent, may serve more than a simple marking function; rather, they may carry semantic force of their own, specifying the meanings of relations that hold between propositions and, as in the example, constraining the kinds of inferences that may be drawn.

1.2.2 Processing of semantic relations

When a reader derives the propositions that underlie a text and, in the process, detects the presence of a high order semantic relation among propositional units, how is such a unit integrated with its antecedent(s) to form a coherent, structured representation of the text's meaning? Theorists have proposed three routes by which related propositions may be integrated (Clark, 1975; Lesgold, Roth & Curtis, 1979). In one case, propositions that co-reside in working memory are automatically integrated. This might, for example, reflect the fact that the related propositions occur in adjacent or nearly adjacent clauses or sentences and are, in consequence, processed sequentially without exceeding the capacity limitations of working memory. In the second case, related antecedent propositions are no longer available in working memory and, as a result, must be reinstated from long term memory into working memory. In this case, for example, the related propositions are not contiguous in the text but are at some distance from one another, and the connection between them, while explicit, is one that has not been thematically central within the intervening text. Lastly, in cases where a reinstatement search has failed to uncover any explicitly related antecedent propositions, inferential bridges that link the currently

processed propositions to those in long term memory must be built. In this case, the tie between the related propositions is likely to be implicit, with the result that inferences must be constructed from one proposition to the next in order to preserve the integrity of the text model.

In a study of inferential processing in high school students, Frederiksen, Weaver & Warren (1981) found that the integration of related propositions could be modelled in terms of automatic integration and reinstatement processes. The experiment revealed that in cases where semantic relations among the sentences of a text exist but have not yet been represented in the reader's mental model of the text's meaning, readers spend additional time in processing a sentence when it is introduced by a conjunction. By contrast, in cases where related propositions were adjacent in a text and thus likely to be active simultaneously in working memory, processing time was unaffected by the presence or absence of a conjunction, suggesting that integration was automatic. In effect, the conjunction, not unlike a pronoun, may serve at the least as an instruction to the reader to search long term memory for propositions containing the presupposed or related information needed to complete the integration of the newly encoded propositions into the reader's text model. Conjunctions may thus have a special status in discourse. Often separated by commas from the sentences in which they appear, they can provide guidance as to when sentences should be integrated and, by virtue of their meanings, may also provide clues as to the relations involved.

1.3 Contextual Influences

High order semantic relations among the propositions underlying a text may also be communicated by features of the semantic content of those propositions. Semantically related propositions may, for example, differ in the degree to which the

concepts or arguments they contain overlap, or are coreferential, a condition that is thought to contribute substantially to the ease of propositional integration (Kintsch & van Dijk, 1978, Kintsch & Vipond, 1979). This notion that the repetition of concepts can contribute to a text's comprehensibility is not new, as an examination of early reading materials will attest What is new, however, is the elaboration of some of the ways in which particular characteristics of a text will affect processes involved in deriving meaning from that text For example, in the following

> The decorative case in which the mummy of Lady Tashat is wrapped shows a face with a calm, peaceful expression. X-rays of the mummy show that the skeleton is horribly twisted, with one arm broken and several ribs smashed.

the repetition of "mummy" represents an instance of coreference which, in theory, can provide a basis on which the propositions of one sentence may be integrated with those of another In the model of text comprehension proposed by Kintsch & van Dijk (1978), for example, the first step in forming a coherent text base involves checking incoming propositions for arguments that overlap with those already processed. In the example, then, the repetition of "mummy" in combination with other types of semantic linkages present in the context would, in theory, provide a basis on which to construct an integrated representation of the meaning of the text and to infer the unstated adversative relation of contrast ("...whereas x-rays...").

In addition to argument repetition, linkages between the meanings of propositions may be carried in the case frame for a particular event or action. For example, the verb used in one case frame may strongly entail a missing agent that is supplied by the accompanying clause or sentence, as in

> The ball was hit on a line past second base (As a result), the batter made it safely to first

Such case system entailments may involve agents or objects, as in the above text, or associated actions, themes or events, as in

> The worker failed to solder a critical connection in assembling the guidance computer. (As a result), the guidance system malfunctioned at a critical point in the mission.

where the action "failed to solder" entails the associated result, "malfunction". In both of these cases, the linkage between the two base sentences is implicit in the underlying representation of a central verb, comprehension of the intended relation does not seem to rely on explicit marking of it through a connective such as "as a result."

Still another source of semantic information constraining linking relations lies in verb identifications, i.e., manner systems. These include modals, time, location, tense, and aspect specifications for verbs. For example, in

> The delicate machinery in the lunar module had to be carefully mounted so that the impact of the landing wouldn't smash it.

the modal auxiliary "had to be" and adverb "carefully" for "mounted" in combination with the auxiliary "wouldn't" for "smash" clearly imply a conditional relation.

Finally, text propositions are often related through a chain of lexical relations, including use of synonymous and near-synonymous terms, superordinate categories, general words, or association. The latter, termed collocation, is especially interesting in that it establishes ties between the meanings of arguments in sentence propositions that do not rely on identity of reference, as in

> Japanese schools have always been known for being orderly and calm. (But), in recent years, sharp increases in school violence have been noted.

where the properties "orderly" and "calm" are systematically related to the concept of "violence" through the relation of oppositeness that underlies them. Similarly, the temporal markers "always" and "in recent years" are readily associated through their participation in the same ordered series.

Research that has investigated contextual influences on ease of propositional integration offers ample evidence to support a role for forms of referential and lexical cohesion other than argument repetition (Just & Carpenter, 1978; Singer, 1980). Just & Carpenter (1978), for instance, have shown that the case frames for particular actions can affect the ease with which a reader infers the relation between the verb in a case frame (e.g. murder) and an associated agent (e.g. killer). In particular, they found that readers spent additional time processing a target sentence containing the associated case when the antecedent contained a verb that entailed the case (e.g. murder–killer) than when it contained a non-entailing verb (e.g. die–killer). This finding suggests that integration of related propositions can in fact be influenced by semantic relations involving case frames for events or actions and need not be limited to relations involving coreference (cf. Foss, 1982; Singer, 1980; Rosebery, 1983).

1.4 Reader Skill Differences

Research on comprehension of high order semantic relations has typically focused on readers' understanding of connective terms (Katz & Brent, 1968; Paris, 1973; Pearson, 1974–75; Robertson, 1968; Stotsky, 1974; Townsend, 1983). In the present study, the influence of connective terms representing particular types of relations is studied as one aspect of a complex, integrative process which also involves skill in analyzing the semantic content of related propositions. In the following section, studies that have examined skill differences among readers, including some developmental evidence, relating to knowledge and use of connectives,

understanding of particular types of relations, and sensitivity to semantic constraints are discussed. The implications that these studies have for the issues addressed in the present study are also presented.

1.4.1 Knowledge of connectives

A number of investigators have examined readers' comprehension of and sensitivity to conjunctive relations among propositions (Katz & Brent, 1968; Paris, 1973; Pearson, 1974-75; Robertson, 1968; Townsend, 1983). Katz & Brent (1968), for example, studied children's acquisition and understanding of English language connectives on three levels: usage of connectives in spontaneous speech, ability to differentiate a correct from an incorrect usage, and ability to explain the function of a connective in a sentence. The study revealed clear developmental trends in children's understanding of connectives, especially in those cases where children were required to explain the function of a connective in a sentence. While 6-7 year olds produced "because" spontaneously in free conversation and showed a clear preference for sentences that were explicitly linked by "because" over those in which the causal relation was left implicit, they were unable to explain the function of the connective in a sentence. However, in their explanations they were able to make explicit the inference required by the context. For example, given the sentence

> We did not sit down because the benches
> were wet.

the older subjects (11-12 year olds) explained the connective on the basis of its functional role, saying that 'Because tells you why they didn't sit down'. The younger subjects offered an explanation which, while less abstract, nonetheless revealed an ability to reason inferentially, they explained that "because" meant that if they were to sit down, they would get their pants wet. The interesting point here is the suggestion of levels of understanding involving, at one level, inferential analysis of the

semantic implications of a stated relation and, at another level, abstract reasoning about the functional role of linguistic connectives in discourse. The latter might reflect knowledge, possibly metalinguistic, that enables readers to analyze relations among propositions even when these are not easily recoverable from context, as was the case with the contexts used in the Katz & Brent study.

1.4.2 Influence of connectives on text comprehensibility

The clear preference for marked relations demonstrated by the youngest subjects in the Katz & Brent study suggests that explicit connectives may contribute to text comprehensibility. Yet the impact of conjunctions, or connective terms in general, on the comprehensibility of texts is not necessarily straightforward, in fact, this issue has recently been the subject of considerable debate (Davison, 1981; Marshall & Glock, 1978–1979, Pearson, 1974–75; Walmsley, 1977).

For example, in measuring text readability, sentence length is used as an indicator of text difficulty (Dale & Chall, 1948; Klare, 1974–75). One way in which a text's readability score may be lowered is to split complex sentence forms into their component parts to produce shorter, simpler sentences. However, simplifying sentence structures by shortening them does not necessarily enhance a text's comprehensibility (Davison, 1981). For example, in the process of simplifying sentences, explicit connections between the meanings of related clauses may be excised. It is possible that explicit connectives, rather than increasing a text's complexity, may actually contribute to its comprehensibility by lessening the inferential demands that the text makes on the reader. In the Katz & Brent (1968) study, for example, subjects as young as six years old were found to prefer sentences containing explicit causal markers to those in which the connection was left implicit. And, in a study of the effects of certain text structures on college students' comprehension and recall of

connected text. Marshall & Glock (1978–1979) found that less skilled readers' recall of text propositions depended upon the explicit marking of semantic relations by a conjunction.

While these findings suggest that conjunctions may in fact contribute to the comprehensibility of text, dependence on the presence of explicit markers may actually represent a strategy adopted by the less skilled reader to offset, or compensate for, lack of thoroughness in analyzing the semantic content of text propositions (see below for a discussion of skill differences in use of semantic constraints). Adoption of such a compensatory strategy on the part of younger and less skilled, older readers has been observed in studies of contextual influences on the word analysis processes of these readers (Stanovich, 1980). In addition, less skilled readers have been shown to rely on other surface features of text in performing particular comprehension tasks. For instance, Frederiksen (1981a) found that, in resolving problems of pronominal reference, less skilled, high-school age readers appeared to depend on topicalization to guide referent assignment, whether or not the strategy led to the correct assignment. One concern of the research reported here is to examine the influence of particular connective types (verbs and conjunctions) on skilled and less skilled readers' immediate processing of high order semantic relations among propositions.

1.4.3 Acquisition of connectives

Katz & Brent (1968), among others, have also shown that there may be an acquisition order for connectives representing different types of relations. Causal connectives were, in general, found to be acquired earlier than those expressing adversative meanings (e.g., but, although). For example, given the sentence

> Jimmy went to school, but he felt
> (sick, fine)

most of the 6-7 year olds preferred the sentence when it concluded with the adjective "fine" while 68% of the 11-12 year olds preferred the correct form. Of greater interest, however, are the explanations offered by the youngest subjects. Their explanations suggested that they were generally insensitive to the meaning of the adversative connective during their reading of the sentences. their evaluation of the sentence cited above rested on the juxtaposition of attendance at school with health which, while contextually consistent, is at odds with the meaning of the stated relation College students, by contrast, showed nearly perfect understanding of adversative connectives when the task involved judging correct usage in a sentence. results for this group on the explanation task were not reported.

In a related, but more recent study of the influence of connectives on sentence processing time and recall, Townsend (1982) found that, even among college students, integration of successive sentences was easier the more explicitly a connective in the second sentence signalled a causal/temporal relation as opposed to an adversative one One possible explanation for the processing difficulty associated with adversatives as compared with causals lies in the subtle connotations of meaning that can be expressed through the set of adversative connectives. Table 4 illustrates a number of these. from relations involving simple contrast and violated expectation to those involving defiance and exception to a rule. Interestingly, the connectives themselves are, for the most part, interchangeable. that is, they are not typically reserved to express one meaning or the other Owing to this mutability, interpretation of the precise meaning of an adversative relation might be expected to depend heavily -- more heavily perhaps than in the case of other, more stable relations such as the causal -- on an analysis of the semantic content of the related propositions This study examines the possibility that there may indeed be an ordering among types of relations as to difficulty, and that this difficulty may be related to readers skill in analyzing the semantic content of text propositions

1.4.4 Skill differences in use of semantic constraints

Numerous studies of contextual influence on the word-level processes of skilled and less skilled readers have been carried out (Frederiksen, 1981b, Perfetti & Roth, 1981, Stanovich, 1981, West & Stanovich, 1978). They have shown that skilled and less skilled readers differ in their sensitivity to and use of the semantic information contained in a context frame in identifying words and extracting contextually appropriate word meanings. Findings from these studies have led to the conclusion that different information processing mechanisms may mediate contextual influence in the word recognition performance of skilled and less skilled readers. In one study (Frederiksen, 1981b), for example, high school age readers were asked to pronounce high and low frequency target words that were either strongly or weakly constrained by a prior sentence context or presented in isolation. Skilled readers, regardless of level of constraint, showed equal degrees of contextual priming for high and low frequency words. Less skilled readers, by contrast, showed marked priming effects for high frequency words only in contexts of high constraint. For words presented in isolation or in low constraining contexts, the effect averaged 49 and 52 msec, respectively, while for contexts of high constraint, the effect averaged 87 msec. Thus, the le skilled readers showed a savings from context only when it was highly consti ing and the target was a high frequency word.

In a second, related study (Frederiksen & Warren, 1982), contextual influences on readers' skill in retrieving specific meaning categories for lexically ambiguous words were examined. Skilled and less skilled, high school age readers were asked to read sentence contexts of high and moderate constraint and then to judge the semantic appropriateness of a target occurring at or near the end of the sentence. Targets were lexically ambiguous words having dominant and subordinate meanings

(e g "break" meaning, respectively, "smash" or "tame") In the absence of strongly constraining context, all readers tended to assign the dominant meaning of an ambiguous word, even when context pointed to the subordinate meaning. Following contexts of high constraint, however, the skilled readers were able to retrieve whichever meaning of an ambiguous word had been constrained, that is, they made fewer errors and were equally efficient in retrieving either the dominant or subordinate meaning. Less skilled readers, by comparison, were not able to gain direct, automatic access to specific meaning categories Even when context tightly constrained the subordinate meaning of an ambiguous word, the less skilled readers tended to retrieve the more dominant meaning for that word, and, in those cases where their judgment of semantic appropriateness was correct, they showed benefits of context on speed of access to dominant meanings only.

Taken together, these results suggest that reader differences in sensitivity to semantic constraints contained in a context frame can be characterized as follows. Skilled readers appear to have available a parallel, automatic process for effecting the identification, retrieval and integration of a range of semantically congruent items using the semantic information they derive from context. Less skilled readers, by contrast, are able to use only the most obvious semantic constraints to retrieve only the most common word or meaning that fits the context.

It is possible that skill in analyzing the variety of cohesive relations that can hold between the arguments of text propositions is a critical element in understanding high order semantic relations among text propositions. One concern of the research reported here is to extend our understanding of contextual influence to high order comprehension processes Research that has focused on contextual influence at more local levels -- word recognition and integration of individual word meanings with a

prior sentence context -- suggests that analysis of the semantic information contained in sentence context should have a strong impact on high order integrative processes of comprehension and that the magnitude or impact of any such effect should be related to reading skill.

2. METHOD

2.1 Subjects

Thirty-two high school students were selected from a larger, pretest pool of students to participate in this study. Selection was based on their performance on the Comprehension subtest of the Gates-MacGinitie Reading Test, Level F, Form 2. The students were grouped into four ability levels. Group 1 (grade level equivalent 12.9+ or higher), Group 2 (grade level equivalent 11.5 to 12.5), Group 3 (grade level equivalent 8.3 to 11.2), Group 4 (grade level equivalent 5.2 to 8.7). There were eight subjects in each group. Subjects were paid for their participation in the study.

2.2 Materials and Design

A total of 96 passages were written for this study. Of these, 64 were written to be semantically consistent and 32 semantically anomalous. A semantically consistent passage is one in which the relation implied by context and that made explicit by a connective are in agreement. A semantically anomalous passage is one in which the relation implied by context and that made explicit by a connective are not compatible.

In this subsection, the set of consistent passages is described first. This is followed by a description of the anomalous passages. The design of the study is then presented.

In constructing the 64 consistent passages, three factors were varied: (1) type of relation (causal or adversative), (2) scaled degree of contextual constraint (high or low), and (3) type of connective (conjunction or verb). These are described below.

2.2.1 Type of relation

Type of relation refers to the relation implied by the context and made explicit through a connective. It included relations of two types: causal and adversative.

2.2.2 Degree of contextual constraint

Degree of contextual constraint refers to the extent of the overlap between the relation implicitly conveyed by context and the relation made explicit by a particular connective. It was determined using the following scaling procedure. A corpus of 116 passages representing roughly equal numbers of causal and adversative relations was written. In a number of these cases, a passage was written in two versions. One version was written to be high in contextual constraint and the other low in contextual constraint. This was done to increase the pool of passages to be scaled and, therefore, the likelihood that there would be a sufficient number of high and low constraining passages for each type of relation. In other cases, there was only one version of a passage, either high or low in contextual constraint. In addition, 20 passages which did not express a high order relation were written.

The corpus of passages was divided into two versions of 68 sentences each. These were then presented in two sessions to a group of 40 high school students. Each student read 34 passages per session. No subject was shown the same passage in more than one of its versions. The passages were presented as two base sentences, that is, without any explicit marking of the linking relation, as in the following example.

All the figures were correct and had been checked twice.

(_____) The total came out wrong.

The students were asked to determine if the sentences were linked together in some way and, if so, to generate a linking expression. The linking expression, they were told, could be of any type, from a conjunction or verb to whatever expression might come to mind.

Each sentence was then scored in terms of the percent of subject-generated linking expressions that fit the semantic domain of the intended relation (as implied by the context). On this basis, sentences were classified as high or low in constraining the linking relation. The final set of 64 consistent passages was selected from this pool. Sentences selected as high in constraint were those for which, on the average, 68% of the subject-generated linking expressions fit the intended semantic domain. In contrast, sentences selected as low in constraint were those for which, on the average, 35% of the subject-generated linking expressions fit the intended semantic domain. Of the 64 sentences selected, 32 conveyed a causal relation (half of which were high in constraint and half low) and 32 an adversative relation (half of which were high in constraint and half low).

