AUTOMATIC AND ATTENTIONAL PROCESSES IN WORD RECOGNITION: A COMPARISON OF THE TWO-PROCESS AND THE TWO-STRATEGY VIEW

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AUTOMATIC AND ATTENTIONAL PROCESSES IN WORD RECOGNITION: A COMPARISON OF THE TWO-PROCESS AND THE TWO-STRATEGY VIEW

BY

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ABSTRACT

An experiment was conducted to examine the patterns of facilitation and interference in the lexical decision task with respect to two important variables: the time course of processing and list context. Two current models of word recognition, the two-process view and the two-strategy view, make specific predictions with respect to each variable. The two-process view emphasizes the time course of processing and the two-strategy view emphasizes the effect of list context. The present study was designed to reconcile these two views. The effects of list predictability (high and low) and stimulus-onset asynchrony (SOA) (short and long) on lexical decision times to related, neutral and unrelated prime-target trials were examined. Lists of high and low predictability were generated by using category-exemplar pairs of either high or varying typicality. The results are consistent with automatic processing in short SOA conditions and strategic processing in long SOA conditions.

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Introduction

Semantic context effects in word recognition have been studied by examining the effect of a context word (i.e., a cue) on the processing of a target word. Typically context refers to a semantic relationship between the cue and target stimuli, such as category or associate pairs. The word pairs are either presented simultaneously or successively with an interval of up to 2000 msec between the presentation of the cue and target stimulus. The lexical decision task is frequently used to assess the influence of context on target processing (e.g., Becker, 1980, 1982; den Heyer, Briand and Smith, 1985; Koriat, 1981; Neely, 1976, 1977). In the lexical decision task some of the target stimuli are words while others are nonwords. Subjects have to decide whether the target stimulus is a word or a nonword as quickly as possible. On word trials the cue is sometimes related and sometimes unrelated to the target. Reaction time to make a correct word decision is generally faster when the cue and target stimuli are related to each other than when they are not (e.g., Fishler and Goodman, 1978; Koriat, 1981).

Although this procedure demonstrates the influence of context, it does not tell us why word decisions are faster for related cue-target trials than for unrelated cue-target trials. Target word processing could be facilitated by the presence of a related cue or interfered with by the presence of an unrelated cue. Alternatively, the context effect may reflect some complex combination of facilitation and interference. To distinguish between facilitation and interference effects, a neutral cue trial must be used. The neutral cue may be a row of Xs or a word, such as NEUTRAL or BLANK. Facilitation is assessed by comparing reaction time from a related word trial with reaction time from a neutral word trial; interference is assessed by comparing reaction time from an unrelated word trial with reaction time from a neutral word trial.

The neutral cue in this design is utilized to examine the relative contribution of facilitation and interference in making the lexical decision. However, Jonides and Mack (1984) suggest that the choice of a neutral nonword cue (e.g., XXXXX) or a word neutral cue (e.g., NEUTRAL or BLANK) could influence the apparent magnitude of facilitation and interference effects. Since these effects are important to arguements presented in critical studies (Neely, 1976, 1977; Becker, 1980), the present research will use the neutral cue common to all these studies i.e., a row of X's. Further research is required to clarify what type of cue is truly neutral.

Results from experiments using neutral cue trials show that the pattern of facilitation and interference varies according to (a) stimulus onset asynchrony (SOA), the time interval between cue and target presentation (Neely, 1976, 1977; Posner and Snyder, 1975a, 1975b), and (b) the semantic relationship between the cue and target pair (e.g., categorical, associative) (Becker, 1980, 1982; Becker and Eisenberg, 1982, den Heyer et al., 1985).

Stimulus onset asynchrony is measured from the onset of the cue to the onset of the target. To investigate the real-time characteristics of context effects, positive SOAs have been varied from a low of 40 msec (Fishler and Goodman, 1978) to a high of 2000 msec (Neely, 1977). Varying the amount of time a subject has to examine the prime affects how the target stimulus is processed. In general, facilitation has been found for all positive SOAs, while interference is more typical of SOAs greater than 300 msec to 400 msec.

Both the type of stimuli (e.g., associates, category examplars etc.) and the response strength between the cue and the target have been varied. Some investigators have used associates (Fishler and

Goodman, 1978; Koriat, 1981; Neely, 1976). Others, as discussed below in the section on the two-strategy view, have used categorical material and antonyms (cf. Becker, 1980). In general, patterns of facilitation and interference depend on the type of material used and on the overall strength of the relationship within a type of material.

While both SOA and the cue-target relationship are important, a focus on one or the other has led to two different approaches to the study of semantic context effects in visual word recognition: the two-process view (Posner and Snyder, 1975a, 1975b) and the two-strategy view (Becker, 1980). These views will be expanded upon next. Since the focus of the present study is on the patterns of facilitation and interference found in the lexical decision task, the following sections will examine only those studies employing the lexical decision task which include neutral cue trials.

