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THE EFFECT OF PREVIOUS CONTEXT ON READING INDIVIDUAL WORDS

Glenn M. Kleiman

University of Illinois at Urbana-Champaign

February 1977

Center for the Study of Reading

UNIVERSITY OF ILLINOIS
AT URBANA-CHAMPAIGN
1005 West Nevada Street
Urbana, Illinois 61801

BOLT BERANEK AND NEWMAN INC.
50 Moulton Street
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ABSTRACT

The aim of this study was to determine whether a general or specific context facilitation mechanism should be incorporated into information processing models of reading. General facilitation models, such as the logogen (Morton, 1969) and spreading activation (Collins & Loftus, 1975) models, claim that a context can facilitate recognition of any word that is related to it. Specific facilitation models claim that a context will facilitate recognition of only those words that are highly expected on the basis of the context. That is, specific models predict facilitation for a subset of those words for which facilitation is predicted by general models.

Three experimental procedures were used. The first required a lexical decision (word or nonword?) about a test item that was sometimes preceded by a context (a sentence with the final word deleted, e.g., The cup was placed on the). There were three types of test words: (1) words highly expected on the basis of the context, such as table for the above example (set E); (2) words related to the expected words, such as chair (set R); and (3) words unrelated to the expected words, such as floor (set U). The last two types of words were equated for how well they completed the sentence frames. Lexical decision times for the three word types without context did not differ significantly. With context, the decision was much faster for the E set than for the other two. This would be predicted by both types of models. The more important finding is that with context decision time for the R set was significantly less than for the U set. This would be predicted by general models, but not by specific models. However, this finding does not eliminate the possibility that general and specific mechanisms operate in conjunction.

The other two experimental procedures did not yield any information that favored either type of model. One experiment used a successive lexical decision task in which subjects make word/nonword decisions about two words. It has previously been shown that recognition of the second word is facilitated when it is a word that is often elicited by the first word in a free association task (e.g., hot - cold). Both general and specific models can account for this result. The experiment was designed to determine if facilitation also occurs when the first word does not elicit the second, but the two are related (e.g., hot - summer). Only general models predict facilitation for these pairs. The results were inconclusive: The related but not associated word pairs did not show a significant amount of facilitation, but they did not show significantly less facilitation than the associated pairs.

The final experiment used a sentence acceptability judgment task. Subjects read a sentence frame and decided if a presented word formed a semantically acceptable completion. The stimuli of interest consisted of a subset of the R and U sets used in the first procedure. This task is a step closer to normal reading than the lexical decision task, since it is necessary to integrate the meaning of the final word with the rest of the sentence. However, this means that additional processes are involved in this task. Reaction times were much longer and variable than those in the lexical decision task and no significant differences were found between the two key sets of words.

Overall, the experiments provide some evidence for a general facilitation context mechanism but don't eliminate the possibility that a specific facilitation mechanism is also operating. To determine whether these results should influence the construction of models of reading, tentative criteria are proposed for deciding whether an experimental effect needs to be accounted for by models of reading.

CHAPTER 1

Introduction

The importance of the study of reading cannot be denied. The need for applied research contributing to the teaching and learning of reading is frequently expressed. The theoretical importance of the study of reading was well described by Huey:

> To completely analyze what we do when we read would almost be the acme of a psychologist's achievements, for it would be to describe very many of the most intricate workings of the human mind (1908, p. 6).

Much of the early research in American psychology focused upon reading. This is witnessed by Huey's classic book, almost 70 years old, which discusses many aspects of reading and contains a great deal of information of interest to current researchers. Woodworth's 1938 volume, Experimental Psychology, contains an excellent chapter on reading that is also still of interest. With the onset of the behavioristic domination of American psychology, empirical work in reading took a sharp decline. The 1954 version of Experimental Psychology (Woodworth & Schlosberg) did not have a chapter on reading. In the 1971 version (Kling & Riggs) the only indexed references to reading list pages in chapters on effector mechanisms in vision and on shape perception. Many of the fascinating aspects of reading were totally neglected.

In recent years there has been a recovery from this neglect and many studies on various aspects of reading have appeared in the psychological literature. Much of this work follows an information processing approach. The information processing approach is often thought of in terms of the computer metaphor: Mental processing is described in terms of a computational system that transforms an input into an output. In a model of reading, written text would be the input and an internal representation of the meaning or information contained in the text would be the output. The model itself would attempt to specify the sequence of processes involved in transforming the input into the output.

The components of information processing models can be divided into three sets: processing mechanisms, knowledge bases and temporary storage buffers. One set contains processing mechanisms which transform inputs into outputs. For example, one type of processing mechanism recodes the input into its equivalent in another modality (e.g., converts printed words into their spoken equivalents). Another type of processing mechanism compares two input elements and outputs a match or mismatch decision.

An information processing model of a complex mental ability such as reading consists of a series of stages, each of which contains at least one processing mechanism. The first stage processes or transforms the input to the model in some way. The end result of this processing is the output of the first stage, which serves as the input to the second stage, and so on until the final stage, the output of which is the output of the entire model. The stages are viewed as representing mental processes that occur in real time. Therefore, information processing models are often tested via predictions about the relative reaction times to make various decisions.

The second set of components consists of knowledge bases. These contain permanently stored information that must be available for processing to occur. The information must be organized in some way so that it can be rapidly retrieved. Examples of knowledge bases necessary for reading include knowledge of the letters represented by particular visual patterns and knowledge of the meanings of individual words.

The remaining set of components consists of temporary storage buffers. In order to see the need for this type of component, consider the case where stage n operates upon individual words one at a time, while the next stage, n+1, operates upon strings of words. That is, stage n+1 cannot operate until stage n has undergone several sequential operations. The ouput of stage n must therefore be stored until enough has collected for the processing that occurs in stage n+1. Therefore, a temporary storage buffer is necessary. Storage buffers can be found in most information processing models under such names as iconic storage, sensory-information-storage, short-term memory and working memory.

The questions that information processing psychologists ask reflect the types of models they construct. Many studies have investigated whether a given stage is necessary for a given task; for example, whether a recoding to speech stage is necessary before a written word can be understood (Baron, 1973; Kleiman, 1975; Meyer, Schvaneveldt, & Ruddy, 1974a; Rubenstein, Lewis, & Rubenstein, 1971). The goal of other studies has been to explicate the details of particular components that appear in information processing models. For example, many studies have explored whether the visual characteristics of a string of letters are determined in sequence or in parallel (Smith & Spoehr, 1974, review this work). Other studies have considered the form and organization of certain classes of knowledge. Examples include work on the representation of word meanings in "semantic" memory (Smith, 1976) and attempts to determine whether knowledge about spelling patterns is in the form of productive rules or memorized units (Baron & Strawson, 1976). Others have attempted to determine characterists of the various temporary storage buffers, such as their storage capacity and the temporal parameters of the loss of information (Klatzky, 1975, Chapters 3, 5, 6).

Information processing models of reading can be found in Venezky and Calfee (1970), Geyer (1972), Gough (1972), Kleiman (1975), Massaro (1975) and elsewhere.[1] All of these models contain similar components. In any model of reading, processing components are necessary for perceiving the written words (visual encoding), retrieving information stored in memory about individual words (lexical access), determining the syntatic characteristics of sentences (parsing procedures), combining the meanings of individual words to form a representation of the meaning of the sentence or some other linguistic unit (combinatorial procedures), and combining what is being read with previous knowledge (integrative processes). Temporary storage buffers are also necessary for such things as holding theoutput of visual encoding and lexical access to enable later processing to occur. Various knowledge bases are also necessary. The reader uses knowledge of the orthographic constraints of English (Baron, 1976), knowledge about the meanings and possible syntactic categories of individual words, knowledge of the syntax of English, and so on.

Information processing models of reading have the potential to characterize the complex processing involved in reading in interesting ways. In fact, this approach has yielded new insights into some old questions about reading (cf. Baron, 1976; Kleiman, 1975). The information processing

[1] These models all describe the processes used by skilled (i.e., college level) readers and this is the only population which will be considered here.

approach yields more analytic information and avoids some of the problems of other commonly used approaches to studying reading, such as those based on factor-analytic techniques (Holmes, 1970), or those which describe reading as a single wholistic process (Goodman, 1970; see Smith & Kleiman, 1976, for further discussion). However, there is at least one major problem with most available information processing models of reading: They ignore the possibility that the later or higher order processing stages may feedback and affect processing at the earlier stages (Rumelhart, 1976). That is, most available models are entirely "bottom up," driven by sensory input, without any contribution of "top-down" conceptual organization processes. There is evidence that context can affect processing at the letter, word, sentence and paragraph levels (Rumelhart, 1976). Bottom up models cannot account for these effects of context.

This dissertation will focus upon a limited domain of context effects: The effects of previous context on reading individual words. Most information processing models do not contain a mechanism which enables the interpretation of the first few words of a sentence to feedback and affect reading the later words. There is some evidence that such a mechanism is necessary in a model of reading. The next chapter describes this evidence and reviews the available work on how this mechanism might operate. Although a variety of processes have been hypothesized, little is known about how context affects reading individual words. The aim of this dissertation is to determine some of the characteristics of this context effect. Chapters 3, 4, and 5 describe experiments aimed at further determining how previous context affects reading individual words. Chapter 6 summarizes the experiments, draws some tentative conclusions, and discusses the relevance of this work to models of reading.

CHAPTER 2

Literature Review

The psychological literature contains innumerable studies of context effects. This chapter contains a review of this literature, divided into three sections. The first section briefly summarizes context effects in several different tasks. The second contains a detailed description of the most directly relevent studies, those on the effects of previous context on processing individual words. Models that can account for these empirical findings are discussed in the final section.

