NOTICE

The quality of this microform is heavily dependent upon the quality of the original thesis submitted for microfilming. Every effort has been made to ensure the highest quality of reproduction possible.

If pages are missing, contact the university which granted the degree

Some pages may have indistinct print especially if the original pages were typed with a poor typewriter ribbon or if the university sent us an inferior photocopy.

Reproduction in full or in part of this microform is governed by the Canadian Copyright Act, R.S.C. 1970, c. C-30, and subsequent amendments.

AVIS

La qualité de cette microforme dépend grandement de la qualité de la thèse soumise au microfilmage. Nous avons tout fait pour assurer une qualité supérieure de reproduction.

S'il manque des pages, veuillez communiquer avec l'université qui a conféré le grade

La qualité d'impression de certaines pages peut laisser à désirer, surtout si les pages originales ont été dactylographiées à l'aide d'un ruban usé ou si l'université nous a fait parvenir une photocopie de qualité inférieure

La reproduction, même partielle, de cette microforme est soumise à la Loi canadienne sur le droit d'auteur, SRC 1970, c. C-30, et ses amendements subséquents

The Assessment of Sentence Context Effects in Reading for Comprehension

Mahmoud Khodaverdi-Khani

A Thesis

in

The Department

of

Psychology

Presented in Partial Fulfillment of the Requirements
for the Degree of Master of Arts at
Concordia University
Montréal, Québec, Canada

Concordia University

February 1992

ISBN 0-315-73641-0

Abstract

The Assessment of Sentence Context Effects in Reading for Comprehension

Mahmoud Khodaverdi-Khani

Easy and difficult target words (96 of each) were embedded in sentence frames that produced either a congruous, an incongruous, or a neutral context in order to assess the effects of sentence context on word reading times. Using a moving window technique, the reading times of 32 English speaking subjects (16 males and 16 females) were measured for the target, the word following the target, and the last word of the sentences. The analysis of the target word reading times demonstrated an interaction between context and difficulty, where the difficult target words were read faster in a congruous sentence than in an incongruous sentence. In contrast, the easy target words were read equally fast in the three types of sentences. The analysis of reading times for the word following the target revealed that the characteristics of the target words, in terms of word difficulty and congruity, affected the word reading times of the following words. The analysis of last word reading times revealed that incongruent context had an inhibitory effect on the process of integration. The implication of these results for the theories of reading, as well as the nature of context effects on lexical and post-lexical processing are discussed.

Acknowledgments

I would like to express my sincere gratitude towards my supervisor Dr. Melvin K. Komoda, not only for providing every possible opportunity for the development of this thesis, but also for his insightful ideas, constructive criticisms, and his tolerance. Without his understanding and assistance, this work would not have been completed.

I also wish to thank the members of my committee, Dr. Diane Poulin-Dubois and Dr. Norman Segalowitz for their helpful comments on the early and the final version of this thesis.

The other friends and colleagues to whom I am indebted for their suggestions are; Miriam Muermans, Lina Murdaca, Terry Cooper, and Susan Keely.

Finally, I would like to thank my family who despite the distance and their own hardships, have always encouraged me along this journey.

Table of Contents

List of Figures

List of Appendices

List of Tables

The Assessment of Sentence Context Effects in Reading for Comprehension

Theories of reading assume that reading is a complex, multiprocess skill. The reader integrates information regarding letters, words, and sentences with past experiences in order to make a conceptual representation of the visual input. Despite general agreement on the involvement of different levels of processing and different sources of knowledge, researchers in the area do not share a common understanding of the functions of, or the interactions among, the subprocesses in reading (Ehrlich & Rayner, 1983; Forster,1979; Gough, 1972; Just & Carpenter, 1980; Rumelhart, 1977; Rumelhart & McClelland, 1981; Smith, 1972). A major source of disagreement among researchers appears to arise from their differential emphasis on the relative importance of the contribution of bottom-up and top-down processes to the process of reading. The processes which begin with physical analysis of the sensory information such as feature extraction and letter identification and proceed through a series of sequential stages of processing until an abstract representation of the read materials is available to a reader, are referred to as bottom-up processes. In contrast, top-down processes rely on conceptual knowledge such as anticipation of a word to follow from a given context. The differential emphasis on the roles of bottom-up and top down processes has led to the emergence of different models of reading.

The bottom-up models of reading postulate that from the printed information to a mental representation, information passes through a series of independent and autonomous processing stages or modules

series of independent and autonomous processing stages or modules (Forster, 1979; Gough,1971; Laberge & Samuels, 1974). For example, a model in the class of bottom-up models developed by Forster (1976, 1979) postulates that the language comprehension system is composed of a set of autonomous processing modules such as a lexical processor, a syntactic processor, and a message processor. Each module performs a subset of the processes necessary for comprehension and sends its output to a higher module. The analysis of input begins with the lexical processor which receives feature information from the perceptual system and analyses these features in an attempt to access the entries in the lexicon. As lexical entries are located, the information regarding entries is passed to the syntactic processor. As soon as a sufficient number of entries is located, the syntactic processor extracts from the lexical entries the information it requires for assigning a syntactic structure to the sentence. In the final stage, the message processor converts a purely linguistic representation into a conceptual representation of the intended message. The model assumes that presenting a module with a certain stimulus will always produce the same output regardless of the state of the other modules.

In contrast to bottom-up models, the interactive models of reading propose that the outputs from top-down and bottom-up processes are readily available and thus allow for the possibility that processing at any level may be directly influenced by an output from any other level of processing.

One of the seminal models of this class of models was introduced by Rumelhart (1977). In the heart of this model, there is a pattern synthesizer

which receives sensory and nonsensory information from different sources of knowledge. Sensory information is available through a feature extraction device that extracts the necessary features from the representation of the graphic input stored in the visual information store. Simultaneously, the pattern synthesizer has access to the content of a set of nonsensory knowledge sources, each of which contains specialized information about orthographic, lexical, syntactic and semantic knowledge. The pattern synthesizer continuously evaluates in parallel the tenability of the hypotheses generated at various levels (e.g., feature level, letter level, word level, syntactic level) to come up with the most probable interpretation of the graphic information. The model assumes that a hypothesis generated at one level can influence the hypothesis generated at any other level. This assumption of interactive models would lead one to believe that a hypothesis generated at a higher level would affect the processing of stimuli at a lower level. From the description of the top-down and bottom-up mdels of reading, it is clear that they have different predictions regarding the role of previously read materials or context on the recognition of a word in a text. In contrast to bottom-up models, the interactive models allow for contextual information to affect word recognition. From the work of Tulving and Gold (1963), it has been known that contextual information affects the process of word recognition but it was not clear what type of information provided by the text produced the observed effects. Gough, Alford, and Holly-Wilcox (1981) elaborated on two types of context; global and local. Global context refers to the entire text in

which the word is embedded whereas local context is restricted to the immediately surrounding phrase or sentence. Shebilske and Fischer (1983) presented a more complete definition and distinguished three kinds of contextual effects: (1) situational context, referring to the task demands, the purpose of reading, and the mode of presentation; (2) conceptual context, related to the reader's knowledge from the text, topic, and general world knowledge; (3) linguistic context dealing with orthographic, syntactic, and semantic knowledge.

The present study focuses on the problem of how semantic context provided by a sentence would affect the process of word recognition. However, some of the methodological and theoretical issues relevant to the study of sentence context stem from single word context studies. It would therefore be useful to review some of the priming or single word studies which contributed to such methodological and theoretical developments.

Single Word Priming Studies

Using a lexical decision task in which the subjects are asked to decide if two presented letter strings are both words or nonwords, Meyer and Schvaneveldt (1971) found that positive responses were faster for semantically related words (e.g., BREAD-BUTTER) than for semantically unrelated words (e.g., BREAD-DOCTOR). They interpreted these results as the outcome of a spread of activation process. According to the spread of activation theory (Collins & Loftus, 1975), information in memory is organized in a semantic network of nodes or concepts with semantically or associatively related concepts stored close together and connected to each

other. According to this view, presenting a prime word (the first word of the pair) to the system activates a representation of that concept in the network. As the level of activation passes a certain threshold for the prime word, its recognition occurs. The activation from the prime word then spreads to related concepts. As a result of the partial activation received from the prime word, the amount of information required for the recognition of a related target word (the second word of the pair) would be less than for an unrelated target word and thus, a related target word would be recognized faster than an unrelated target word. Although the automatic spread of activation provides an explanation for the above results, later evidence suggested that in addition to the automatic spread of activation, attentional processes may also be operative in word recognition.

Neely (1977) used a lexical decision task in which the prime words were category names and the target words were the category exemplars. He experimentally manipulated the semantic relationships between the prime and the target words (related, unrelated, and neutral), the stimulus onset asynchrony (SOA), or the interval between the presentation of the prime and onset of the target word (from 250 ms to 2000 ms). He also manipulated the expectations of the subjects such that in one condition a category label was followed by an exemplar from the same category (for example, the category "bird" was followed "robin"). In another condition, however, subjects were led to expect that certain category labels were followed by exemplars from another category (e.g., subjects expected that a body category prime was to be followed by an exemplar from the building

category). The results indicated that at the short SOA (250 ms), the recognition of a related-expected target word was facilitated and there was no inhibition effect for the recognition of an unrelated-unexpected target word. The facilitation and inhibition were obtained by comparing the reaction times of a related and unrelated target words to the reaction times of a neutral condition, respectively. As SOA increased, the amount of facilitation for the expected-related condition remained constant but the amount of inhibition effect for the recognition of expected-unrelated target words increased. For the shift condition in which subjects were expecting the target word to be chosen from another category, at the long SOA (2000 ms), he reported a facilitation effect for the decisions regarding the expected-unrelated target words and an inhibition effect for decisions regarding the unexpected-unrelated target words when compared to a neutral condition. As the SOA decreased for the shift condition, the amount of facilitation and inhibition decreased until, at the short SOA (250 ms), there was no facilitation or inhibition effects. He interpreted these results based on Posner and Snyder's (1975) two-process theory which postulates that retrieval from long term memory involves two different classes of processing or mechanisms, the automatic spread of activation mechanism and a limited-capacity attentional mechanism. The automatic spread of activation process is fast, unavoidable, and is not controlled by a subject's strategies. It facilitates the processing of related target words but does not inhibit the processing of unrelated ones. The attentional mechanism is slow, under a subject's control. This mechanism also produces a

facilitation effect for a set of contextually appropriate words on which attention is being focused through conscious expectations, but also produces inhibition effects for contextually inappropriate words.

Neely reasoned that context affects word recognition by means of either an automatic spread of activation mechanism and/or an attentional mechanism. He argued that at the short SOA (250 ms), for related target words, only the automatic spread of activation was operative because of its rapid nature and because it did not produce any inhibition effects. As the interval increased the effects of the automatic spread of activation to related target words decayed and the attentional processes became more involved. As a result, the observed facilitation and inhibition effects at long interval were attributed to the attentional processes. For the shift condition, however, where facilitation and inhibition effects were observed at the long SOA, he argued that the effects were produced by attentional processes.

Neely's results provided some empirical evidence that context exerts its effects through the automatic spread of activation or through a conscious prediction. His results clearly showed that the facilitation for semantically related target words produced by the automatic spread of activation occurs quickly after the presentation of the prime word. This type of facilitation is not accompanied by an inhibition effect for semantically unrelated target word. The facilitation effect produced by attentional processes, however, occurs later in time after the presentation of the prime word and is always accompanied by an inhibition effect for recognition of unrelated target words.

Sentence Context Studies

Although the single word priming studies reveal the role of context on the process of word recognition, generalizability of these findings to a normal reading situation may be limited. In normal reading, readers probably do not devote their entire processing resources for identification of a single word because of the demands of comprehension, whereas in single word recognition, where such demands are not present, the subjects can devote their entire attentional resources for the development of some types of strategies (Spoehr & Schuberth, 1981).

The effects of semantic context on word recognition have been replicated in a situation where a sentence acted as a prime for recognition of a target word. Shubert and Eimas (1977) asked subjects to make lexical decisions to the letter strings in the final position of a sentence. When the string of letters formed words, they were either high or low frequency words. They reported that regardless of context, the high frequency words were classified faster than the low frequency words and sentence context facilitated the decision regarding congruous target words and interfered with the classification of incongruous target words. They explained these results using Morton's (1969) logogen model of word recognition. According to this model, recognition of a word depends in part on the identification of the visual features from the stimulus and the accumulation of the feature information in a word detector or logogen. As the amount information exceeds the activation threshold for that logogen, the corresponding word would be recognized. The model also assumes that

the logogens receive information from context and that high frequency words have a lower threshold than low frequency words.