2.2.3 Type of connective

Type of connective used to mark a relation includes conjunctions and verbs representing causal or adversative meanings. Table 2 contains examples of connectives falling under these two categories of relations. Each sentence selected for use in the study was written in two final, matched versions, one with a conjunction marking the relation and the other with a verb, as in the following example.

Japanese schools have always been known for being orderly and calm but in recent years sharp increases in school violence have been noted.

Japanese schools have always been known for being orderly and calm, differing from recent years when sharp increases in school violence have been noted.

The conjunctions and verbs selected for a particular sentence were matched as closely as possible on frequency of occurrence (Carroll, Davies, & Richman, 1971), although it must be noted that the most frequent conjunctions have higher frequency counts than the more frequent verbs. However, inasmuch as conjunctions represent a much more limited vocabulary than verbs, this is not surprising. In matching the connectives, therefore, very high frequency conjunctions were matched with verbs having relatively high frequency counts within the vocabulary of verbs. Frequencies (SFIs) for the two types of connectives ranged from 75.6 to 42.9 for conjunctions, and 66.7 to 41.7 for verbs.

Table 5 contains two sample passages for the causal relation, one high in constraint and one low in constraint. Table 6 contains two sample passages for the adversative relation, one high in constraint and one low in constraint.

In addition to the set of 64 consistent passages, a set of 32 anomalous passages was constructed for use in the study as foils. They were written to the same specifications as the consistent passages, with the exception that degree of contextual constraint was ignored. Half of the 32 passages were written to represent causal relations and half to represent adversative relations before any anomaly was introduced. Anomaly was introduced in one of two ways. (1) the connective used to mark the relation was incompatible with the relation implied by context, or (2) the

content of a clause following the subordinate clause was rewritten to be semantically inconsistent with the preceding context and meaning of the connective. Each anomalous passage was also written in two matched versions, one with a conjunction and one with a verb. Table 7 contains two sample anomalous passages, one representing a violation of a causal relation, the other a violation of an adversative relation.

2.2.4 Critical clause

For presentation purposes, the passages were divided into clauses on the basis of two pragmatic criteria. Clauses were defined as comprising one or more naturally occurring units, i.e., noun and verb phrases, prepositional phrases, subordinate clauses, adverb clauses, and the like. In addition, an attempt was made to preserve the semantic integrity of the sentence information. In an informal pilot of the clause presentation method, it was found that longer clauses made for more natural reading than did a series of short clauses. The length of clauses in the corpus of test sentences ranged from three to nine words. The number of clauses per sentence ranged from four to nine clauses.

In a separate procedure, five raters were asked to determine for the set of 96 test passages which of the clauses (or clause) following, and possibly including, the one containing the connective were critical in judging the semantic consistency or inconsistency of each passage as a whole. In this context, "critical" refers to the clause (or clauses) containing information or assertions which essentially complete the relation implied in the preceding context and made explicit by the stated connective. The raters were asked to mark these clauses as (1) critical, or (2) important but not critical. From these ratings, a critical clause (or clauses) was designated for each consistent passage. However, for the final selection, clauses containing the connective

and final clauses were eliminated from consideration since separate analyses of these text segments were planned. Reading time for these clauses was then used as a dependent variable in data analyses.

The five raters agreed on one or more clauses (not including the connective or final clause) in each consistent passage 88% of the time. For a clause (or clauses) to be finally designated as critical, it had to be selected by a majority of the raters. In every case, at least one clause met the majority criterion.

2.2.5 Experimental Design

The experimental design included three within-subjects factors. (1) type of relation (causal or adversative), (2) degree of contextual constraint (high or low), and (3) type of connective (conjunction or verb). Reader ability group, a between-subjects factor, had four levels. Within reader groups, the assignment of sentence-conditions to individual subjects was counterbalanced so that equal numbers of subjects were tested in each sentence-condition combination, eight of each type for consistent passages. The same procedure applied to the anomalous foils, except that in their case the only relevant factor was type of connective. No subject was shown the same sentence in more than one condition. Passage presentation order for each subject was randomly assigned, with the exception that eight practice passages were always presented first and in the same order. Each subject thus read a total of 96 test passages and 8 practice passages.

2.3 Procedure and Apparatus

The experimental task was implemented on an IBM PC. Subjects were presented with a test sentence, one clause at a time. The pace of presentation was under subject control. The subjects' task was to read a sentence, one clause at a time. At

the end of the sentence, when the final clause was displayed, subjects had to judge whether the sentence as a whole was semantically consistent or inconsistent. Subjects were instructed to make their judgments on the basis of the information stated, and not on the basis of the information's "fit" with real events or their prior knowledge of the topic. In this way, subjects were required to analyze carefully the relations among stated text propositions in order to make their judgments.

The test sentences were presented in the following manner. The subject pressed the Enter key to initiate display of a sentence. First, the sentence was displayed, but with each letter of each word replaced by an underscore (Figure 1). The subject then pressed a designated key on the computer keyboard to initiate display of the first clause of the sentence and to call up each subsequent clause. In this way, when the subject pressed the key after reading the first clause, that clause disappeared and the second clause appeared. As a result, only one clause was visible at any one time (Figure 2). The subject proceeded through the sentence in this manner. When the final clause appeared and the subject had read it, he was required to indicate whether or not the sentence made sense by pressing either a key marked "Yes" (the sentence was semantically consistent) or a key marked "No" (the sentence was semantically anomalous)

This technique allowed reading times for each clause presented to be measured (for the final clause, the reading time reflected an additional judgment component). In addition, subjects' judgments on each passage were recorded.

Finally, since there were half as many anomalous passages as consistent passages, a correction for possible response bias was made. In addition to being paid for participating in the study, subjects were paid a bonus based on the number of correct judgments they made, with the bonus for correct judgments of anomaly being worth twice as much as that for correct judgments of consistency.

3. RESULTS AND DISCUSSION

3.1 Overall Performance on Consistent and Anomalous Texts

An initial set of analyses of variance was carried out on the full set of consistent and anomalous passages. The purpose of these analyses was to determine if readers, in general, had greater difficulty in comprehending anomalous passages than consistent passages, and if this difficulty was related to reading ability. For these analyses, the dependent variables were: (1) accuracy in semantic consistency judgment, (2) per syllable reading time for a clause, and (3) per syllable reading time for the final clause. Reading times are for correct judgments only. These analyses had two factors: (1) type of passage (consistent or anomalous), and (2) reading ability group (four levels), with subjects nested under groups. Results for planned comparisons are also reported.

3.1.1 Overall accuracy on consistent and anomalous passages

Main effects of passage type and reader group were significant, $F(1,28)=20.1058$, $p=.0001$ and $F(3,28)=6.1649$, $p=.002$, respectively. As depicted in Figure 3, readers were, in general, more accurate in their judgments of semantic consistency for consistent passages than for anomalous passages (73% vs 51%). However, Group 1 readers were more accurate overall, with an accuracy rate of 72% as against 61%, 56% and 58% for Groups 2, 3 and 4, respectively. In addition, in comparisons of accuracy rates for consistent and anomalous passages for each of the reader groups, significant differences were obtained for Groups 2, 3 and 4, but not for Group 1, $t(28)=1.98$, $p=.059$, $t(28)=3.23$, $p=.004$, $t(28)=3.02$, $p=.007$, $t(28)<1$, respectively. Mean accuracy rates for each of the four groups on consistent and anomalous passages were: 76% vs. 68% for Group 1, 71% vs. 52% for Group 2, 72% vs. 41% for Group 3, 72% vs. 43% for Group 4.

These data testify to the overall difficulty of the task for even the most highly skilled group of readers. However, as the figure makes clear, readers in Group 1 were more accurate overall than readers in either of the other three groups. The low rates of accuracy of Groups 2, 3 and 4 on anomalous passages are open to a number of interpretations. First, it is possible that these readers were processing the texts in only a shallow manner and guessing when the time came to make their judgments. Second, it is possible that the less skilled readers were processing the texts sufficiently to "sense" the presence of anomaly but were unable to identify cisely its nature or its source. This difficulty may have manifested itself as a response bias, with subjects responding "Yes" most of the time. The reading time data shed some light on the answer to these questions.

3.1.2 Reading times for consistent and anomalous passages

Analyses were performed on mean per syllable clause reading times and on per syllable reading/judgment times for the final clause. In the first analysis, a significant main effect of passage type was obtained, $F(1,28)=21.11$, $p=.0001$. The two-way (Group x Passage Type interaction was not significant, $F(3,28)<1$. Mean per syllable clause reading times were longer for anomalous passages (384 msec) than for consistent passages (340 msec). A comparison of mean clause reading times for the two passage types for each of the four reader groups showed that readers in Groups 2, 3 and 4 had significantly longer reading times for anomalous passages than for consistent passages, $t(28)=2.44$, $p=.02$, $t(28)=2.90$, $p=.009$, $t(28)=2.54$, $p=.017$, respectively. In contrast, the reading times of readers in Group 1 for consistent and anomalous passages were not significantly different, $t(28)=1.35$, $p=.16$. Mean per syllable clause reading times for consistent and anomalous passages were 321 msec vs. 347 msec for Group 1, 323 msec vs. 370 msec for Group 2, 330 msec vs. 386 msec for Group 3, 383 msec vs. 433 msec for Group 4.

In the analysis of per syllable final clause reading/judgment times, there was also a significant effect of passage type, $F(1,28)=14.2168$, $p=.007$. The two-way (Group x Passage Type) interaction was not significant, $F(3,28)=1.2152$, $p=.32$. In general, subjects read the final clauses of consistent passages considerably faster than those of anomalous passages (582 msec per syllable versus 741 msec per syllable for consistent and anomalous passages, respectively). A comparison of final clause reading times for each of the reader groups revealed that this effect of passage type was not significant for Group 1 readers (621 msec for consistent passages vs. 651 msec for anomalous, a difference of 30 msec per syllable for the two passage types), $t(28)<1$. However, it was significant for Groups 2, 3 and 4 (527 msec vs. 696 msec, 566 msec vs. 817 msec, and 617 msec vs. 799 msec, with differences of 169 msec, 251 msec and 182 msec, respectively), $t(28)=2.01$, $p=.056$, $t(28)=2.99$, $p=.007$, and $t(28)=2.17$, $p=.04$, respectively.

On the basis of these findings, it cannot be said that readers in Groups 2, 3 and 4 were processing the texts in a purely shallow manner and then guessing when the time came to register a judgment. If they were, there would be no reason to expect their mean clause reading times for anomalous passages or their reading/judgment times for the final clauses of these passages to be longer than those for consistent passages. Rather, it appears that readers in these groups were in fact exerting some effort to comprehend the anomalous passages, their high rates of inaccuracy notwithstanding.

While this set of analyses does not directly address the nature or source of the comprehension difficulty, it does raise some interesting possibilities. Consider first the finding that highly skilled readers' comprehension of text relations did not appear to be disrupted by the introduction of semantically anomalous information. This

suggests that, for these readers, the task demands for consistent and anomalous passages were comparable. In judging the semantic consistency of texts, whether these are consistent or anomalous, readers must, in theory, analyze the semantic content of the text propositions in relation to the meaning expressed by an explicit connective. If readers are sensitive to and able to use these sources of information effectively, then their rates of comprehension for anomalous passages should not differ from those for consistent passages. On the other hand, if, in the extreme case, readers make ineffective use of semantic constraints and are at the same time reliant on particular connective types representing particular types of relations, then these readers should suffer failures of comprehension, especially in the case of anomalous texts. As the results demonstrate, skilled readers were as accurate in their judgments about anomalous passages as in their judgments about consistent passages, and at no cost in efficiency of processing. Less skilled readers, by contrast, were highly inaccurate in their judgments of anomalous passages. And, in those cases where they were correct, they were markedly slower in reading and judging the semantic consistency of such passages as compared with the set of consistent passages.

This increase in reading times shown by less skilled readers may reflect more than difficulty in analyzing the semantic base of a text against the meaning of an explicit connective. In particular, it may reflect involvement of another aspect of comprehension, namely, comprehension monitoring. In the experiment, readers were asked to read a text and determine whether or not it made sense. To do this, readers must construct a model of the text's meaning and "monitor" their comprehension for gaps in the coherence of this model, whether these are the result of ambiguous reference, change of topic or information that contradicts the meaning represented.

Brown (1980) has suggested that failures of comprehension in tasks involving

comprehension monitoring may be thought of as reflecting a greater tolerance on the part of less skilled readers for inconsistent information. In the present study the low rates of accuracy and longer reading/judgment times of less skilled readers for anomalous texts as compared with consistent texts suggests that they may have been somewhat sensitive to anomaly (at least to the obvious cases). But, in Brown's terminology, they may have been at the same time willing to tolerate anomaly inasmuch as they were unable to identify precisely its nature or its source. It may be that these readers tend to attribute incoherence not to the text but to their own process of comprehension, leading them either to judge as sensible texts that appear not to be, or simply to hesitate in marking a text as anomalous. In either of these cases, the result is a bias to judge a text as semantically consistent.

This is not to suggest that active attempts to monitor one's comprehension are necessarily separable from, or consciously laid over, comprehension itself. Rather, as Markman (1979) has argued, "...much [of the] information about one's comprehension is a by-product of active attempts to understand and not just of attempts to monitor" (p.75). With this perspective in mind, it becomes clear that, in the very process of constructing a representation of a text's meaning, readers who are skilled in analyzing the semantic base of a text will likely be sensitive to gaps in the coherence of that representation. By contrast, readers who make less effective use of semantic constraints, will tend to construct less coherent models of text meaning and, in consequence, will not be as sensitive to gaps in the coherence of these models. As a result, they will be more likely to suffer failures of comprehension.

The purpose of the next set of analyses was to uncover some of the specific factors which may influence readers' comprehension of semantic relations among text propositions. In the process, some of the possiblities raised by the results of these initial analyses will be addressed.

3.2 Accuracy and Reading Time Analyses for Consistent Passages

This second series of analyses of variance focused on factors which influenced readers' comprehension of the set of consistent passages. Through these analyses, a more precise understanding of the comprehension of semantic relations can be developed. There were four factors in these analyses. (1) type of relation (causal or adversative), (2) level of constraint (high or low), (3) type of connective (conjunction or verb), and (4) reading ability group (four levels), with subjects nested under groups. Accuracy in judging the semantic consistency of these passages and per syllable reading time for various segments of text were the dependent variables. The accuracy data are taken to represent a measure of overall comprehension, while reading times are taken as a more direct reflection of on-line integrative processing at various points in the reading of a text. The reading time analyses, which were for correct judgments only, focused on the following text segments. (1) final clause (which included judgment time as well), (2) critical clause(s), (3) the clause containing the connective, and (4) the clauses preceding the connective clause. In addition to the results of these analyses, results for planned comparisons are reported.

3.2.1 Accuracy rates in judging consistent passages

There were significant main effects of constraint level and type of connective on judgment accuracy for consistent passages, $F(1,28)=49.0725$, $p<.0001$ and $F(1,28)=6.7162$, $p=.015$. The other two main effects were not significant.

All readers were more accurate in their judgments when the level of semantic constraint for a particular relation was high (79%) than when it was low (66%). This result suggests that semantic constraints play a considerable role in readers' comprehension of semantic relations among text propositions. When the semantic content of related propositions was rich in information supporting a stated relation,

readers were more accurate in judging the semantic consistency of those propositions. When the contextual support was weaker, as in the low constraint condition, even the explicit marking of a relation by a connective did not appear to be sufficient to overcome the lack of semantic detail in the surrounding context.

In addition, subjects' accuracy was influenced by the type of connective used to mark a relation. Readers were, in general, more accurate when conjunctions were used to mark a relation than when verbs were used. With conjunctions, subjects' rate of accuracy was 75% while for verbs it was 70%. And, although the main effect due to type of relation was not reliable, $F(1,28)=2.2443$, $p<.15$, subjects were, in general, somewhat more accurate in judging the consistency of passages expressing causal relations than in judging those expressing adversative relations (74% vs. 71%).

The two-way (Relation x Constraint) interaction was significant also, $F(1,28)=4.7594$, $p=.037$. Mean percent correct judgments are shown in Figure 4. When the level of semantic constraint was high, subjects were more accurate in their judgments of causal relations (82%) than in their judgments of adversative relations (76%), $t(28)=2.50$, $p=.02$. In contrast, when the degree of constraint for a stated relation was low, comprehension of the two types of relations did not differ (66% and 67% for causal and adversative relations, respectively), $t(28)<1$. This finding suggests that there is some difficulty associated with comprehension of adversative relations. Even when an adversative relation was strongly constrained by the surrounding context and marked by a connective, readers were less successful in constructing adequate representations for the intended meaning of that relation than they were in the case of causal relations.

Although the three-way (Group x Relation x Constraint) interaction did not reach significance, $F(3,28)=1.6206$, $p=.21$, there are trends in the data that hint at

the possibility of skill differences among readers in use of semantic constraints in understanding particular types of relations. Mean percent correct judgments for causal and adversative relations are plotted separately in Figures 5 and 6, respectively.

Looking first at the plots for the causal relation (Figure 5), it is clear that while the accuracy of all readers suffered under conditions of low constraint, the accuracy of readers in Group 1 was less affected by constraint manipulations than was that of Groups 2 and 4. The accuracy of Group 3 readers was actually the least affected by constraint level, however, the pattern of results for this group is difficult to interpret. At times the pattern parallels that of the least skilled readers, at other times that of Group 1 and, at still other times, it runs counter to the other groups as a whole. For this reason, results for Group 3 will be reported throughout, but no attempt to interpret them will be made.

Returning to Figure 5, it shows that, for Group 1, there was a 14% drop in accuracy from 85% under high constraint to 71% under low constraint as against a 21% drop for Group 2 from 83% to 62%, a 4% drop for Group 3 from 75% to 71% and a 25% drop for Group 4 from 84% to 59%. Group 1 readers were, in effect, the only group able to maintain a reasonable rate of accuracy when the semantic constraint for a stated causal relation was high or low.