I. Context effects in a variety of tasks

There are many studies which consider how context affects some aspect of reading other than the processing of individual words. Some of these have demonstrated that previous context affects the types of errors made in oral reading, both by young children (Weber, 1970) and by adults reading text transformed to make the task more difficult and thereby increase the frequency of errors (Kolers, 1970). Also in oral reading, Levin and Kaplan (1970) showed that context affects the eye-voice span (measured by suddenly removing the text someone is reading aloud and measuring how much more of it they can report). In a study of silent reading, Marcel (1974) demonstrated that context can increase the functional visual span--the amount of information that is taken in during a single eye fixation. He also demonstrated that the better readers show a larger context effect.

There is an abundant literature comparing the identification of an individual letter with the identification of a letter within a string of random letters, within a pseudoword (a nonword that follows the orthographic constraints of English), and within a word (Reicher, 1969;

Wheeler, 1970; Baron, & Thurston, 1973; Baron, 1976). These studies have repeatedly demonstrated that a letter is more accurately identified when presented in the context of a word or pseudoword than when presented in the context of a random letter string or when presented alone. That is, the context of a word or pseudoword facilitates the identification of individual letters. This effect has lead to models in which units larger than single letters, such as letter groups, syllables and whole words, play a role in the early visual encoding stage of reading (Estes, 1975; Massaro, 1975; Smith, & Kleiman, 1976). When more is known about the effect of context on reading words, a comparison of context effects involving individual letters and those involving words may be fruitful. However the possibility of fundamental differences between previous and simultaneous contexts must be kept in mind.

There is also a large literature on the effect of context on processing spoken words. For example, Miller and Isard (1963) found that the more predictable a word is from context, the more often it is correctly identified when presented in noise. Pollack and Pickett (1964) found that spoken words identifiable in context often are not identifiable when presented alone. Clearly, context can facilitate the recognition of spoken words.

Context effects have also been demonstrated in processing nonlinguistic materials. For example, Biederman (1975) found when a briefly presented picture of a real world scene was jumbled, the accuracy of identifying a cued object was less than when the scene was coherent. This effect held even when the subject knew where to look and what to look for. Thus, context can facilitate recognizing a picture of an object. In another study using non-linguistic materials, Pomerantz and Sager (1975) demonstrated a "configural superiority effect" with line segments. They showed that the addition of a context line can facilitate judging the shape of line segments same or different. They consider this finding to be analogous to the finding that identifying a letter is easier when it is presented within a word then when presented alone.

Context effects have been demonstrated in a wide variety of tasks, including oral reading, recognizing briefly exposed letters, identifying spoken words, and perceiving scenes and patterns. Unfortunately, the literature contains little more than demonstrations: There is very little of interest at a theoretical level to account for the results.[2] There has also been very little consideration given to the similarities and differences among various context effects. Apparently little work has been directed towards determining whether the same principles govern context effects with spoken and written language, or with linguistic and nonlinguistic materials, or with simultaneously and previously presented contexts.

II. The effects of previous context on processing individual words

Empirical studies of context effects on reading individual words can be divided into two sets according to the experimental technique used. One set consists of studies using brief tachistoscopic exposures of words. The data collected in these consists of visual duration thresholds (the minimal length of exposure at which the stimuli can be correctly reported)

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[2]There is interesting theoretical work on the effects of context on recognizing individual letters. The models that account for the empirical results (e.g., Estes, 1975) postulate units larger than individual letters, such as letter groups, syllables and whole words, are stored in memory. Clearly one would not want to take an analogous course of action and claim all sentences that show context effects are stored in memory as single units.

and the erroneous reports of the presented stimuli. In the other set of studies, subjects decided whether a string of presented letters forms a word (a lexical decision task) and reaction times and error rates were measured.

A. Tachistoscopic recognition experiments. The earliest study of context effects still cited is that of Pillsbury (1897). He presented subjects with a brief exposure of words with missing letters, substituted letters, or an x typed over another letter, and studied the differences between what subjects reported and the presented stimuli. In one condition a context consisting of a single word preceded the tachistoscopic exposure. The finding of interest is that context often acted to conceal a change in a word. For example, a context consisting of the word sky increased the probability that the presented string eanth would be reported as earth.

The first well known relevant study from after the rebirth of cognitive psychology is that of Tulving and Gold (1963). In their first experiment they determined the visual duration threshold for nine letter "target" words, using the method of ascending limits. For each target word a nine word sentence was produced so that the target word occurred last. Examples include: Three people were killed in a terrible highway collision and The actress received praise for being an outstanding performer. One important variable was the amount of context the subject was given to read before the trial. This ranged from no context to the entire eight word sentence frame, with intermediate values of the final 1, 2, or 4 words of the sentence frame. Another important variable was whether the context was congruous or incongruous. Incongruous context were formed by interchanging target words, yielding combinations such as: Three people were killed in a terrible highway performer and The actress received praise for being an outstanding collision.

The results showed that the congruous context decreased recognition threshold (i.e., facilitated word recognition), while the incongruous context increased the threshold (i.e., inhibited word recognition), relative to the no context condition. Furthermore, the amount of facilitation or inhibition increased as the length of the congruous or incongruous context increased. However, there are several problems with this experiment that make the value of these results questionable. The major problem is the results may be entirely due to the subjects guessing, and therefore not tell us anything about how context affects the recognition of individual words. In the instructions Tulving and Gold used, subjects were encouraged to guess when in doubt about the identity of the target word. The possibility of a guessing artifact is increased by the fact that only ten different target words were used and each subject was shown each word in a variety of contexts. Also, in the procedure used for each trial, the exposure duration was gradually increased until the word was correctly identified, without any consideration of the incorrect reports which may have provided evidence whether guessing occurred. Later studies reviewed below eliminated these problems. However, none of these studies have attempted to replicate the finding that incongruous context increased recognition threshold.

In a second experiment, Tulving and Gold eliminated the problem of subjects being shown each target word in many different context conditions. Each subject provided one visual duration threshold per word.

The same target words as in the previous study were used, but there were only three context conditions: no context, four word congruous context, and eight word congruous context. The results showed that context decreased threshold and the longer context yielded a lower threshold than the shorter.

Tulving and Gold showed that a measure of the degree of congruity between the context and the target word accounts for a very large proportion of the variance in thresholds, much more than is accounted for by the length of the context. This measure of congruity consists simply of the proportion of subjects who produced the target word when given the context and asked to produce a final word.[3] That is, the reduction in threshold is accounted for by a measure of the number of subjects who respond with the target word without receiving any stimulus information at all. This is consistent with the simple guessing interpretation of their results.

Morton (1964) provided additional evidence that Tulving and Gold's (1963) measure of congruity predicts the reduction in visual duration threshold with context. Each of Morton's target words appears in three conditions: (1) preceded by a highly congruous context; (2) preceded by a less congruous context and (3) without any preceding context. Congruity of context for a given word was determined by the proportion of subjects who filled in that word as a completion when given the context. There were no incongruous contexts. The results were clear cut: Visual duration threshold decreased as the congruity of the context increased.

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[3]Different subjects from the same college population were used in the recognition and production tasks.

Morton argues that his results cannot be accounted for by simply guessing. Each subject was presented with each target word in only one of the three context conditions, so guessing based on expecting words to be repeated should not be a problem. Subjects were asked to report the word or part of it they saw, and instructed not to guess. Morton reports several types of evidence that subjects followed these instructions. For example, at very short exposure durations the probability of a correct response was very low (much lower than the probability of guessing the target) and not affected by the degree of congruity with the context. Furthermore, there were errors that were incongruous with the context and there were frequent erroneous reports of words of the same length and with the same initial and final letters as the target. Therefore, subjects certainly were attending to the stimulus.

Since simple guessing seems to be eliminated, Morton concludes that in the presence of context fewer visual cues were required for a word to be identified. The model he proposes to account for this results will be discussed later.

Tulving, Mandler and Baumel (1964) tested three hypotheses about how stimulus and context information combine to determine the threshold for a target word. One hypothesis is that the stimulus and context effects are independent and therefore additive. This hypothesis can be characterized by the following formula:

$$(1) \quad p_{d,c} = p_d + p_c - p_d p_c$$

where p_d is the probability of correct response at a given exposure duration without any context information, p_c is the probability of correct response for a given context without any stimulus information, and $p_{d,c}$ is the probability of a correct response given both context and stimulus information. The second hypothesis is that the two sources are redundant so that:

$$(2)\quad p_{d,c} = p_c \text{ if } p_c > p_d$$

$$(3)\quad p_{d,c} = p_d \text{ if } p_d > p_c$$

The third hypothesis is that the two sources of information interact to facilitate recognition over and above the value predicted by the additive and independent hypothesis characterized in formula (1). This hypothesis predicts:

$$(4)\quad p_{d,c} > p_d + p_c - p_d p_c$$

Tulving <u>et al</u>. (1964) used a procedure similar to Tulving and Gold (1963) to test these hypotheses. They used 18 target wrods, each of which was the final word of a nine word sentence. Before an exposure of the target word, the subject received either no context, the entire eight word context, the last two, or the last four words of the context. All contexts were congruous with the target word exposed. Each target word was presented once at each exposure duration for each subject, so the measure of interest is the proportion of subjects correctly identifying a target word at a given exposure duration and a given condition.