A more comprehensive and detailed examination of the effects of sentence context on word recognition along with a theoretical framework has been presented by Stanovich and his colleagues (Stanovich, Cunningham, & West 1981; Stanovich, Nathan, West, & Vala-Rossi,1985; Stanovich & West, 1978, 1979, 1981, 1983a; 1983b; West & Stanovich, 1978, 1982; West, Stanovich, Feeman, & Cunningham, 1983).

West and Stanovich (1978) tested three different age groups, fourth grade, sixth grade and adult subjects. The subjects read an incomplete sentence aloud and at the end of the sentence frame, which always ended with "the", the experimenter presented the target word and had the subjects name it. The target words were embedded in sentence frames that provided either a congruous, incongruous, or a neutral context for the target word. Naming of the target words was faster in a congruous condition when compared to the naming of the same word in a neutral condition (facilitation effect) for all three age groups. However, when the naming times in the incongruous condition were compared to those in the neutral condition, longer naming times (inhibition effects) were reported for both fourth and six grade subjects but not for the adults.

They explained the results in terms of a two-process theory (Posner & Snyder,1976; Neely, 1977) in which facilitation due to attentional processes for congruous targets is accompanied by an inhibition effect for incongruous target words, but a facilitation due to the automatic spread of

activation is rapid and inhibitionless. West and Stanovich (1978) reasoned that because word recognition in adults is rapid, only the fast acting spread of activation component of context has time to operate and produce facilitation, but in children, slower word recognition process provides the slow acting attentional process the opportunity to operate and produce facilitation for a congruous condition and inhibition for an incongruous condition.

Stanovich and West (1979) argued that if the inhibition observed in children's responses were due to the operation of slow acting conscious attentional processes, one would also expect to observe inhibition in adults' responses when their responses were delayed. In two experiments Stanovich and West (1979) tested this hypothesis. The adult subjects read the sentence frames and named the target words appearing at the end of the sentences as quickly as possible in congruous, incongruous, and neutral conditions. Subjects' responses were delayed either by the degradation of the target word through contrast reduction (Experiment 1), or by increasing the interval between the presentation of the last word in the sentence frame and the target word from 150 to 750 ms (Experiment 2). It was assumed that degradation of the target words would slow down the process of word recognition and provide enough time for the attentional processes to operate. Also, increasing the interval between the reading sentence context frames and the presentation of the target words provides the necessary time for attentional processes to become implicated in the task. The results indicated that for the target words in the undegraded and

short interval conditions, only facilitation for congruous sentences was observed, but for the target words in the degraded and long interval conditions, facilitation for congruous along with inhibition for incongruous sentences were observed. These results are in accordance with the prediction of the two-process theory which states that only the automatic component of context has time to operate when word recognition is rapid, and by slowing down the recognition process, the attentional processes become implicated in the performance regardless of the subjects' expectancies.

Stanovich and West (1981) argued that in their previous studies where adult subjects did not show any inhibition reading an intact text, the attentional component of context effects were not observed in adults' responses because subjects might simply choose not to develop expectancies in the experiments where 50% of the trials contained incongruent conditions. They suggested that one way to manipulate strategic processes was to manipulate the expectation of subjects. In one experiment, they manipulated the expectation of subjects by increasing the number of congruous trials to 80 percent (Experiment 1). By increasing the proportion of congruous trials one would expect that subjects would actively use conscious attention to predict a word. The involvement of attentional processes in word recognition then was expected to produce an inhibition effect for an incongruous target word along with a facilitation effect for a congruous target word. The results revealed that there was a significant

facilitation effect for congruous targets without any inhibition effect for incongruous targets.

In the second experiment, they manipulated processing time by using difficult words where the difficulty of a word was defined by the frequency with which the word is used in the language and the length of the word. It is known that the lower the frequency of a word the more difficult it is to recognize it (Broadbent, 1967) and that longer words take more time to be recognized (Just & Carpenter, 1980). When word recognition is slowed through the use of difficult target words, Stanovich & West (1981) reasoned that the slower recognition process provide the necessary time for attentional processes and subjects should rely on them for word recognition. Manipulation of word difficulty resulted in an interaction between context and difficulty such that sentence context had a facilitatory effect on the processing difficult words. The prediction of two-process theory about the presence of inhibition effects with difficult words was not confirmed by the results. The naming of difficult target words showed a facilitation effect without any inhibition effect. The lack of inhibition for difficult words led them to conclude that the facilitation effects were entirely due to the automatic spread of activation. The novel aspect of these results comes from the fact that, when easy and difficult target words were embedded in the same sentence frame, difficult words were less predictable than easy words. The predictability of the target word was measured in another experiment by the Cloze procedure in which subjects were given the incomplete sentences and were asked to complete them with their first

choice completion. The mean predictability of the easy and difficult words were 43% and 11%, respectively. If the subjects were solely relying on expectation, the difficult words would have shown inhibition effect due to their low predictability.

In their studies, Stanovich and West did not investigate whether the facilitory effects of context on lexical access of congruous target words were due to the association of a particular word with the target word or the combination of the words preceding the target word that produced the effect. This question has been addressed in a series of experiments by Duffy, Henderson, and Morris (1989). Using a rapid serial visual presentation (RSVP), in which the words are presented at one location on a computer screen at a fixed rate, they tested whether a single word or the combination of the words prior to the target word facilitated the word reading times of the target words. In their study, a subset of Stanovich and West 's (1981) sentences were used (54 difficult target words along with their congruent sentence frames). They created a new set of neutral sentences by replacing the subject and the verb of the sentences with neutral words along with Stanovich and West's neutral context. Two versions of congruent sentences were also created, once by replacing the subject with a neutral subject and another, by replacing the verb of the sentence with a neutral verb. Their results indicated that facilitation was found when the sentence context contained both critical content words, but no facilitation was found when the context contained only one of them. It is clear from these results that the facilitation effect is not due to priming

from any single content word in sentence context. Furthermore, the simple linear summing activation from both content words was ruled out, because the model predicts that some evidence of facilita ı from the partial content word should be observed.

According to an earlier version of their two-process theory (Stanovich, 1980; Stanovich and West, 1978,1979, 1981), known as the interactive-compensatory model (time-locked version), if the operation of attentional processes was not implicated in performance, the results were due to lack of time and not to a strategic decision on the subject' s part. It was assumed that longer recognition times necessarily lead to the implication of attentional processes in word recognition. However, later results from adult studies (Stanovich & West,1983a, Experiment; 6 ,7 and 8) led them to relax some of the assumptions of the model. In these experiments the process of word recognition was slowed for adult subjects by degradation of the target word (inserting asterisks between letters). The results indicated that the context effects were larger for the degraded condition. A planned comparison test showed a pattern of facilitation but no inhibition as expected. These results present a problem for the time-locked model, since slower word recognition is expected to provide the necessary time for development of attentional mechanism which is responsible for inhibition effects.

The modified version of the interactive-compensatory model states that slowing word recognition does not necessarily lead to contextual compensation. Stanovich and West (1983) argued that the degree to which

the stimulus is degraded determines whether contextual compensation is necessary or not. Contextual compensation is used only when the bottom-up processes are disrupted by very data-limited stimuli.

Although the interactive-compensatory model has been supported by many studies, there are some findings which can not be explained by the model. Several investigators reported inhibition dominance which refers to a situation where both facilitation and inhibition are present but the magnitude of inhibition is larger (Becker,1980; Fischler & Bloom ,1979, 1980). The occurrence of inhibition dominance implies the role of attentional processes in reading.

In a series of lexical decision task experiments, Fischler and Bloom (1979) examined how and when the contextual information present in a sentence affects the processes of word recognition. The target words were either a highly likely completion of the sentence with the Cloze response probability between .09 to .99 (mean probability of .53), or a congruous but unlikely word with a Cloze response probability of .3, or an anomalous completion. For example, the sentence "she cleaned the dirt from her ...." could be completed by a likely completion word "shoe", or unlikely but congruous word "hands", or an anomalous word like "terms." They reported that sentence context facilitated the processing of a target word only in a highly likely completion condition. No facilitation or inhibition effects were observed for the congruous but unlikely completions. However, an inhibition effect was observed for the processing of anomalous target words. The presence of inhibition for incongruous target words are not

consistent with the results of Stanovich and West (1983), indicating that subjects were using attentional processes for word recognition.

In summary, the studies on the effects of context on the process of word recognition have produced two different patterns of results. On one hand, a series of experiments have reported facilitation dominance . On the other hand, there are experiments that showed a pattern of inhibition dominance.

Task Differences

Stanovich and West (1982, 1983a) argued that the discrepancies between their results and those of Fischler and Bloom's were due to task differences. Experiments which employed the lexical decision task produced a pattern of inhibition dominance, whereas the naming task experiments produced a pattern of facilitation dominance. Consistent with this argument are the findings of experiments in which subjects performed both a lexical decision and naming task, using the same stimuli, under identical experimental condition (Stanovich & West, 1982; Stanovich & West, 1983a, Experiments, 9, 10, & 11). The results indicated that stimuli which have shown significant inhibition in a lexical decision task (Fischler & Bloom, 1979, 1980) failed to exhibit inhibition in a naming task. Stanovich and West (1983) explained such a difference in the framework of Forster's (1979) model in which lexical, syntactic and message level processors send their output to a problem solver that determines the appropriate response according to the task requirement. In a lexical decision task when an unrelated target word is presented, the lexical processor signals the

decision making problem solver to choose a "yes" response while the message-level processor detects the incongruity between the target word and the sentence and biases towards a "no" response. They argued that overcoming this bias may lengthen response time in the incongruous condition for a lexical decision task, but the naming task may be less affected by such postlexical process because there is no decision in the naming task and thus, a more direct connection exists between the lexicon and the response.

A similar explanation for the different results obtained by the two tasks has been offered by others. Balota and Lorch (1986) found mediated priming effects (lion-tiger-stripe) in a naming task but not in the lexical decision task. In mediated priming, the prime 'lion' and target 'stripe' are not directly related but they are related through another word 'tiger' which is referred to as the mediating prime. They argued that their failure to detect the priming effects in the lexical decision task was due to a post access checking strategy in which a subject checks whether or not the target word was related to the prime and the lack of that direct relationship between the prime and the target may bias them to choose a "no" response to the target. Overcoming this bias would delay the response, as a results no priming effects would be observed in the lexical decision task.

Seidenberg, Waters, Sanders and, Langer (1984) postulated two loci for priming effects. One is a pre-lexical effect due to the spread of activation for highly associatively or semantically related items and the second is a post-lexical effect which is due to judgments of the relatedness of word and

context. They asserted that a lexical decision task is a signal detection task because the subjects' performance depends on the discriminability of the words and nonwords and subjects' response criteria. Contextual information can affect either the subjects' sensitivity or their bias. They argued that the sensitivity was influenced by semantic priming due to spread of activation but the task requirement that subject discriminate between words and non-words influenced subject's bias. They assumed that the lexical decision task is more likely to be affected by a post-lexical processes due to its intrinsic signal detection character.

In summary, context exerts its effects on word recognition differentially in a naming task and a lexical decision task. In a naming task context affects the pre-lexical processes by speeding the process of lexical access, either through the spread of activation (Meyer & Schvaneveldt, 1971), or through conscious expectancy. Stanovich and West (1983) suggested that the role of attentional processes is limited only to situations where a reader has some difficulties with bottom-up processes. In the lexical decision task, not only the lexical processes but also post-lexical processes, the processes which occur after lexical access is completed, are affected by context (Seidenberg et. al. , 1984).

In addition to the differential effects of context in naming and lexical decision tasks, the demands of these tasks may differ from the demands in normal reading where subjects are not forced to make a word-nonword decision or to pronounce a word. The existence of such differences between normal reading and these tasks encouraged some researchers to employ

paradigms which do not suffer from potential task related problems. The eye movement procedures and the moving window technique (Just, Carpenter, & Woolley, 1982) that mimic more closely the process of natural reading have been used as alternatives to the lexical decision task or the naming task.

Eye Movement Studies of Sentence Context Effects

Development of eye tracking procedures allowed researchers to study the reading process in more natural situations (Carrol & Slowiaczek, 1986; Ehrlich & Rayner, 1981; Ehrlich & Rayner, 1983; Just & Carpenter, 1980; Just, Carpenter, & Woolley, 1982; Inhoff, 1984; Rayner & Duffy, 1986; Underwood, Bloomfield, & Clews, 1988; Zola, 1984). In eye movement procedures, subjects' eye movements are monitored as they read the text. The locus of fixations indicate which word is under fixation and the duration of the fixations reflect the processing activities associated with comprehension of the word under fixation (Just & Carpenter, 1980; McConkie & Rayner 1975; Rayner, 1977). It has been shown that the fixation times are sensitive to word frequencies (Just & Carpenter 1980; Rayner & Duffy, 1986), sentence structure (Frazer & Rayner, 1982), contextual constraint (Balota, Pollatsek,& Rayner, 1985; Ehrlich & Rayner, 1981; Carrol & Slowiaczek, 1986), and lexical ambiguity (Rayner & Duffy, 1986).