Looking now at the data plotted in Figure 6 for adversative relations, it is clear that the accuracy of all readers decreased when a stated adversative relation was only minimally constrained by context. When an adversative relation was more strongly supported by contextual information, however, readers in Groups 1 and 2 showed larger increases in accuracy than did the least skilled readers (from 69% to 80% for Group 1, 62% to 74% for Group 2, 68% to 74% for Group 3, and 69% to 76% for

Group 4). This suggests that less skilled readers' comprehension of texts expressing an adversative relation is less affected by the presence or absence of rich semantic information.

These trends, together with the finding that adversative and causal relations are not equally comprehensible, provide some hints as to the nature of the difficulty that seems to underlie comprehension of adversative relations in particular and semantic relations in general. In the case of the adversative relation, the source of the difficulty appears to be rooted in the mutability of meaning that seems to underlie it. As was noted in the opening section, the adversative relation covers not one meaning but a variety of subtle connotations of meaning, from violated expectation to simple contrast. Moreover, the vocabulary of connectives representing the adversative is itself imprecise, the same connectives can be used to mark different meanings ("but" is probably the most representative example of this kind of semantic mutability). It is this underlying mutability that, in theory, makes determination of the intended meaning of an adversative relation heavily dependent upon the presence of rich semantic constraints for a stated relation as well as on the ability of readers to exploit such constraints.

This dependence on context is presumably what makes the adversative relation difficult to comprehend, particularly for the less skilled reader. Even when the relation is strongly constrained by context, identification of the particular meaning intended is likely to require an especially thorough analysis of the semantic content of the related propositions. Skilled readers showed evidence of being able to exploit strong semantic constraints for a stated adversative relation in building representations for such relations. However, even skilled readers experienced difficulty in comprehending adversative relations that were only weakly constrained by the semantic content of the related propositions.

The causal relation, by contrast, appears to represent a stable category of meaning. Causal sequences are quite reliably represented through the vocabulary of causal connectives, although some of these are less precise than others. For example, "as a result" leaves little room for doubt as to the relation intended whereas "then" may signal a causal sequence as well as a temporal one. In any event, the vocabulary of causal connectives, in theory, can augment the information a reader derives from an analysis of the semantic content of the related propositions. Even subtle semantic information, when combined with the relatively stable meaning of a causal connective, can adequately constrain the meaning of a causal relation to allow skilled readers to construct a representation for the intended meaning.

For less skilled readers, however, comprehension of causal relations seems to depend upon the presence of rich semantic supports for the stated relation. In fact, the evidence suggests that these readers were able to use semantic constraints effectively in only one condition, when the constraint for a stated causal relation was strong. They were markedly less accurate when the semantic supports for a stated causal relation were weak, even though the relation was marked by an explicit causal connective.

The two-way (Relation x Connective) interaction was also marginally significant. $F(1,28)=3.3932$, $p=.076$. Mean percent correct judgments are plotted in Figure 7. First, note that accuracy rates for passages containing causal and adversative relations were nearly identical when the relations were marked by a conjunction (75% and 76%, respectively). In addition, the accuracy rate for passages in which a causal relation was marked by a verb was comparable (73%). However, when an adversative relation was marked by a verb, subjects' rate of accuracy fell to 67%. Based on these findings, it would appear that although causal relations are conveyed equally well

through either type of connective, verbs are not as effective in marking adversative relations as are conjunctions.

These results also support the view outlined above concerning differences in the ease with which causal and adversative relations are understood. Readers' comprehension of causal relations was less affected than was their comprehension of adversative relations by the type of connective used to mark them. This reflects perhaps the fact that comprehension of relations that are stable in meaning is less likely to be susceptible to the influence of particular types of connectives than is comprehension of relations that are mutable.

There was also evidence for skill differences among reader groups in use of explicit connectives. The two-way (Group x Connective) interaction was significant, $F(3,28)=3.2806$, $p=.035$. The data are plotted in Figure 8. Planned comparisons indicated that for Groups 2 and 4, type of connective was significant, $t(28)=3.33$, $p=.003$ and $t(28)=2.05$, $p=.05$, respectively; readers in these groups were, in general, more accurate when relations were marked by a conjunction than by a verb (77% vs. 64% for Group 2, 76% vs. 68% for Group 4). By comparison, readers in Group 1 and those in Group 3 showed no difference in accuracy rate due to type of connective (77% vs. 74% for Group 1, 70% vs. 73% for Group 3), $t(28)<1$. While the results for Group 3 are uninterpretable, those for Group 1 suggest that skilled readers are better able than less skilled readers to use explicit connectives in judging the semantic consistency of related propositions, irrespective of the way they are expressed linguistically. Less skilled readers, on the other hand, appear to depend upon the explicit marking of semantic relations through conjunctions.

Earlier it was suggested that, in the case of weakly constrained causal relations, skilled readers were not only better able to analyze the semantic content of text

propositions but were better able to use the vocabulary of causal connectives in constructing representations for such relations. The present findings buttress that explanation. Further, recall that in Section 1 other research was discussed suggesting that less skilled readers rely on explicit, reliable surface features of text to aid comprehension. In light of the present results, it appears that, in the case of semantic relations, conjunctions are one such reliable surface marker. Verbs, unlike conjunctions, serve multiple functions in the language and, therefore, may not be as reliable as conjunctions in marking semantic relations among text propositions, particularly for less skilled readers.

Finally, it is interesting to note that, while conjunctions tend to have higher printed frequencies than do verbs, an explanation for this finding based on freqency alone is not adequate. The conjunctions and verbs used in the study were matched as closely as possible on frequency.

3.2.2 Summary

The accuracy data suggest that comprehension of semantic relations among text propositions is strongly influenced by the degree to which a stated relation is constrained by context. In particular, the results demonstrated that comprehension of both causal and adversative relations was enhanced when the semantic content of the related propositions strongly constrained the relation. Accuracy rates for strongly constrained causal relations, however, were higher than were those for strongly constrained adversative relations.

In addition, type of connective also exerted an influence on comprehension. Readers' comprehension of causal relations was less affected than was their comprehension of adversative relations by the type of connective used to mark them

In particular, the findings revealed that verbs were not as effective as conjunctions in communicating adversative relations. By contrast, conjunctions and verbs were equally effective in communicating causal relations.

There was some evidence to suggest that comprehension of semantic relations depends on the ability of readers to use semantic constraints in text to construct representations for the meanings of those relations. Skilled readers showed evidence of being able to use even weak semantic constraints in constructing representations for stated causal relations. By contrast, less skilled readers appeared to depend upon the presence of rich semantic constraints for a stated causal relation to aid comprehension. Comprehension of adversative relations also appeared to depend upon the ability of readers to exploit semantic constraints for a stated relation. Skilled readers tended to be more accurate than other readers in comprehending strongly constrained adversative relations among text propositions. However, even skill in using semantic constraints was not sufficient to overcome the difficulty that appears to underlie comprehension of adversative relations that are only weakly constrained.

Finally, there was also evidence of skill differences among reader groups in use of the connective vocabulary in constructing representations for the meaning of semantically related text propositions. The most highly skilled readers showed no effect of connective type on accuracy of comprehension. The least skilled readers, by comparison, tended to be more accurate in those cases where a conjunction was used to mark a relation than in those where a verb was used.

3.2.3 Reading/judgment time for the final clause

Final clause reading/judgment time is a measure of the amount of time it takes a reader to read the final clause, integrate it into a text model and judge the semantic

consistency of the text as a whole. In this analysis, the only effect to reach significance was the main effect of constraint level on per syllable reading/judgment times for the final clause, $F(1,28)=28.2950$, $p=.0001$. As illustrated in Figure 9, reading/judgment times of all readers were faster for the final clause of passages which strongly constrained a stated relation than for those which only weakly constrained a stated relation (485 msec vs. 758 msec for Group 1, 456 msec vs. 600 msec for Group 2, 502 msec vs. 632 msec for Group 3, and 571 msec vs. 665 msec for Group 4). A planned comparison of reading/judgment times for the two levels of constraint revealed that this difference in ease of processing was significant for all groups but Group 4, $t(28)=4.53$, $p=.0001$, $t(28)=2.38$, $p=.029$, $t(28)=2.17$, $p=.04$, and $t(28)=1.56$, $p=.11$, respectively.

These results demonstrate that, in general, sensitivity to and use of semantic constraints can have an effect on efficiency of processing as well as comprehension accuracy. However, as Figure 9 illustrates, it was the most highly skilled readers who showed the largest difference in processing time for high and low constraint passages. This result suggests that, in general, when there are strong semantic constraints for a stated relation, expert readers are highly sensitive to such constraints. Moreover, they are able to use these constraints in constructing a coherent representation of the meaning of a text such that, at the moment when a judgment of semantic consistency is required, they can readily base their judgment on this representation. On the other hand, when the constraint for a stated relation is weak, this judgment is not as readily made. The additional processing time under low constraint reflects perhaps the skilled reader's attempt to "make sense" of the text which, owing to the lack of richness in the semantic base, is not thoroughly coherent. In particular, the longer reading times may reflect skilled readers' attempts to resolve apparent gaps in the coherence of the model they have constructed, perhaps by retracing paths in the

representation to resolve any remaining problems of reference, infer unstated premises or otherwise elaborate the model that serves as the basis for their judgment of semantic consistency. On this view, the large difference in processing time for these readers under high and low constraint reflects, at least in part, their sensitivity to gaps in the coherence of the models of meaning they have constructed.

The least skilled readers, by contrast, showed less evidence that they were engaging in additional processing when the constraint for a stated relation was weak. This suggests that their analysis of the semantic base of a text is not as thorough as is that of highly skilled readers. It suggests further that their level of skill is not sufficient to enable them to analyze precisely, or trace, the sources of incoherence when these are subtle in nature. Nor is their level of skill sufficient to enable them to readily trace obvious violations of coherence, as in the case of anomalous passages. Recall that less skilled readers' successfully detected anomaly on only a few occasions and, in those cases, their processing was labored. Skilled readers, by contrast, were markedly more accurate and efficient in judging anomalous texts than were less skilled readers.

More generally, the present finding supports the trends noted in the accuracy analyses, particularly those concerning differences among readers in skill in analyzing the semantic content of related propositions. The smaller amount of additional processing for texts that were weak in constraint is compatible with the view that less skilled readers' comprehension of semantic relations is dependent upon the presence of obvious semantic constraints for stated relations. So while both skilled and less skilled readers were, in general, less accurate in their judgments of weakly constrained semantic relations as compared with those that were strongly constrained, the reading time data suggest that skilled readers were more sensitive to and better

able to use the more subtle constraints in text to comprehend semantic relations among text propositions. The least skilled readers, by comparison, showed less evidence of sensitivity to and thoroughness in using subtle semantic constraints for stated relations.

3.2.4 Reading times for the critical clause

Critical clause reading time is a measure of the amount of time it takes a reader to integrate the clause with its related antecedents. There was a significant main effect of constraint on per syllable reading times for the critical clause (340 msec vs. 426 msec for high and low constraint, respectively), $F(1,28)=25.0131$, $p<.0003$. Main effects of type of connective, relation and group were not significant, $F(1,28)=2.4711$, $p<.13$, $F(1,28)<1$ and $F(3,28)<1$.

Mean per syllable reading times for each reader group under conditions of high and low constraint are shown in Figure 10. While the two-way interaction was not significant, a planned comparison of reading times for each reader group in the two conditions revealed that the effect of constraint on critical clause reading times was significant for all reader groups but Group 3, $t(28)=4.21$, $p=.0003$, $t(28)=2.00$, $p=.056$, $t(28)=1.68$, $p=.09$, $t(28)=2.12$, $p=.045$, for Groups 1, 2, 3, and 4, respectively. Mean per syllable reading times under conditions of high and low constraint were 321 msec vs. 466 msec, 319 msec vs. 388 msec, 346 msec vs. 404 msec, and 375 msec vs. 448 msec for Groups 1,2,3, and 4, respectively.

It is noteworthy that although three of the four reader groups showed significant gains in efficiency in those cases where text propositions had rich semantic connections among them, the most highly skilled readers showed the largest difference in processing efficiency. (Differences were 144 msec, 69 msec, 58 msec, and 73 msec,

for Groups 1, 2, 3, and 4, respectively.) This parallels the trend noted for final clause reading times. When the semantic information in a text strongly constrained a stated relation, skilled readers were the most efficient in integrating critical propositions with their antecedents. The basis for integration in such cases is presumably clear and unambiguous, involving perhaps, among other things, overlapping arguments. In the case where a stated relation was only weakly constrained, skilled readers were considerably slower at integrating propositions with their antecedents. The longer integration time may be viewed as reflecting the time it takes to infer semantic connections between the propositions currently being encoded and those antecedents in the text model. The suggestion is that Group 1 readers are more sensitive to and expend more time in analyzing the linkages between newly encoded propositions and related antecedents than less skilled readers, as manifested in the larger effect of semantic constraint on their processing times for critical propositions.

The two-way (Group x Relation) interaction approached significance, $F(3,28)=2.3486$, $p=.09$. As illustrated in Figure 11, the reading times of readers in Groups 1 and 2 for critical clauses in texts expressing causal relations were faster than those for critical clauses in texts expressing adversative relations (354 msec vs. 433 msec for Group 1, 319 msec vs. 389 msec for Group 2). This contrasts with the reading times of Group 3 and 4. Readers in these groups showed either a difference in the opposite direction from Groups 1 and 2 or no difference in reading times for critical clauses in passages expressing causal or adversative relations (409 msec vs. 341 msec for Group 3, 414 msec vs. 409 msec for Group 4).

These findings suggest that, for the more highly skilled readers, propositions that participate in causal relations are more readily integrated with their antecedents than are propositions that participate in adversative relations. Causally related

propositions, perhaps owing to the greater stability of meaning that underlies them, appear to provide a more straightforward basis for semantic integration than do adversatives. The latter are presumably more dependent upon context for specification of the particular meaning intended. In contrast to the more skilled readers, less skilled readers appeared less able to exploit the semantic stability of causal relations in the immediate processing and integration of propositions with their related antecedents. However, it is perhaps this stability of meaning that, in combination with obvious semantic constraints, enabled less skilled readers to construct adequate representations for strongly constrained causal relations, as demonstrated by their high rates of accuracy in that condition.

The two-way (Relation x Constraint) interaction was also significant, $F(1,28)=11.6709$, $p=.0019$. Mean per syllable reading times for each of the conditions are presented in Figure 12. As shown in the figure, manipulations of semantic constraint more greatly affected readers' processing of critical clauses in passages conveying adversative relations than in those conveying causal relations (361 msec vs. 386 msec for causal relations, 320 msec vs. 466 msec for adversative relations). As was suggested above, the immediate integration of propositions connected through an adversative relation appears to depend more heavily on a thorough analysis of the semantic content of the related propositions than does immediate integration of causal relations, owing to the various connotations of meaning that underlie the adversative relation.

This finding, in combination with the accuracy data, testifies to the complexity that seems to characterize adversative meanings. Recall that under conditions of strong semantic constraint, readers were, in general, more accurate in their comprehension of causal relations than adversative relations. On the basis of these

findings it appears that the mutability that underlies the adversative relation has two effects First, it makes comprehension of such relations more difficult overall and, second, it makes immediate integration of critical propositions with their related antecedents more dependent upon contextual influences.

While the three-way (Group x Relation x Constraint) interaction was not significant, the data do suggest a trend in the direction of skill differences among readers, particularly in the integration of clauses that participate in an adversative relation (see Figure 13). Consistent with the accuracy data, it is the most highly skilled readers who show the greatest sensitivity to semantic constraints for stated adversative relations (301 msec vs. 565 msec, or a difference of 264 msec per syllable under high versus low constraint). This difference is more than double that for either of the remaining three reader groups who registered differences of 112 msec (333 msec vs. 445), 101 msec (291 msec vs. 392 msec), and 110 msec (354 msec vs. 464 msec), respectively. Recall in this connection that the accuracy data contained a suggestion that Group 1 readers were more accurate than readers in the other groups in their judgments about texts with strongly constrained adversative relations. The present findings suggest further that when skilled readers encounter clauses that are critical to comprehension of the intended relation, they readily integrate such clauses with their related antecedents when the semantic constraints for the relation are strong. When, by contrast, the constraints for a stated adversative relation are weak, skilled readers take considerably more time to integrate critical clauses with their antecedents. It is in this sense that skilled readers are at once more sensitive to semantic constraints and more thorough than other readers in their analysis of such constraints in constructing representations for relations among text propositions.

3.2.5 Reading times for the connective clause

Reading time for the connective clause is a measure of the amount of time it takes to encode a connective representing a particular type of relation. The only effect to reach significance in this analysis was the three-way (Group x Relation x Connective) interaction, $F(3,28)=2.9916$, $p=.04$. While somewhat unruly, the data contain a suggestion that Group 1 readers processed clauses containing a causal verb somewhat faster than clauses containing a causal conjunction (233 msec vs. 205 msec), $t(28)=1.77$, $p=.08$, Group 1 readers did not process clauses containing an adversative verb any more efficiently than those containing an adversative conjunction (227 msec vs. 248 msec), $t(28)=1.33$, $p=.16$. There were no differences in the processing times of Groups 2 and 4 for clauses containing causal or adversative verbs or conjunctions. Group 3 readers showed an advantage in processing for causal conjunctions as against causal verbs (225 msec vs. 255 msec), but no difference in processing times for adversative connective clauses.