The Two-Process View

Posner and Snyder (1975a, 1975b) examined automatic and attentional processes in visual letter and word recognition. They assumed that recognition occurs whenever activation of a logogen, the representation of a word in memory, exceeds some critical value. This assumption is also common to the Logogen model (Morton, 1970, 1979) of word recognition. According to the two-process view, two different processes may be involved in visual word recognition: automatic processing and attentional processing. Posner and Snyder (1975a, 1975b) indicate that because these processes are time dependent, specific patterns of facilitation and interference across time can be used to distinguish an attentional process from an automatic process. They varied SOA to examine the time course of facilitation and interference effects.

The first process which influences visual word recognition is automatic processing. This type of processing is fast acting, occurs automatically without intention or awareness, and operates without depleting the resources of the limited capacity central processor. As soon as the cue is presented, a logogen is automatically activated and some of the activation spreads to semantically related logogens. The activation threshold of the related logogens is reduced. Thus, facilitation can result from presentation of a related word cue. Unrelated logogens are not affected by the spreading activation and hence no interference is evident. The automatic process occurs rapidly and accounts for facilitation effects in short SOA conditions.

The second process which influences visual word recognition is attentional processing. Unlike the first, this process is slow acting and draws upon the resources of the limited capacity central processor. The presentation of the cue draws attention to its logogen and allows the subject to use some unspecified controlled strategy designed to enhance word recognition. Because it takes time to engage attentional processing, facilitation and interference effects are expected only at longer SOAs, i.e., greater than 300 msec to 400 msec. Facilitation occurs when the cue and the target are related to each other because strategic processes have decreased the amount of energy needed to activate a related logogen. Interference occurs when the word pair is unrelated. If attention has been directed to an unrelated cue word, subjects must shift their attention to the target logogen before making a response and this takes time.

To summarize Posner and Snyder's (1975a, 1975b) view, word recognition involves two processes. The first process, an automatic one, begins with the presentation of the cue. Activation of a logogen facilitates the processing of a related target word, but does not interfere with the processing of an unrelated target word. The attentional process has to be evoked strategically by the subject, so it requires more time than automatic processing. Attentional processing can facilitate the processing of related targets and interfere with the processing of an unrelated target, but only at longer SOAs, i.e., greater than 300 msec to 400 msec.

The two-process view was tested in lexical decision experiments by Neely (1976, 1977). Neely (1976) had three SOA conditions (360 msec, 600 msec, and 2000 msec) and used associates (response strength was 40%) as the cue-target pairs. The short SOA condition was set at 360 msec because Neely assumed that subjects would need that much time to process the cue word. The results showed that both facilitation and interference were evident in target processing in all three SOA conditions. The presence of facilitation and interference suggests that all SOA conditions were influenced by attentional processing. Contrary to expectation, the short SOA condition was apparently too long to examine the automatic process.

Neely's (1977) experiment included several SOA conditions varying between 250 msec and 2000 msec. Categorical material (high and low typicality exemplars of three different categories) were used as the cue-target pairs. Neely used the standard category-exemplar trials (e.g. bird-robin) in nonshift conditions. In addition, Neely used shift category-exemplar trials to increase attentional processing. In these shift conditions, subjects were trained to expect a category exemplar that was not typical of the cue word. For example, subjects were trained to expect a bird target when the cue was furniture. One-third of the experimental trials were non-shift trials, while the remaining trials were shift trials. Stimulus onset asynchrony was varied within subjects such that one group received a mixed sequence of 250 msec and 2000 msec SOA trials; a second group received 400 msec and 2000 msec SOA trials, and the third group received 700 msec and 2000 msec SOA trials. A fourth group experienced only the 2000 msec trials.

The results from non-shift trials revealed facilitation without interference at the 250 msec SOA, and both facilitation and interference at longer SOAs. These findings are consistent with Posner and Snyder's (1975a, 1975b) view. Results from shift trials showed facilitation coupled with interference at the 700 and 2000 msec SOA conditions which is again consistent with Posner and Snyder's (1975a, 1975b) view. Also consistent with this view are the results from those 250 msec SOA shift trials. In these trials subjects were trained to expect an unrelated exemplar. However, when a related pair was presented facilitation was evident. This indicated that the early facilitation was independent of the strategy induced by the instructions.