The eye movement studies of semantic context effects have shown that context affects word reading times. However, they do not agree on the loci of the effects. On the one hand, there are some studies which indicate that

context mainly affects the process of lexical access (Balota,et. al., 1985; Ehrlich & Rayner, 1981). On the other hand, there are studies suggesting that context affects lexical as well as post-lexical processes (Carroll & Slowiaczek, 1986).

Using eye-movement procedures, Ehrlich and Rayner (1981) monitored subjects eye movements while reading texts in which the predictability of target words were manipulated. They reported that the highly predictable words were fixated for shorter durations and skipped more often than the less predictable target words. Inasmuch as their target words appeared earlier in the text, and it is known that a reader spends less time on the words that appear earlier in the text (Just & Carpenter, 1980), the facilitation observed in their results can be attributed to repetition effects.

Using an eye movement procedure, Balota, Pollatsek, Rayner (1985) attempted to assess the effects of context on word reading times. They showed that the words are fixated for shorter periods of time and skipped more often when they are predictable from sentence context. They manipulated the parafoveal information and the predictability of the target words and found an interaction between the two factors. The interaction indicated that the effects of parafoveal information were greater when the target word was predictable. They concluded that a semantic context facilitates the extraction of visual information in the parafovea and thus suggested that context affects lexical access during reading.

In two studies, using eye movement procedures, Carroll and Slowiaczek (1986) examined semantic and associative priming effects. In

the semantic priming experiment (Experiment 1), the target and the prime words belonged to the same semantic category (e.g. , "table" and "sofa" in the category of furniture). In associative priming experiments (Experiment 2), however, the prime and the target words were associatively related items from different categories (e. g. , "rake" and "leaf").

In Experiment 1, they monitored subjects' eye movements as they read sentences in which the type of prime, the typicality of the target word and its distance within the sentence from the prime were manipulated. They defined typicality as a measure of how well an exemplar fit the properties of a category (Rosch, 1973). Carroll and Slowiaczek reported that the primed target words were processed faster than the unprimed target words. The prime type main effect could be interpreted as evidence for the influence of semantic context. However, it is not clear whether the effect was facilitory or inhibitory due to a lack of an appropriate neutral condition. There was also a main effect of typicality where the high-typicality exemplars were processed faster than the low-typicality exemplars. The expected interaction of typicality and prime type was not significant. The lack of such an interaction is problematic for the spread of activation explanation of context effects because one would expect little or no typicality effect in the no prime condition when the low and high-typicality exemplars are matched on length and frequency. Carroll and Slowiaczek hypothesized that the priming effect may be explained by the spread of activation process or, the ease of integration of the target word into a semantic representation, but the observed typicality effects can be explained with the ease of

integration. The results from experiment one suggested that the context affected word recognition but it was not possible to specify the exact locus of the effects.

In Experiment 2 they investigated whether the priming effect might also be due to the integration of the word into the sentence by manipulating the prime type (associative prime, and two control prime conditions, nonassociative, and neutral), and the location of the target words in the structure of the sentences (same clause and different clause conditions). In the same clause condition the prime (e.g.. king) and the target (e.g., queen) words occurred in the first clause of the sentence (e. g., the guard saluted the king and the queen in the carriage, but they did not notice), whereas in the different clause condition, a clause boundary marked by a comma intervened between the prime and the target word (e. g., the guard saluted the king, and the queen in the carriage looked annoyed). They reasoned that if the semantic priming is due to a spread of activation, it should not be limited within a clause boundary. However, if the priming effect is due to integration processes, facilitation should happen only in the same clause condition and not in the different clause condition. The results indicated that the targets preceded by an associative prime were processed faster than the targets preceded by a neutral or nonassociative prime. More importantly, they obtained the critical interaction between the type of prime and the sentence structure, where priming had a larger effect when both the prime and the associated target were in the same clause than when they were in different clauses. Carrol and Slowiazeck concluded that the

effect of context happens only when the strongly associated pairs were in the same clause. The results from experiment two suggest that the observed priming effect could be due to integration processes.

Their results however, are open to another interpretation. Inasmuch as they did not report the stimulus onset asynchrony (SOA) between the prime and the target word in their second experiment, i is not clear whether the SOA was longer for the different clause condition due to the integration process or wrap-up effect at the end of the clause, compared with the same clause condition which lack such a wrap-up effect. The SOA reported in the first experiment was measured by taking the time difference between the first fixation on the prime and the first fixation on the target word (the mean SOA reported for the first experiment, were 488 and 1,247 msec for short and long interval, respectively). The potentially longer SOA can explain the lack of facilitation effect for the 'different clause' condition. It has been shown that the longer SOA between the prime and the target word would provide the necessary time for spread of activation process to lose its effects (Neely, 1977). This speculation is reinforced by the fact that they had their subjects complete a comprehension test after reading each text. The presence of a comprehension task might have forced subjects to engage in integrative processing which was more pronounced at the end of a clause or sentence (Haberlandt & Grasser,1985; Just & Carpenter, 1980; Murdaca & Komoda, 1991). If the SOAs were not different in the same and different clause conditions, the Caroll and Slowiaczek (1986) results indicated that the facilitation observed in adults reading were not entirely

due to the automatic spread of activation mechanism, but it could have also resulted from the ease of integrating of a congruent target word into a semantic representation.

Moving Window Technique

The moving window technique (Just, Carpenter, and Wolley, 1982) is another useful method of studying the processes of reading in which the successive words are presented across the computer screen. This method simulates the natural reading situation as closely as possible without recording eye movements. In this technique, the initial display is filled with dashes, each letter being replaced by a dash. When a subject presses a button for the first time, the first word of the first sentence appears, replacing the dashes corresponding to that word. By pressing the button for next word, the previous word will be replaced by dashes as the next word appeared. In this way only one word is visible on the display at any given time. The time between two successive button presses was recorded by computer as the reading time for the exposed word. The moving window technique has the advantages of resembling as closely as possible the normal reading situation in that the subjects read the text with their own pace and process of reading is not interrupted by a secondary task. In addition, subjects have access to the perceptual cues such as word length, sentence length, and punctuation. The disadvantage of this technique, however, is that the readers are not able to make a regressive eye movement.

Just et. al. (1982) have also presented other alternative approaches to the study of reading such as: A central window in which successive words are presented in the central location, and a cumulative display in which the earlier words remain on the screen. They compared the data resulting from these methods to the data resulting from the measurement of the gaze durations of subjects reading the same texts. The gaze durations were obtained by adding the durations of consecutive fixations on a single word. Among different types of window procedures, the moving window procedure produced the strongest correlation between the gaze durations and the exposure durations. In addition, the moving window procedure was shown to be sensitive to factors, such as, word length, word frequency, and the syntactic location of the words. Accordingly, they showed that the variations in the exposure duration found in the moving window procedure were similar to variations in gaze durations.

Using a moving window technique, Murdaca and Komoda (1991) attempted to assess the effects of sentence context on the reading of words. They made a few changes from the Stanovich and West (1981) design. Murdaca and Komoda revised Stanovich and West's sentence frames by extending sentences beyond the target words in an attempt to separate the effects of context on word recognition and sentence integration. In addition they created a neutral sentence for each pair of sentence frames. They manipulated context (congruous, incongruous, neutral), and word difficulty (easy, difficult).

The analysis of the target word data replicated the major findings of Stanovich and West (1981, 1983). The interaction between context and difficulty indicated that word reading times for congruous difficult target words were facilitated. Consistent with the pattern of results obtained by Stanovich and West (1981, 1983), no inhibition effects were observed. Inasmuch as the analysis on the word reading times of the last word showed no facilitation effect for the congruous target words, they concluded that the observed facilitation effect in the reading of target words was not due to integration processes but resulted from the effects of context on lexical access.

The analysis on word reading times of the words following the target words (target-plus-one words), showed that the word reading times of the target-plus-one words preceded by a difficult or an incongruous target word were slower than the word reading times of the a target-plus-one word preceded by an easy or a congruous target word. Inasmuch as the characteristics of the target-plus-one words (i.e., frequency, length) were not significantly different from those in context sentences (congruous, incongruous), the variations of the word reading times of the target-plus-one word as a function of the property of the target word could be due to a carry-over from the target words. Murdaca and Komoda argued that the target words are identified and partially processed as they are being fixated, but the process of integration may carry over to the next word.

Although consistent with Stanovich and West (1983) findings, in that the overall results of Murdaca and Komoda (1991) indicated that context

facilitates the recognition of a congruous difficult target word, a closer inspection of the results reveals that the male and female subjects did not perform the same way as it was expected. The pattern of two-way interaction on the reading times of target words showed that male subjects displayed a facilitation effect while female subjects tended toward an inhibition effect. The presence of facilitation in male subjects' reading times is consistent with Stanovich and West's results, indicating that the automatic spread of activation was implicated in reading. The female subjects' results, however, are more comparable with the results obtained from a lexical decision task in which more inhibition is observed and may indicate that the attentional processes were involved in reading process. Murdaca and Komoda argued that the difference between male and female performance could be due to the adoption of different reading strategies. Although they tested their subject for comprehension, the liberal nature of comprehension task used in their study could allow subjects to develop different type of strategies. After reading seven sentences from a computer screen, the subjects were presented with a statement about one of the previously read sentences. For example, subjects were presented with a noun like "spider" or two nouns like "spider" and "wall" and were asked to decide whether or not the noun or nouns were presented in one of the previous sentences. To answer the question correctly, the subject could check the list of content words remembered from the previous seven sentences. As a result, a full comprehension of the previously presented

sentences was not necessarily required to successfully complete the comprehension task.

It appears that more female subjects engaged in sentence level processing (integration processes) as they read the text and tried to integrate every word into a developing mental representation of the sentence as they encounter each word. This idea was supported by the presence of a trend in inhibition effect for females for incongruent target words reading times. As it was discussed before, the presence of inhibition indicates that the attentional processes are implicated in reading performance. The lack of such a trend in inhibition effect for reading times male subjects reading incongruous target words may indicate that the process of word recognition had not been completed for the target words when male subjects moved to the next word. This idea was supported by the presence of an inhibition effect on the reading times of incongruous target-plus-one words, showing that there was a lag in comprehension processes for male subjects.

Haberlandt, Grasser and, Schneider (1989) have also reported results that support the presence of a lag in the word processing. Using a moving window technique, they compared the reading profile of the 10 fastest and the 10 slowest readers from a pool of subjects. The analysis revealed that reading times of the target word were influenced by features (word length and word frequency) of the preceding words only for the fast readers. In another experiment, they were able to induce the subjects to choose a particular strategy by asking them to read either quickly or carefully. The

group that was instructed to read quickly showed a lag of processing but not the group that were told to read carefully. These findings show that the degree to which a task demands a reader to engage in integrative processes would determine the type of strategy they choose for processing the text.

Statement of the Problem

The precise effects of context on word recognition is not clear from Murdaca and Komoda (1991)'s study because the male and female subjects adopted different types of strategies. To get a better picture, this experiment attempted to force subjects to use one strategy. This goal was achieved by changing Murdaca and Komoda's comprehension task to one that requires subjects to engage in greater integrative processing. Consistent with Haberlandt, et.al., (1989), it was predicted that the demand of a comprehension task would force subjects to get involved in more integrative processing and reduce the chance of developing different types of strategies. In the current experiment, instead of asking subjects to identify certain words from the previous sentences, they were asked if a test sentence was a paraphrase of one of the previously presented sentences. In order to answer correctly, subjects should build a semantic representation of the previously presented sentences and then compare those representations with the gist of the test sentence. It is expected that by changing the comprehension task, the results of the male and female subjects will become more similar and the gender effects and its interactions with the other factors should disappear.

Furthermore, this study attempts to assess the locus of the context effect (lexical, post-lexical) and the mechanism (automatic, attentional) by which context affects the process of word recognition in a situation where subjects are required to engage in integrative processing. The results from the studies that showed a reader uses the physical and linguistic boundaries for integration may be used for evaluating the effects of context on lexical and post-lexical processing (Just & Carpenter, 1980; Haberlandt & Grasser, 1985). If the context has any effects on the process of lexical access, the effect should manifest itself mainly on target word reading times. Similarly, if the context has any effects on integrative processing, the effects should be more pronounced on the last word reading times where subjects try to put the whole meaning of a sentence together. If context affects lexical and post-lexical processes, the effects should be observed on the reading times of target and last word, respectively.