The results support the third hypothesis (formula (4)), which states that the two sources of information interact to facilitate recognition. However, this conclusion depends on using probability of correct recognition as the response measure. Other measures may lead to different conclusions. For example, the use of a logit transformation of the observed response probabilities (logit p = $\log \frac{p}{1-p}$, where p is the probability of a correct response) leads to the conclusion that information from the two sources is additive. Therefore whether the two sources of information are additive or interactive cannot be determined until the use of a particular response measure can be justified.

B. Lexical decision experiments. Meyer and his associates (Meyer & Schvaneveldt, 1971; Meyer, Schvaneveldt, & Ruddy, 1972; Schvaneveldt & Meyer, 1973; Meyer, Schvaneveldt, & Ruddy, 1974) have used reaction time measures and the lexical decision task to study the effects of context on processing individual words. In these studies the context consisted of an individual word. In an experiment by Meyer and Schvaneveldt (1971) subjects saw two simultaneously presented strings of letters (e.g., BREAD - BUTTER, WINE - PLAME, NART - TRIEF) and had to decide whether or not both strings formed words. The pairs in which both strings formed words were of two types: Those in which the words were associated (e.g., BREAD - BUTTER, NURSE - DOCTOR) and those in which the words were unassociated (e.g., NURSE - BUTTER, BREAD - DOCTOR). The result of interest is that reaction time to decide that both were words was less for the associated pairs than the unassociated pairs. That is, an associated word context facilitates the lexical decision. The same finding holds when the letter strings are presented sequentially and just the reaction time for the second string is considered. Several other studies have explored this associated context effect further.

Meyer et al. (1974) attempted to determine the temporal course of the associated context effect in lexical decisions. They sequentially presented two strings of letters and required a word or nonword decision for each. The delay between the response to the first string and the onset of the second was either 0, 1500, or 4000 milliseconds. When both strings formed words, they were either associated or unassociated. The results show an association effect at all three delays, although it decreased slightly as the delay increased. Meyer et al., therefore have demonstrated that this effect both occurs rapidly (at the 0 delay condition) and lasts a long time, at least when the subject does not have to attend to anything during the delay.

In another study, Meyer et al. (1974) assumed that at least three independent stages are involved in making a lexical decision: stimulus encoding, lexical-memory retrieval, and response execution. They attempted to determine whether the encoding or retrieval stage is the locus of the context effect. To do so, the additive stage logic described by Sternberg (1969) was used. They assumed that degrading the stimulus would affect the encoding stage. If the associated context also affects the encoding stage, the effects of stimulus degradation and context should interact. If context affects the retrieval stage, the effects of degradation and context should be additive. The results of their experiment show that stimulus degradation and context interact, so they concluded that context affects encoding. However there are two weaknesses in their argument.

First of all, Meyer et al., never provided evidence that their stages are independent. That is, they do not demonstrate any effect on the lexical decision task that does not interact with stimulus degradation. Furthermore, they argue that stimulus degradation must affect an encoding stage, but not substantially affect later processing. In support of this they cite evidence that the initial encoding stage includes a grapheme-to-phoneme transformation. If further processing operates upon this transformed information, the effect of degradation should be specific to the encoding stage. However, the evidence in support of the grapheme-to-phoneme transformation in encoding is very weak (Meyer & Ruddy, 1973; Kleiman, 1975), and so the argument that degradation effects are specific to encoding is not convincing. With these weaknesses, this work does not provide strong evidence about the locus of the context effect.

Meyer et al. (1972) and Schvaneveldt and Meyer (1973) have used another variation of the lexical decision procedure to test three models that might account for their effect. One is the spreading activation model. Their version of this model claims that related words are stored near one another and that accessing a given memory location causes a spread of activation to other nearby locations. The activation of these locations facilitates the subsequent retrieval of information stored there.

The second model is a location shifting model. This claims that word recognition involves a process like retrieving information from a magnetic tape. Again it is assumed that related words are stored near each other. The model claims that memory locations are searched serially, that time is required to shift from one location to the next, and that shifting time increases with the distance between locations.

The spreading activation and location shifting models both claim that the association effect in the lexical decision task depends upon processes involved in retrieving information form memory. An alternative to this is found in the semantic comparison model, which attributes the association effect to changes in the subject's response criterion as a function of semantic similarity of the presented words. Meyer et al derive this model from one proposed by Schaeffer and Wallace (1970). Similarity is claimed to induce a bias in favor of positive (word) responses and a bias against negative (nonword) responses. Since many associated words are semantically similar, a bias towards the positive response would be induced, thereby facilitating that response. This facilitation would not occur for unassociated word pairs.

In an experiment designed to test these three models (Meyer et al., 1972), three strings of letters were presented one at a time and subjects had to press a word or nonword response button after each string. There was a 250 millisecond interval between the subject's response to one string and the appearance of the next string. Various combinations of nonwords, associated words and unassociated words were used. Only those combinations for which differences are predicted by the models will be reported here.

According to the location shifting model, when associated words are separated by an unassociated word (e.g., BREAD - STAR - BUTTER) retrieval of the lexical information for the two associated words will be separated by retrieval for the unassociated word. Since according to this model the unassociated word is not stored near the others, no facilitation would be predicted. The other two models predict there will be facilitation in this situation. The results support this prediction and are inconsistant with the location shifting model.

The semantic comparison model predicts that when the first two strings are associated words, a bias to respond that the final string forms a word, and against responding that it is a nonword, is induced. Therefore, this model predicts that it should take longer to decide that a string of letters does not form a word when it is preceded by two associated words than when it is preceded by two unassociated words. This prediction is not supported by the data. Therefore, the results of Meyer et al. study support the spreading activation model.

III. Models of the effects of context on reading individual words

Collins and Loftus (1975) present a spreading activation model which is consistent with that of Meyer et al. Since they provide a more detailed description of the model, Collins and Loftus' model will be used to represent the set of spreading activation models. Morton (1969) presents a logogen model which differs in form from the spreading activation model, but makes identical empirical predictions. Both the spreading activation and logogen models predict a context will facilitate (to varying degrees) the recognition of all words semantically related to it. The spreading activation and logogen models are summarized below and the reasons they make this prediction are discussed. These two models are examples of general facilitation models: They predict that one context can facilitate recognition of a large set of words. An alternative type of model, specific facilitation models is also discussed.

According to specific facilitation models, a context can facilitate recognition of only a small set of words; those words the context leads the reader to expect.

General facilitation models and specific facilitation models can both account for the available empirical findings. However, there are differences between these two types of models that are empirically testable. Chapters 3, 4, and 5 describe experiments aimed at determining which type of model gives a better account of the effects of previous context on reading individual words.

In the Collins and Loftus spreading activation model a concept (which is regarded as a particular sense of a word or phrase) is represented by labelled relational links from the concept node to other nodes which designate the concepts of the properties. For example, the node representing the concept apple is linked to nodes representing the concepts fruit, food, round, red, etc.

The links have labels designating the types of relationships between the concepts. Several types of links are given special attention, such as subordinate and superordinate. However, the label on a link can itself be a concept, so any relationship can be designated. Links also have criteriality markings which indicate how essential each link is to the concept. For example, the link from apple to fruit will have a higher criteriality than the link from apple to red. Two related concepts will usually have links in both direction (e.g., a subordinate link one way, a superordinate link the other), and the link in each direction will have its own criteriality marking. Collins and Loftus also use a notion of strength or accessibility of links, but refuse to commit themselves as to whether this is equivalent to the criteriality of a link.

When context primes or activates a concept, activation spreads from the concept node along the paths of the network, activating each node it reaches. The activation of a node by context makes that node easier to access, so less sensory information will be needed to access it. The amount of activation that spreads from one node to another is inversely proportional to the accessibility or strength of the link between them. Activation is like a signal from a source that is attenuated as it travels outward. The total amount of activation that spreads from one concept to another is also affected by the number of intermediate paths connecting the nodes. For example, Collins and Loftus point out that if fire engine is primed by vehicle it will in turn prime truck, bus, ambulance, etc., and each of these will in turn activate the others.

On the surface, Morton's logogen model seems quite different from the spreading activation model. In his model there is a logogen for each word. A logogen is a device that accepts both sensory and contextual information relevant to the word. In reading, sensory information is in the form of visual attributes, context information is in the form of semantic attributes. The logogen registers the number of relevant attributes that occur, regardless of the source, on some sort of internal counter. When the counter passes a threshold value, the word represented by the logogen becomes available; i.e., has been recognized. Context facilitation occurs for a given word when the context provides some relevant semantic features, since these would increment the counter and therefore less sensory information would be needed for recognition. The amount of facilitation depends on the number of semantic attributes the word shares with the context.

The logogen and spreading activation models are similar in a basic way. Consider how each accounts for the context effect found by Schvaneveldt and Meyer (1973). In the spreading activation model the node representing the context word is activated and activation spreads from this node to related concept nodes. The activation of these related concepts facilitates accessing them. In the logogen model, the counters of all words sharing semantic features with the context word would be incremented, thereby facilitating recognition. Any concepts linked in Collins and Loftus' representation would share semantic features in Morton's representation, and any concepts sharing semantic features would be linked in Collins and Loftus' representation. Therefore, these two models make identical predications in regard to context facilitation.

The situation is more complex when the context is a phrase or sentence frame (a sentence missing the final word). It seems that the meaning of the entire phrase or sentence frame, not just the individual words in it, will determine which words get facilitated. If facilitation depended only on individual words, Tulving and Gold's (1963) and Morton's (1964) results should be predicatable by the relationship of the target word to individual words in the sentence, and not by how expected the target word is when given the sentence frame. Of course, these may be confounded, but they do not seem to be, at least in Morton's stimuli. Since the meaning of the entire phrase or sentence frame determines which words get facilitated, a complete model of context facilitation would provide an account of how the meanings of individual words get combined to form a representation of the meanings of larger linguistic units.