Balota (1983) measured patterns of facilitation and interference with threshold and suprathreshold presentations of the cue word. The SOA conditions were 350 msec and 2000 msec. High associates were used as the cue-target word pairs. The suprathreshold results showed facilitation coupled with interference in the long SOA condition especially in the second half of the session. In the short SOA condition, facilitation without interference was evident during both session halves. These patterns are consistent with Neely's (1977) results and with the Posner and Snyder (1975a, 1975b) view of visual word recognition. However, these results are inconsistent with Neely (1976), who found both facilitation and interference when the SOA was 360 msec. The variability of the results in the range of SOAs from 350 - 400 msec suggests that this is the period wherein attentional processes begin to appear. Small differences in presentation and task conditions might determine exactly when attentional processes emerge. Thus, SOA conditions which are shorter than this range have provided the clearest evidence of automatic processing.

Posner (1978) noted that one difficulty with the two-process view is that it fails to account for the types of strategies that subjects may adopt. There is some evidence that attentional effects (patterns of facilitation and interference) increase across the testing situation (Neely, 1976; Balota, 1983; den Heyer, 1986). This suggests that strategies need to be taken into account. Becker's research, to be discussed next, has focused on how the semantic relationships in a list may affect a subject's choice of strategies.

Two-Strategy View

Becker (1980, 1982; Eisenberg and Becker, 1982) has argued strongly that the Posner-Snyder framework does not adequately account for one aspect of the data. One prediction of the Posner-Snyder framework is that the amount of interference on unrelated trials must covary with the amount of facilitation on related trials. That is, conditions which increase interference for trials with unrelated cues should lead to increased facilitation for trials with related cues. Becker's results revealed either a facilitation-dominant pattern or an interference-dominant pattern, depending upon the type of stimulus material used. The facilitation-dominant pattern occurs when related trial reaction times are faster than the reaction times from neutral or unrelated trials and there is no substantial difference between neutral and unrelated trials. The interference-dominant pattern occurs when both related and neutral trial reaction times are faster than the reaction times from unrelated trials and there is no substantial difference between related and neutral trials. He suggests that the patterns of facilitation and interference reflect the operation of two different strategies, not the operation of two processes (automatic and attentional processing). Subjects select a strategy on the basis of the type of semantic relationship in the stimulus list as described below.

Becker (1980) performed a series of lexical decision experiments which support the two-strategy position. In all experiments a SOA of 1050 msec was used, subjects had substantial practice, the probability of a word trial was .67, and the probability of a nonword trial was .33. Also, filler trials were used to insure that the cue was related to the target in 67% of the word trials.

In Experiment 1, antonyms (e.g., hot-cold) were used as the cue-target pairs. A total of four blocks of 50 trials (one practice block followed by three experimental blocks) was used. A significant facilitation effect was evident, but no interference effect emerged. These results are typical of a facilitation-dominant pattern. In Experiment 2, Battig and Montague (1969) category norms were used to select the cue-target pairs. The cue-target pairs were chosen such that high typicality exemplars (e.g., fruit-orange), medium typicality exemplars (e.g., fruit-plum), and low typicality exemplars (e.g., fruit-lime) were equally represented in the list. Four blocks of 45 trials (one practice followed by three experimental blocks) were used. The results indicated a significant interference effect, but no facilitation effect. These results reflect an interference-dominant pattern.

According to Becker, the overall word list provides a context which allows subjects to develop specific predictions of related targets or it allows subjects to develop general expectations. If the stimulus material allows subjects to make specific target predictions, a facilitation-dominant pattern will result. On the other hand, if the material is not predictive but does allow a general expectancy for target stimuli, an interference-dominant pattern will be observed.

Becker (1980, Experiment 5) further examined the effects of list context by creating one list composed of a mixture of antonyms, categorical materials, and high associates as the cue-target pairs. The procedure was identical to that used in Experiments 1 and 2. Facilitation-dominant patterns were evident for antonyms, associates and categorical material. However, when performances on the high and low typicality categorical materials were examined separately, there was a significant facilitation effect for the high typicality pairs, but not for the low typicality pairs. While the results of this experiment indicate that the overall list context can influence the pattern of facilitation and interference, they also suggest that the strength of the semantic relationship is an important factor.

Becker (1980) utilized his verification model of word recognition to explain these results. Unlike the Logogen model, the extraction of features (line or arc segments of a group of letters) is not sufficient for word identification in the verification model. The function of feature extraction is to isolate a set of potential words which share common features. Once a feature-defined set of words is identified, a verification process selects one of the words to match to information in sensory memory. If there is a match, recognition occurs; otherwise another candidate word is selected. Semantic context (i.e., a cue word) generates a semantically-defined candidate set. This set of words is used by the verification process in the same fashion as the set of feature-defined words. Members of the semantic set are evaluated as soon as a new stimulus (i.e., the target word) is available in sensory memory. This set is evaluated exhaustively by the verification process prior to generating and evaluating the feature-defined set.