Another estimate of context effects on post-lexical processes may be obtained by analyzing the carry-over effects. The results from the Murdaca and Komoda study produced evidence that the processing of the target words continues to the following words. Murdaca and Komoda argued that the processing of lexical access has been completed by the time subjects move their fixations, but the integration processes were continued to the next word. Given their interpretation, the analysis of the reading times for the target words should largely reflect the effects of context on the lexical access or word level processing, whereas the analysis on the target-plus-

one word reading times should reflect the effect of context on post-lexical processes.

To assess whether the effects of context are due to the automatic spread of activation or due to attentional processes, one should examine the pattern of facilitation and inhibition. According to the two process theory, the automatic spread of activation facilitates the recognition of congruous target words without inhibiting the processing of incongruous target words. The attentional processes, however, facilitate the recognition of congruous target words and inhibit the recognition of incongruous target words.

By forcing subjects to engage in a more integrative processing, it was hypothesized that on one hand, if context has an effect on post-lexical processes, it should facilitate the processing of congruous target words regardless of word difficulty, and inhibit the processing of incongruous target words. Similarly, a facilitation and inhibition effect should be observed for the rea ing times of last words in congruous and incongruous sentences, respectively. On the other hand, if context has any effects on the processes of lexical access, then depending on the mechanism by which context exerts its effects (automatic or attentional), two different pattern of results would be predicted. Firstly, if the effects are due to the automatic spread of activation, it should facilitate the reading times of congruous difficult target words (Stanovich & West, 1983), but if the effects are due to attentional processes, regardless of difficulty, a facilitation effect for the

reading times congruous target words and an inhibition effect for the reading times of incongruous target words would be expected.

Method

Subjects

A pool of potential subjects was recruited through advertisements at Concordia University. To participate in the experiment, subjects were required to meet two criteria. First, they were required to have normal or corrected to normal vision as assessed by the Keystone School Vision Screening test, developed by the Keystone View Company, Meadville, Pennsylvania. Secondly, subjects were required to have reading rates of at least 250 words per minute with 70% comprehension based on a screening test. For the screening test the potential subjects were asked to read two texts with a mean length of 1574 words (Favreau, Komoda, Segalowitz, 1980) as well as to answer 10 multiple choice questions after each text. The texts and questions were taken from Series IJ-16/20 by Educational Development Laboratories, Don Mills, Ontario. About 40% of the potential subjects met the screening requirements.

During the course of the experiment, subjects answered 24 true and false comprehension test questions. They were required to perform with at least 70% comprehension (17 correct out of 24 questions). The data from 32 subjects (sixteen males whose age ranged from 19 to 38 years with mean age of 24.4 and 16 females whose age ranged from 17 to 40 years with mean age of 23.5) who met the experimental requirement entered the final

analysis. Only one subject failed to meet the experimental requirement and was replaced by another one who met the criteria. The screening mean reading rate of males and females were 299.81 (SD = 44.83) and 293.5 (SD = 32.5) words per minute, respectively. The mean comprehension scores from the possible score of ten for female and male subjects were 8.8 (SD = 0.78) and 8.5 (SD = 1.08), respectively. All subjects indicated that English was their first language.

Materials and Apparatus

Sentences from Stanovich and West (1981) as revised by Murdaca and Komoda (1991) were used. In the Stanovich and West study, there were 96 sentence frames, ending with "the". Each sentence frame could be completed with either an easy or a difficult target word, where difficulty was defined by word frequency (Kucera and Francis,1967) and word length. The mean natural log frequency of the easy target words was 4.20 per million (SD = 1.25) and the mean natural log frequency of the difficult words was 1.47 per million (SD = 1.13). The mean number of letters for easy and difficult target words were 5.0 (SD = 1.3) and 7.4 (SD = 2.1) respectively.

To separate potential wrap-up effects from any context effects, the Murdaca and Komoda (1991) sentences were used. These were generated by modifying Stanovich and West's sentences by adding three words to the end of each sentence frame following the blank. For example, the sentence " the driver stepped on the ------". was changed to, "the driver stepped on the ----- after the curve". Each sentence frame was paired with an easy and a difficult target word to produce 96 congruous-easy and 96 congruous-

difficult sentences. In addition to being paired with its own target words, a sentence frame was paired with the target words from another sentence frame to produce 96 incongruous-easy and 96 incongruous-difficult sentences. In this way, each sentence frame was combined with its own target words and the target words from another sentence frame to produced four sentences that were systematically placed into four sets. When this procedure was applied to all sentences, four sets of 96 sentences were produced with the constraints that (1) each sentence frame appeared only once in each set, and (2) each target word appeared only once in each set. In addition a set of 48 neutral sentence frames was created and was added to each of the four sets, producing four sets of 144 sentences with the constraint that (1) there was an equal number of neutral, congruous and incongruous sentences used in each set, and (2) there was an equal number of easy and difficult target words distributed over neutral, congruous and incongruous sentence frames in each set.

The order of presentation of sentences in each of the four sets were then permuted to form four different sequences of presentation for each set. When the permutation procedure was applied to all four sets, it produced 16 unique orders of presentation. In each sequence of presentation no more than four sentences of the same type (i.e., congruous, incongruous, and neutral) followed each other and no more than four target words of the same type (i.e., easy or difficult) followed each other.

The 144 sentences in each sequence of presentation were divided into 24 blocks of six sentences for presentation on the screen. As it was

assumed that subjects would spend more time on the last word in a block due to the anticipation of the comprehension task, a filler sentence was added to the end of each block. The characteristics of the filler sentences were similar to those of experimental sentences in terms of the inclusion of approximately equal number of sentences of each type. Data from the filler sentences did not enter in the analyses.

To familiarize the subject with the testing procedure, two extra blocks of practice sentences similar to those of experimental sentences were created.

For the comprehension test, a set of 26 statements were created (two for the practice blocks of trials and 24 for the experimental blocks of trials) for each of the 16 orders of presentation. To create a true statement (i.e., test sentence that paraphrased one of the previous sentences) for a block of sentences, the surface structure of one of the sentences in the block was changed to produce a different sentence but one that retained the exact meaning of the original sentence. For example the original sentence "The meteorologist forecasted the weather we all feared" was changed to "*The weather we all feared was forecasted by the meteorologist*". To create a false statement, two components of one of the original sentences in the block (from among the subject, the verb, the adverb and the direct or indirect object) were changed to create a new sentence which has a different meaning from the original sentence. For example the original incongruous sentence "The swimmer swam across the plant without some

help" was changed to "The *runner* swam across the plant *with some* help".

The statements for the comprehension test were constructed with the constraint that, (1) an equal number of congruent, incongruent and neutral sentences were paraphrased, (2) an equal number of components from the original sentences (from among; subjects, verbs, adverbs and direct and indirect objects) were changed to produce the false statements, (3) an equal number of active-true, active-false and an equal number of passive-false, passive-true statements were created, and (4) no more than 3 statements of the same type (true or false) followed each other (Appendix C presents an example of the comprehension test for one order of presentation).

An Olivetti M24 microcomputer was used to generate the stimuli on a monochrome monitor and record subject's responses. Subjects were seated at a distance of approximately 54 cm with character size set at 5 mm vertically and 3 mm horizontally. Subjects used the button on a mouse to control the pace of the presentation of words. Reading time for each word was measured to the nearest millisecond by using the computer's system clock.

Procedure

Subjects were tested in two stages; the screening test, and the experiment. Subjects were introduced to the screening procedure through a consent form which they signed if they agreed to follow the procedure. Then their vision was assessed using the Keystone School Vision Screening Test. A subject's reading proficiency was assessed by asking the subject to

read two texts. The time required to read each text was recorded, as well as the number of correct answers for the ten multiple choice questions used as a comprehension test.

Prior to the experiment, subjects were introduced to the testing procedure through a consent form which they read and signed if they agreed to follow the procedure. Subjects were randomly assigned to one of the 16 unique orders of presentation with the constraint that in each order of presentation equal numbers of male and female subjects be tested. They were tested individually for one session of about 30 minutes. They were asked to read 26 blocks of seven sentences (2 practice and 24 experimental blocks). After reading each block of seven sentences the subjects were presented a test sentence and were required to determine whether the test sentence paraphrased one of the sentences in the previous block of seven sentences. The subjects answered the true-false questions by pressing on a mouse button. Their responses were recorded by the computer.

The moving window technique (Just, et. al., 1982) was used to present the sentences. In this technique, the initial display was filled with dashes. Each letter was replaced by a dash so as to preserve the word length and punctuation. When the subject pressed the mouse button for the first time, the first word of the first sentence appeared, replacing the dashes corresponding to that word. By pressing the button for the next word, the previous word was replaced by dashes as the next word appeared. In this way only one word was visible on the display at any given time and the

subjects could not re-read previous words. The time between button presses was recorded by the computer as the reading time for the exposed word.

Results

Inasmuch as gender was a factor in the analyses of the word reading times, the comparability of the two groups in terms of reading proficiency was assessed. Although subjects were selected using a set of criteria such as the reading rate of at least 250 words per minute with 70% comprehension, they were not explicitly matched for their reading proficiency. The two groups of subjects could have differed with respect to reading proficiency.

The results from the screening procedure indicated that mean reading rates of 299.81 (SD = 44.83) and 293.5 (SD = 32.5) words per minute for male and female subjects, respectively. The comprehension scores of male and female subjects were 89.3% (SD = 9.8) and 84.6% (SD = 8.8) respectively. Neither the mean reading rates (t (30) = .83) nor the comprehension scores (t (30) = 1.46) of the two groups differed significantly.

In the experiment, the reading times for three word positions in a sentence were of interest; the target word, the target-plus-one and the last word reading times. A separate 2 x 2 x 3 (Gender x Difficulty x Context) between-within analysis of variance (ANOVA) was performed on the target, target-plus-one, and last word reading times of the sentences. In all three analyses, gender served as a between-subjects factor and the within-

subjects factors consisted of context (congruent, incongruent, neutral) and difficulty (easy and difficult).

Before analyzing the data, for every subject, in each unique condition (six conditions were formed by the factorial combination of two levels of difficulty with the three levels of context), the outliers were identified. The reading times longer or shorter than three standard deviations above or below the mean of the respective condition were identified as outliers. Each outlier so identified was replaced by a score that was one unit smaller or larger, respectively, than the next most extreme score in the distribution as suggested by Tabachnick & Fidell (1983). Less than 1.7% of the total data points were detected as outliers.

Target Word

The analysis of the target word reading times revealed that there was a significant main effect of context $F(2,60) = 4.539$, $p<.015$, with mean reading times of 423, 447 and 433 ms for congruent, incongruent and neutral conditions, respectively. A post hoc test (Tukey's HSD = 20) indicated that the mean word reading times of the target words in the congruous sentences differed from the mean word reading times of the same target words in the incongruous sentences. The value of Tukey's HSD test for these comparisons and later comparisons were all calculated at alpha = 0.05. A significant main effect of difficulty was observed, ($F(1, 30) = 25.705$, $p<.001$), with mean reading time of 405 and 464 ms for easy and difficult words respectively. Also there was a significant interaction of context by difficulty ($F(2,60) = 5.338$, $p<.007$). The source of

interaction can be best seen by looking at facilitation and inhibition scores. The facilitation and inhibition scores were obtained by taking the difference between the mean reading times of the congruent and incongruent conditions from the mean reading times of the neutral condition, respectively. Figure 1 presents the amount of facilitation and inhibition observed for the easy and difficult target words in congruous and incongruous conditions. As presented in Figure 1 and confirmed by the post hoc test (HSD = 31), the source of interaction was due to the fact that the reading times of easy words did not differ in congruent, incongruent and neutral conditions (the means were 407, 407, and 402 ms, respectively), whereas the mean word reading times for difficult target words differed in congruent and incongruent conditions (439, 487, and 463 ms for congruous, incongruous, and neutral conditions, respectively). The interaction of gender with other factors or the main effect of gender was not significant.

Target-plus-one Word

The mean word reading times for words following the target words were analyzed to determine whether any processing of the target word continued during the reading of the word following the target word (the target-plus-one word). In this case, the factors of word difficulty and context in the ANOVA refer to the characteristics of the target word and not the target-plus-one word.