The exact implication of this finding is not at all clear. However, it is noteworthy that the more efficient encoding of causal verbs did not have an impact on subsequent processing of text segments or on accuracy of comprehension for Group 1 readers. This suggests that the effect may be a phenomenon of immediate encoding, and not one that necessarily has an impact on the ease of subsequent integrative processing or on the overall coherence of the representation a skilled reader constructs for a text. However, these comments should be viewed with some caution. On the one hand, the data themselves are not clearcut. On the other hand, the range of textual conditions in which the influence of connectives was studied was strictly limited. Connectives conjoined adjacent or nearly adjacent propositions, never spanning a distance of more than a few clauses. Connectives might be found to have a stronger impact on processing time in those cases where the connective conjoins

propositions or larger units of meaning that are at some distance from one another. In such cases, the connective might function more deliberately to cue reinstatement of previously encoded propositional structures, leading to more clearcut effects on ease of subsequent processing or judgment accuracy

3.2.6 Reading times for preconnective clauses

The purpose of this analysis was to determine how early in the processing of a text the influence of type of relation or semantic constraint may make itself felt. In this analysis, there was a significant main effect of type of relation, $F(1,28)=24.8983$, $p=.00002$, and a marginally significant two-way (Group x Relation) interaction, $F(3,28)=2.5647$, $p=.07$. The preconnective clauses of passages expressing causal relations were read, on the average, 21 msec per syllable faster than were those of passages conveying adversative relations (302 msec vs. 323 msec). This interacted, though not very reliably, with reading ability. A comparison of reading times in these two conditions for each reader group showed that, for readers in Groups 1 and 2, there were no differences in reading times for preconnective clauses in passages expressing either causal or adversative relations (274 msec vs. 283 msec for Group 1, 296 msec vs. 308 msec for Group 2), $t(28)=1.04$, $p=.23$, $t(28)=1.39$, $p=.15$. For readers in Groups 3 and 4, by contrast, there were differences (287 msec vs. 316 msec for Group 3, 350 msec vs. 387 msec for Group 4), $t(28)=3.35$, $p<.003$, and $t(28)=4.27$, $p<.0003$. Readers in Groups 3 and 4 tended to read preconnective clauses in passages expressing a causal relation somewhat faster than those in passages expressing an adversative relation.

The implications of this finding are also unclear. To begin with, the increased efficiency of Groups' 3 and 4 for preconnective clauses in texts expressing a causal relation does not carry over to the processing of later text segments. Some

manifestation of facilitation might be expected if this finding were taken to imply that less skilled readers were in general more adept at encoding the causal relation than other types of relations. However, at the time that they read a connective clause, they showed no savings in reading time for connectives representing causal relations over those representing adversative relations. Even more striking, perhaps, is the fact that it was the skilled, and not the less skilled, readers who, at the time they read the critical clause, showed a savings in reading time for causally related propositions. It is true, however, that for less skilled readers there was some advantage attributable to causal relations inasmuch as they were most accurate in their judgments of strongly constrained causal relations. Thus, the cautious view of this finding is that adversative relations may be from the start more difficult to understand than are causal relations. It is possible, for instance, that causal preconnective clauses, unlike adversative ones, are more readily encoded because they may contain action verbs that typify causal sequences, enabling the reader to at least identify the causal nature of the text. In the case of adversatives, such identification is unlikely for, as has been demonstrated, determination of the precise meaning of an adversative relation is clearly dependent upon a thorough analysis of the surrounding context.

3.2.7 Summary

Reading and judgment times for the final clauses of texts conveying semantic relations were strongly influenced by the degree to which those relations were constrained by the semantic content of the related propositions. Three of the four reader groups were significantly faster in reading/judging the final clauses of texts in which semantic relations were strongly constrained as compared to those in which relations were only weakly constrained. The reading/judgment times of the least skilled readers, those in Group 4, were not significantly different for texts that were rich in semantic detail as against those that were weak in semantic detail. Group 1

readers showed the largest effect of constraint on final clause reading times, a difference that was two times as great in magnitude as that for Groups 2 and 3 and three times as great as that for Group 4.

In the case of critical clause reading times, degree of semantic constraint more greatly affected readers' immediate integration of clauses which were linked through an adversative relation than those which were linked through a causal relation. And, consistent with the results for final clause reading times, this effect was measurably greater for Group 1 readers than for any of the other three reader groups. In addition, there was evidence to suggest that, in general, readers in Groups 1 and 2 were faster at integrating causally related critical clauses than those connected through an adversative relation.

With respect to other text segments, there was a suggestion in the data that Group 1 readers processed clauses containing a causal verb somewhat faster than clauses containing a causal conjunction, although this advantage did not have any impact on processing of subsequent text segments or on overall accuracy. Finally, readers in Groups 3 and 4 tended to read preconnective clauses in passages expressing a causal relation somewhat faster than those in passages expressing an adversative relation, although there was no evidence of an effect of facilitation for subsequently processed clauses in texts expressing a causal relation.

4. THEORETICAL IMPLICATIONS

The purpose of this study was to develop an understanding of the nature of expertise in analyzing high order semantic relations among text propositions and, at the same time, to uncover sources of difficulty in this component of comprehension for the less skilled reader. Implicit in this purpose was the view that expertise in this

aspect of text comprehension is multifaceted, involving at least (1) sensitivity to and skill in using the semantic content of related text propositions to constrain analysis of the meaning of relations between those propositions, and (2) knowledge of and skill in using the vocabulary of connectives representing different types of semantic relations. Effective use of these information sources, in theory, enables the reader to analyze the meaning of particular relations among propositions and integrate propositions with their related antecedents into a coherent representation of a text's meaning. The focus in this section is on exploring some of the implications of this research for models of text comprehension.

Both the reading time and accuracy data provide clear evidence that the richness of the underlying semantic content of related propositions significantly influences the difficulty a reader has in comprehending particular relations among text propositions. In addition, the reading time data reveal consistent differences in the extent to which skilled and less skilled readers were able to use the semantic content of related propositions to constrain analysis of particular relations and construct coherent representations for those relations. Given these results, we now need to consider how skill in analyzing the semantic content of related propositions can mediate or enable comprehension of high order semantic relations among text propositions. For models of text comprehension this is an important issue because it focuses on how the propositions of a text base are organized into higher order units of meaning to represent the relational complexity and structure of a text (cf. Kintsch & van Dijk, 1978).

4.1 Semantic Analysis and Integration Processes

As a first step, we need to think about what happens when readers analyze the semantic content of text propositions. What is the nature of the process by which

they gain access to related concepts in semantic memory to construct coherent text models? The underlying process is thought to be one of spreading activation (Collins & Loftus, 1975). A theory of spreading activation assumes that concepts are organized in a semantic network on the basis of semantic relatedness. In simple terms, the theory states that when one concept node is activated, other nearby, related concept nodes are also activated. Activation spreads outward from the original node in proportion to the semantic distance between that node and other related nodes. Nodes that are close in semantic distance to the originally activated concept receive more activation than those that are at a greater semantic distance. In such a theory, it is assumed further that nodes require a threshold for "firing," one consequence of which is that activated nodes are accessed more rapidly than are those that are not activated.

In what way, then, does the reader's analysis of the semantic content of related propositions enable comprehension of high order semantic relations? The precise nature of the enablement between processes of semantic analysis and comprehension of high order semantic relations, also discussed in Frederiksen & Warren (in press), can perhaps best be captured through examination of an illustrative text, as in the following.

> For many years intelligence has been measured as a number like height or weight. (But) another view that intelligence is made up of a number of independent abilities is now gaining support.

This example illustrates several ways in which the meaning of a high order semantic relation can be constrained by context. In what follows, I discuss some of these ways in more detail. Furthermore, I will suggest that it is through these various sources of constraint that a basis for integrating related propositions into a coherent representation of the text's meaning is established.

To begin, consider some of the semantic relations expressed in the sample passage from a purely textual standpoint. Note, for instance, that the lexical term "intelligence" is not only repeated as an argument in two related propositions, but also functions in important roles as the subject noun or embedded topic of these propositions. In a similar manner, "number" is repeated as an argument related to "intelligence", although it is not used in precisely the same sense in the two cases. Moreover, the local identifications for "number" (e.g. "like height or weight" and "of independent abilities") contain the critical terms of the underlying relation of comparison or contrast. Finally, there are temporal markers of the contrastive relation as well, with "for many years" juxtaposed against "now".

Consider now the way in which these aspects of text content and structure may influence processes of semantic analysis and integration. At the moment when the reader begins to encode the propositions that underlie the second sentence of the sample text, there are two classes of information available that originate from the reader's memory for prior text. One is in the form of a text model containing a representation of the text's propositions and relational structure. The other is in the form of an activation state within semantic memory representing the pattern of activation following retrieval of concepts related to the context frames being read. In the proposed theory, it is assumed that there are linkages between these two forms of "text" information, in the form of bi-directional pointers or links between propositions in the text model and their referent concepts in semantic memory.

To illustrate, "intelligence" is the subject noun of the first sentence and is an embedded, but topically central, noun in the second. Owing to its status in sentence #1 as a foregrounded concept (cf. Lesgold, Roth & Curtis, 1979), it will be activated. And, as the concept about which things have been asserted (e.g., "intelligence has

been..." and "intelligence is..."), it will occupy a central position within the reader's text model (cf. Kieras, 1981b, Just & Carpenter, 1980). When the reader encounters "intelligence" for the second time (in sentence #2), it should still be activated in semantic memory as a result of its initial mention. This residual activation serves to (1) "signal" the proposition as one that contains information that is related to something previously mentioned and still active (in this case the relation is one of lexical reference), and (2) make available a pathway back to the referent, thereby enabling automatic integration of the proposition with its related antecedents in the reader's text model

This parallels closely the mechanism proposed by Kintsch & van Dijk (1978) for automatic integration of propositions that contain shared arguments. In their model, the first step in forming a coherent text base involves checking incoming propositions for arguments that overlap with those already processed. In the theory proposed here, however, the basis for integration is not limited to argument repetition. It covers the range of forms that characterize coherent text structures, from synonymy and superordinates to relations of entailment among actions and events. In the sample text, for example, the temporal markers "for many years" and "now" are related as two terms in an ordered series, a relationship that could also establish a basis for integration of related propositions.

The results of the present study provide support for a theory that assumes that activation processes of the kind discussed above enable comprehension of high order semantic relations. The results for critical clause reading times are especially germane here. Presumably, these times would reflect the ease with which newly encoded propositions are integrated on-line with their related antecedents in the reader's text model. Recall that substantial effects of semantic constraint were found

on the reading times for critical propositions, that is, propositions on which the comprehension of a particular relation depended. Moreover, this effect was greater in the case of adversative relations than in the case of causal relations, indicating that comprehension of the particular meaning of an adversative relation appears to rely more heavily on an analysis of the semantic content of the related propositions.

The comparison of causal and adversative relations -- one stable in meaning, the other mutable -- proved to be an important one. Through this comparison, it was possible to explore the particular conditions under which various aspects of text structure and content influence readers' comprehension of semantic relations. In the case of the causal relation, immediate integration of the related propositions seemed to occur regardless of the degree of semantic constraint. Thus, even when there is weak semantic constraint for a stated causal relation, a causal connective appears to contain reliable information as to the meaning of the intended relation. In the case of adversatives, however, integration of related propositions was affected by semantic constraint. And, when the constraint for a stated adversative relation was weak, the connective was not very informative as to the particular meaning intended since adversative connectives can take on any one of a number of meanings.

The findings relating to reader differences also support the proposed theory Skilled readers consistently demonstrated the largest effects of semantic constraint on ease of propositional integration. Indeed, at every point in the processing of texts, the most highly skilled readers showed a sensitivity to the semantic properties of text to a *degree not* matched by the other reader groups. This finding is consistent with other research that has investigated contextual influences on processes of semantic integration (Frederiksen, 1981a, b). When there were strong semantic constraints for a stated adversative relation, for example, skilled readers readily integrated critical

propositions with their related antecedents. It is presumably in such cases that the activation state in semantic memory is sufficient to support automatic retrieval of related antecedents and efficient integration of the newly encoded propositions within the reader's text model. When, by contrast, there were weak semantic constraints for a stated adversative relation, integration times for critical clauses were substantially longer. In theory, this increase in processing time indicates that the state of activation within semantic memory is below threshold and that the text model is not thoroughly coherent. In such cases, skilled readers engage in processes of inference, which take time.

An instance of a semantic connection that requires the reader to infer an antecedent is contained in the sample text, namely, the ellipsis embodied in the noun phrase "another view". This instance of ellipsis neatly illustrates the role of constructive processes of semantic analysis in integration of propositions that are connected through a high order semantic relation. Here the phrase represents an instance of cohesion whereby there is a presupposition of something left unsaid (i.e., that "one view" had already been presented) and, in this way, underscores the contrastive relation. An important point to emphasize is that the noun phrase refers back to the prior text (i.e., is anaphoric), signaling the reader to search for related antecedents and to identify from among them the correct referent.

However, in the case of the sample text, when the reader encounters "another view", there is no direct antecedent, either active in semantic memory or represented in the text model, that can be assigned as its referent. Indeed, the actual referent is not a single concept, rather, it is the propositional structure for the content of the entire first sentence. Therefore, to identify the referent, the reader must analyze the semantic character of the term "another view," in addition to analyzing its elliptical

function. These analyses would lead the reader to infer that the presupposed information or referent for this term is the propositional structure currently represented in the text model. In the process of recovering the referent, the reader would also, in theory, be led to identify the structure of the text as one of simple contrast ("one view" as opposed to "another view").

In the case of ellipsis, a certain amount of construction is required on the reader's part to infer the precise referent. In other cases, however, referents for pronouns and other forms may be identified automatically on the basis of residual patterns of activation of concepts in semantic memory, in a way that closely parallels that described above for the case of repeated arguments (Kintsch & van Dijk, 1978; Lesgold, Roth & Curtis, 1979). Thus, if semantically related propositions do have a number of traceable referential paths between them, then one effect of mapping referring terms to their referents is to bring forward -- automatically or through inference -- propositions that are critical to the comprehension of high order semantic relations among text propositions. In this way, antecedent propositions that are related to those being encoded are made available for integration with newly encoded propositions.

As this sketch illustrates, skill in analyzing the semantic content of related text propositions entails considerable flexibility on the reader's part. On one hand, there is great variety in the kinds of semantic connections that can hold between the propositions of a text. On the other hand, the language itself has a wide variety of means for expressing these various kinds of semantic ties, from different ways of referring to other elements in the text to different ways of conjoining propositional units. As a consequence of the complexity of this domain, considerable room exists for comprehension failure. If, for example, the reader analyzes only superficially the

nature of the semantic ties that hold between related text propositions, then the resulting text model is likely to remain incoherent. This will lead to failures in comprehension, particularly where more complex semantic relations are involved. More specifically, a reader's failure to resolve problems of reference can lead to loss of activation for related, earlier occurring contexts (i.e., those propositions that are the antecedents to which later occurring propositions are related). In such cases, the reader can be forced to rely on the explicit marking of semantic relations through a connective. As the results from the present study show, this is a strategy which is less than optimal in the case of particular relations.

The findings of this study suggest that for skilled readers the overriding influence on comprehension of semantic relations among text propositions is the degree of semantic constraint for a stated relation. Type of explicit connective did not have an impact on skilled readers' comprehension of semantic relations. Less skilled readers, by contrast, are less sensitive to semantic constraints and more dependent upon particular connective types in understanding text relations. This places them in double jeopardy, one consequence of which is that relations that are mutable in nature -- such as the adversative -- and relations that are only weakly constrained -- whether mutable or not -- are likely to pose serious problems, as the findings demonstrate. These readers seem unable to exploit the fact that the language has within it a variety of means, both explicit and implicit, for expressing relations among text propositions. It is possible, too, that imprecise knowledge of the connective vocabulary itself may compound these difficulties.

In conclusion, skill in analyzing the variety of cohesive relations that can hold between the arguments of text propositions appears to be a critical element in understanding high order semantic relations among those propositions. The proposal

put forward in this section is that effective use of semantic constraints in text enables readers to activate, in parallel, concepts in memory that are related to the context frames they are reading. The resulting patterns of activation in semantic memory can then be used to mediate retrieval of antecedent propositions that are related to those currently being processed. In these ways, the effect of thoroughly analyzing the semantic content of context frames, particularly for linkages to related antecedents, is to heighten the reader's accessibility to those antecedents. Such mediated retrieval of antecedents through activation in semantic memory enables integration of the newly encoded, related propositions into a unified model of a text's meaning.

Specifying the nature of the enablements among components of text comprehension is a necessary step in developing more complete models of the process of text comprehension and in understanding more fully some of the sources of comprehension failure. Implications for instruction aimed at improving readers' skill in understanding semantic relations among text propositions are addressed in the next section.

5. INSTRUCTIONAL IMPLICATIONS

Comprehension of high order semantic relations among text propositions is an important component of text comprehension. In broad terms, it reflects an aspect of language understanding that deals with the relationships that can hold among ideas and events, from the straightforward temporal and causal sequences of simple narratives to the complex patterns of argumentation characteristic of philosophical inquiry. As such, the system of semantic relations is one that pervades the texts we read at virtually every level of development, although to different degrees of complexity

As a child progresses in school from the demands of simple narrative texts to those of expository texts, the nature of the "problems" he must solve as a reader change markedly as does the repertoire of skills he must bring to the task. Lacking the necessary skills, older readers such as those studied here will be unable to cope with the demands of schooling, from reading of content area texts to understanding of algebraic word problems. A principal aim of this study was to develop an understanding of the skills that underlie skilled comprehension of high order semantic relations and to identify sources of difficulty for the less skilled reader. In this section, I examine some of the implications of this research for improving the comprehension skills of older, less skilled readers.

Above all, comprehension of semantic relations among text propositions appears to require skill in processes of semantic analysis and integration as well as sensitivity to the particular ways in which the language marks relations among propositions. One outcome in particular of the present study illustrates this point. Recall that less skilled readers' comprehension of semantic relations was aided when the relation was conveyed through a conjunction as opposed to a verb. One interpretation of this finding might be that skill in using explicit conjunctions represents an effective strategy that enhances comprehension. However, in light of the body of findings, it seems more likely that this result reflects less skilled readers' attempts to (a) offset the difficulty they have in analyzing thoroughly the semantic content of related text propositions by (b) relying on explicit markers such as conjunctions. As a result, reliance on conjunctions, rather than representing an optimal strategy, actually serves to mask weakness in other skills that underlie comprehension of semantic relations. This interpretation parallels that of Stanovich (1980) who has proposed an explanation for reader differences in word recognition that rests on the notion of compensatory processing. He has argued that less skilled readers actually rely on contextual

information to aid word recognition in order to compensate for inefficiencies in processes of word recognition (cf. Warren, 1982 for an analysis of this literature). This is in contrast to skilled readers who can efficiently recognize words in and out of context. From an instructional perspective, the inefficient strategy of reliance on a particular type of connective needs to be supplanted by a more general ability to analyze the semantic content of text propositions in order to construct coherent representations of text meaning.