However, no well developed account of the necessary "combinatorial procedures" is available. This is a crucial problem in models of context facilitation. This problem will not be solved here, but the next chapter presents a method of circumventing it for the purpose of comparing general and specific facilitation models.

The spreading activation and logogen models both claim context facilitation is a very general effect. Using the terminology of the logogen model, some facilitation will occur for every word which shares one or more semantic features with the context. A very different type of model is a specific facilitation model which claims a context can facilitate recognition of only a single word or a small set of words. One reasonable specific facilitation model would claim that context leads the reader to expect a particular word and this expectation alters how the visual input is processed. That is, the reader's first analysis of the visual pattern would be a check to determine if it represented the expected word.

Specific facilitation models can be consistent with the available empirical findings. In the threshold task it is possible that for any given trial only one highly expected would be facilitated by the context, but this word would differ across subjects. The proportion of subjects who give the target word to complete the sentence frame would reflect the proportion of subjects who expect that particular word. As for the lexical decision task, after the inital trials subjects might expect related word pairs. So far, context facilitation has been demonstrated only for highly associated words. The associated word pairs were drawn from word association norms such as Bousfield, Cohen, Whitmarsh, and Kincaid (1961). These norms were collected by giving subjects one word and asking them to report the first word that comes to mind. It seems likely that in this free association task the words elicited by a given word, *X*, would be the same words subjects would expect in the successive lexical decision tasks when *X* is the context word. That is, association norms would reflect the pattern of subjects' expectations. Therefore, the available data from both the threshold and successive lexical decision tasks is consistent with the view that only a few specific words are facilitated.

The experiments to be reported attempt to determine whether general or specific facilitation models give a better account of the effects of context on reading individual words. They were designed to provide information about the scope of context facilitation. In Experiments I and II, described in Chapter 3, the time to decide a string of letters forms a word was measured when the word was presented alone and when it was preceded by a sentence frame. The relationship between the word and the sentence frame was varied. In Experiment III, described in Chapter 4, Meyer's successive lexical decision task was used and the relationship between the context and target words was varied. In Experiment IV, described in Chapter 5, reaction time was measured while subjects determined whether a word forms a semantically acceptable sentence when combined with a previously presented sentence frame context. This task was designed to test the generality of context facilitation. Since the final word must be integrated with the sentence frame rather than considered independently of it, the acceptability task better approximates a normal reading situation than does the lexical decision task.

The specific-general distinction is only one of many possible distinctions among types of context facilitation models. Other possible distinctions include: (1) bottom-up _vs_ top-down models; (2) active _vs_ passive models; (3) models claiming context facilitates visual encoding _vs_ models claiming context facilitates the retrieval of lexical information from memory; (4) conscious _vs_ automatic facilitation models; and (5) models claiming facilitation is all-or-none _vs_ models claiming there are degrees of facilitation. The relationship of each of these to the specific-general distinction will be discussed below.

A bottom-up model is one which is "entirely driven by the sensory input" while a top-down model is at least partly "driven by conceptual organization" (Norman & Bobrow, 1976). The distinction can be easily conceptualized within a stage model. In a bottom-up model all the links between stages go in one direction. Consider, for example, a processing stage that combines the meanings of individual words to form a representation of a larger linguistic unit such as a sentence. In a bottom-up model, this stage simply waits for all the words to be processed by the earlier stages, such as visual encoding and lexical access. In a top-down model there are one or more links that go in the opposite direction of the others. These "feedback links" enable the later stages of processing to affect the earlier.

In a top-down model, processing the initial words of a sentence could result in an expectation for a particular word, and this expectation could alter the visual encoding stage so that it first checks the visual pattern to determine if it represents the expected word. This description makes it clear that top-down models are perfectly compatible with specific models. However, they can also be compatible with general models. Suppose the expectation is not of a particular word but of any word containing a given semantic feature. This expectation could feedback to the lexical retrieval stage and cause facilitation for every word that contains the semantic feacture.

A model with only bottom-up processing cannot be consistent with either type of context facilitation model at least when the context is a sentence frame. As discussed previously, it seems that the overall meaning of the sentence frame, not the individual meanings of the words within it, determines facilitation. In any model, syntactic and semantic information for the individual words would have to be retrieved before the parsing and combinatorial procedures necessary to determine the overall meaning of the sentence frame could operate. A sentence frame context can facilitate tasks that require processes that occur prior to the parsing and combinatorial processes: The threshold and lexical decision tasks require retrieving information about individual words, but not parsing and combinatorial procedures. Therefore, information from the later parsing and combinatorial processes must feedback to affect an earlier process, such as visual encoding or lexical access. By definition, bottom-up models do not contain such feedback links.

Active and passive models do not seem to have standard definitions in the literature. As used here, active facilitation models claim context results in qualitative changes in one or more processes. In passive facilitation models, there are only changes in the amount of processing necessary. For example, consider a visual encoding stage, such as that described by Smith and Spoehr (1974), which extracts visual features from the input and interprets them in terms of letter categories.

According to active models, a context could lead to specific expectations that would direct the encoding process; the context could result in the input being actively searched for certain visual features. According to passive models, context cannot direct encoding; the order in which visual features are extracted cannot be altered by context. However, context could facilitate recognition by reducing the number of features necessary to interpret the input as a certain letter.

The general models discussed so far are passive. The amount of information necessary for retrieval is changed, but the type of information is not. That is, fewer visual features are necessary, but there are no changes in how these visual features are determined. It would be possible to make a more specific passive model by simply limiting the number of counters a single context could increment (or the number of nodes activated), or by requiring many common semantic features between context and the word before facilitation occurs, or by placing constraints on the types of semantic features which will result in facilitation. There is currently no justification for any of these revisions. Therefore, general models are most compatible with passive models, while specific models are most compatible with active models.

Another possible distinction is between models claiming context facilitates visual encoding and models claiming context facilitates retrieval from memory.[4] The general models discussed so far place facilitation effects at the retrieval process. The specific model described previously places facilitation effects at visual encoding. However, neither of these is necessarily the case. Models in which

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[4]The discussion of this distinction requires the assumption that visual encoding and lexical retrieval are independent stages.

specific expectations affect the retrieval stage are clearly possible. For example, a context could be limited to incrementing the counters of only the one or two logogens with which it shares the most semantic features (yielding a specific model at the retrieval stage). A general model at the visual encoding stage is also possible. Recent models that account for the letter within a word effects have postulated word units available at the visual encoding stage (cf., Smith,& Kleiman, 1976). Context could make word units related to it more readily available. This would yield a general passive model at the visual encoding stage.

Posner and Snyder (1975a,b) have recently explored the distinction between automatic and conscious processing. They propose three criteria for automatic processing: It occurs without conscious awareness, it occurs without intention, and it does not produce interference with on-going mental activity. They operationalize the third criterion in terms of a cost-benefit analysis. By their analysis, if context facilitation is automatic, an associated context should facilitate recognition of a word, while an unassociated should not hinder recognition. If facilitation is conscious (i.e., not automatic) an associated context should again facilitate recognition, but an unassociated context should be a hindrance (relative to a no-context condition).

In the general models discussed so far, there is no mechanism by which an unassociated context could hinder recognition. Such a mechanism could be added (Smith & Spoehr, 1974), but as they stand now, the logogen and spreading activation models seem to fit Posner and Snyder's criteria of automatic processing. The specific model probably would not fit the criteria. In line with Bruner's (1957) theory of perceptual readiness an expectation for a specific stimuli should impede recognizing any other stimuli.

The final distinction to be discussed is between models claiming one context can facilitate the recognition of different words to various degrees and models claiming facilitation is all or none. Both general and specific models can be consistent with the former type. In general models the number of common semantic features determines the amount of facilitation. Specific models could have an ordered list of expectation, so that the most expected word will be highly facilitated, the next most expected word slightly less facilitated, and so on.

Specific models can also be compatible with all-or-none models. Facilitation would simply be limited to a single most expected word, or several words which are equally facilitated. The revision necessary to make all-or-none general models is not quite as simple. There would need to be some critical number of semantic features. If the context and word share more than the criterial number of features, facilitation would occur. However, the number of shared features above the criterion would not affect facilitation.

CHAPTER 3

Experiments I and II

Both specific and general models predict a context will facilitate recognition of a highly expected word. For example, the context He hit the nail with a should facilitate recognition of the word hammer. In a specific model this facilitation would occur because the context leads the reader to expect the word hammer, and this expectation leads to analyzing the visual pattern to see if it is this particular word. Therefore, specific models predict expected words will be the only ones for which recognition will be facilitated. It is possible that facilitation could occur for more than one word. For example, the context He paid the man twenty might lead the reader to expect either dollars or cents, and facilitation might occur for both.

In the experiments reported here, expected words were determined by having subjects complete the contexts. The words produced were assumed to be the same words subjects expected when given the context. The sentence frames were chosen so that each had only one highly expected word. Specific models would predict facilitation for these particular words only.

General models also predict facilitation for expected words because the context provides many of the semantic features of that word. In addition, general models predict facilitation for many other words; the facilitated set will include any word that shares semantic features with the context.