To make sure that any potential differences in mean word reading times of the target-plus-one words revealed by ANOVA were not due to systematic variation in the length and the word frequency of the

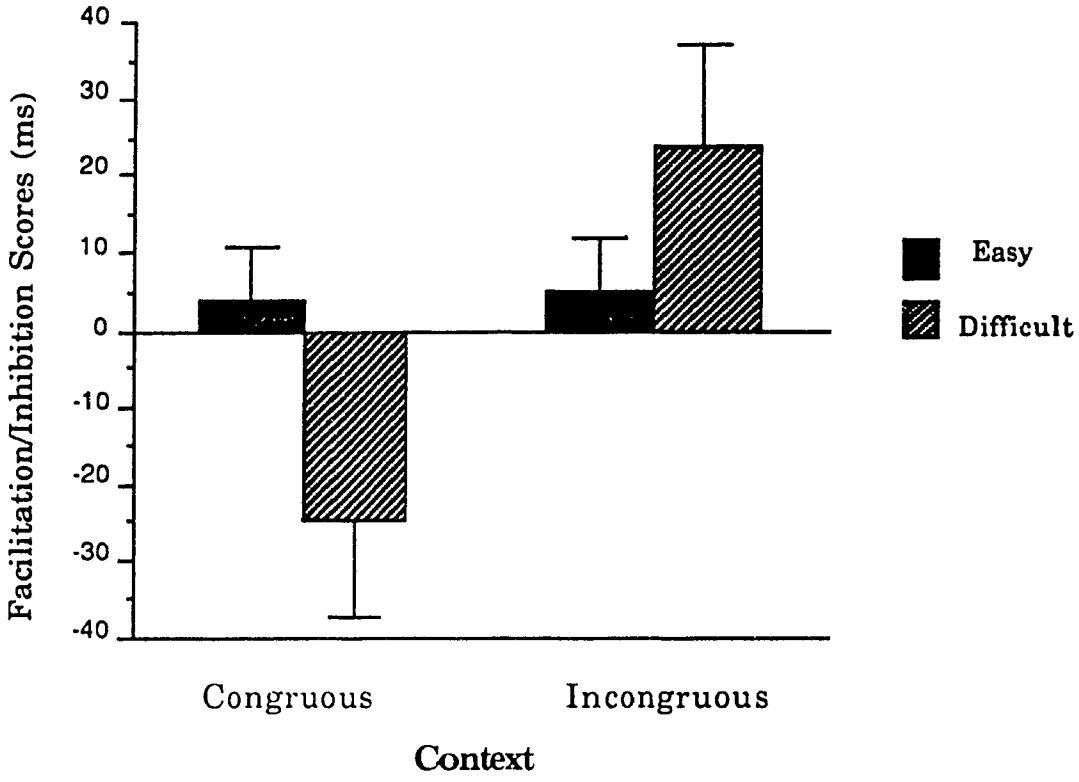

Figure 1. Mean differences in word reading times between context conditions (congruous and incongruous) and neutral condition for the target words.
Note: Negative differences imply facilitation, whereas positive differences imply inhibition.

target-plus-one words, the characteristics of the target-plus-one words in congruous, incongruous, and neutral conditions were compared. The same target-plus-one words were used in congruous and incongruous conditions (word length = 3.25 letters; log frequency = 8.65 per million), however, in the neutral condition, the target-plus-one words were different (word length = 3.50 letters; log frequency = 8.55 per million). To assess whether or not the frequency and length of the target-plus-one words which varied systematically in context (congruous, incongruous) and neutral sentences, can be responsible for any potential differences, separate t-tests for independent means were performed on word length and log frequency of target-plus-one words in neutral and context sentences. The results revealed that there were no significant differences between the word length or log frequency of the target-plus-one words in the neutral and congruous or incongruous sentence frames ($t(142) = -1.318$, and $t(142) = 0.592$ for word length and word frequency, respectively).

The analysis of variance on the target-plus-one mean word reading times revealed that there was a main effect of context ($F(2, 60) = 26.021$, $p<.001$) with mean reading time of 382, 437, and 397 ms for congruent, incongruent and neutral conditions respectively. The Tukey's post hoc test (HSD = 19) showed that there was a significant inhibition effect for the reading times of target-plus-one words in incongruous sentences (longer word reading times observed for an incongruent sentence in comparison to a neutral sentence). There was also a main effect of difficulty

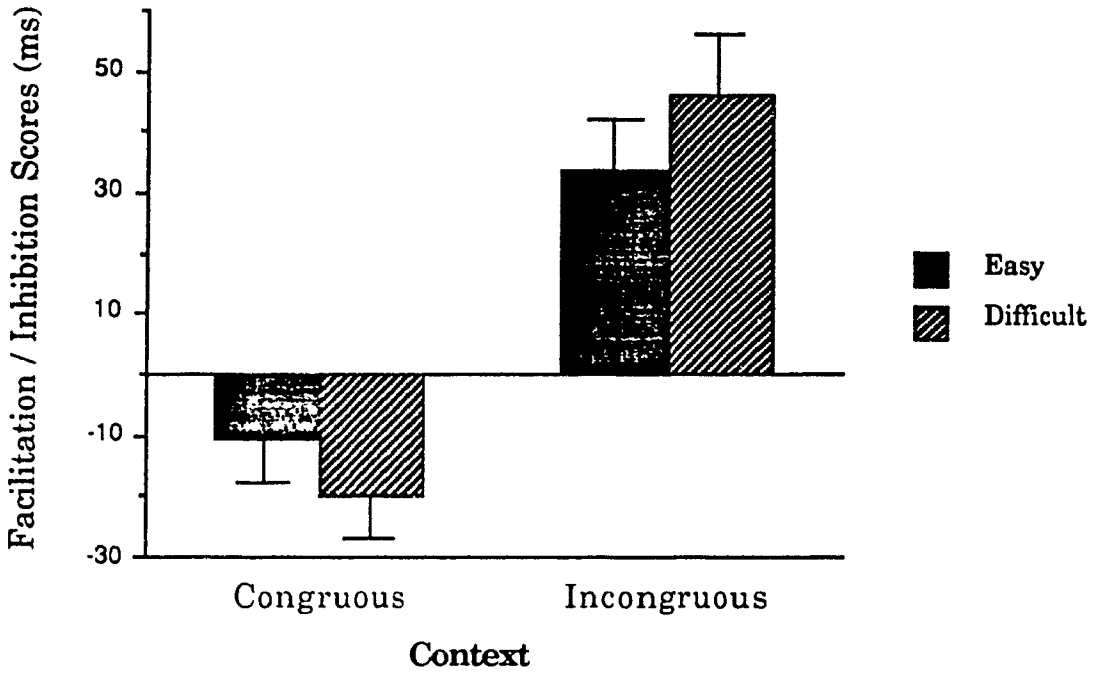

Figure 2. Mean differences in word reading times between context conditions (congruous and incongruous) and neutral condition for the target-plus-one words as a function of target word difficulty.
Note: Negative differences imply facilitation, whereas positive differences imply inhibition.

($F(1, 30) = 21.417$, $p < .001$) with mean reading times of 392 and 419 ms when the preceding word was easy and difficult, respectively.

The analysis of the reading times of the target-plus-one words suggests that the processing of target words continues to the target-plus-one words. In order to compare the pattern of facilitation and inhibition effects on the target and target-plus-one word reading times, facilitation and inhibition scores for the reading times of target-plus-one were obtained. Figure 2 displays a pattern of facilitation and inhibition effects similiar to the pattern of facilitation and inhibition effects on target word reading times, suggesting that the reading times of the target-plus-one words varies with the cahracteristics of target words. The fact that the reading times of the target words continued to the next words may indicate that the analysis of target word reading times alone cannot reflect the whole effects of sentence context on target word processing. The summed word reading times of the target and target-plus-one words might provide a better measure of the effects of context on target word processing.

Summed Word Reading Times of Target and Target-plus-one Words

The mean word reading times for the target and the target-plus-one words (the outliers had been already taken out) were added to produce a single value for every subject in six conditions. The same ANOVA design on the summed word reading times revealed that there was a significant main effect of difficulty ($F(1,30) = 44.596$, $p < 0.001$) with mean reading times of 797 and 879 ms for easy and difficult scores, respectively. There was a significant main effect of context ($F(2, 60) = 18.830$, $p < .001$) with mean

mean reading times of 804, 884, and 829 ms for congruous, incongruous, and neutral conditions. A post hoc test (Tukey's HSD = 38) indicated that there was a significant inhibition effect. There was also a significant interaction between context and difficulty ($F(2, 60) = 8.307$, $p < 0.001$). Figure 3 presents the facilitation and inhibition scores of the summed word reading times in the easy and difficult conditions. The source of the interaction, as Figure 3 shows and as was confirmed by the post hoc test (Tukey's HSD = 35), was due to different patterns of facilitation and inhibition for easy and difficult conditions. The post hoc test revealed that the summed word reading times in easy condition showed inhibition effect in incongruous condition (+39 ms) when compared to the neutral condition, whereas the difficult condition exhibited a significant facilitation (- 44 ms) in the congruous condition and a significant inhibition (+70 ms) in the incongruous condition when compared to the neutral condition. Here also, the interaction of gender with other factors or the main effect of gender was not significant.

Last Word

To determine whether or not the word level processing and sentence level processing of the target words were differentially affected by context, the mean word reading times for the last words of the sentences were analyzed. As with the analysis of the target-plus-one word reading times, the factors of word difficulty and context in the ANOVA refer to the characteristics of the target word and not the last word. To make sure that any potential differences in mean word reading times of the last words are

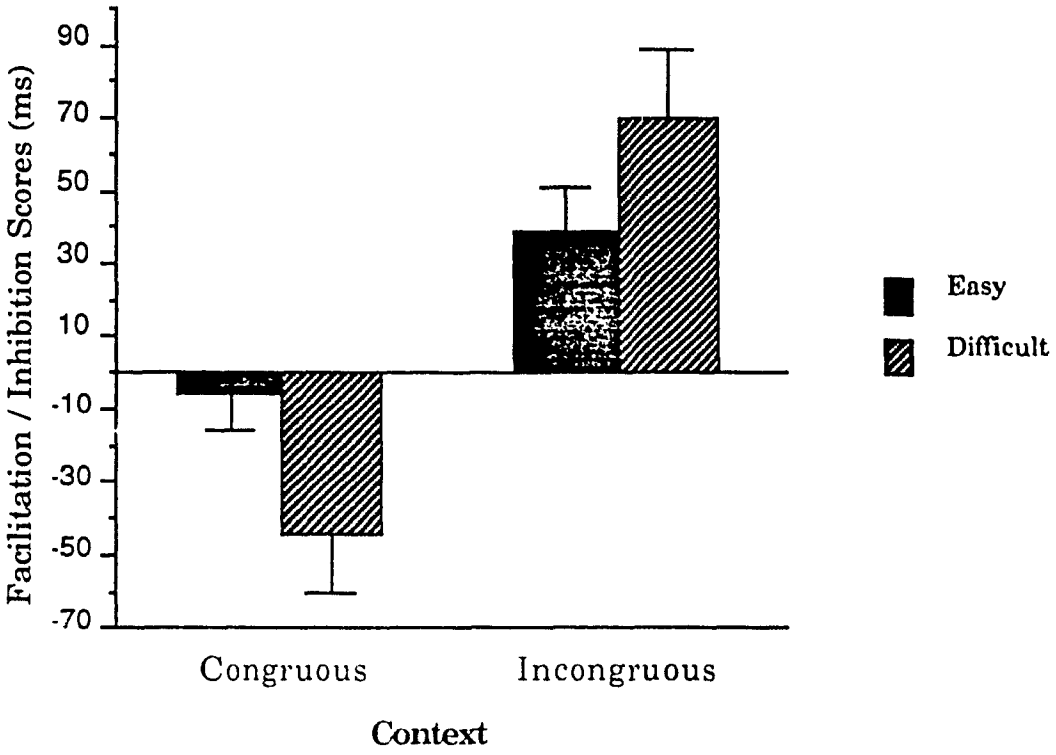

Figure 3. Mean differences between the summed word reading times of the target and target-plus-one words in context conditions (congruous and incongruous) from the summed word reading times of the target and target-plus-one words in neutral condition.
Note: Negative differences imply facilitation, whereas positive differences imply inhibition.

not due to systematic variation in the length and the word frequency of the last words, the characteristics of the last words in different conditions were assessed. Similar to target-plus-one words, the same last words were used in congruous and incongruous conditions (word length = 5.3 letters, log frequency = 4.91 per million), however, in the neutral condition, the last words were different (word length = 5.52 letters, log frequency = 4.649 per million). Separate *t*-tests for independent means were performed on word length and log frequency of the last words. The results revealed that there were no significant differences between the word length or log frequency of the last words in the neutral sentence frames and the word length or log frequency of the last words in congruous or incongruous sentence frames ($t(142) = -.88$, and $t(142) = 1.387$ for word length and word frequency, respectively).