It is possible to imagine a number of activities that would focus the learner's attention on analyzing the semantic content of related propositions. Students might, for instance, be presented with texts, initially brief and rich in semantic connections, in which explicit connectives have been omitted. Their task is to generate an explicit connective term to fit the context and then to provide an explanation for their choice that includes explicit reference to the ways in which the semantic relation was conveyed by the surrounding context. In this way, the student would be required to reason, using the information in context, about the intended relation and to generate an appropriate connective, the exact opposite of the behavior observed in this study. This sort of procedure is not unlike sentence-combining activities (cf. Stotsky, 1974) in which students are given simple sentences and are asked to combine them using more complex syntactic structures, including subordinate structures, relative and adverbial clauses, among others. However, there is a sense in which sentence-combining activities and the activity proposed here differ, at least in emphasis. In sentence-combining programs, the emphasis is on enhancing syntactic fluency in children's writing whereas the activity proposed here focuses explicitly on the semantic nature of the connections between text propositions as conveyed through the content of those propositions.

A second activity, actually the inverse of the first, would be to have students generate contexts for particular connectives, beginning perhaps with connectives representing stable meanings and building towards those that are more mutable in meaning. In generating semantically appropriate contexts in this manner the learner would be actively engaged in constructing semantically related units of meaning. Additionally, it would be essential to have students work in depth with contexts that accept multiple meanings (that is, those that can carry a different set of inferences depending upon the particular connective used) so as to highlight the particular ways in which semantic context and connectives can jointly determine the intended meaning of a particular text relation. It is possible to imagine this last suggestion, in particular, being the heart of an interactive computer-based learning environment wherein the solution to some problem depends upon the student's having, for example, correctly inferred the protagonist's motives, expressed as a particular relation among text propositions.

Two more general points are brought into focus by the preceding comments. The first is that instruction aimed at developing students skill in comprehension of semantic relations be designed so that the student is actively engaged in analyzing semantic contexts rather than, for example, passively marking answers to multiple choice questions. The rationale behind this is that the learner's attention must be focused on (1) the ways in which, as a reader, he must actively construct meaning from texts (cf. Palinscar & Brown, 1984), and (2) the variety of ways in which texts themselves can convey relations among text propositions. On this point, the telling evidence from this study was in (1) the thoroughness or "depth" to which skilled readers, unlike less skilled readers, processed texts that were weak in semantic constraint, especially at critical points of propositional integration, and (2) the differential impact of type of connective on skilled and less skilled readers' comprehension of semantic relations.

The second general point pertains to the way in which the textual materials themselves are constructed and ordered for the purpose of instruction in comprehension of high order semantic relations. Here the discussion touches on one of the basic goals of research in text readability, namely, effecting an appropriate match between a reader and a text for comprehension and learning (Chall, 1958; Gates, 1930). For at least two reasons, it is important that instruction in this domain begin with texts that are accessible to the less skilled reader

First, in order to ensure that the student is able to focus attention on analyzing sources of textual constraint, texts are required that do not place too many obstacles in the way of processing such that the student expends resources on levels of analysis other than the semantic. For example, the words used to convey particular concepts should be familiar to the reader so as to reduce the involvement of inefficient decoding processes, where possible. Word meanings should be familiar as well since the learner's attention should be focused on constructing representations for the meaning of related propositions and not on inferring the meanings of unknown words. And, within the set of high order semantic relations itself, it is important that the range of difficulty be carefully ordered. This would mean, for example, that at the start of the instructional sequence the student would read texts of a suitable vocabulary which express causal relations that are strongly constrained. Only as the students' skill in analyzing sources of constraint increased would texts representing more complex relations such as the adversative be introduced.

Second, the student needs to develop a sense of competence as an active comprehender of text. For example, in reading the anomalous texts, it appeared that the less skilled readers were able to "sense" the presence of semantic anomaly without being able to identify precisely its nature or its source. It may be that these readers

attribute incoherence not to the text but to their own process of comprehension. This may be one outcome of their lack of skill in semantic analysis and may explain why, in Brown's (1980) terminology, their tolerance for ambiguity is particularly high. For this reason, the texts selected for instruction in understanding semantic relations must not be so difficult as to undermine students' initial attempts at analysis.

This perspective can be expanded to include the kinds of prerequisite skills a student may need in order to develop expertise in understanding semantic relations. In the last section, some of the ways in which readers may use semantic constraints in text to construct coherent representations for the meanings of semantically related text propositions were discussed. It was suggested in particular that analysis of these sources of constraint -- e.g., tracing lines of reference, identifying overlap between arguments of propositions, inferring unstated premises or presuppositions -- enables the reader to establish a basis for integrating related propositions into a coherent representation of a text's meaning and relational structure. Failure to analyze thoroughly these sources of semantic constraint can lead not only to frequent failures in comprehension but to reliance on inefficient strategies, such as dependence on explicit conjunctions. What this view suggests is that expertise in understanding semantic relations requires that the reader be able, at a minimum, to manage the variety of cohesive forms within the language that are used to convey relations among text propositions. It suggests further a possible hierarchy in which instruction in one component of comprehension can build upon the development of expertise in another.

One way to realize this hierarchical model is to engage students in comprehension activities that require them to analyze context in order to gain access to, for example, particular word meanings but that at least initially do not necessarily involve comprehension of high order semantic relations (cf. Frederiksen, Warren &

Rosebery, 1985). Recent research has shown that less skilled, older readers have difficulty in using any but the most obvious semantic constraints to identify frequent words and common meanings (Frederiksen, 1981a, Perfetti & Roth, 1981, Stanovich, 1980). At the next level, students might be required to focus on analyzing and resolving problems of reference in text. Recall that in the previous section it was observed that propositions that participate in high order semantic relations tend to be linked through referential relations which, when identified, can facilitate integration of semantically related propositions. And, there is some evidence to suggest that skilled and less skilled, older readers may differ in ability to analyze particular cohesive forms, such as forms of reference (Frederiksen, 1981b). The first instructional goal at this level, then, would be to foster skill in effectively analyzing and resolving a range of reference problems, from those involving pronouns to those that are more complex (e.g., ellipsis), and only as competence in this skill developed to introduce problems involving high order semantic relations. A general prediction about the effects of instruction in the skills associated with contextually-based activation of concepts and reference tracing on skill in understanding high order semantic relations follows from this model. It is that improvements in these skills will have demonstrable effects on any subsequent development of skill that focuses on particular difficulties readers have in understanding high order semantic relations among text propositions (e.g., through the activities suggested earlier in this section).

Finally, the findings of this study are compatible with current thinking on the importance of metacognitive components in text comprehension, as exemplified by the work of Brown (1980) and Markman (1979). The suggestion put forward in the literature on metacomprehension processes is that explicit instruction in monitoring texts for inconsistencies will lead to improvements in reading comprehension. However, the results from this study suggest that failures to monitor texts for

inconsistencies may be a consequence of difficulty in analyzing semantic relationships among text propositions rather than a cause of comprehension difficulty. The view put forward here is that less skilled readers, because they are less sensitive to and less skilled in analyzing the variety of relations that can hold among the propositions of a text, tend to construct models of text meaning that are not thoroughly coherent. This suggests that it is only as readers' skill in processes of semantic analysis and integration are improved that their sensitivity to gaps in the coherence of the text models they build will develop.

TABLE 1

MEANS FOR EXPRESSING HIGH ORDER

RELATIONS IN A TEXT

(1) No Explicit Marking of the Relation

The moon passed between the earth and the sun at 5:05 p.m. EST.

A shadow crossed over New York City, and brought the late afternoon traffic to a crawl.

(2) Verb Expressing the Relation

The moon passed between the earth and the sun at 5:05 p.m. EST,

causing a shadow to cross over New York City, and bringing the late afternoon traffic to a crawl.

(3) Conjunction Expressing the Relation

The moon passed between the earth and the sun at 5:05 p.m. EST.

As a result, a shadow crossed over New York City and brought the late afternoon traffic to a crawl.

TABLE 2

SAMPLE CONNECTIVES FOR CAUSAL AND

ADVERSATIVE RELATIONS

Relation	Sample Conjunctions	Sample Verbs
Causal	as a result	cause
	therefore	lead to
	consequently	result in
	because	give rise to
	since	bring about
	so	produce
	then	create
Adversative*	yet	not accord with
	although	run counter to
	but	oppose
	however	not anticipate
	nevertheless	not expect
	instead	surprise
	on the contrary	contrast with

* According to Halliday & Hasan (1976), the basic meaning of the adversative relation is 'contrary to expectation' in the sense that an expected cause or effect is violated, as in the following:

Although Guidry pitched a no-hitter, he lost the game.

or

Guidry pitched a no-hitter, but lost the game.

The adversative can also occur in a comparative sense which Halliday & Hasan (1976) call 'contrastive', as in the following:

Palmer failed. However, he tried his best.

or

He's not exactly good-looking, but he's got brains.

The adversative may carry other meanings as well.

TABLE 3

SUMMARY TABLE OF CONJUNCTIVE RELATIONS
(Halliday & Hasan, 1976, pp. 242-243)

Summary Table of Conjunctive Relations

	External/internal	Internal (unless otherwise specified)		
Additive	Additive, simple: Additive *and, and also* Negative *nor, and . . . not* Alternative *or, or else*	Complex, emphatic: Additive *furthermore, in addition, besides* Alternative *alternatively* Complex, de-emphatic: Afterthought *incidentally, by the way*	Apposition: Expository *that is, I mean, in other words* Exemplificatory *for instance, thus*	Comparison: Similar *likewise, similarly, in the same way* Dissimilar *on the other hand, by contrast*
Adversative	Adversative 'proper': Simple *yet, though, only* Containing 'and' *but* Emphatic *however, nevertheless, despite this*	Contrastive: Avowal *in fact, actually, as a mater of fact* Contrastive (external): Simple *but, and* Emphatic *however, on the other hand, at the same time*	Correction: Of meaning *instead, rather, on the contrary* Of wording *at least, rather, I mean*	Dismissal: Closed *in any case, in either case, whichever way it is* Open-ended *in any case, anyhow, at any rate, however it is*
Causal	Causal, general: Simple *so, then, hence, therefore* Emphatic *consequently, because of this* Causal, specific: Reason *for this reason, on account of this* Result *as a result, in consequence* Purpose *for this purpose, with this in mind*	Reversed causal: Simple *for, because* Causal, specific: Reason *it follows, on this basis* Result *arising out of this* Purpose *to this end*	Conditional (also external): Simple *then* Emphatic *in that case, in such an event, that being so* Generalized *under the circumstances* Reversed polarity *otherwise, under other circumstances*	Respective: Direct *in this respect, in this regard, with reference to this* Reversed polarity *otherwise, in other respects, aside from this*
Temporal	Temporal, simple (external only): Sequential *then, next, after that* Simultaneous *just then, at the same time* Preceding *previously, before that* Conclusive: Simple *finally, at last* Correlative forms: Sequential *first . . . then* Conclusive *at first . . . in the end*	Complex (external only): Immediate *at once, thereupon* Interrupted *soon, after a time* Repetitive *next time, on another occasion* Specific *next day, an hour later* Durative *meanwhile* Terminal *until then* Punctiliar *at this moment*	Internal temporal: Sequential *then, next, secondly* Conclusive *finally, in conclusion* Correlative forms: Sequential *first . . . next* Conclusive *. . . finally*	'Here and now': Past *up to now, hitherto* Present *at this point, here* Future *from now on, henceforward* Summary: Summarizing *to sum up, in short, briefly* Resumptive *to resume, to return to the point*

TABLE 4

SUBTYPES OF THE ADVERSATIVE RELATION

(1) Contrast

The decorative case in which the mummy of Lady Tashat is wrapped shows a face with a calm, peaceful expression whereas x-rays of the mummy reveal that the skeleton is horribly twisted, with one arm broken and several ribs smashed.

(2) Violation of Expectation

Sara White had avoided Sam for three months yet during their meeting she treated him as if those three months had made him an old friend.

(3) Defiance

Mountain climbers continue to be fascinated by Mt. Everest, although the feat is an awesome one that includes conquering nature and the fear of death.

(4) Exception

The city gangs of 1984 are in some ways different from gangs of ten or twenty years ago even though black leather jackets are still a part of the gang costume and violence still rules the landscape.

TABLE 5

SAMPLE PASSAGE EXPRESSING A

CAUSAL RELATION

High Constraint

During 1984, six advances in research on tooth decay and its treatment were reported, so public health officials are predicting the end of tooth decay by the year 2000.

During 1984, six advances in research on tooth decay and its treatment were reported, leading public health officials to predict the end of tooth decay by the year 2000.

Low Constraint

Illegal sports gambling is no longer the target of investigation by the F.B.I., so illegal sports betting has become a thriving underground business.

Illegal sports gambling is no longer the target of investigation by the F.B.I., allowing illegal sports betting to become a thriving underground business.

TABLE 6

SAMPLE PASSAGE EXPRESSING AN

ADVERSATIVE RELATION

High Constraint

In books and movies, the fingerprint has long been used as a key in solving crimes but, in reality, crime scene fingerprints are hard to find and, when found, are rarely sharp enough to make a match.

In books and movies, the fingerprint has long been used as a key in solving crimes, differing from reality where crime scene fingerprints are hard to find and, when found, are rarely sharp enough to make a match.

Low Constraint

Horses are very important in Poland today for everyday needs of farming and transportation but the Arabian horse, bred in Poland since the 1500s, is the key to Poland's romantic past.

Horses are very important in Poland today for everyday needs of farming and transportation compared with the Arabian horse which, bred in Poland since the 1500s, is the key to Poland's romantic past.

TABLE 7

SAMPLE ANOMALOUS PASSAGES

Violated Causal Relation

When it came to drawing explorers into the great unknown, the lure of pepper was as strong as the yen for glory or gold yet men launched ships in search of the spice and the riches it would bring.

When it came to drawing explorers into the great unknown, the lure of pepper was as strong as the yen for glory or gold, discouraging men from launching ships in search of the spice and the riches it would bring.

Violated Adversative Relation

Loss of the senses of taste and smell, a serious problem for two million Americans, can be a hardship and a danger, as a result little research on its causes and possible treatments has been undertaken.

Loss of the senses of taste and smell, a serious problem for two million Americans, can be a hardship and a danger, resulting in little research on its causes and possible treatments having been undertaken.

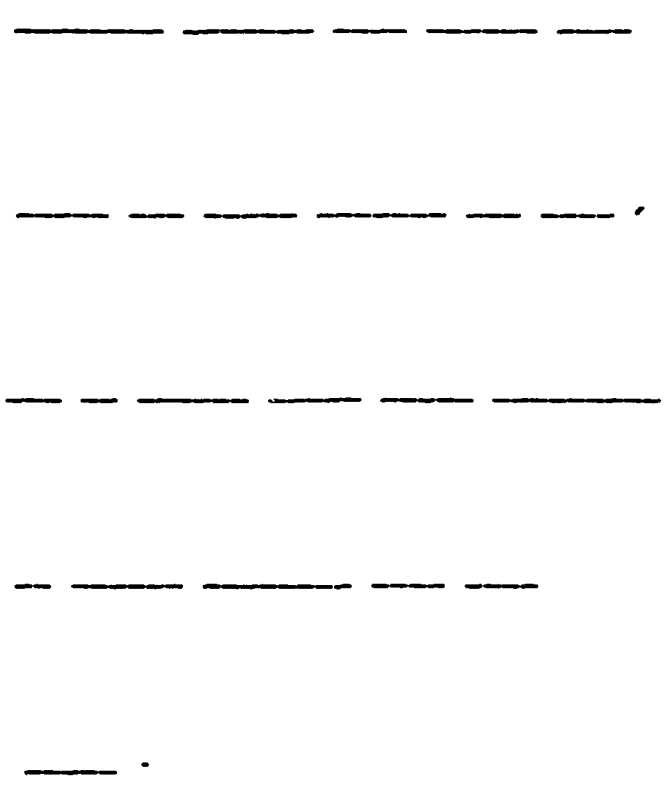

Figure 1. First screen display in the experiment.

Display 1

Japanese schools have always been known

Display 2

for being orderly and calm,

Display 3

but in recent years

Figure 2. Clause-by-clause presentation.