Becker (1980) suggested that the facilitation- and interference-dominant patterns indicate that subjects can use two different strategies to assemble the semantically-defined set. Facilitation-dominant patterns indicate that subjects are taking advantage of the predictability of the cue to generate a small semantically-defined set. This prediction strategy has two consequences. First, if a target word is in the set, it will be matched quickly leading to facilitation for related targets. Because there are only a few candidates to test, the semantically-defined set can be exhausted before the feature-defined set becomes available for evaluation. Second, in the case where no match is found there is no significant delay before the feature-defined set can be evaluated. Therefore, no interference for an unrelated target will be produced. The prediction strategy is used when the list context allows subjects to develop specific predictions for each cue and results in facilitation without interference.

Interference-dominant patterns indicate that subjects develop generalized expectations about targets which result in a large semantically-defined set. This is the expectancy strategy. Use of this strategy also has two main consequences. First, since search time increases with set size, the average time to identify a related target will increase to a point where there is no advantage over feature-defined recognition and hence, no facilitation to related targets will occur. Second, a large set cannot be searched exhaustively before the feature-defined set becomes available. So if there is no match, a delay is imposed before the feature-defined set becomes available for evaluation, resulting in interference dominance for unrelated targets.

Eisenberg and Becker (1982) discussed the discrepancy between the interference-dominant patterns they and Becker (1980) obtained using categorical materials and the pattern observed by Neely (1977) for non-shift categories. Recall that Neely (1977), using equivalent categorical material, found both facilitation and interference in the longer SOA conditions. Eisenberg and Becker first suggested that facilitation coupled with interference might reflect individual differences in the use of prediction or expectancy strategies during reading. They found that readers who could read difficult text quickly showed a facilitation-dominant pattern (i.e., used a prediction strategy) while readers who reduced their reading rate for difficult text showed an interference-dominant pattern (i.e., used an expectancy strategy). However, further examination of Neely's (1977) data revealed that a majority of the subjects in the longer SOA conditions showed both facilitation and interference in nonshift conditions suggesting that individual differences cannot account for Neely's results. Second, Eisenberg and Becker (1982) suggested that the facilitation in Neely's (1977) data resulted from the instructions given for the shift conditions. The use of shift categories demanded special attentional processing which may have affected performance on nonshift trials, and, hence, may be partially responsible for the difference between Becker (1980) and Neely (1977). Third, Eisenberg and Becker (1982) acknowledged the potential importance of SOA and suggested that the predictions of the two-strategy view should be investigated at SOAs other than the 1050 msec SOA condition used in their studies.

Both the two-process and the two-strategy views provide important perspectives on the process of word recognition. The two-process view emphasizes a distinction between early (short SOAs) and late (long SOAs) processing, while the two-strategy view focuses on the effects of the semantic relationship between a cue and a target. These views differ because each utilizes a unique pattern of facilitation and interference to support their views.

The following experiment examines the patterns of facilitation and interference for high and low predictability lists at short (250 msec) and long (1050 msec) SOA conditions. This experiment was designed to answer general questions about how these views can be merged. For instance, Posner (1982) suggested that one way to merge these views was to propose that during attentional processing, subjects may select specific strategies. And, as outlined below, a number of specific questions will be discussed.

Is the decision to use the prediction or expectancy strategy determined by list context as suggested by Becker (1980)? Or is it determined by the predominant type of semantic relationship in a list? Becker (1980) argued that when list context allows specific predictions (e.g., when antomyms are used), a prediction strategy is adopted and a facilitation-dominant pattern results. Where no specific predictions can be adopted; the expectancy strategy is utilized and an interference-dominant pattern results. When category decisions are made in the context of associates and antonyms (e.g., a highly predictable list context), high typical category decisions yield a facilitation-dominant pattern (Becker 1980, Experiment 5). This led Becker (1980) to conclude, "...It may be, then, that the distribution of the relationship strengths in a list of stimulus material determines the facilitation and interference effects and not simply the size of the related set for a particular cue stimulus..." (Becker, 1980, p. 495).

However the generality of this claim has not been clearly established. Becker's Experiment 1 used antonyms, while Experiment 2 (1980) used categorical material. This confounded overall list context with the nature of the semantic relationship between the cue and target. The one experiment which demonstrated a facilitation-dominant pattern for categories required the presence of associates and antonyms in the list and even then, only highly typical category-exemplar pairs showed the facilitation-dominant pattern (Becker 1980, Experiment 5). Neely (1977), in contrast, found both facilitation and interference for a mixed range of category stimuli in long SOA (both mixed and pure) conditions.