Experiments I and II tested whether facilitation occurs for highly expected words, as is predicted by both types of models, and whether facilitation occurs for words that are not expected but which share semantic features with the context, as only the general models would predict. Experiment II was a replication of Experiment I designed to collect more data overall and more of the key data within rather than between subjects. In both experiments, reaction time was measured while subjects determined whether a string of visually presented letters formed a word. The string of letters was either presented without any context or preceded by a sentence frame. Each word appeared in both conditions and the measure of interest was the difference between reaction time with and reaction time without preceding context.

There were three types of words, with type being defined by the relationship of the word to the sentence frame (examples are shown in Table 1 and all the stimuli for Experiment I are listed in Appendix A). One set consisted of words highly expected on the basis of the context, such as hammer in the above example. This will be referred to as the E (for expected) set. It is assumed that (in the logogen model) the E word shares more semantic features with the context than any other word, or (in the spreading activation model) the E word is more activated by the context than any other word. Both general and specific models predict facilitation for the E set.

The models differ in predicting whether facilitation will occur for words which share semantic features with the context, but are not words one would expect to complete the context. The E words share many semantic features with the context. Therefore, words which share semantic features with the E words should, on the average, share more semantic features with the context than words that do not share features with the E words. In

The cup was placed on the

table (highly expected = _E_)

chair (related to expected word = _R_)

floor (unrelated to expected word = _U_)

The king of the beasts is the

lion (_E_)

roar (_R_)

work(_U_)

The threw a rock at the house and broke a

window (_E_)

door (_R_)

dish (_U_)

He needs a new pair of laces for his

starn (_Pw_)

The invisible man is impossible to

derove (_Pw_)

Table 1: Sample Stimuli for Experiment I

order to set up the experiments, a set of words which share semantic features with the E words was needed. Ideally, semantic feature analyses for many words would be available and this set could be easily selected. Unfortunately, this is not the case. However, it seems safe to assume that related words, such as hammer and wrench share more semantic features than unrelated words, such as hammer and book. Therefore, one of the sets consisted of words related to the E words. Relatedness was determined by using a rating scale which is described below. This will be referred to as the R (for related) set.[5]

The third set of word stimuli consisted of words not related to the expected words, such as book for the He hit the nail with a context. These are assumed to share fewer semantic features with the context than the R words share with the context. This will be referred to as the U (for unrelated) set.

The final set of stimuli consisted of pseudowords: Nonwords that follow the orthographic patterns of English words, and are therefore pronounceable (see examples of Pw set in Table 1). This set was necessary for the experimental task, but not involved in any of the empirical predictions that differentiate specific and general models.

The highly expected words were determined by having 26 subjects[6] complete each sentence frame with a single word. Only sentences with one frequent completion were used. At least 11 of the 26 subjects completed

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[5]According to the spreading activations model, whenever a word is activated some activation will spread to all related words. Therefore an R word will not only be activated by the context, but also by the E word.

[6]In all experiments to be reported, all subjects were Stanford University students, participating for course credit or for $2.00 per session.

each sentence with the appropriate E word and no other word was given by more than five subjects. For the 42 sentence frames in Experiment I, .78 of the completions consisted of the appropriate E words and only .007 of the completions consisted of the R or U words.

The relatedness of the R and E words, and the lack of relatedness of the U and E words, was checked by having 22 subjects rate the relatedness of the word pairs on a 1 to 5 scale, where 1 signified "not at all related," 3 signified "somewhat related" and 5 "very related." The mean relatedness rating for the E-R pairs was 4.1 (s.d. = .54). The mean rating for the E-U pairs was 1.9 (s.d. = .54).

The R and U sets were controlled in two other ways. As can be seen in the examples in Table 1, sometimes the final word completed the sentence frame in an acceptable way (e.g., The cup was placed on the chair) and sometimes it did not (e.g., The king of the beasts is the roar). The R and U sets of words were equated on how well they completed the sentences. This was done by having 22 subjects rate how well each word completes its sentence frame, using a 1 to 5 scale where 1 signifies the word doesn't fit the sentence frame at all and 5 signifies the word fits the frame very well. The mean sentence completion rating for the R words was 2.5 (s.d. = 1.0). The mean rating of the U words was 2.6 (s.d. = 1.1). The R and U sets were also approximately equated for frequency. The antilog of the means of the logs of the Kucera and Francis (1967) frequency counts was 42 for the R words and 55 for the U words.

Experiment I

Procedure and design. Each of the 12 subjects received two blocks of trials, one with and one without preceding context. In the trials without context the subject pressed an onset button and one-half second later a string of letters appeared to the right of a fixation point. Subjects decided whether or not the letters, in the order in which they were written, formed a word. They signalled their response by pressing the appropriate response button, and were instructed to to so as rapidly as possible. For the context trials, subjects pressed an onset button and the sentence frame appeared in the top half of the viewing field. The subjects read the context at their own rate and then pressed the onset button again. The sentence frame disappeared immediately and after a one-half second delay, the string of letters appeared in the bottom half of the viewing field.[7] Subjects then made a word or nonword response as rapidly as possible. To insure that they were reading the context, on randomly selected trials, after making the word or nonword response, subjects were asked to report the context.

There were 42 sentence frames, each with three different types of final words, yielding 126 words. Data was collected for each word both with and without context. These stimuli were divided into three sets, each consisting of one block with context and one without. Every sentence frame appeared once in each set, with one of the three possible final words. One of the other two final words for each frame appeared in the without context block. There were 14 of each type of word in each block. Each subject received both blocks of one of these sets. Therefore, three subjects were necessary to provide one complete set of data, con-

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[7]The first letter of the string always appeared in the same position of the viewing field, but this position was not marked by a fixation point in the Experiment I context trials. The lack of a fixation point was remedied in Experiment II.

sisting of one observation for each word with and one without context.

The complete stimuli set contained 72 pseudowords and 36 additional sentence frames. Each subject saw all the pseudowords, half with preceding context and half without. The pseudowords were filler items to keep the subjects decision criterion reasonable. They do not provide any useful information and will not be considered in the analysis.

Each subject received two blocks of trials, each block consisting of 42 words (14 of each type) and 35 pseudowords. In one of these blocks each trial was preceded by the sentence frame context. Each block was preceded by practice trials of the same type. Within each block, there were two sub-blocks of 21 words (7 of each type) and 18 pseudowords. The order of the with and without context blocks and the order of the sub-blocks within these was counterbalanced across subjects. The stimuli were randomly ordered within each sub-block.

Results. Table 2 lists the mean reaction times and proportion of errors for each word type with and without context.[8] Comparing the context and no context conditions shows a very unexpected finding: For all word types, including the E set, the decision took longer with context than without. Further work has shown this strange effect disappears with minor changes in procedure. These changes are having a fixation point before the string of letters appears in the context condition (there was already a fixation point in the no context condition) and slightly increasing the delay between when the subject signals finishing reading the context and when the string of letters appears.

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[8]All means given in tables and the text are the means of the subjects' means. Reaction times from error trials and those more than three standard deviations from the subject's mean for a given treatment were excluded from the data analyses.

	E	R	U
with context	587(.01)	698(.05)	725(.06)
without context	579(.03)	590(.02)	582(.03)

Table 2: Mean Reaction Times (and Error Proportions) for Experiment I

The predictions of interest were tested by comparing the differences in reaction times with and without context for the E, R, and U sets of words. There are significant differences: The word type by context condition interaction is significant, min F'(2,52)=7.81, p<.01.[9] In the no context condition the three mean reaction times were 579 (E set), 590 (R), and 582 (U). These do not differ significantly, min F'(2,76)=1.35. Therefore, the reaction times for the no context condition will be considered equal for all word types and the mean reaction times for the three word types with context can be compared. These times are 587 (E), 698 (R), and 725 (U). These differ significantly, min F'(2,68)=17.63, p<.01. Orthogonal contrasts show the E set differs from the other two, min F'(1,67)=34.97, p<.01. Although the results are in the direction predicted by the general models, the R and U sets do not differ significantly, min F'<1.[10] The error rates do not show any significant differences.

The results demonstrate that this experimental procedure will show facilitation effects for words highly expected on the basis of the context. The statistically significant results provide evidence only for very speci-

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[9] Since different sets of subjects received different items, item means were corrected for subject differences in overall reaction time. This was done by subtracting the subject's overall mean reaction time from each individual reaction time. This correction was used in calculating F_2(F by items), but not F_1(F by subjects). The same correction was used in Experiments III and IV. It was not necessary in Experiment II since a full set of data was collected from each subject.

[10] The predictions of interest were about the differences between context and no context trials for the three word types. This difference could be affected by differences in the no context condition, even though these differences are not significant. However, the same pattern of results holds when the analysis considers context by no context interactions: The E set differs significantly from the other two, min F' (1,51)=14.87, p<.01, while the R and U sets do not differ significantly, min f'<1.

fic facilitation. However, the R - U difference is in the direction predicted by the general models. The possibility that there may be a real difference between these two sets is explored further in the next experiment.

Experiment II

Experiment II was a replication of Experiment I designed to collect more data overall and a full set of data from every subject. This allows several comparisons to be made for which sufficient data was not available in Experiment I. It also enables a more powerful test for differences between the R and U sets.

The subjects' tasks were exactly the same as in Experiment I. Again there were three types of word stimuli: Words highly expected on the basis of the context (set E), words related to the highly expected word (set R), and words unrelated to the highly expected word (U). The 42 contexts and words for the R and U sets were identical to Experiment I. Forty-two new context were generated, each with one highly expected final word. These provided a new set of E stimuli, which are given in Appendix B. Therefore, comparisons of the R and U sets involve identical contexts, but comparisons of these sets with the E set involve different contexts. Additions were made to the pseudoword set so there were 96 pseudowords and 48 sentence frames.