The analysis on the last word mean reading time indicated that there was a significant main effect of context ($F(2, 60) = 15.087$, $p < 0.001$) with mean reading times of 988, 1194 and 1056 ms for the congruent, incongruent and neutral conditions, respectively. Tukey's post hoc test (HSD= 95) revealed a significant inhibition effect for the reading of the last words in incongruous sentences. Figure 4 presents the pattern of facilitation and inhibition effects for the last word reading timesin congruous and incongruous sentences.

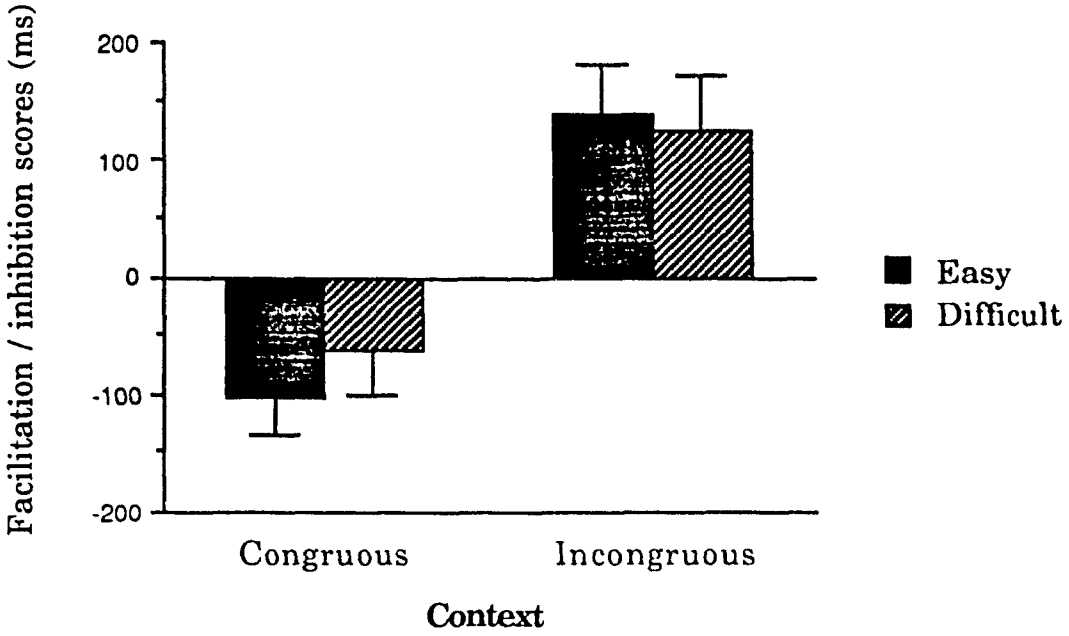

Figure 4. Mean differences in word reading times between context conditions (congruous and incongruous) and neutral condition for the last word of the sentences as a function of target word difficulty.
Note: Negative differences imply facilitation, whereas positive differences imply inhibition.

Discussion

The current experiment attempted to assess the mechanism by which context exerts its effects on word recognition and the location of the effects (pre- or post-lexical) in a situation where subjects are required to integrate every word into a mental representation. However, before evaluating the nature and the locus of context effects, it is necessary to clarify that the subjects were involved in integrative processing. It was suggested that the gender difference in Murdaca and Komoda's (1991) study was due to the adoption of different strategies by male and female subjects. Their results indicated that the male and female subjects adopted two different strategies in that the female subjects were engaged in more integrative processing than the male subjects as they encountered and read each word. It was hypothesized that forcing subjects to read for comprehension would require them to choose a strategy similar to those of the female subjects in the Murdaca & Komoda's study. By changing Murdaca and Komoda's ambiguous comprehension task to a more restrictive comprehension task, it was predicted that the gender difference and the interaction of gender with the other factors, found in Murdaca and Komoda's study should disappear.

The Effects of Task Demands on Subjects' Strategy

Changing the Murdaca and Komoda's comprehension task (the other factors, such as the paradigm, the power of the test, and the stimulus remained the same), the gender related interactions found in their study disappeared. However, the effects of word difficulty on the target and

target-plus-one word reading times and the effects of context on the target, target-plus-one, and last word reading times were replicated. Moreover, the pattern of interaction between context and difficulty revealed that in the congruous sentences, the difficult target word reading times showed a trend towards facilitation. The lack of gender effects in this experiment, may be interpreted as a support for the hypothesis that the demand of comprehension has forced subjects to engage in a more integrative processing. In addition to the lack of gender effects, the presence of inhibition effects for the reading times of the target-plus one and the last words in the incongruous sentences also imply that subjects were engaged in integrative processing. The occurrence of inhibition indicated that the subjects had difficulty integrating an incongruous target word into the mental representation of the sentence.

Sentence Context Effects

The results from the analysis of the target word reading times indicated that the while there was a trend towards facilitation for the reading times of congruous difficult target words, there was also a trend towards inhibition for the reading times of the incongruous target words (see Figure 1). If the presence of the trends toward facilitation and inhibition implies that the context produced these effects, then one should clarify why those effects did not reach significance. It is possible that subjects decided to move to the next word before the total underlying processing of the target word (lexical and post-lexical) was completed. For example, the reader may have decided to move to the next word as soon as

the information processing system had the necessary features for the eventual identification of the word being processed, but the search for the lexical entry, case role assignment, and discourse integration may have continued to the target-plus-one word. As a result, the word reading time of the target word by itself does not reflect all the underlying cognitive processing of that word. In that case, the assessment of the influence of context on the reading times of target words may not be provide a good estimate of context effects simply because the processing of the target word has not been finished. The reading times of the words following the target words may be used for further evaluation of the effects of sentence context and word difficulty on lexical and post-lexical processing of the target word.

As it was indicated in the result section, the characteristics of target-plus-one words in terms of length and word frequency were the same over context (congruous, incongruous) sentences and did not differ from those in neutral sentences. Hence, a major portion of the variability in the word reading times of target-plus-one words, then, could be attributed to the characteristics of the preceding target words. The reading times of target-plus-one word reading times then largely reflected the continued lexical and post-lexical processing of the target words. The analysis revealed that the word reading time of a target-plus-one-word was longer when it was preceded by an incongruous target word. As the effects were inhibitory and were observed on the reading times of target-plus-one word, it may be concluded that the incongruous context had an inhibitory effect on post-lexical processing of the target words.

The analysis has also revealed that the difficulty factor affected the word reading times of target-plus-one words. The reading times of the target-plus-one words were longer when it was preceded by a difficult target word. The observed difficulty effects could have resulted, from either the slower integration of the difficult target word into the semantic representation of sentence, or, from the slower lexical access of the difficult target word. The two views regarding the effects of difficulty on target-plus-one word reading times can be evaluated by inspection of the interaction between context and difficulty on target word reading times. The processing of congruent difficult target words have been shown to benefit from context (Murdaca & Komoda; Stanovich and West, 1981, 1983). The same trend was present in the current experiment. If a reader had difficulty in integrating a congruent difficult target word into the semantic representation, the benefit from sentence context should have been offset by the cost of the difficulty of integration. As a consequence, the congruent difficult target words should have shown little or no facilitation effects. By contrast, if the congruent easy target words had integrated faster than the difficult congruous target words, the easy words should have shown larger facilitation effect. The trend towards facilitation for the difficult target words and the lack of any facilitation for the easy target words, may be interpreted that the presence of difficulty effect on reading times of target-plus-one words reflect a reader's difficulty to access the meaning of the target word and not his or her difficulty of integrating the target word with the previous words.

The analysis of the summed word reading times which reflects both lexical and post-lexical processing of the target word provides further evidence that sentence context facilitated the reading times of difficult target words and there was no facilitation effect for the word reading times of congruous-easy target words (see Figure 3). The lack of facilitation effects for the congruent-easy target words may indicate that context did not influence lexical or post-lexical processing for that type of word. In an incongruous context however, there was a significant inhibition for both the easy and difficult target words. The presence of inhibition effect on the summed word reading times may indicate that context affected post-lexical processing of incongruous target words regardless of word difficulty. Further support for this idea comes from the analysis of last word reading times which revealed that incongruity slowed the integration processes. Insofar as the difficulty of target words did not affect the reading times of last words, it may be concluded that the difficulty mainly affects word level processing whereas different types of sentence context affect word and sentence level processing. An incongruent context may inhibit the post-lexical processing of a word in a sentence regardless of the word difficulty as it was shown by the analysis of target-plus-one and last word reading times, but a congruous context facilitates the lexical access of a difficult target words. The finding that contextual information provided by a sentence frame facilitates the process of lexical access for a difficult target word is consistent with the results of Stanovich and West (1981, 1983a) and the results of Murdaca and Komoda (1990), indicating that the effect

appears to be robust enough so as to be evident in an experimental situation that better approximates the natural reading situation where readers generally read for comprehension.

The presence of carry-over effects is consistent with the findings of Murdaca and Komoda (1991), Haberlandt, et al. (1989), and Rayner and Duffy (1986). Rayner and Duffy (1986) monitored the eye movements of subjects reading sentences which contained a target word. The lengths of the target words were controlled. They reported that the mean fixation time on low frequency words was longer than the mean fixation times on the high frequency words. The fixation times on target-plus-one words were also significantly longer for the words which followed the difficult target than the word which followed an easy target. They concluded that the lexical access for the target word is accomplished while the subjects fixated the target words, but the integration processes were carried to the next word. They assumed that the meaning of a low frequency word is represented in a less complete or less-elaborated form than the meaning of a high frequency word and as a result, the integration of a low frequency word would be harder. As it has been discussed earlier, the results from the current experiment cannot be explained merely on the basis that the difficult target words are integrated slower than the easy target words. The results suggest that the carry-over effects are due to the difficulty of subjects in accessing the meaning of the difficult target words.

The occurrence of carry-over effects have also been demonstrated by Haberlandt, et al. (1989). They reported that word reading times of the "N" words were influenced by the features (word length and log frequency) of "N-1" words for fast readers but not for slow readers. They postulated two possible explanations for the observed lag in the processing of fast readers. One, a chunking strategy explanation, which assumes that a fast reader tends to group the adjacent words in a buffer and integrate them later at a marked physical (the end of lines or paragraphs) or linguistic (the end of a clause or sentence) location. As the integration processes take place only at some marked physical or linguistic locations, the carry-over effect could be due to the difficulty of grouping. Secondly, they did not rule out the possibility that the lag may reflect a reader's difficulty in lexical processing of the target word.

Regardless of the way that the presence of carry-over effects is interpreted, the presence of the effects is problematic for the eye-mind assumption (Just & Carpenter, 1980) which postulates that a reader will perform all possible processes, from encoding a word to discourse integration, on a fixated word before moving his or her eyes to the next one. Although they pointed out that information later in the text can modify the interpretation of the current word, they ruled out any overlap of process from one word to the next one. In the present experiment, while the effects of both factors (congruity and difficulty) on word reading times of target-plus-one words violate the eye-mind assumption, the presence of a carry-over of difficulty seems to be a greater violation of the eye-mind assumption,

because it shows that before completion of the very early processes such as lexical access, the subject moves his or her fixation to the next word. Such an obvious violation of eye-mind assumption suggests that the results from studies that have used a single word reading time as an indication of the total underlying cognitive processes associated with that word must be interpreted with caution. These results clearly demonstrated that in order to evaluate all processes related to a target word, in addition to the analysis the target word reading times, the word reading times of the words following the target words should also be considered.

Conclusions

The results of this experiment indicated that sentence context differentially affected lexical and post-lexical processes of a target word in a situation where subjects were reading for comprehension. Consistent with the findings of Stanovich and West (1981, 1983) and Murdaca and Komoda (1990), it was shown that sentence context facilitated the lexical access of the congruous difficult target words. The mechanism for the observed facilitation effect may be attributed to the automatic spread of activation because, if the facilitation effect was due to attentional processes, one would have expected to observe a facilitation effect for congruous easy target words as well, considering that the easy target words were more predictable from context. From the results of this experiment it may be concluded that the process of lexical access for a fluent reader is not guided by attentional processes. Contextual information through the attentional processes, however, affected the post-lexical processing of the incongruous target

words regardless of their difficulty. Contrary to the popular belief that skilled readers are more sensitive to contextual information because it provides a structure for integration of new information and the use of this structure would facilitate the integration of new information (Stanovich, Nathan, West, & Vala-Rossi, 1985), the results from this experiment showed that affects post-lexical processes of a target word in incongruous sentences. This study did not find enough evidence that contextual information provided by a sentence would facilitate the integrative processing of a congruous target word.

References

Balota, D. A. , & Chumbley, J. I. (1984). Are lexical decisions a good measure of lexical access? The role of word frequency in the neglected decision stage. *Journal of Experimental Psychology: Human Perception and Performance, 10*, 340-357.