To determine if list context is the controlling factor in strategy selection, it is necessary to manipulate the list context without changing the nature of the semantic relationships within the list. To achieve this, only category-exemplar pairs were used in the present study. High and low predictability lists were developed by selecting categorical materials at different typicality levels. The stimuli used in this experiment mirror the categorical semantic relationships chosen by both Neely (1977) and Becker (1980). The only difference is that the critical stimuli were chosen from prototypicality norms (Uyeda and Mandler, 1980).

rather than production frequency norms. In this way typicality can be better controlled, since production frequency is only partially related to typicality (Uyeda and Mandler, 1980).

Highly typical exemplars of each category were used in the high predictability list context. High, medium and low exemplars of each category were chosen for the low predictability list context. Word frequency and word length were equated across lists.

If list context is the critical variable as Becker (1980) suggested, subjects should be able to use a prediction strategy for the high predictability list, but not for the low predictability list. Highly typical exemplars are normatively predictable and show little variability in typicality ratings, and therefore a prediction strategy should work. According to Becker (1980) this should result in a facilitation-dominant pattern. However it would be difficult for subjects to develop predictions in the low predictability list context. Thus subjects should adopt an expectancy strategy, resulting in an interference-dominant pattern. On the other hand, the type of semantic relationship may be the critical factor. Because both high and low predictability lists consist of category exemplar pairs, all subjects may adopt the expectancy strategy. In this case, an interference-dominant pattern should be found for both lists.

The two-process view has emphasized the effects of the time course of processing rather than the type of stimulus material. The simple prediction from the two-process view is that performance in the 250 msec SOA condition will reflect only the operation of the automatic process. In a recent experiment, den Heyer et al. (1985) found facilitation and no interference for antonyms and categorical material at a short SOA of 200 msec. Likewise, the present results should show facilitation only for both high and low predictability lists in the short SOA condition.

But what of performance in the 1050 msec SOA condition for the high predictability list? Posner (1982) suggested that subjects do not need to develop a specific active strategy, but can obtain a facilitation-dominant pattern by passively maintaining the effects of automatic activation. With highly predictable materials, subjects may adopt this passive maintenance strategy, thereby showing a facilitation-dominant pattern. If the facilitation in high predictability lists is of the same magnitude in the 250 msec and 1050 msec SOA conditions, passive maintenance may be an alternative explanation to Becker's prediction strategy. The facilitation should be equivalent in both SOA conditions because the automatic process would be responsible for the facilitation effect. Interference would not be expected in either SOA condition because subjects do not engage active attentional mechanisms, the primary source of interference effects.

For the low predictability lists in the 1050 msec SOA condition, both facilitation and interference would be expected. A facilitation-dominant pattern could occur, at least for high typicality related pairs, if subjects were to maintain the effects of the automatic process. However, other trials will require subjects to process medium and low typicality related exemplars where reliance on the automatic process would not be an effective strategy. Thus, subjects would have to utilize attentional mechanisms to develop an alternate strategy for all typicality levels. The development of the strategy will utilize limited capacity resources, resulting in interference when the strategy is not effective and facilitation when it is effective.

High and low predictability lists were tested in a between-subjects design to ensure no contamination across list contexts. The short and long SOA conditions were treated as a within-subject factor and were randomized within blocks as in Neely (1977).

Recent experiments (den Heyer et al., 1985) have demonstrated early automatic processing at short SOAs and strategic processing at longer SOAs in a between-subject design. Replicating these findings with SOA conditions as a within-subject factor will further clarify the time course effects.

Method

Subjects

Twenty-four male and twenty-four female right-handed subjects were paid for their participation. Subjects were recruited through advertisements placed around the university. All subjects were tested individually. Data from an additional six subjects were not analysed because their error rate exceeded 10%.

Apparatus

Presentation of cues and targets, and collection of data were controlled by an Apple 2 computer equipped with a Mountain Hardware clock. Subjects were seated in front of a video monitor and a response panel equipped with three microswitches.

Design

List context (high and low predictability) was a between-subjects factor and SOA (250 msec and 1050 msec) and cue condition (related, unrelated and neutral) were within-subjects factors. One hundred and eighty trials were divided into six experimental blocks. Each block had an equal number of trials devoted to each SOA condition. The proportion of word to nonword trials was .67, the same as that used by Becker (1980) and by Neely (1977). The cue-target validity was .67, which is also consistent with those studies. A summary of the number of critical word trials (related, neutral, and unrelated), filler trials (related and neutral) and nonword trials (cued and neutral) is presented in Table 1.

Stimulus Material

All critical materials were selected from category prototypicality norms (Uyeda and Mandler, 1980), while the filler materials were selected from the category production frequency norms (Battig and Montague, 1969). All words were selected such that the maximum number of letters was not greater than ten or less than four. The minimum word frequency was 41.2. A list of all stimulus material can be found in Appendix A.