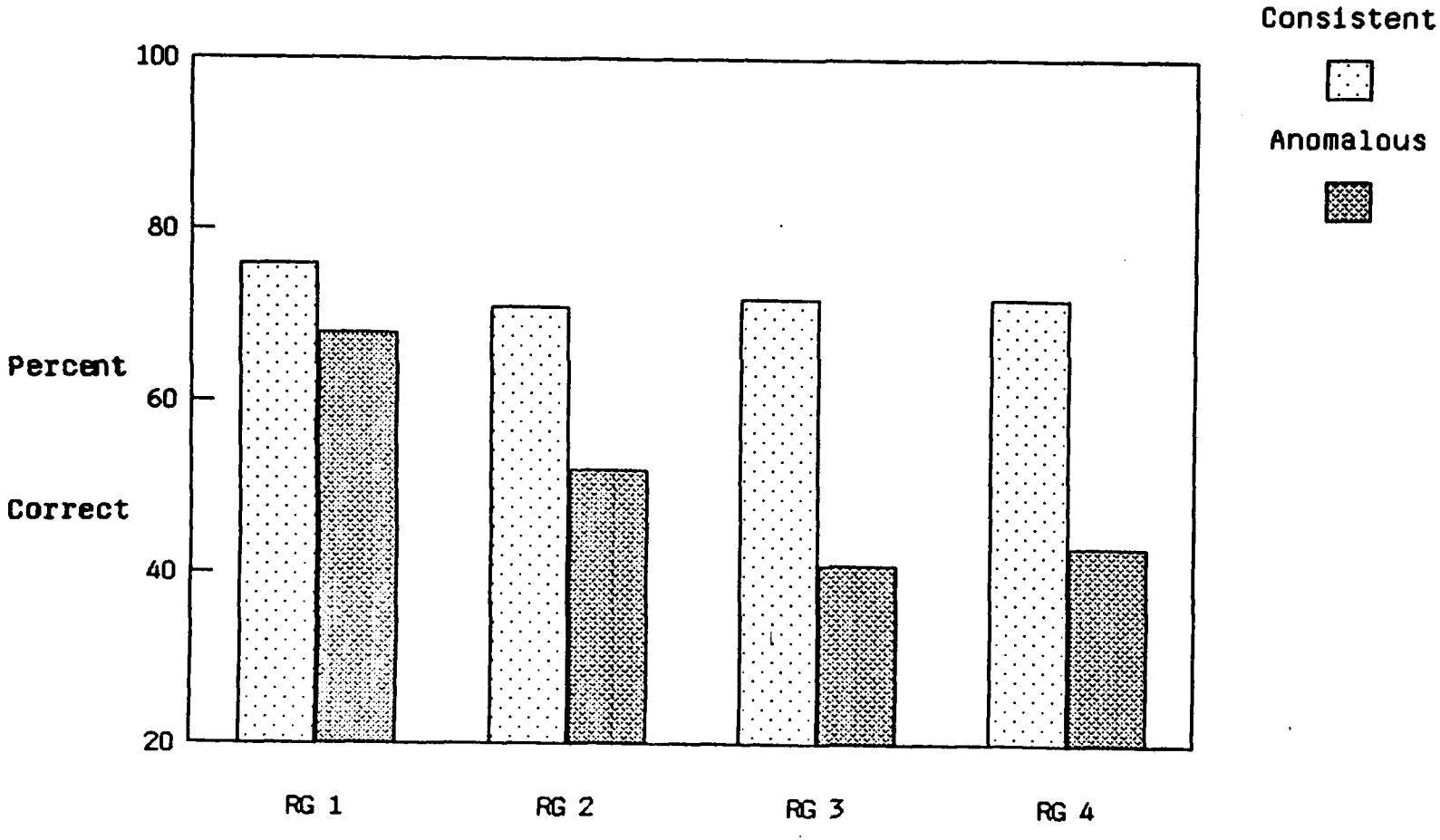

Figure 3. Accuracy rates for consistent and anomalous passages

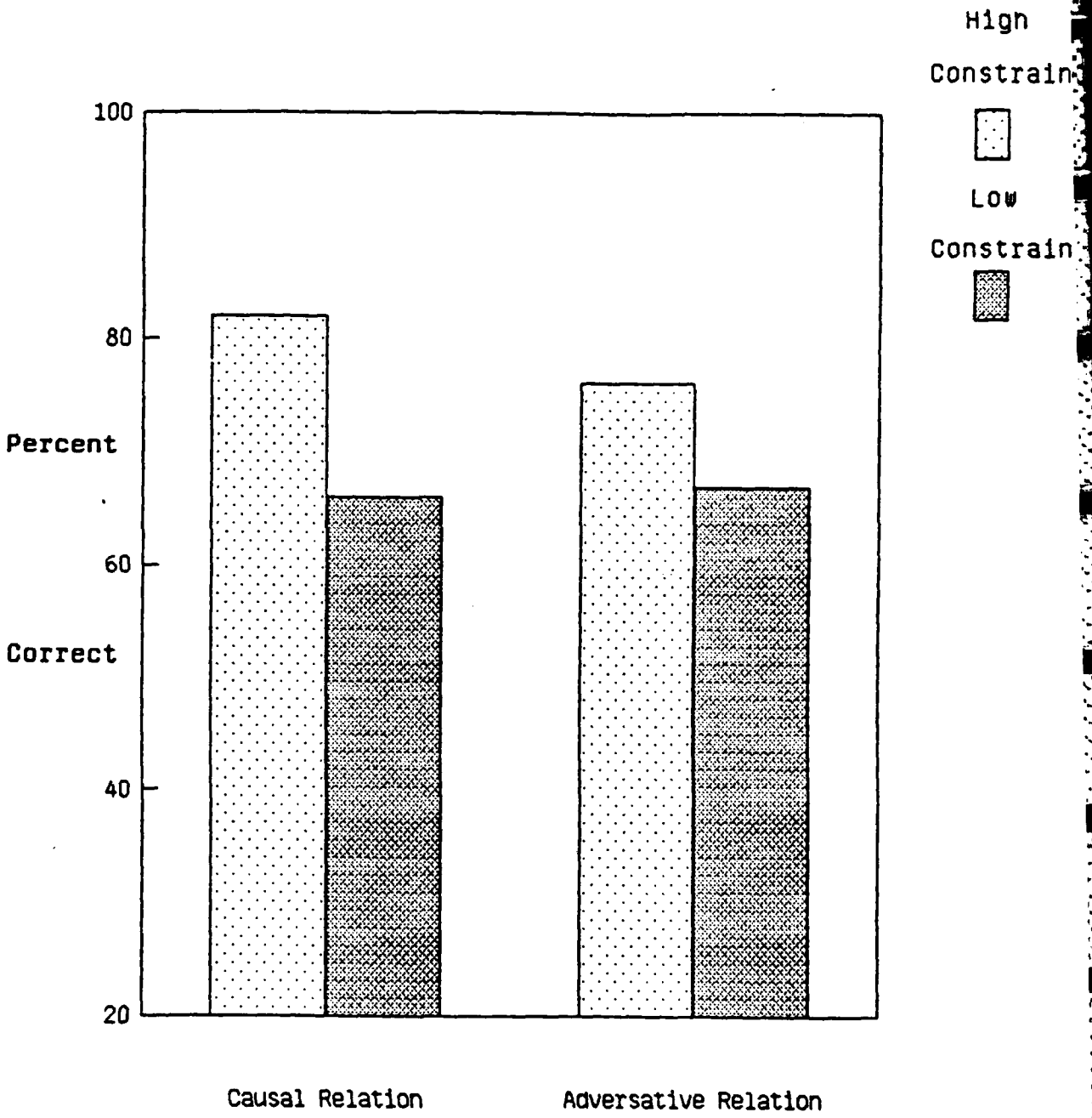

Figure 4. Accuracy rates for consistent passages

(Type of Relation x Degree of Semantic Constraint)

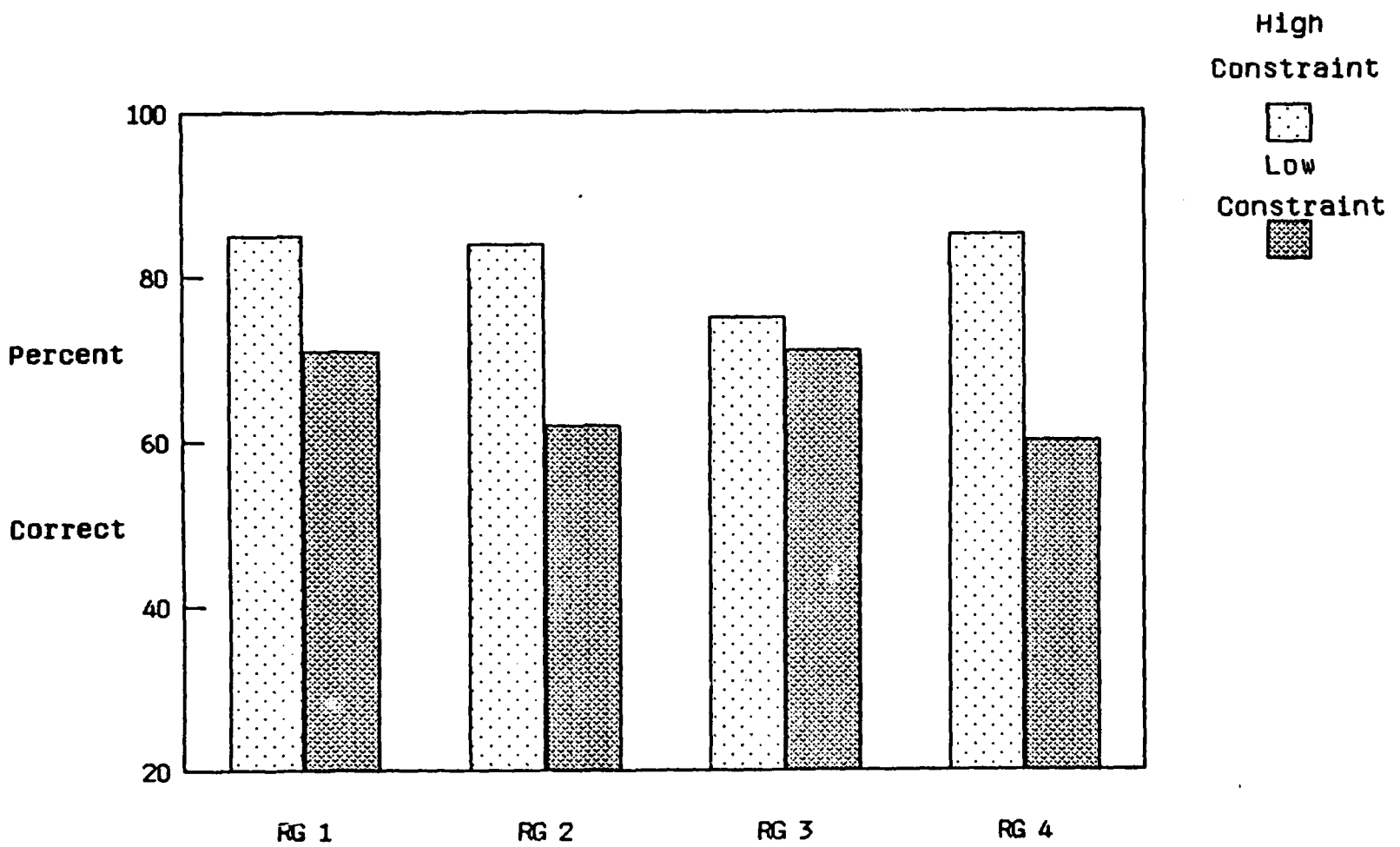

Figure 5. Accuracy rates for consistent passages (Causal relation)

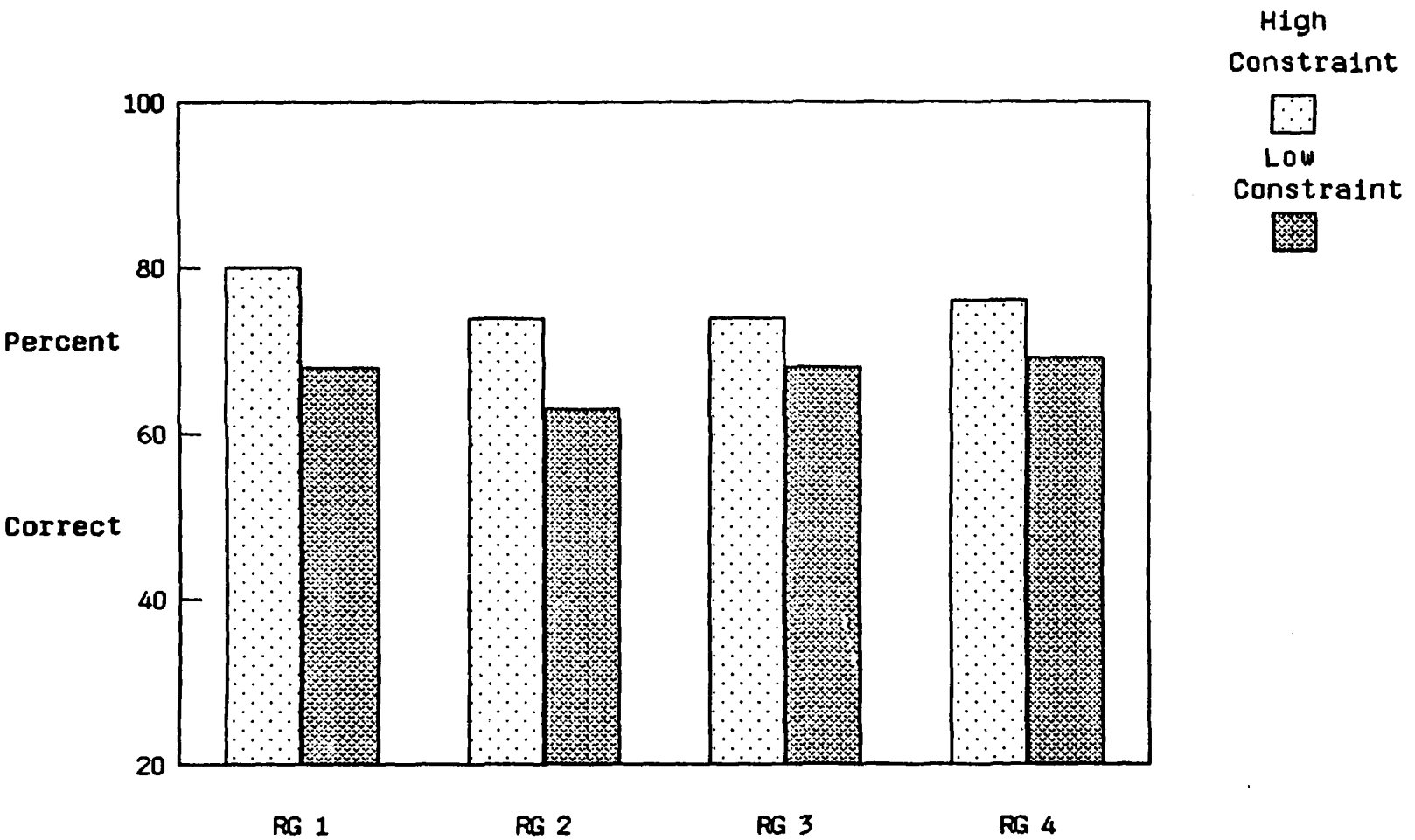

Figure 6. Accuracy rates for consistent passages

(Adversative relation)

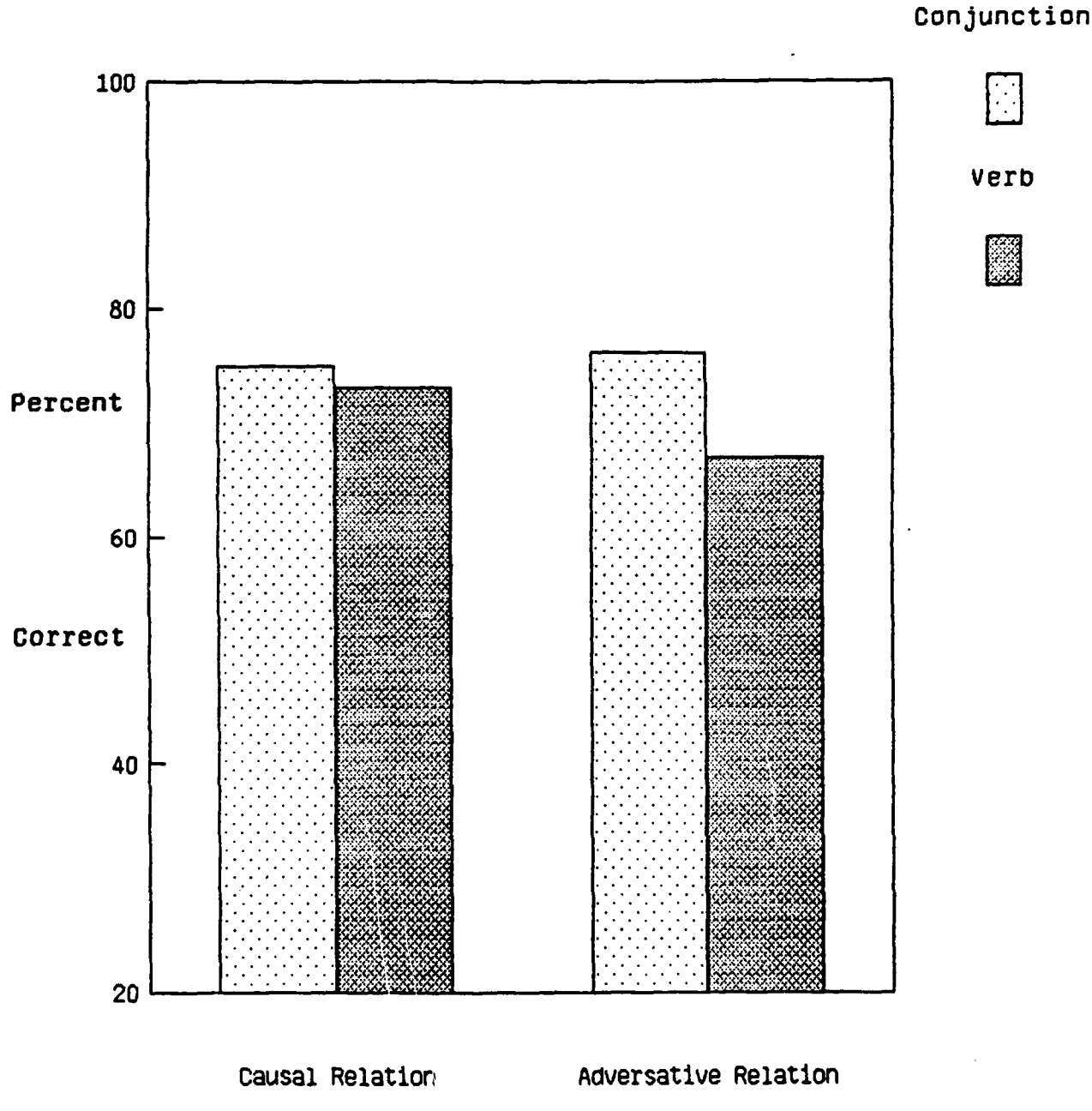

Figure 7. Accuracy rates for consistent passages

(Type of Relation x Type of Connective)