Each of the 12 subjects participated in two sessions, about one week apart. This allowed a full set of data (one observation for each word with and one without context) to be collected from every subject without repeating any words or contexts in the same session. Each subject received one block of trials with context and one without context in each session.

Half of the words in each set, and half the pseudowords, appeared in the context condition. These were arranged so that no word or context was repeated in the same session. Each block was divided into two sub-blocks, each containing 21 words (7 of each type) and 16 pseudoword trials. The order of context and no context blocks, and the order of the sub-blocks, was counterbalanced across subjects, as were the sessions in which each word appeared with and without context. The stimuli within each sub-block were randomly ordered.

There were two minor changes in procedure from Experiment I. Both affected the interval between the subject's finishing reading the context and the appearance of the string of letters. This interval was increased slightly to 600 msecs and a fixation point appeared during the interval to indicate where the string of letters was about to appear.

Results. Reaction times were faster in the second session than the first, min $F'(1,25)=13.56$, $p<.01$. However, the effects of interest were the same in both sessions: The magnitude of the context effect for each word type did not differ between sessions, min $F'<1$. Therefore the data from both sessions were pooled for the following analyses. The mean reaction times and proportion of errors for each word type with and without context are shown in Table 3.

Context differentially affected the three word sets: The context by word type interaction was significant, min $F'(2,86)=54.69$, $p<.01$. The differences among the word-types in the no context were not significant, min $F'(2,119)=1.43$. The differences in the context condition were significant, min $F'(2,88)=58.88$, $p<.01$. In this condition, reaction time for the E set (444 msec) was significantly less than the other two sets, min F'

	E	R	U
with context	444(0)	533(.02)	555(.04)
without context	539(.03)	524(.03)	521(.01)

Table 3: Mean Reaction Times (and Error Proportions) for Experiment II

$(1,88)=113.34$, $p<.01$. As in the previous experiment, reaction time for the R set (533) was less than the U set (555), and in this case the difference was significant, min $F'(1,84)=4.42$, $p<.05$.[11] The error rates do not show any significant differences. Therefore, facilitation does seem to be occurring for the words related to the expected words, as predicted by the general facilitation models. The amount of the facilitation is meager when compared to the E set, but there is a reliable difference.

Experiment II provides sufficient data to perform several analyses that would not be reasonable with the data from Experiment I. For the following analysis, the R and U sets were each divided into three subsets according to the ratings of how well each word completes it sentence frame. The mean reaction times and error rates with context are shown in Table 4, divided into low, medium and high sentence completion ratings (14 words in each cell). There was a significant sentence completion effect: Reaction times were faster for the more highly rated completions, min $F'(2,60)=3.49$, $p<.05$.[12] The sentence completion effect was the same for both word types: The word type by sentence completion interaction was not significant, min $F'<1$. Therefore, the R - U differences holds even when the words do not complete the sentence frames in a reasonable way.

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[11] The same pattern of results holds when the analyses considers context by no context interactions: The E set differs significantly from the other two, min $F'(1,87)=105.23$, $p<.01$, and the R and U sets differ min $F'(1,76)=4.11$, $p<.05$.

[12] There were no differences among the mean reaction times in the no context conditions for the words that fell into the high, medium and low sentence completion ratings. These means ranged from 520 and 524 milli-seconds.

	Low	Medium	High
R	555(.04)	524(.03)	520(.01)
U	582(.08)	550(.04)	542(.02)

Table 4: Mean Reaction Times (and Error Proportions) for R and U words, Divided into Low, Medium and High Sentence Completion Ratings Sets

There are at least two possible accounts of the sentence completion effect. One is a response interference explanation. Some subjects reported they were always aware of whether the word completed the sentence, although this was irrelevant to the task. Suppose information about how well the word completes the sentence becomes available very soon after the information necessary to determine wordness: A "negative" sentence completion judgment (i.e., determining the word does not complete the sentence frame) might interfere with making a "positive" (i.e., word) response. However, Experiment IV provides some evidence against this explanation. In that experiment, subjects made a sentence acceptability decision. The stimuli were a subset of the R and U stimuli used in Experiment II. Reaction times for the acceptability decision were almost twice as long as reaction times for the lexical decision. This suggests that the information about how well the word completes the sentence would not be available soon enough after the wordness information to interfere with the response.

The second possible explanation is that the sentence completion ratings reflect how many semantic features the word shares with the context. Therefore recognition of the words that receive high sentence completion ratings should be facilitated, as compared to recognition of the words that received low sentence completion ratings. This explanation seems to be the most reasonable. It is consistent with general facilitation models but could not be incorporated into models with only specific facilitation.

It is often assumed that basically the same processing occurs in reading a word with and without context. However, some, such as Goodman (1969) dispute this assumption. If context does not change any aspect of processing individual words, any effect found in tasks where words are presented without context should also be found in tasks with words in context. A word frequency effect is generally found in lexical decision tasks (Fredrickson & Kroll, 1976): The more common the word the faster the decision. Using the corrected item means (see footnote 9) for all 126 E, R, and U words in Experiment II, the correlation of RT in the no context condition and log word frequency (Kucera & Francis, 1967) is -.526. The correlation between reaction times and the context condition and log word frequency is -.187. The difference between these two correlations is significant, $z=2.51$, $p<.05$. Looking at the correlation of the E, R, and U sets individually, the correlation of log word frequency and reaction time without context is always larger than the correlation of log word frequency and reaction time with context. However, the differences are not significant for the individual sets, $z=.99$, $z=1.47$, and $z=1.63$ for the E, R, and U sets, respectively.

The attenuation of the word frequency effect in all word sets when context is added is not accounted for by either the general or specific models that have been considered. In the logogen model, context provides semantic features that increment the counters of words containing these features. These logogens thereby need less stimulus information to pass threshold. In this model, word frequency effects are accounted for by assuming that before any contextual or stimulus information is presented, high frequency words are closer to threshold than low frequency words. It is possible that when the context provides some semantic features, the increase in the counter is large enough to override the differences due to word frequency. This would account for the E and possibly the R sets. However, a decrease in the word frequency effect in the context condition would not be expected for the U set.

Models which claim context results in specific expectations might predict the word frequency effect will vanish for the E set. However, in the specific expectation model outlined so far, it seems most reasonable that once it was determined the expected word did not occur, processing would be like it is without context. This would predict an equivalent word frequency effect in the context and no context condition for the R and U sets.

The attenuation of the word frequency effect in the context condition for the U set cannot be accounted for by any of the available models. This effect is intuitively surprising and seems to warrant replication before causing revisions in the models that can account for all the other results.

One final analyses is of interest. The associated word pairs used by Meyer and his colleagues were derived from word association norms. There may be crucial differences between using association norms and rated relatedness to determine the word pairs. For example, association norms might be a better predictor of the spread of activation. In what follows, related word pairs are pairs of words that subjects rate as highly related. Associated word pairs are those in which the first word often elicits the second in a free association task. All highly associated words are also related, but not all highly related pairs are associated. Examples of related but not associated pairs include bath-towel, hammer-wrench, hand-glove, night-dream, sky-moon and hot-summer

To enable a test of whether association strength predicts facilitation, association norms for the E words were collected from 30 subjects. For the 42 E words, the proportion of subjects who responded with the R word ranged from 0 to .67, with a mean of .14. The words in the U set were never given. That is, the R words were always highly related to the E words but their associative value varied. The U words were neither related nor associated to the E words. Since the R set contains a range of association values to the relevant E words, it is of interest to determine whether association predicts the size of the facilitation effect within the R set. This set was therefore partitioned into low (never given as an associate to the relevant E word), medium (given as an associated by some, but less than 17% of the subjects) and high (given by more than 17% of the subjects) association values. Each set contained 14 words. The differences between the context and no context conditions were 6, 7, and 15 msec, for the low, medium and high sets, respectively. These do not differ significantly. It appears that association norms do not predict the context effect within the R set. The next experiment further explores whether association strength or relatedness better predicts context facilitation.

CHAPTER 4

Experiment III

Meyer and Schvaneveldt (1971) have demonstrated context facilitation in the successive lexical decision task. In this task, subjects are shown one string of letters (the context), make a word or nonword decision, and then are shown another string of letters (the target) and make a second decision. Meyer and Schvaneveldt have shown that when both strings form words, the decision for the target word is facilitated (i.e., reaction time is reduced) when it is highly associated with the context word. It is important to note that Meyer and Schvaneveldt's word pairs were taken from association norms. Production tasks like that used to collect free association norms seem likely to reflect subject's expectations: Those words subjects produce when given a context (either a single word or a sentence frame) should coincide with those words subjects will expect when given the context. Since associated words are in some way similar in meaning (Clark, 1970), associated word pairs have some semantic features in common. Therefore, both general and specific models predict facilitation when the target and context words are associated, and Meyer and Schvaneveldt's results are consistent with either type of model. However, the models differ in predictions about word pairs that are related but not associated: General models predict facilitation and specific models do not. Experiment III tested whether facilitation will occur in the successive lexical decision task when related but not associated word pairs are presented.

Design. The stimuli of this experiment were presented intermingled with those of another experiment which will not be reported here. The type of stimuli, procedure, and tasks were identical for both experiments, and subjects were not aware they were participating in two experiments. Overall, each of the 30 subjects received 210 trials (plus 20 practice trials). Each subject received a different random order.[13] Two strings of letters were presented on each trial and two decisions were required. Eighty-four of the trials consisted of word-word pairs, with about half of these being related pairs. There were 42 word-pseudoword, 42 pseudoword-word and 42 pseudoword-pseudoword trials. The pseudowords were similar to those used in Experiments I and II. The trials containing pseudowords were included to keep subjects' criteria reasonable. No predictions were made about these trials and no analysis of the data will be reported.