High Predictability List. Twenty-four critical categories from the Uyeda and Mandler (1980) norms were used. Three exemplars were randomly selected from the six most typical instances of each of the 24 categories to maintain an even distribution of prototypicality. Critical stimuli had a mean standard frequency index of 54.08, ranging from 41.2 to 70.8 (Carroll, Davies and Richman, 1971). This value was reasonably close to the standard frequency

Table 1. Summary of word and nonword trial types.

Cue Condition	Example	Number of trials
SOA-1050		
Word Word Related	MONEY-PENNIES	12
Neutral Word	XXXXX-HAND	12
Word Word Unrelated	WEAPON-ROOF	12
Related Fillers	DISTANCE-INCH	12
Neutral Fillers	XXXXX-GARLIC	12
Word Nonword	BIRD-SINATOR	12
Word Nonword Fillers	FLOWER-SKOTES	6
Neutral Nonword	XXXXX-SHIRRY	12
SOA-250		
Word Word Related	SPORT-SOCCER	12
Neutral Nonword	XXXXX-GREEN	12
Word Word Unrelated	CLOTHING-COTTAGE	12
Related Fillers	TIME-SECOND	12
Neutral Fillers	XXXXX-DENTIST	12
Word Nonword	FRUIT-SIRGEANT	12
Word Nonword Fillers	DANCE-VILLEY	6
Neutral Nonword	XXXXX-Merch	12

index of the material chosen by Becker (1980), that is 51.2. The mean prototypicality rating for these stimuli was 1.74, ranging from 1.12 to 2.44 on a 7-point scale. Twelve additional filler categories were selected from the Battig and Montague (1969) norms to maintain a cue-target validity of .67. Four exemplars were randomly selected from the six most frequent instances of each of the categories to maintain an even distribution of typicality. The stimuli had a mean standard frequency index of 51.78, ranging from 40.0 to 66.2 (Carroll, Davies and Richman, 1971). The mean production frequency for these stimuli was 262.42 (range 107 to 438), which was reasonably close to the production frequency for the high typicality category exemplars (i.e. 298) used by Becker (1980, Experiment 2). Responses to these stimuli were not analyzed as they do not map onto the prototypicality ratings used for critical material.

Six exemplars from ten unused categories of the Battig and Montague (1969) norms were selected for use as nonwords. All nonwords were pronounceable and were generated by changing a vowel in a word. This method of generating nonwords is similar to the procedure used by Becker (1980) as reported in Eisenberg and Becker (1982).

Low Predictability List. All stimulus materials were selected from the same sources used to create the high predictability list. The critical and filler categories were also the same as those used in the high predictability list. However, the exemplars were chosen to create a low predictability list in the same fashion as Becker (1980). Three critical stimuli were selected from each category from the Uyeda and Mandler (1980) norms. One high typicality item from each category was randomly chosen from the top third of the norm list, yielding a mean prototypicality rating of 1.52. A medium typicality item from each category was randomly chosen from the middle third of the list, yielding a mean prototypicality rating of 2.98. A low typicality item from each category was randomly chosen from the bottom third of the list, yielding a mean prototypicality rating of 4.80. The mean standard frequency index of these materials (55.7, 53.4 and 51.4 for the high, medium and low exemplars, respectively) was similar to those used by Becker (51.2, 54.8 and 48.6 for the high, medium and low exemplars, respectively). To check for an effect of word frequency, the standard frequency index of high, medium and low typicality targets was submitted to an analysis of variance with typicality level as the single factor. No significant effects were noted.

Four filler exemplars were randomly selected from each category from the Battig and Montague (1969) norms: one from the high typicality portion of the list (mean production frequency= 351.5), two from the medium typicality portion of the list (mean production frequency= 125.58) and one from the low typicality portion of the list (mean production frequency= 47.69).

List Construction. Critical stimuli were randomly assigned to one of three sets, A, B and C, where each set contained eight category names with three exemplars for each category for a total of 24 cue-target pairs. Each set was arranged such that eight cue-target pairs were related, eight cue-target pairs were unrelated (by pairing a category name from another set with the target exemplar) and eight were neutral trials (this was achieved by substituting a 'XXXXX' for the category name).

Filler trials were generated in a similar fashion. Four exemplars from 12 categories were used to form an additional 24 related trials and 24 neutral trials. Neutral nonword trials were formed by pairing 'XXXXX' with the remaining nonwords.

An experimental block of 30 trials was generated by using four related, four unrelated and four neutral trials from the critical stimuli, plus four related and four neutral trials from the filler material. In addition to these 20 word trials, the 10 nonword trials consisted of six nonword cued trials (four critical and two filler) and four neutral nonword trials. A SOA of 250 msec was then assigned to half of each of the trial types and a SOA of 1050 was assigned to the other half. The order of these 30 trials was randomized and the next 30 trials were generated until six blocks were formed.