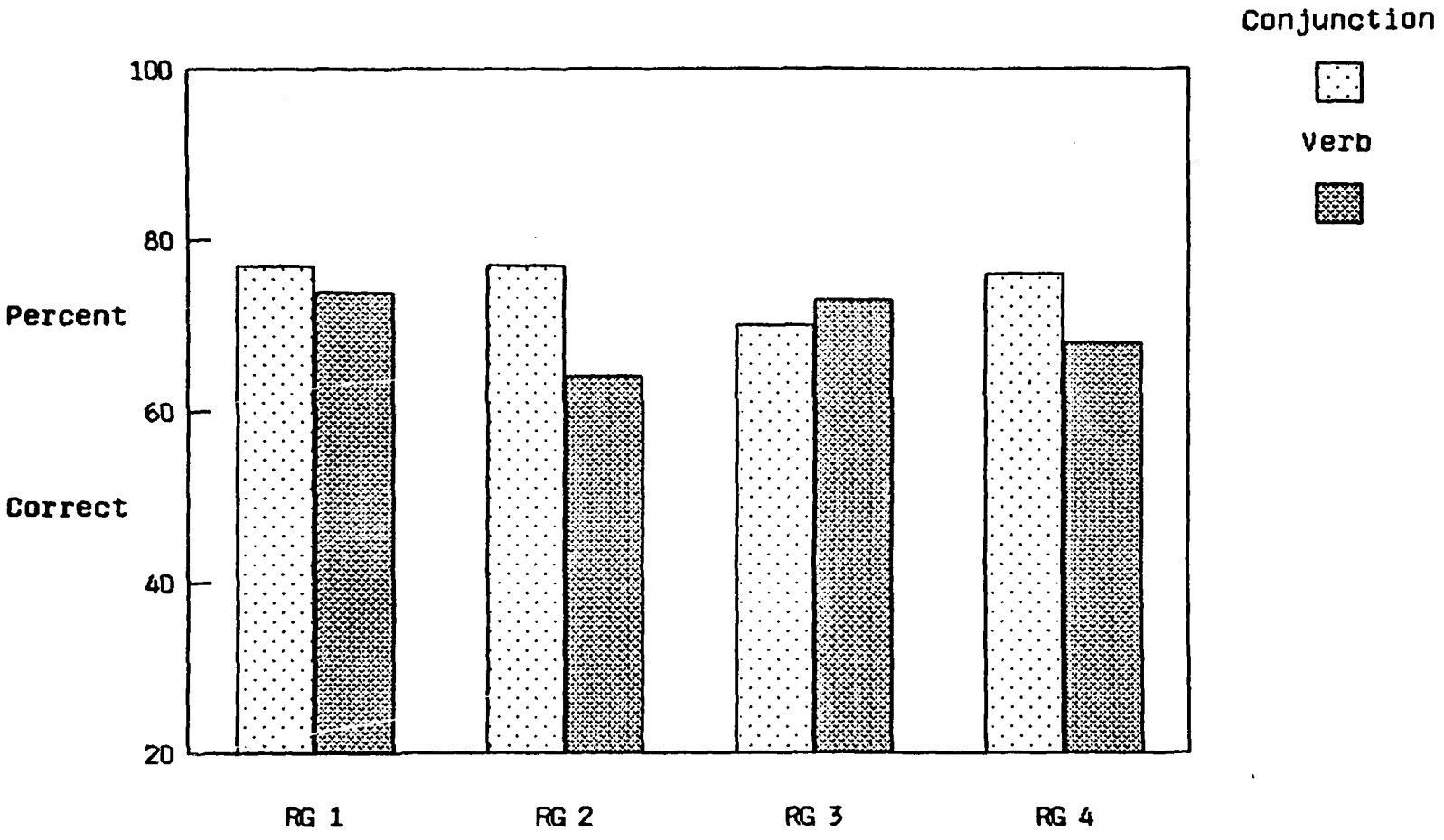

Figure 8. Accuracy rates for consistent passages

(Reading Group x Connective)

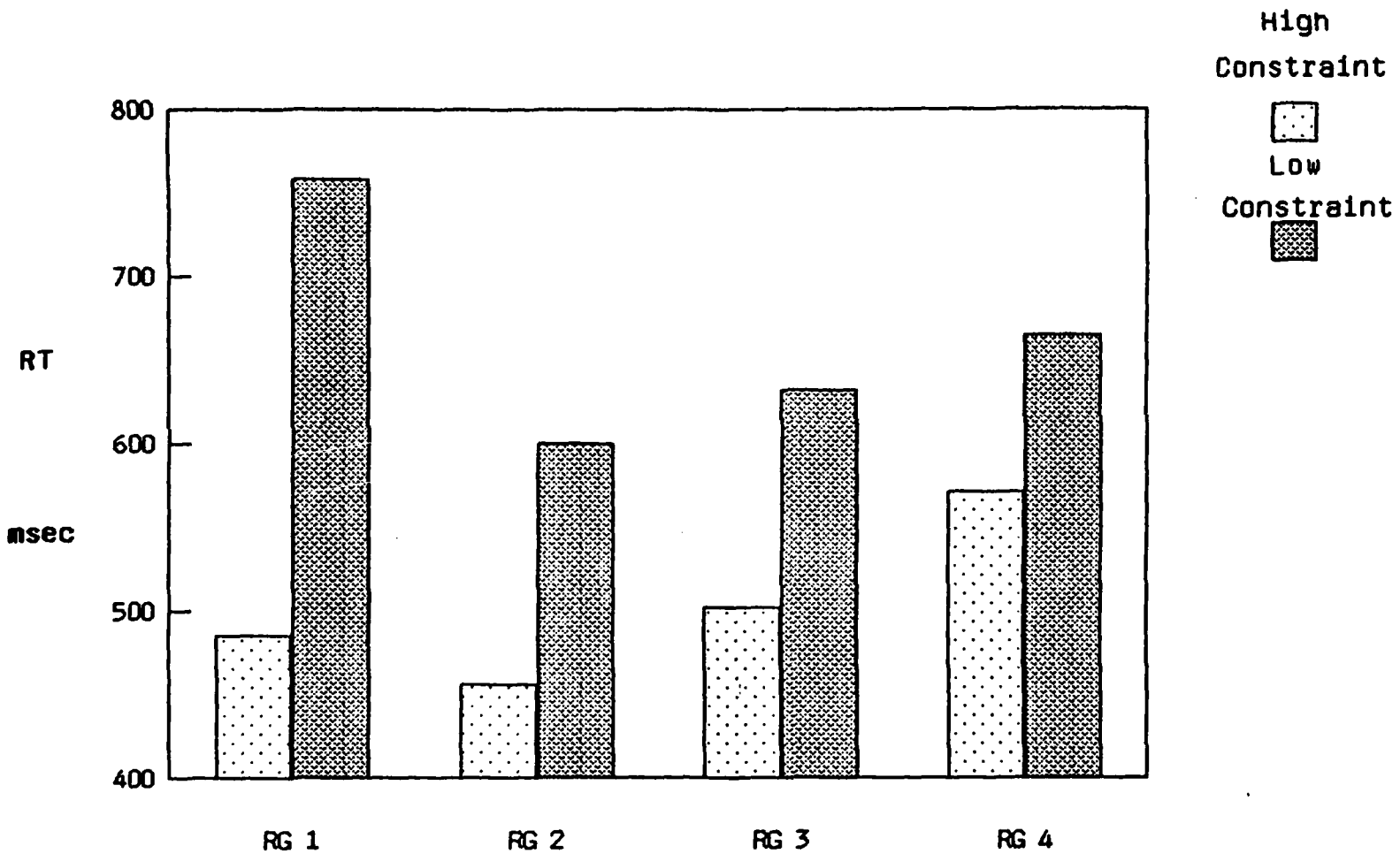

Figure 9. Per syllable reading/judgment times for the final clause

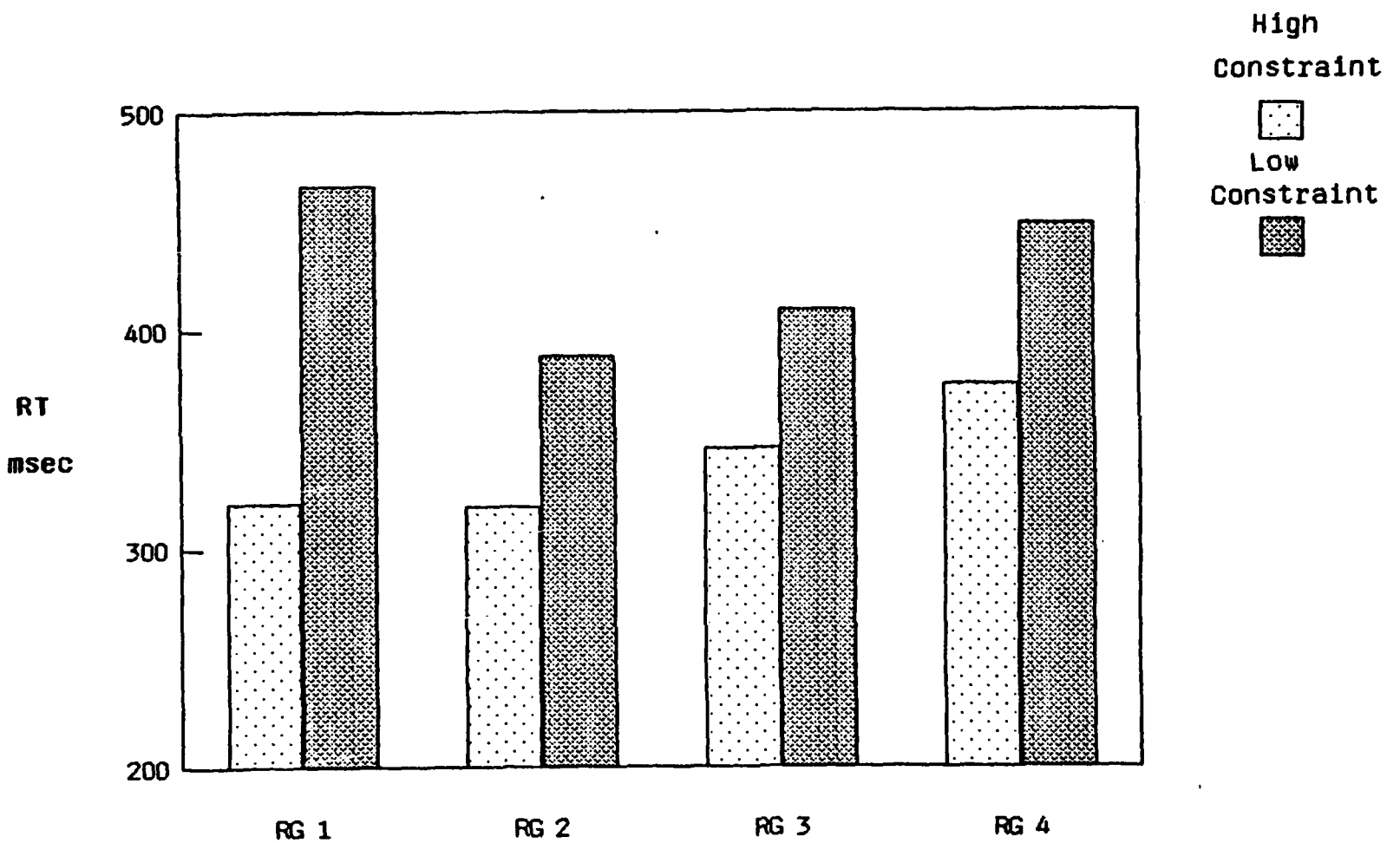

Figure 10. Per syllable reading time for the critical clause.

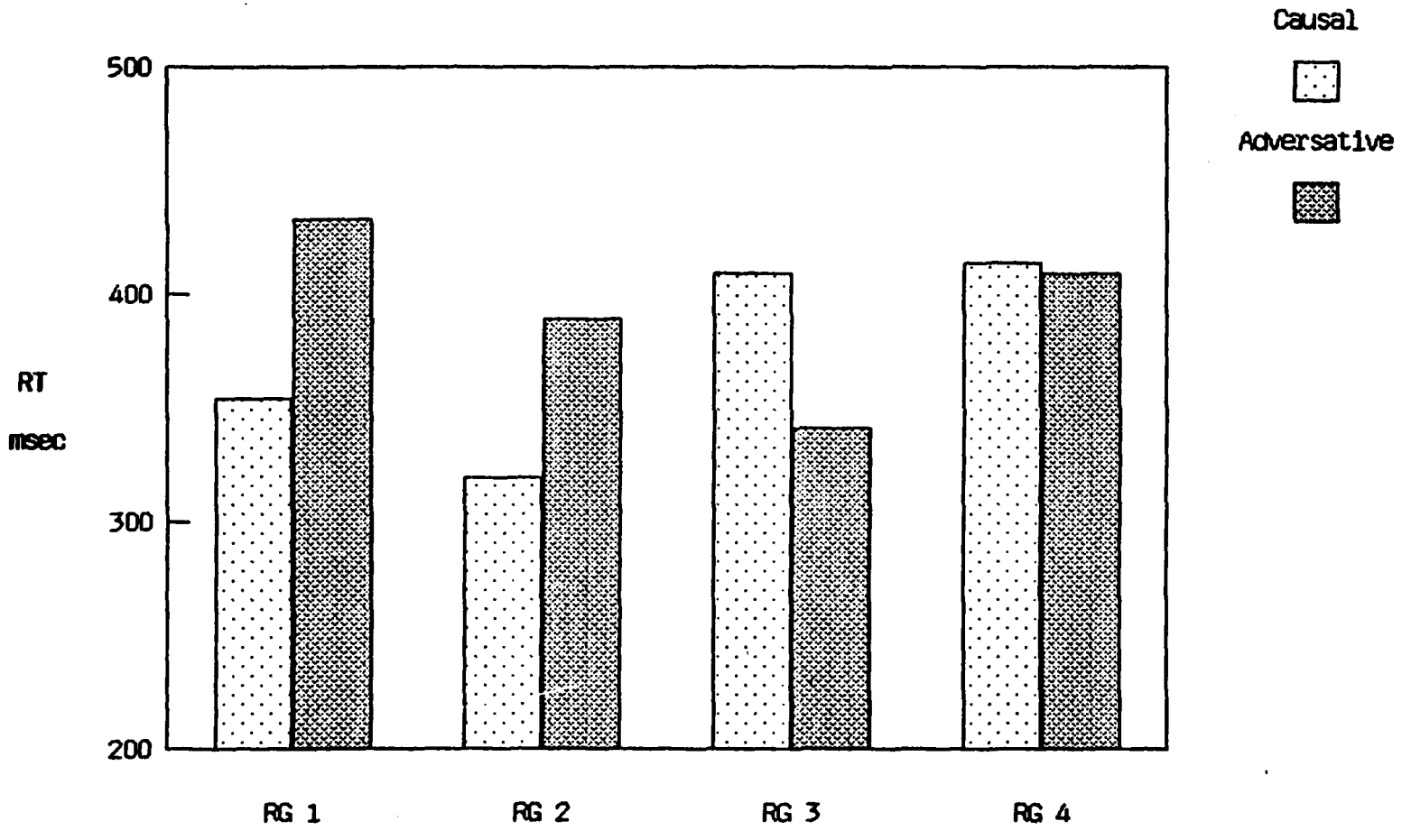

Figure 11. Per syllable reading times for critical clauses
(Reading Group x Type of Relation)

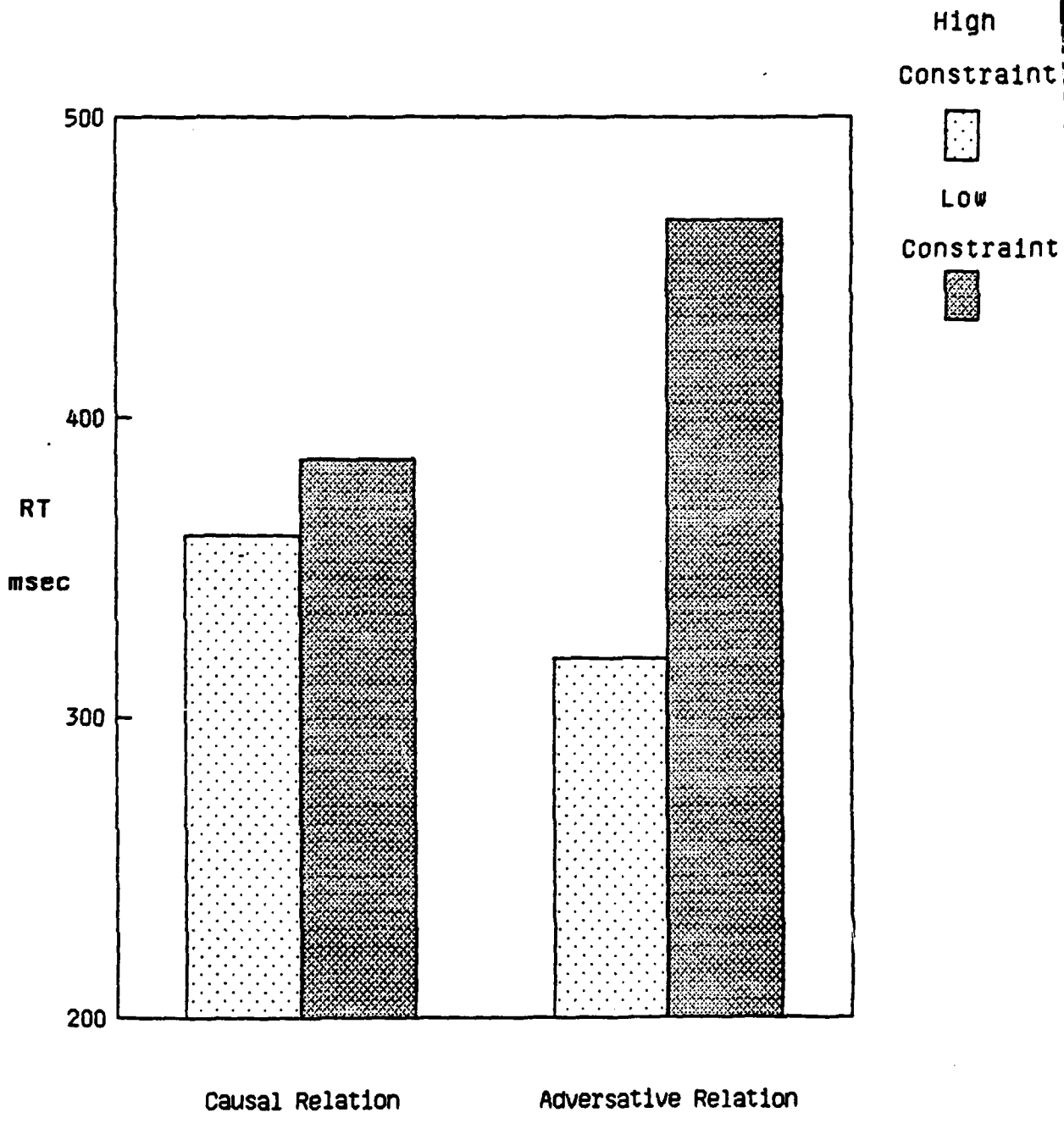

Figure 12. Per syllable reading times for critical clauses
(Type of Relation x Degree of Constraint)