There were four sets of word pairs of critical concern for testing the predictions of the general and specific facilitation models. The *related-only* set consisted of context and target words that were highly related but not associated. The *related-and-associated* set consisted of words that were both highly related and highly associated. The other two sets were the relevant controls. One consisted of the target words from the related-only set preceded by unrelated context words, the other consisted of the target words from the related-and-associated set preceded by unrelated context words.

The total stimuli set contained 24 related-only pairs and 24 related-and-associated pairs. These are listed in Appendix C, along with the unrelated context words from the control sets. Each subject received half of

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[13]Due to a programming error, four subjects received the same random order.

the target words from each set, arranged so that no subject received the same word twice. Therefore, for each target word, the 30 subjects yielded 15 observations with a related context and 15 with an unrelated context. Facilitation is said to occur when decision time was faster for a word when it was paired with its related context than when it was paired with its unrelated context.

All the related pairs had relatedness ratings greater than 3.5, on the five point scale described in Chapter 3. The mean relatedness rating was 4.1 for the related-only pairs and 4.2 for the related-and-associated pairs. In the free association task, the related-only context words elicited the relevant target words 2% of the trials (the maximum for any given pair was 6%). The related-and-associated context words elicited the relevant target words on 37% of the trials (the minimum for any given pair was 17%). Most of the association values were obtained from the Connecticut word association norms (Bilodeau & Howell, 1966). For the words that did not appear there(12 of the 48 necessary), association norms were collected from 30 subjects from the same population as those used in the experiment.

The experiment was computer run on a NOVA-1082 based system. Stimuli were presented on a Tetronix terminal, in uppercase letters. Before each trial, an asterisk appeared in the center of the screen. The subject pressed an onset button and 350 msecs later the first string of letters appeared, centered on the screen. The subject decided whether or not the string of letters formed a word and pressed either the word or nonword response button. The second string appeared 300 msec after the response and the subject made a second response using the same buttons. Instructions stressed both speed and accuracy.

Results. The results do not provide clear cut support for either general or specific models. Ths responses were significantly faster for words preceded by related-and-associated words than for the same words preceded by unrelated words (514 vs 544 msecs), min $f'(1,44)=6.94$, $p<.05$. The responses were also faster for words preceded by related-only words than for the relevant controls (547 vs 561 msec), but this difference was not significant, min $f'(1,50)=1.85$, $F_1(1,29)=4.12$, $F_2(1,23)=3.35$, all n.s. However, the size of the facilitation effect for the related-and-associated set was not significantly greater than the size of the facilitation effect for the related-only set, min $F'<1$. This pattern of results does not provide evidence for or against either general or specific models.

CHAPTER 5

Experiment IV

A crucial weakness of information processing models of reading is that the evidence cited in support of them is generally from tasks very unlike normal reading. Unfortunately, with the exception of what can be obtained from studying eye movements, it seems impossible to obtain much analytic information from subjects who are simply reading normally. The most reasonable course of action therefore is to obtain evidence from a variety of tasks, each of which resembles normal reading in some way. This chapter described an attempt to replicate some of the findings of Experiment II with a task that better approximates normal reading. The experiment was small in scope since it was an initial attempt to determine whether the task might yield useful information.

A sentence acceptability task was used. As in Experiment II, the subject read a sentence frame, pressed an onset button, and 600 msecs later a word appeared on the screen. The subject was asked to decide if the word completes the sentence in a reasonable way. That is, to decide if the sentence frame and word form an acceptable sentence--one which makes sense. Subjects were told that some of the sentences will describe a situation which is not the most expected one, but is still quite possible. The sentence The old horse moved very fast was given as an example. They were instructed to consider such sentences acceptable. Subjects were instructed to consider sentences which describe impossible or very implausible situations unacceptable. Furthermore, they were asked to make the decision as quickly as possible.

To insure subjects were following the instructions and had criteria of acceptability similar to each other and to the experimenter, there were 30 practice trials, during which feedback was given. Also, after the experimental trials the subject was given a set of sentences consisting of all the sentences for which his response was incorrect and an equal number of randomly selected sentences on which the subject had given the correct response. The subject was asked to sort these into acceptable and unacceptable groups. The results showed that subjects almost always agree on which judgment is correct when there are not time pressures.

The stimuli of interest were 20 sentence frames used in Experiment II and their R and U words. For 10 of these sentences, both the R and U words formed an acceptable completion. (These are marked by * in the Appendix A.) For the other 10, both the R and U words formed unacceptable completions. (These are marked by ** in Appendix A). Two measures were checked to determine acceptability or unacceptability. The acceptable sentences all had sentence completion ratings (as described in Chapter 3) greater than or equal to 3.0 (mean=3.8). The unacceptable sentences all had sentence completion ratings less than or equal to 2.0 (mean=1.3). Secondly, nine subjects were asked to judge each sentence acceptable, unacceptable, or cannot decide. At least seven of the nine marked each acceptable sentence acceptable and at least seven marked each unacceptable sentence unacceptable.

Each of the 24 subjects received each of the crucial sentence frames once, half with the R word and half with the U word. In addition, there were 20 filler sentences, 10 acceptable and 10 unacceptable. Each subject received all of these. A different random order was used for each subject. The apparatus and preparation of stimuli were identical to Experiment II.

Results. The original intent was to use this experimental task to obtain information about how subjects process the final word. A pattern of results like that obtained with the lexical decision tasks was expected. In particular, it was expected that the judgment would take longer when the sentence frame was completed by the U words than when it was completed by the R word. Also, a positive correlation was expected between lexical decision time and acceptability judgment time. However, it became clear from subjects' comments that much more was involved in the acceptability decision than processing the final word. Many of the crucial stimuli did not seem clearly acceptable or unacceptable in the rapid decision situation. The reaction times were nearly twice those in the lexical decision task and it seemed likely that the small R - U difference found in the lexical decision task would be buried in the longer times.

In fact, the results (see Table 5) show no significant differences, either between acceptable and unacceptable sentences, min $F'(1,59)=1.40$, or between sentences completed by R and U words, min $F'(1,59)=2.78$, or the interaction of these two variables, min $F'<1$. More surprisingly, for the 40 sentences used in both Experiments II and IV (the 20 sentence frames, each with two different final words) reaction time in the lexical decision task was negatively correlated with reaction time in the acceptability task, $r= -.342$. The correlation was negative for both acceptable and unacceptable sentences, $r= -.280$ and $r= -.189$, respectively. None of these correlations are statistically significant, but the fact that they are negative is surprising. The implications of different results in the lexical decision and acceptability tasks is discussed in the final chapter.

	$\underline{R}$	$\underline{U}$
Acceptable	1007(.15)	946(.08)
Unacceptable	903(.16)	833(.08)

Table 5: Mean Reaction Times (and Error Proportions) for Experiment IV

CHAPTER 6

Summary and Inconclusions

The aim of this work was to determine what type of context facilitation mechanism needs to be incorporated into information processing models of skilled reading. In particular, the distinction between specific and general models was focused upon. Specific models claim that a single context can facilitate recognition of only a small set of expected words. General models claim a context can facilitate recognition of a large set of words, each of which shares semantic features with the context.

Specific and general models both predict facilitation for words highly expected on the basis of context. Experiments I and II provide strong evidence for this effect in the lexical decision task. A small amount of facilitation was also shown for words which were not expected but were related to the expected words and therefore presumably share some semantic features with the contexts. The amount of facilitation was determined by comparing reaction times for the expected (E) and related to expected (R) words with reaction times for words that were unrelated to the expected words (U).

The difference between the R and U sets held even when neither word was a reasonable completion of the sentence frame context. Clearly models claiming facilitation occurs for only a small set of expected words cannot account for differences among words that are not expected. Therefore these results support general facilitation models. However, the amount of facilitation for the R set (22 msecs in Experiment II)was very small when compared to the amount of facilitation for the E set (111 msecs in Experiment II). Therefore it is quite possible that two types of mechanisms are operating: A general facilitation mechanism which solely accounts for the small effect on the R words and which combines with a specific facilitation mechanism to cause the larger effect on the E words. Whether just a general mechanism or both general and specific mechanisms are operating cannot be determined from the results of the Experiments.

For Experiment III, it was assumed that association norms reflect subjects'expectations while relatedness ratings reflect how many semantic features two words share. In the successive lexical decision task, specific models predict facilitation only for associated pairs, general models predict facilitation for all related pairs including those that are not associated. Unfortunately, the results of Experiment III were not clear-cut. There was a significant facilitation effect for the pairs that were both associated and related and a small but not statistically significant facilitation effect for the pairs that were related but not associated. The amount of facilitation for the two sets did not differ significantly. These results do not favor either type of model over the other.

Clearly, results from threshold and lexical decision studies can tell us something about human information processing. However, whether what they tell us is relevant to models of skilled reading is another question. A strong argument that any given phenomenon needs to be accounted for by a model of reading requires that the phenomenon be demonstrated in a variety of tasks, each resembling reading in some way. In Experiment IV, a sentence acceptability task was used to test the generality of R - U difference found in Experiment II. This task better approximates reading sentences than the lexical decision task, since the subject must integrate the meaning of the final word with the rest of the sentence. This experiment made it apparent that determining whether a sentence is acceptable involves many complicated processes that are not involved in the lexical decision task. Besides the syntactic and semantic processing necessary to integrate the final word with the sentence frame, a criterion of acceptability and decision processes are required. When these additional processes come into play, the small difference between R and U words found in the lexical decision task is no longer discernible. No evidence has been found that the effects obtained with the lexical decision task generalize to the acceptability task. In fact, there is a negative (although not significant) correlation between reaction times in the lexical decision and sentence acceptability tasks.