This procedure was used to generate the base list. Additional lists were created such that there were 12 experimental lists altogether. The base list was read backwards to create a second list. Another two lists were created by rotating exemplars within each block such that exemplars used in related pairs would be used as unrelated pairs, etc., and reading these lists backwards. Another two lists were created by an additional rotation such that the original related pairs would now be neutral pairs, and reading those lists backwards. The next six lists were generated by randomly reassigning categories to each of the three blocks and repeating the above procedure.

Two unused categories from Uyeda and Mandler (1980) and two unused categories from Battig and Montague (1969) were used to generate 30 practice trials. For the critical material the three most frequent exemplars were selected (mean SFI= 58.7, range 50 to 64.3, Carroll, Davies and Richman, 1971). Four exemplars from two categories were selected for filler material (mean SFI= 55.92, range 50 to 61.6) from the Battig and Montague (1969) norms. Nonwords were generated from unused Battig and Montague (1969) categories. The list was constructed such that several nonword trials occurred early insuring that subjects were alerted to making a lexical decision rather than making a relatedness judgement.

Procedure

Subjects were informed that they would have to decide whether each string of letters formed a valid English word. An outline of a 3 cm X 6 cm box was presented in the middle of the screen to warn subjects that a new trial was about to begin. The cue stimulus was presented approximately 1500 msec after the presentation of the box outline. On each trial the cue stimulus was presented for 150 msec in the top half of the box. The box was then blanked for either 100 msec or 900 msec, depending on SOA condition, before the presentation of the target stimulus in the bottom half of the box.

All subjects were instructed to press the left hand button of the response panel (labeled WORD) if the target letter string spelled a word and to press the right hand button (labeled NONWORD) if the target letter string did not spell a word. To acquaint subjects with the button box 20 sample trials were given. Subjects were instructed to press the button marked WORD if the string WORD was presented on the screen and to press the button marked NONWORD if the string NONWORD was presented on the screen.

Subjects were then informed that the same procedure would be used throughout the experiment. They were asked to read the target string, to decide whether it was a word or a nonword and then to respond as quickly and accurately as possible. Reaction time was measured to the nearest millisecond, from the onset of the target string display to the subject's response. The subject's response terminated the target string display. If subjects pressed the wrong button, an error message was displayed for 1000 msec. The total intertrial interval (from the subject's response to the presentation of the cue in the next trial) was 3000 msec.

In addition to the response requirements, subjects were informed of the various trial types (related word, neutral word, unrelated word, cued nonword and neutral nonword). They were told that the cue would either be a word or a row of X's. If the cue was a word, subjects were informed that they should read it to themselves to get the meaning, as it was likely to be meaningfully related to the target. An example, SNAKE-RATTLER, was given to illustrate the type of relationship.

To ensure that subjects were familiar with making lexical decisions, not relatedness judgments, 30 practice trials on the lexical decision task were given prior to the presentation of the experimental blocks. The first 15 trials had an SOA of 1050 msec and the second half had both short and long SOAs (250 msec and 1050 msec). A short break was given after the first half. After the practice trials, subjects were informed that they were to begin the experimental trials and were reminded of the requirements for the lexical decision task.

The subject rested for 15 secs between blocks. Each session lasted approximately 35 minutes. After completion of the six experimental blocks, each subject was debriefed and paid.

Results

To prepare the data for analysis, the mean reaction time for correct responses to critical word trials was calculated for each subject. Any individual reaction time further than 2.5 standard deviations from the mean was considered to be an outlier. Outlying reaction times were excluded and the mean reaction time was recalculated. This would appear to be an accepted standard (P. Siple, Personal Communication, Nov., 1984). Outliers acccounted for 3.4% of the data in the high predictability list and 3.4% of the data in the low predictability list conditions.

The following analyses were performed on the mean and on median reaction times. Because the same pattern of results was obtained in both analyses, only the results of the analyses of mean reaction times will be reported. In the initial analysis, gender was included as a factor. Because there was no main effect of gender and no interaction of gender with any other factor, gender was not included in further analyses.

Mean reaction time and percent error for all conditions are shown in Figure 1 and in table format in Appendix B. A three-factor analysis of variance