Balota, D. A. , & Chumbly, J. I. (1990). Where are the effects of frequency in visual word recognition task? Right where we said they were! Comment on Monsell, Doyle, and Haggard (1989). *Journal of Experimental Psychology: General, 119*, 231-237.

Balota, D. A. , & Lorch, R. (1986). Depth of automatic spreading activation: Mediated priming effects in pronunciation but not in lexical decision task. *Journal of Experimental Psychology: Learning, Memory & Cognition, 12*, 336-345.

Balota, D. A. , Pollatsek, A. , & Rayner, K. (1985). The interaction of contextual constraints and parafoveal visual information in reading. *Cognitive Psychology, 17*, 364-390.

Becker, C. A. (1980). Semantic context effects in visual word recognition: An analysis os semantic strategies. *Memory & Cognition, 8*, 493- 512.

Becker, C. A. , & Killion, T. H. (1977). Interaction of visual and cognitive effects in word recognition. *Journal of Experimental Psychology: Human Perception and Performance, 3*, 389-401.

Broadbent, D. E. (1967). Word frequency and response bias. *Psychological Review, 74*, 1-15.

Carroll, P. & Slowiaczek, M. L. (1986). Constraints on semantic priming in reading: A fixation time analysis. *Memory & Cognition, 14* , 509-522.

Collins, A. M. , Loftus, E. F. (1975). A spreading -activation theory of semantic processing. *Psychological Review, 82*, 407-428.

Duffy, S. D. , Henderson, M. , Morris, R. K. (1989). Semantic facilitation of lexical access during sentence processing. *Journal of Experimental Psychology: Learning , Memory & Cognition, 15*, 791-801.

Ehrlich, S. F. , & Rayner, K. (1981). Contextual effects on word perception and eye movements in reading. *Journal of Verbal Learning and Verbal behavior, 20*, 641-655.

Ehrlich, S. F. , & Rayner, K. (1983). Pronoun assignment and semantic integration during reading: Eye movements and immediacy of processing. *Journal of Verbal Learning and Verbal Behavior, 22*, 75-87.

Favreau, M. , Komoda, M. K. , & Segalowitz, N. (1980). Second language readi ;: Implications of the word superiority effect in skilled bilinguals. *Canadian Journal of Psychology, 34*, 470-480.

Fischler, I. , & Bloom, P. A. (1979). Automatic and attentional processes in the effects of sentence context on word recognition. *Journal of Verbal Learning and Verbal Behavior, 18,* 1-20.

Fischler, I. , & Bloom, P. A. (1980). Rapid processing of the meaning of sentences. *Memory & Cognition, 8*, 216-225.

Fischler, I. , & Goodman, G. O. (1978). Latency of associative activation in memory. *Journal of Experimental Psychology: Human Perception and Performance, 4*, 455-470.

Fischler, I. (1977). Semantic facilitation without association in a lexical lexical decision task. *Memory & Cognition, 5*, 335-339.

Forster, K. I. (1981). Priming and the effects of sentence and lexical context on naming time: Evidence for autonomous lexical processing. *Quarterly Journal of Experimental Psychology, 33*, 465-495.

Frazer, L. , & Rayner, K. (1982). Making and correcting errors during sentence comprehension: Eye movements in the analysis of structurally ambiguous sentences. *Cognitive Psychology, 14*, 178-210.

Gough, P. B. (1972). One second of reading. In J. F. Kavanagh & I. G. Mattingly (Eds.), *Language by Eye and Ear*, Cambridge: MIT Press, 331-358.

Gough, P. B. , Alford, J. A., Jr. , & Holly-Wilcox, P. (1981). Words and context. In O. J. L. Tzeng & H. Singer (Eds.), *Perception of Print: Reading Research in Experimental Psychology* . Hillsdale, NJ: Erlbuam.

Haberlandt, K. F. , & Grasser, A. C. (1985). Component processes in text comprehension and some of their interactions. *Journal of Experimental Psychology: General, 114*, 357-374.

Haberlandt, K. F. , & Grasser, A. C.,Schneider, N. J. (1989). Reading strategies of fast and slow readers. *Journal of Experimental*

Psychology: Learning, Memory, and Cognition, 15, 815-823.

Inhoff, A. W. (1984). Two stages of word processing during eye fixations in the reading of prose. *Journal of Verbal Learning and Verbal Behavior, 23*, 612-624.

Inhoff, A. W. & Rayner, K. (1986). Parafoveal word processing during eye fixations in reading: Effects of word frequency. *Perception and Psychophysics, 40*, 431-439.

Just, M. A. , & Carpenter, P. A. (1980). A theory of reading: From eye fixations to comprehension. *Psychological Review, 87*, 329-354.

Just, M. A. , Carpenter, P. A. , & Woolley, J. D. (1982). Paradigms and processes in reading comprehension. *Journal of Experimental Psychology: General, 111*, 228-238.

Kucera, H. , & Francis, W. N. (1967). *Computational Analysis of Present-day American English*. Providence: R. I. Brown University Press.

McClelland, L. , & Rumelhart, D. (1985). Distributed memory and the representation of general and specific information. *Journal of Experimental Psychology: General, 114*, 159-188.

Meyer, D. E. , & Schvaneveldt, R. W. (1971). Facilitation in recognizing pairs of words: Evidence of a dependence between retrieval operations. *Journal of Experimental Psychology, 90*, 227-234.

Meyer, D. E. , & Schvaneveldt, R. W. , & Ruddy, M. G. (1974). Functions of phonemic and graphemic codes in visual word recognition. *Memory and Cognition, 2*, 309-321.

McConkie, G. W. , & Rayner, K. (1975). The span of the effective stimulus during reading. *Perception and Psychophysics, 2*, 157-177.

Morton, J. (1969). The interaction of information in word recognition. *Psychological Review, 76*, 165-178.

Murdaca, L. & Komoda, M. K. (1991). The assessment of context effects in sentence reading using a moving window paradigm. *Canadian Psychology, 32*, Abstracts, 285.

Neely, J. H. (1990). Semantic priming effects in visual word recognition: A selective review of current finding and theories. In D. Besner & Humphreys (Eds.), *Basic processes in reading: Visual word recognition* . Hillsdale, N. J. : Erlbaum, 263-336.

Neely, J. H. (1976). Semantic priming and retrieval from lexical memory: Evidence for facilitatory and inhibitory processes. *Memory & Cognition, 4*, 648-654.

Neely, J. H. (1977). Semantic priming and retrieval from lexical memory: Roles of inhibitionless spreading activation and limited capacity attention. *Journal of Experimental Psychology: General, 106*, 226-254.

Posner, M. I., & Snyder, C. R. R. (1975). Facilitation and inhibition in the processing of signals. In P. M. A. Rabitt & S. Dornic (Eds.), *Attention and Performance V*, New York: Academic press.

Rayner, K. (1977). Visual attention in reading: Eye movements reflect cognitive processes. *Memory & Cognition, 4*, 443-448.

Rayner, K. & Duffy, S. A. (1986). Lexical complexity and fixation times in reading: Effects of word frequency, verb complexity, and lexical ambiguity. *Memory & Cognition, 14*, 191-201.

Rosch, E. (1975). Cognitive representations of semantic categories. *Journal of Experimental Psychology: General, 104*, 192-233.

Rumelhart, D. E & McClelland, L. (1982). An interactive model of context effects in letter perception: part 2. The contextual enhancement of effects and some tests and extensions of the model. *Psychology Review, 89*, 60-94.

Rumelhart, D. E. (1977). Toward an interactive model of reading. In S. Dornic (Ed.), *Attention and Performance VI*, New York: Lawrence Erlbaum Associates, 573-603.

Schubert, R. E. , & Eimas, P. D. (1977). Effects of context on the classification of words and nonwords. *Journal of Experimental Psychology: Human Perception and Performance, 3*, 27-36.

Seidenberg, M. S. , Waters, G., Sanders, M. , & Langer, P. (1984). Pre- and post-lexical loci of contextual effects on word recognition. *Memory & Cognition, 12*, 315-328.

Shebilske, W. L. , & Fisher, D. F. (1983). Eye movements and context effects during reading of extended discourse. In K. Rayner (Ed.), *Eye Movements in Reading: Perception and Language Processes.* New York: Academic press.

Stanovich, K. E. , & West, R. F. (1979). Mechanisms of sentence context effects in reading: Automatic activation and conscious attention. *Memory & Cognition, 7*, 77-85.

Stanovich, K. E. , & West, R. F. (1981). The effect of context on ongoing word recognition: Tests of a two-process theory. *Journal of Experimental Psychology: Human Perception and Performance, 7*, 658-672.

Stanovich, K. E. , & West, R. F. (1983a). On priming by a sentence context. *Journal of Experimental Psychology: General, 112*, 1-34.

Stanovich, K. E. , & West, R. F. (1983b). The generalization of context effects on word recognition. A reconsideration of the role of parafoveal priming and sentence context. *Memory & Cognition, 11*, 49-58.

Stanovich, K. E., & West, R. F., & Feeman, D. J. (1981). A longitudal study of sentence context effects in second-grade children: Tests of an interactive -compensatory model. *Journal of Experimental Child Psychology, 32*, 185-199.

Stanovich, K. E., Nathan, R. G., West, R. F., & Vala-Rossi, M. (1985). Children's word recognition in context: Spreading activation, expectancy, and modularity. *Child Development, 56*, 1418-1428.

Tabachnick, B. G. , & Fidell, L. S. (1983). *Using Multivariate Statistics.* Harper & Row, Publishers, New York.

Tulving, E. , & Gold, C. (1963). Stimulus information and contextual information as determinants of tachistoscopic recognition of words. *Journal of Experimental Psychology, 66*, 319-327.

West, R. F. , & Stanovich, K. E. (1978). Automatic contextual facilitation in readers of three ages. *Child Development, 49*, 717-727.

West, R. F. , & Stanovich, K. E. (1982). Source of inhibition in experiments on the effect of sentence context on word recognition. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 8*, 385-399.

West, R. F. , & Stanovich, K. E. , Feeman, D. J., & Cuningham, A. E. (1983). The effect of sentence context on word recognition in second-and sixth-grade children. *Reading Research Quarterly, 19*, 6-15.

Zola, D. (1984). Redundancy and word perception during reading. *Perception and Psychophysics, 36*, 277-284.

Appendix A

Test sentence frames and target words

(1) The accountant balanced the ____ before he came.
books ledger

The congressman appealed to the ____ for their support.
people constituency

He referred to the ____ we had studied.

(2) The preacher spread the ____ in the town.
word gospel

The cat drank from the ____ on the floor.
bowl saucer

It could have been the ____ that we overlooked.

(3) The movie was at the ____ down the street.
cinema theater

The meal was prepared by the ____ in the kitchen.
cook chef

They said it was the ____ they had visited.

(4) The pianist played at the ____ for the children.
concert recital

The young man was convicted of the ____ by the judge.
crime felony

We all agreed it was the ____ of the century.

(5) The painter fell off the ____ he was using.
ladder scaffold

The election was won by the ____ we had favored.
candidate incumbent

We all saw the ____ you built up.

(6) The man put his leg in the ____ he had bought.
pants trousers

We stayed until the ____ before we left.
end finale

After a while they found the ____ they were seeking.

(7) The coed belonged to the ____ of the university.
group sorority

She walked down the ____ without her bag.
street aisle

This one is the _____ we had photographed.

(8) The insane patient lived in the ____ before he died.
hospital asylum

The waiter handed them the ____ as he left.
check menu

The next thing will be the ____ for the group.

(9) The banker locked the ____ with the money.
safe vault

The tennis player found the ____ on the lawn.
ball racquet

It apparently was the ____ on the floor.

(10) The boy was bitten by the ____ on the farm.
dog mosquito

The awards were presented after the ____ had been announced.
dinner banquet

They were talking about the ____ that was missed.

(11) The prospector found the ____ in the mine.
gold uranium

The honeymooners made up after the ____they had earlier.
fight quarrel

At first it was the ____ that was lost.

(12) The jewel thieves planned the ____ of the bank.
robbery heist

They worshipped in the ____ of the village.
church synagogue

She told her about the ____ in the village.

(13) The lady paid the ____bill before she left.
bill cashier

The bomb destroyed everything in the ____ when it exploded.
area vicinity

At times it is the ____ we purposely avoid.

(14) The house was destroyed by the ____ before we arrived.
fire tornado

The team won the ____ of the year.
game tournament

He said it was the ____ that had ended.

(15) The locomotive pulled into the ____ late at night.
station depot

The couple adopted the ____ from the agency.
child orphan

She said it is the ____they would wash.