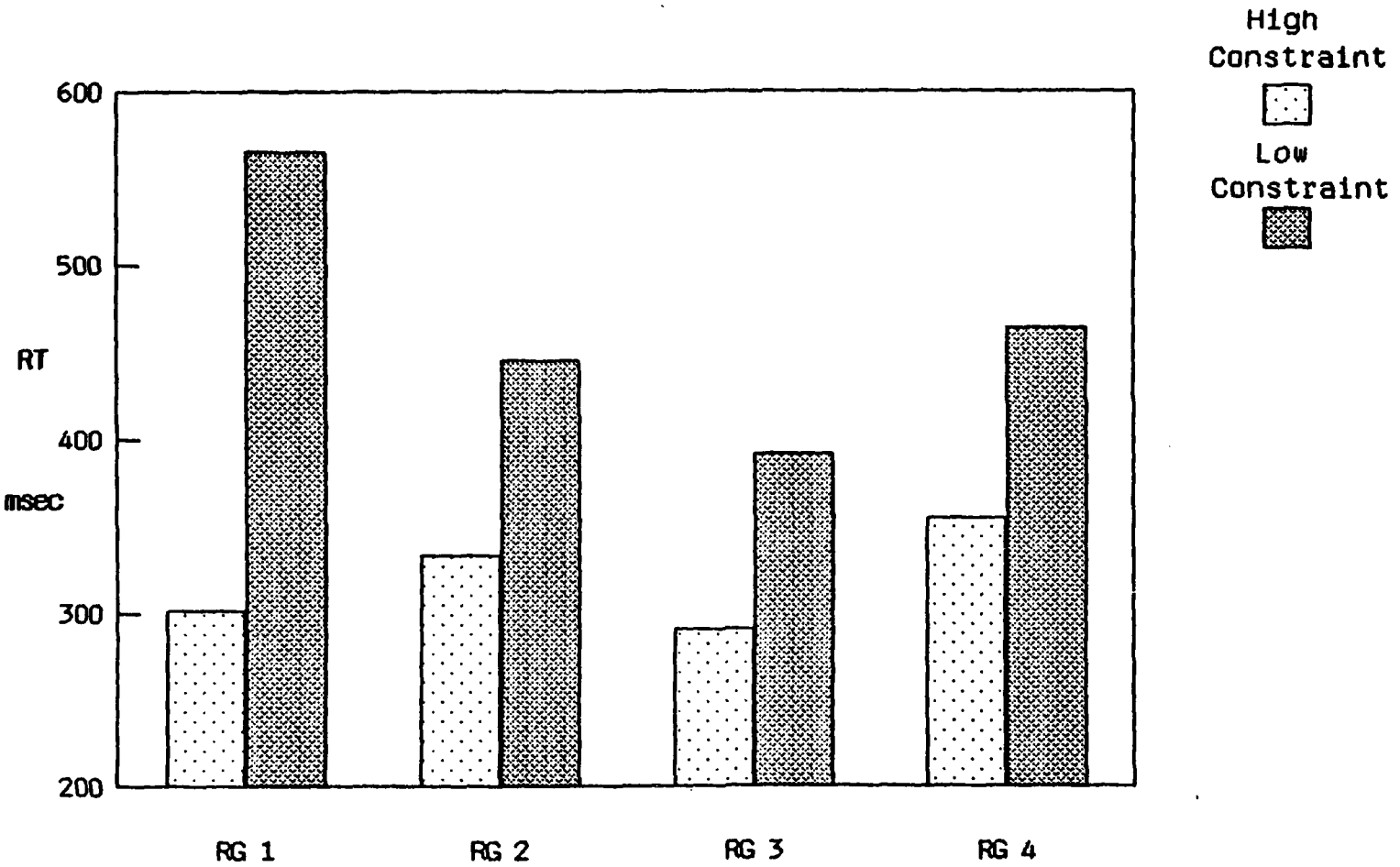

Figure 13. Per syllable reading times for critical clauses in texts expressing adversative relations

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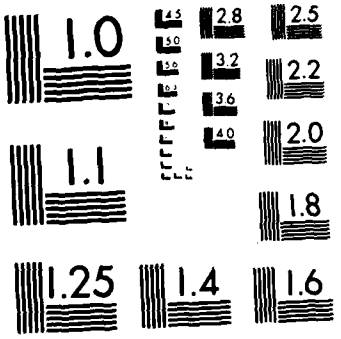
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Bolt Beranek & Newman/Frederiksen

Dr. Robert Ahlers
Code N711
Human Factors Laboratory
NAVTRAEQUIPCEN
Orlando, FL 32813

Dr. Ed Aiken
Navy Personnel R&D Center
San Diego, CA 92152

Dr. Robert Aiken
Temple University
School of Business Administration
Department of Computer and
Information Sciences
Philadelphia, PA 19122

Dr. James Algina
University of Florida
Gainesville, FL 32605

Dr. Earl A. Alluisi
HQ, AFHRL (AFSC)
Brooks AFB, TX 78235

Dr. Thomas H. Anderson
Center for the Study of Reading
174 Children's Research Center
51 Gerty Drive
Champaign, IL 61820

Technical Director, ARI
5001 Eisenhower Avenue
Alexandria, VA 22333

Special Assistant for Projects,
OASN(M&RA)
5D800, The Pentagon
Washington, DC 20350

Dr. Alan Baddeley
Medical Research Council
Applied Psychology Unit
15 Chaucer Road
Cambridge CB2 2EF
ENGLAND

Dr. Patricia Baggett
University of Colorado
Department of Psychology
Box 345
Boulder, CO 80309

Dr. Meryl S. Baker
Navy Personnel R&D Center
San Diego, CA 92152

Dr. John Black
Yale University
Box 11A, Yale Station
New Haven, CT 06520

Arthur S. Blaiwes
Code N711
Naval Training Equipment Center
Orlando, FL 32813

Dr. Robert Blanchard
Navy Personnel R&D Center
San Diego, CA 92152

Dr. Richard Braby
NTEC Code 10
Orlando, FL 32751

Dr. Robert Breaux
Code N-095R
NAVTRAEQUIPCEN
Orlando, FL 32813

Dr. Ann Brown
Center for the Study of Reading
University of Illinois
51 Gerty Drive
Champaign, IL 61280

Dr. Patricia A. Butler
NIE Mail Stop 1806
1200 19th St., NW
Washington, DC 20208

Dr. Robert Calfee
School of Education
Stanford University
Stanford, CA 94305

Dr. Joseph C. Campione
Center for the Study of Reading
University of Illinois
51 Gerty Drive
Champaign, IL 61820

Dr. Pat Carpenter
Carnegie-Mellon University
Department of Psychology
Pittsburgh, PA 15213

Dr. Robert Carroll
NAVOP 01B7
Washington, DC 20370

Dr. Fred Chang
Navy Personnel R&D Center
Code 51
San Diego, CA 92152

Dr. Davida Charney
Department of Psychology
Carnegie-Mellon University
Schenley Park
Pittsburgh, PA 15213

Dr. Stanley Collyer
Office of Naval Technology
800 N. Quincy Street
Arlington, VA 22217

Dr. Lee Cronbach
16 Laburnum Road
Atherton, CA 94205

Dr. Mary Cross
Department of Education
Adult Literacy Initiative
Room 4145
400 Maryland Avenue, SW
Washington, DC 20202

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2500 Garden Road
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CDR Mike Curran
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Code 270
Arlington, VA 22217-5000

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AFHRL/LRT
Lowry AFB, CO 80230

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Information Center
Cameron Station, Bldg 5
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Dr. Thomas M. Duffy
Communications Design Center
Carnegie-Mellon University
Schenley Park
Pittsburgh, PA 15213

Dr. Richard Duran
University of California
Santa Barbara, CA 93106

Edward E. Eddowes
CNATRA N301
Naval Air Station
Corpus Christi, TX 78419

Dr. John Ellis
Navy Personnel R&D Center
San Diego, CA 92252

Dr. Susan Embretson
University of Kansas
Psychology Department
Lawrence, KS 66045

Dr. Randy Engle
Department of Psychology
University of South Carolina
Columbia, SC 29208

Dr. William Epstein
University of Wisconsin
W. J. Brogden Psychology Bldg.
1202 W. Johnson Street
Madison, WI 53706

ERIC Facility-Acquisitions
4833 Rugby Avenue
Bethesda, MD 20014

Edward Esty
Department of Education, OERI
MS 40
1200 19th St., NW
Washington, DC 20208

Dr. Beatrice J. Farr
Army Research Institute
5001 Eisenhower Avenue
Alexandria, VA 22333

Dr. Marshall J. Farr
2520 North Vernon Street
Arlington, VA 22207

Bolt Beranek & Newman/Frederiksen

Dr. Pat Federico
Code 511
NPRDC
San Diego, CA 92152

Mr. Wallace Feurzeig
Educational Technology
Bolt Beranek & Newman
10 Moulton St.
Cambridge, MA 02238

Dr. Linda Flower
Carnegie-Mellon University
Department of English
Pittsburgh, PA 15213

Dr. Carl H. Frederiksen
McGill University
3700 McTavish Street
Montreal, Quebec H3A 1Y2
CANADA

Dr. John R. Frederiksen
Bolt Beranek & Newman
50 Moulton Street
Cambridge, MA 02138

Dr. Arthur M. Glenberg
University of Wisconsin
W. J. Brogden Psychology Bldg.
1202 W. Johnson Street
Madison, WI 53706

Dr. Marvin D. Glock
13 Stone Hall
Cornell University
Ithaca, NY 14853

Dr. Sam Glucksberg
Princeton University
Department of Psychology
Green Hall
Princeton, NJ 08540

Dr. Joseph Goguen
Computer Science Laboratory
SRI International
333 Ravenswood Avenue
Menlo Park, CA 94025

Dr. Sherrie Gott
AFHRL/MODJ
Brooks AFB, TX 78235

Dr. Henry M. Halff
Halff Resources, Inc.
4918 33rd Road, North
Arlington, VA 22207

Mr. William Hartung
PEAM Product Manager
Army Research Institute
5001 Eisenhower Avenue
Alexandria, VA 22333

Dr. Wayne Harvey
SRI International
333 Ravenswood Ave.
Room B-S324
Menlo Park, CA 94025

Prof. John R. Hayes
Carnegie-Mellon University
Department of Psychology
Schenley Park
Pittsburgh, PA 15213

Dr. Joan I. Heller
505 Haddon Road
Oakland, CA 94606

Dr. Melissa Holland
Army Research Institute for the
Behavioral and Social Sciences
5001 Eisenhower Avenue
Alexandria, VA 22333

Dr. Dillon Inouye
WICAT Education Institute
Provo, UT 84057

Dr. Alice Isen
Department of Psychology
University of Maryland
Catonsville, MD 21228

Dr. Zachary Jacobson
Bureau of Management Consulting
365 Laurier Avenue West
Ottawa, Ontario K1A 0S5
CANADA

Dr. Claude Janvier
Directeur, CIRADE
Universite' du Quebec a Montreal
Montreal, Quebec H3C 3P8
CANADA

Margaret Jerome
c/o Dr. Peter Chandler
83, The Drive
Hove
Sussex
UNITED KINGDOM

Dr. Marcel Just
Carnegie-Mellon University
Department of Psychology
Schenley Park
Pittsburgh, PA 15213

Dr. Milton S. Katz
Army Research Institute
5001 Eisenhower Avenue
Alexandria, VA 22333

Dr. David Kieras
University of Michigan
Technical Communication
College of Engineering
1223 E. Engineering Building
Ann Arbor, MI 48109

Dr. Peter Kincaid
Training Analysis
& Evaluation Group
Department of the Navy
Orlando, FL 32813

Dr. Walter Kintsch
Department of Psychology
University of Colorado
Campus Box 345
Boulder, CO 80302

M. Diane Langston
Communications Design Center
Carnegie-Mellon University
Schenley Park
Pittsburgh, PA 15213

Dr. Charlotte Linde
SRI International
333 Ravenswood Avenue
Menlo Park, CA 94025

Dr. Arthur Melmed
U. S. Department of Education
724 Brown
Washington, DC 20208

Dr. George A. Miller
Department of Psychology
Green Hall
Princeton University
Princeton, NJ 08540

Dr. Lance A. Miller
IBM Thomas J. Watson
Research Center
P.O. Box 218
Yorktown Heights, NY 10598

Dr. Andrew R. Molnar
Scientific and Engineering
Personnel and Education
National Science Foundation
Washington, DC 20550

Dr. William Montague
NPRDC Code 13
San Diego, CA 92152

Assistant for Planning MANTRAPERS
NAVOP 01B6
Washington, DC 20370

Assistant for MPT Research,
Development and Studies
NAVOP 01B7
Washington, DC 20370

Director, Training Laboratory,
NPRDC (Code 05)
San Diego, CA 92152

Director, Manpower and Personnel
Laboratory,
NPRDC (Code 06)
San Diego, CA 92152

Director, Human Factors
& Organizational Systems Lab,
NPRDC (Code 07)
San Diego, CA 92152

Library, NPRDC
Code P201L
San Diego, CA 92152

Dr. Harry F. O'Neil, Jr.
Training Research Lab
Army Research Institute
5001 Eisenhower Avenue
Alexandria, VA 22333

Director, Technology Programs,
Office of Naval Research
Code 200
800 North Quincy Street
Arlington, VA 22217-5000

Office of Naval Research,
Code 442PT
800 N. Quincy Street
Arlington, VA 22217-5000
(6 Copies)

Psychologist
Office of Naval Research
Branch Office, London
Box 39
FPO New York, NY 09510

Special Assistant for Marine
Corps Matters,
ONR Code 100M
800 N. Quincy St.
Arlington, VA 22217-5000

Psychologist
Office of Naval Research
Liaison Office, Far East
APO San Francisco, CA 96503

Dr. Judith Orasanu
Army Research Institute
5001 Eisenhower Avenue
Alexandria, VA 22333

Dr. Douglas Pearse
DCIEM
Box 2000
Downsview, Ontario
CANADA

Dr. Nancy Pennington
University of Chicago
Graduate School of Business
1101 E. 58th St.
Chicago, IL 60637

Military Assistant for Training and
Personnel Technology,
OUSD (R & E)
Room 3D129, The Pentagon
Washington, DC 20301

Dr. Ray Perez
ARI (PERI-II)
5001 Eisenhower Avenue
Alexandria, VA 2233

Dr. Steven Pinker
Department of Psychology
E10-018
M.I.T.
Cambridge, MA 02139

Dr. Tjeerd Plomp
Twente University of Technology
Department of Education
P.O. Box 217
7500 AE ENSCHEDE
THE NETHERLANDS

Dr. Martha Polson
Department of Psychology
Campus Box 346
University of Colorado
Boulder, CO 80309

Dr. Peter Polson
University of Colorado
Department of Psychology
Boulder, CO 80309

Dr. Steven E. Poltrock
MCC
9430 Research Blvd.
Echelon Bldg #1
Austin, TX 78759-6509

Dr. Joseph Psotka
ATTN: PERI-1C
Army Research Institute
5001 Eisenhower Ave.
Alexandria, VA 22333

Dr. Lynne Reder
Department of Psychology
Carnegie-Mellon University
Schenley Park
Pittsburgh, PA 15213

Bolt Beranek & Newman/Frederiksen

Dr. Lauren Resnick
Learning R & D Center
University of Pittsburgh
3939 O'Hara Street
Pittsburgh, PA 15213

Dr. Andrew M. Rose
American Institutes
for Research
1055 Thomas Jefferson St., NW
Washington, DC 20007

Dr. Robert Sasmor
Army Research Institute
5001 Eisenhower Avenue
Alexandria, VA 22333

Dr. Ramsay W. Selden
NIE
Mail Stop 1241
1200 19th St., NW
Washington, DC 20208

Dr. Lee Shulman
Stanford University
1040 Cathcart Way
Stanford, CA 94305

Dr. Miriam Shustack
Code 51
Navy Personnel R & D Center
San Diego, CA 92152

Dr. Zita M Simutis
Instructional Technology
Systems Area
ARI
5001 Eisenhower Avenue
Alexandria, VA 22333

Dr. H. Wallace Sinaiko
Manpower Research
and Advisory Services
Smithsonian Institution
801 North Pitt Street
Alexandria, VA 22314

Dr. Edward E. Smith
Bolt Beranek & Newman, Inc.
50 Moulton Street
Cambridge, MA 02138

Dr. Robert Sternberg
Department of Psychology
Yale University
Box 11A, Yale Station
New Haven, CT 06520

Dr. Thomas Sticht
Navy Personnel R&D Center
San Diego, CA 92152

Dr. John Tangney
AFOSR/NL
Bolling AFB, DC 20332

Dr. Douglas Towne
Behavioral Technology Labs
1845 S. Elena Ave.
Redondo Beach, CA 90277

Dr. Paul Twohig
Army Research Institute
5001 Eisenhower Avenue
Alexandria, VA 22333

Headquarters, U. S. Marine Corps
Code MPI-20
Washington, DC 20380

Dr. Beth Warren
Bolt Beranek & Newman, Inc.
50 Moulton Street
Cambridge, MA 02138

Dr. Barbara White
Bolt Beranek & Newman, Inc.
10 Moulton Street
Cambridge, MA 02238

Dr. Robert A. Wisher
U.S. Army Institute for the
Behavioral and Social Sciences
5001 Eisenhower Avenue
Alexandria, VA 22333

Dr. Martin F. Wiskoff
Navy Personnel R & D Center
San Diego, CA 92152

Dr. Wallace Wulfeck, III
Navy Personnel R&D Center
San Diego, CA 92152

Bolt Beranek & Newman/Frederiksen

Dr. Joe Yasatuke
AFHRL/IRT
Lowry AFB, CO 80230

Dr. Joseph L. Young
Memory & Cognitive
Processes
National Science Foundation
Washington, DC 20550

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