Whether or not a given effect can be found in a variety of experimental tasks that resemble reading is an important criterion for determining whether it must be accounted for by models of reading. However, it is not the only criterion. Suppose, for example, there was an effect that appeared in a variety of tasks, but occurred only with words having 14 letters. Since such words occur rarely, if the effect was specific to words having 14 letters and does not tell us anything about processing other words, a model of reading would not have to account for it. That is, models of reading need only account for findings related to processing that would occur with some frequency in typical reading tasks. This is actually a proportion of variance criterion: Only those effects which determine a reasonable proportion of the variance need to be accounted for by a model of reading. However, an important question remains: The variance of what measure? Reading time, difficulty of text, errors in oral reading and comprehension test scores are some of the possibilities. Although an ideal model would account for all of these, at present the measure considered depends upon the goal of the model.

A proportion of variance criterion could lead one astray in models of reading, particularly when it is proportion of variance in reaction times that is considered. For example, it is likely that visual encoding processes take less time and contribute less to the overall variance than parsing and combinatorial procedures. However, no matter how little of the reaction time variance it accounts for, visual encoding is a necessary process: Reading could not occur without it. A model of reading must contain all necessary processes.

Three criteria have been proposed to determine whether an effect needs to be accounted for by models of reading: (1) generality of the effect across tasks that are in some way related to reading; (2) whether the process causing the effect is necessary in reading; and (3) if it is not necessary, whether it determines a reasonable proportion of the variance of some measure of reading. Consider how these criteria apply to the facilitation of words related to the expected words found in Experiment II. The first criterion was not met when the results of Experiment IV did not show a comparable effect.[14] This is especially critical since Experiment IV used a task that is more similar to actual reading than that used in Experiment II. The best guess is that reading could occur without context decreasing the time necessary to read words like those contained in the R set. Therefore the second criterion is not met. Since even when it was found the R - U difference was small compared to other effects, the third criterion is not met either. Therefore models of reading do not need to account for this effect: The evidence for general facilitation is not sufficiently strong to determine aspects of reading models.

Evidence that context facilitates expected words was found in Experiments I and II. This effect was relatively large and therefore merits attempts at replication with other tasks such as the sentence acceptability task. It would also be useful to determine the generality of other effects found without context, such as the word frequency effect. Whether or not studies of individual words are relevant to "real reading" has often been the subject of dogmatic debate (cf. Goodman, 1971; Baron, 1976). It seems time to treat this as an empirical question and test the generality of findings from these studies.

One aspect of the effects of context on reading individual words that has not been directly approached here is how the sentence frame context itself is processed. Little is know about such processing. Ways of circumventing this lack of knowledge for the purpose of setting up experiments have been developed here. However, perhaps the attempt has been premature and studies of the effects of context on reading individual words should be left until there are adequate theories of how the context is understood and how words out of context are processed.

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[14]For the sake of demonstrating the application of the criteria, acceptance of the null hypothesis is assumed.

APPENDIX A

Sentence Frames, E, R, and U Words from Experiment I

	Sentence Frame	E Word	R Word	U Word
1.	All the clothes the mourners wore were	black	white	dirty
*2.	Fluttering by was a pretty	butterfly	insect	leaf
*3.	The barbells the strong man lifted were very	heavy	light	old
*4.	The basketball players were all very	tall	short	nervous
5.	The man who didn't eat all day was very	hungry	thirsty	lazy
*6.	The cup was placed on the	table	chair	floor
*7.	The parking lot was filled with	cars	trucks	trash
8.	He threw a rock at the house and broke a	window	door	dish
*9.	No one at the zoo knew the name of the strange	animal	dog	rooster
*10.	The surprise party made him feel very	happy	sad	tired
*11.	In autum he went looking for pretty colored	leaves	trees	clothes
*12.	It was a very dark	night	day	room
13.	On a hot summer day many people go to the	beach	sand	theater
**14.	The magician took out his hat and made a rabbit	appear	see	laugh

**15. The mother fed the newborn	baby	diapers	radio
*16. The tired mother gave the dirty child a	bath	towel	cookie
**17. On top of the hamburger there was melted	cheese	mouse	plastic
18. He bought a wall-to-wall	carpet	drape	poster
19. The trained seal performed a clever	trick	joke	song
20. They baked many loaves of	bread	cake	clay
21. He put a clean sheet on the	bed	pillow	ground
**22. The king of beasts is the	lion	roar	work
23. The sick man had only six months to	live	breathe	pay
**24. He always forgets because he has a poor	memory	think	speech
25. The hikers slowly climbed up the	mountain	valley	stairs
26. The sad ending made many people	cry	tear	leave
**27. Eat right for good	health	medicine	money
28. The child was frightened, but it was just a bad	dream	night	picture
**29. She sewed the button on with some thread and a	needle	sharp	heavy
30. The Atlantic is a vast	ocean	water	plain
**31. He has trouble adding and subtracting large	numbers	letters	weeks
32. In the crowd there were all kinds of	people	places	tools
33. While skiing he broke his	leg	shoe	hat
34. The old horse moved very	slowly	fast	often

35. Almost everyone has ten	fingers	gloves	pencils
**36. There are two pints in a	quart	milk	recipe
**37. The orchestra played very pretty	music	noise	shells
38. He sanded the wood until it was	smooth	hard	broken
39. While the national anthem plays, everyone is expected to	stand	sit	turn
40. He hit the nail with a	hammer	wrench	book
41. Last night there was a full	moon	sky	party
42. He was stung by a	bee	flower	fish

*denotes sentence frame, R and U words forming acceptable sentences in Experiment IV.

**denotes sentence frame, R and U words forming unacceptable sentences in Experiment IV.

APPENDIX B

E Set Sentence Frames and Words from Experiment II[a]

1.	He was so frightened he was white as a	ghost
2.	Three heavy bags is more than he can	carry
3.	More money buys fewer products during time of	inflation
4.	Three people were killed in a terrible highway	accident
5.	The defendant is charged with	murder
6.	The heavy rains caused a massive	flood
7.	The baby weighed six pounds at	birth
8.	I can't write on the blackborad without any	chalk
9.	For breakfast she wanted bacon and	eggs
10.	At noon they took a break for	lunch
11.	Lincoln was born in a log	cabin
12.	The children enjoyed the three ring	circus
13.	He campaigned so he would win the	election
14.	He can't hear you because he is	deaf
15.	December is the last month of the	year
16.	The prisoners were planning how they would	escape
17.	To keep animals out of the garden, he put up a	fence
18.	He forgot to buy something, so he went back to the	store
19.	The politician spoke out for law and	order
20.	A red light is a signal to	stop

21. The new store had a grand	opening
22. To help wake up, he needed a cup of	coffee
23. After being robbed, he called the	police
24. It's unlucky to walk under a	ladder
25. The lecture should last about one	hour
26. The careless smoker caused a forest	fire
27. He had to wake up early to get there on	time
28. He was luck enough to win first	prize
29. The prison sentence was only six	months
30. There have been two world	wars
31. Some say a dog is man's best	friend
32. It felt much colder when the sun was behind a	cloud
33. Because he had a toothache, he called the	dentist
34. The old man has a long gray	beard
35. After a long wait, the package finally	arrived
36. The wet clothes were hung outside to	dry
37. The underpaid workers went on	strike
38. When he was 65, he had to	retire
39. Hawaii is the newest	state
40. He died of a heart	attack
41. The over-weight man went on a	diet
42. The minister pronounced them man and	wife

[a]The words and sentences frames for the R and U sets were the same as as Experiment I (see Appendix A).

APPENDIX C

Target Words, Related Context Words and Unrelated Context Words from Experiment III

Related-Only Set

	Target Word	Related Context Word	Unrelated Context Word
1.	bread	cake	reader
2.	butterfly	insect	glue
3.	moon	sky	juice
4.	pretty	flower	exit
5.	summer	hot	slice
6.	swim	water	clown
7.	tomato	lettuce	circus
8.	dream	night	hunt
9.	glove	hand	hut
10.	mountain	high	desk
11.	animal	lion	train
12.	appear	see	like
13.	bee	flower	like
14.	cloud	sky	juice
15.	corn	vegetable	clown
16.	memory	think	exit
17.	ocean	water	circus
18.	quart	milk	hut
19.	whiskey	drink	desk
20.	valley	mountain	wash
21.	wings	butterfly	glue
22.	wish	dream	run
23.	night	moon	slice
24.	open	door	hunt

Related-and-Associated Set

	Target Word	Related Context Word	Unrelated Context Word
1.	day	night	run
2.	drink	milk	sock
3.	queen	king	lake
4.	black	white	zoo
5.	rough	smooth	ten
6.	sit	chair	word
7.	tall	short	home
8.	drink	thirsty	sock
9.	pint	quart	loud
10.	shower	bath	year
11.	thread	needle	song
12.	pepper	salt	thick
13.	dark	light	year
14.	blue	color	ten
15.	cold	hot	word
16.	wet	dry	zoo
17.	hard	soft	home
18.	sky	blue	sock
19.	fast	slow	lake
20.	chair	table	loud
21.	nail	hammer	reader
22.	tiger	lion	song
23.	church	priest	train
24.	glass	window	thick

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