(16) The hotel's guests liked the ____ they were given.
rooms accommodations

The city stored water in the ____ they had cleaned.
tank reservoir

We constantly heard about the ____ they would fill.

(17) The climber reached the ____ at supper time.
top summit

The whale was injured by the ____ it ran into.
ship harpoon

Perhaps it could have been the ____ that was hidden.

(18) The body was stolen from the ____ the next morning.
grave morgue

The comb was on the ____ beside the lamp.
table bureau

You were told about the ____ which was dirty.

(19) The game warden fined the ____ for the act.
hunter poacher

The servant made coffee in the ____ after cleaning it.
pot percolator

We all approached the ____ with the coffee.

(20) The general revised the ____ for the attack.
plans strategy

The skier lived in the ____ by the hill.
house chalet

She had thought about the ____ while she worked.

(21) The doctor gave the ____ to the patient.
shot prescription

The artist painted the ____ for his client.
picture mural

We knew it was the ____ you should use.

(22) The car came down the ____ at top speed.
road boulevard

The homecoming was attended by the ____ of the school.
students alumni

He referred to the ____ they would find.

(23) The fisherman exceeded the ____ for the day.
limit quota

The politician attended the ____ as he planned.
meeting convention

It could have been the ____ that was changed.

(24) The cold girl turned up the ____ in the room.
heat thermostat

The anthropologist found the ____ in the cave.
bone artifacts

You were asking about the ____ in the room.

(25) The bodyguard drove the ____ to the house.
car limousine

The mountain climber was buried in the ____ for many hours.
snow avalanche

They said it was the ____they would remember.

(26) The woman dialed the ____ before we came.
number operator

The bridge crossed the ____ for many years.
river ravine

Earlier we felt it was the ____ they should choose.

(27) The interpreter knew the ____ of the people.
language dialect

The baker smelled the ____ after he baked.
bread aroma

They were thinking about the ____ which was unusual.

(28) The train went over the ____ with no cargo.
bridge trestle

The sun was totally hidden by the ____ they had seen.
clouds eclipse

She is asking about the ____we saw yesterday

(29) She ordered the dress from the ____ she had seen.
store catalogue

It is the brightest star in the ____ besides that one.
sky constellations

He wasn't telling us about the ____ we had seen.

(30) The sheriff fired the ____ at the indian.
gun pistols

The soldiers flew in the ____ during the combat.
plane helicopter

They said it was the ____ that was repaired.

(31) The tree was uprooted in the ____ the year after.
flood hurricane

The mortician examined the ____ on the table.
body cadaver

She believed it could have been the ____ which was noticed.

(32) Water dripped from the ____ all night long.
tap faucet

The sick child saw the ____ after he left.
doctor pediatrician

We always thought it was the ____ you really liked.

(33) The cowboy roped the ____ in the pen.
horse mustang

The farmer picked an apple from the ____ on his farm.
tree orchard

It apparently was the ____ up for sale.

(34) The drunkard poured beer into the ____ of his friend.
glass pitcher

The crook was sent to the ____ for his actions.
jail penitentiary

At times it is the ____ which is full.

(35) The patient swallowed the ____ he was prescribed.
pill medicine

The carpenter drove in the ____ with his tools.
nail spike

The next thing will be the ____ in the box.

(36) The flood waters broke over the ____ during the storm.
dam dike

The plane was buffeted by the ____ for some time.
wind turbulence

In many cases it is the ____ which causes problems.

(37) Behind the wheel was the ____ of the car.
driver chauffeur

The hay was in the ____ for the winter.
barn loft

You were asking about the ____ we had used.

(38) The housewife waxed the ____ in the kitchen.
floor linoleum

The ship was in the ____ two days ago.
water harbor

She said it was the ____ they would clean.

(39) The dentist filled the ____ of the child.
tooth cavity

The girl skated across the ____ in the park.
ice rink

We thought it was the ____that was repaired.

(40) The lamp provided the ____ for the room.
light illumination

The gardener dug with the ____ he had found.
shovel trowel

We all agreed it was the ____ that was needed.

(41) The wine was served from the ____ they had brought.
bottle decanter

Music blared from the ____ across the hall.
speaker jukebox

Earlier we felt that it was the ____ which we broke.

(42) The bartender served the ____ to the guests.
drinks cocktails

The boy handed his date the ____ he had bought.
flowers corsage

You were told about the ____ which we sent.

(43) The biologist examined the ____ under the light.
slide specimen

The school allows no running in the ____ during class time.
hall corridor

We knew it was the ____ used by him.

(44) The country was ruled by the ____ for many years.
king dictator

The radiation caused the ____ they were experiencing.
illness mutation

We knew it was the ____ you investigated thoroughly.

(45) The driver stepped on the ____ after the curve.
gas accelerator

The barber trimmed the ____ of his customer.
hair mustache

He assumed it was the ____he complained about.

(46) The bride drank the ____ at the reception.
punch champagne

The singers clapped their hands to the ____ of the music.
beat rhythm

I heard that it was the ____ that was good.

(47) The speaker stood at the ____ during his speech.
front podium

The witness confirmed the ____ of the suspect.
story alibi

Perhaps it could have been the ____ which was bad.

(48) The antiseptic killed the ____ in the glass.
germs bacteria

The stars of the circus were the ____ with red suits.
clowns acrobats

He wasn't telling us about the ____ in the room.

Appendix B

Practice sentences and filler sentences

Practice Sentences

In many cases it is the earthquake that ends everything.

We constantly saw the numbers they would buy.

The mechanic adjusted the parcel of the car.

The meteorologist forecasted the weather we all feared.

The spider slowly crawled up the web in the room.

The previous one had been the merchandise we waited for.

The gardener fertilized the channel in the yard.

The dictionary contained all the synonyms we had used.

It could have been the sandals we had found.

The swimmer swam across the plant without any help.

This one is the degree they talked about.

The fatigued athlete ran the race in record time.

The mathematician added the food to the equation.

The student studied the definition in the book.

Filler Sentences

The mailman delivered the motor early this morning.

We all agreed it was the marathon he participated in.

They were thinking about the letter we had forgotten.

The pirates hid the loot on the island.

The overturned truck dropped the earth it was carrying.

The rain swept through the certificate without any warning.

The shoemaker repaired the shoes he was given.

The first item was the gift for the baby.

The squirrel hid the digit in the tree.

The university graduate was handed the town at the ceremony.

The cook was busy in the galley for many hours.

The actor was not pleased with the arm he had seen.

The repairman adjusted the rehearsal of the television.

Many had hoped for the arrival of the cure.

The bug slowly crawled up the wall in the room.

The divers swam in the sea throughout the morning.

All had approved the brakes for public use.

The tired infant was placed in the culprit for the night.

The babysitter played with the children in the room.

The surgeon performed the crib on the patient.

She most likely had the money in the house.

In church we spoke to the parson before the service.

The skilled seamstress adjusted the mirror in her hand.

We had all argued that the umbrella would be lost.

Appendix C

Comprehension task for Set 1.1

(All other sets followed the same format)

Comprehension Test:

After reading each block of seven sentences from the computer screen, the subjects were presented with the following statement:

" The sentence below is a paraphrase of one of the previous seven sentences"

TRUE OR FALSE

The second sentence of each pair is the paraphrased sentence which the subjects were to answer to, and the first ser nce of the pair is the original sentence from the block of seven se. s. The italic words show the elements of the original sentences which were changed in order to make a false paraphrase.

The comprehension tests for the practice session:

(1) The meteorologist forecasted the weather we all feared.
The weather we all feared was forecasted by the meteorologist

(2) The *swimmer* swam across the plant *without any help.*
The *runner* swam across the plant *with some help.*

The comprehension tests for the experimental sentences:

(1) The tennis player found the racquet on the lawn.

The racquet was on the lawn where the tennis player found it.

(2) She ordered the dress from the store she had seen.

She *tried* the *cake* from the store she had seen.

(3) The plane was buffeted by the dike for some time.

The dike buffeted the plane for some time.

(4) The crook was sent to the pitcher for his actions.

For his *appearance* the crook *climbed* to the pitcher.

(5) We all agreed it was the light that was needed.

The kids all agreed it was the color that was needed.

(6) It apparently was the vault on the floor.

The vault on the floor was the one.

(7) The biologist examined the slide under the light.

The slide under the light was *broken* by the *chemist*.

(8) The tree was uprooted in the flood the year after.

The flood uprooted the tree the year after.

(9) The squirrel hid the digit in the tree.

The digit was hidden by the squirrel in the tree.

(10) He wasn't telling us about the catalogue we had seen.

We were told about the catalogue we had seen.

(11) The servant made coffee in the percolator after cleaning it.

The coffee was *poured* into the clean percolator by the student.

(12) The skier lived in the strategy by the hill.

The skier escaped in the candle by the hill.

(13) The team won the tornado of the year.

The tornado of the year was won by the team.

(14) He referred to the ledger we had studied.

We had studied the ledger he had referred to.

(15) The jewel thieves planned the church of the bank.

The *moon* of the bank was planned by the *movie stars*.

(16) The climber reached the top at supper time.

It was supper time when the climber reached the top.

(17) The mountain climber was buried in the avalanche for many hours.

The *bird watcher* was buried for many hours in *the well.*

(18) I heard that it was the punch that was good.

I heard that the good thing was the punch.

(19) She told her about the robbery in the village.

He heard about the party in the village.

(20) The waiter handed them the asylum as he left.

As he arrived the president handed them the asylum.

(21) The train went over the clouds with no cargo.

The train with no cargo went over the clouds.

(22) The pianist played at the crime for the children.

The pianist played for the children at the crime.

(23) The bomb destroyed everything in the vicinity when it exploded.

Nothing in the vicinity was damaged when the tank exploded.

(24) The wine was served from the bottle they had brought.

They had brought the bottle from which the wine was served.

Appendix D

Summary ANOVA tables

Table D-1

Summary table of ANOVA for the reading times of the target words.

SOURCE	df	MS	P	F
SEX (A)	1	33.195	0.000	0.987
ERROR	30	126321.793		
CONTEXT (B)	2	9929.085	4.539	0.015
ERROR	60	2187.378		
A X B	2	3192.078	1.459	0.241
ERROR	60	2187.378		
DIFFICULTY(C)	1	159630.906	25.705	0.001
ERROR	30	6210.022		
A X C	1	1659.207	0.267	0.609
ERROR	30	6210.022		
B X C	2	9242.747	5.338	0.007
ERROR	60	1731.462		
A X B X C	2	439.942	0.254	0.776
ERROR	60	1731.462		

Table D-2

Summary table of ANOVA for the reading times of the target-plus-one words.

SOURCE	df	MS	P	F
SEX (A)	1	6353.165	0.124	0.727
ERROR	30	51177.616		
CONTEXT(B)	2	51806.258	26.021	0.001
ERROR	60	1990.972		
A X B	2	149.870	0.075	0.928
ERROR	60	1990.972		
DIFFICULTY(C)	1	34167.875	21.417	0.001
ERROR	30	1595.367		
A X C	1	413.586	0.259	0.614
ERROR	30	1595.367		
B X C	2	1836.974	2.780	0.070
ERROR	60	660.803		
A X B X C	2	1777.633	2.690	0.076
ERROR	60	660.803		

Table D-3

Summary table of ANOVA for the summed word reading times of the target and target-plus-one words.

SOURCE	df	MS	P	F
Gender (A)	1	5467.895	0.018	0.895
ERROR	30	306605.882		
DIFFICULTY(B)	2	106611.400	18.830	0.001
ERROR	60	5661.759		
A X B	2	4385.917	0.775	0.465
ERROR	60	5661.759		
CONTEXT (C)	1	341504.555	44.596	0.001
ERROR	30	7657.816		
A X C	1	3729.565	0.487	0.491
ERROR	30	7657.816		
B X C	2	19170.506	8.307	0.001
ERROR	60	2307.639		
A X B X C	2	3670.754	1.591	0.212
ERROR	60	2307.639		

Table D-4

Summary table of ANOVA for the reading times of the last words.

SOURCE	df	MS	P	F
SEX (A)	1	21943.235	0.011	0.917
ERROR	30	1970702.840		
CONTEXT(B)	2	7 58101.058	15.087	0.001
ERROR	60	50249.010		
A X B	2	12207.838	0.243	0.785
ERROR	60	50249.010		
DIFFICULTY(C)	1	29073.910	1.231	0.276
ERROR	30	23622.195		
A X C	1	12202.868	0.517	0.478
ERROR	30	23622.195		
B X C	2	12216.440	0.972	0.384
ERROR	60	12564.843		
A X B X C	2	10678.576	0.850	0.433
ERROR	60	12564.843		