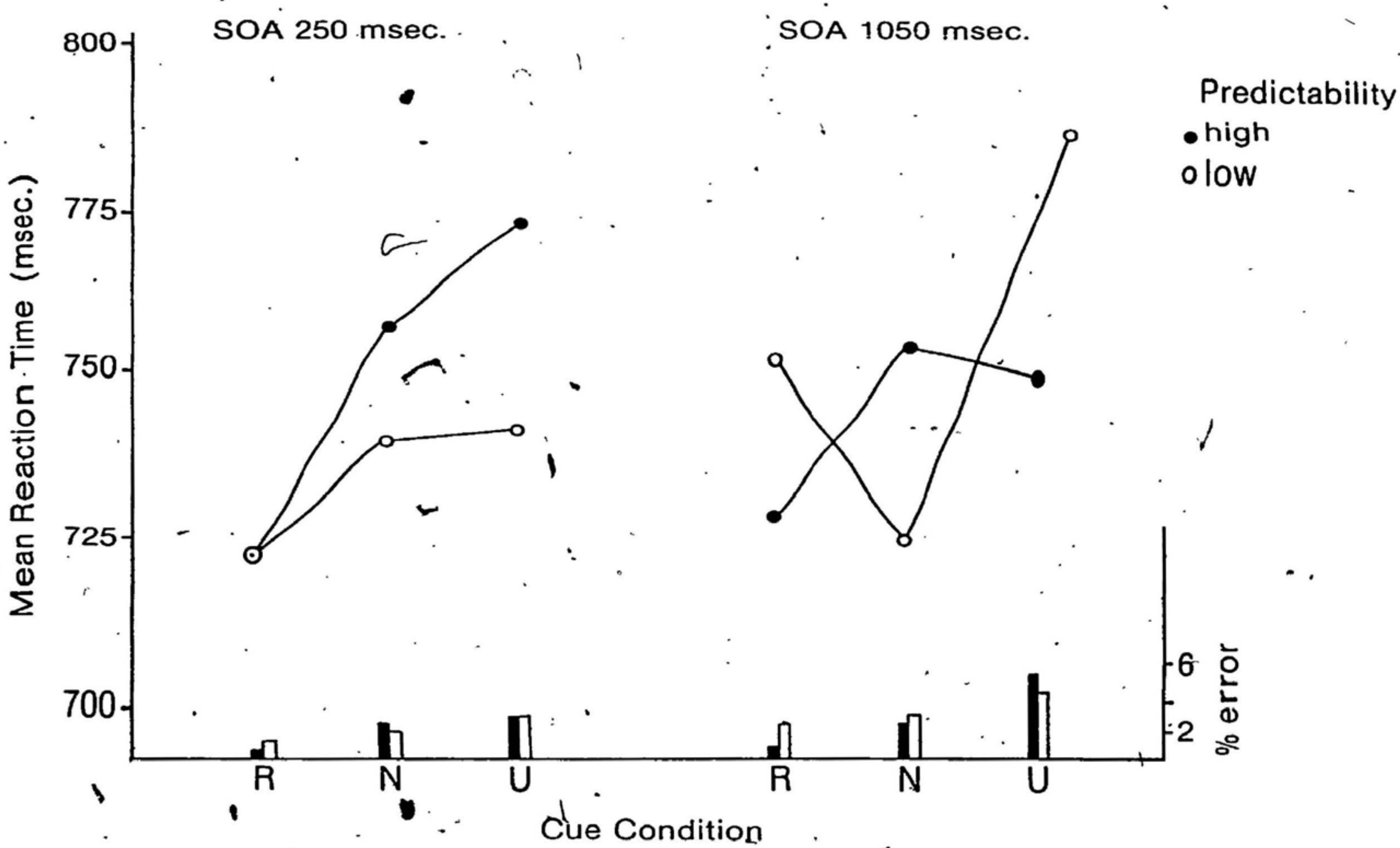

Figure 1: Mean reaction time and percentage error data as a function of cue condition in short (SOA 250 msec.) and long (SOA 1050 msec.) SOA conditions for the high and low predictability lists.

on the reaction time data with list context as a between-subjects factor and SOA and cue condition as within-subjects factors was carried out and the results are presented in Table 2a. The effect of cue condition was significant, $F(2,92) = 6.37$, $p < .01$, reflecting a difference in reaction time between related, neutral and unrelated critical word trials. Overall, reaction time was faster on related and slower on unrelated trials than on neutral trials Neither the main effect of predictability nor SOA was significant. Also none of the interactions was significant.

The results of a similar analysis on percent error are shown in Table 2b. The main effect of SOA was significant, $F(1,46) = 4.40$, $p < .05$, as was the main effect of cue condition, $F(2,92) = 6.67$, $p < .01$. As can be seen in Figure 1, error rates were higher in the 1050 condition than in the 250 msec SOA condition. Figure 1 also shows that related word trials had fewer errors than the neutral or unrelated word trials.

Although the triple interaction failed to reach significance, the data were analysed for specific effects of list predictability and SOA. These analyses were justified because they are central to

Table 2: Global analysis of variance with predictability as a between-subjects factor and SOA and cue condition as within-subjects factors for (a) mean reaction time and (b) percent errors.

(a) Reaction Time

Source	Df	M.S.	F
Predictability	1	484.04	<1
Error	46	180439.00	
SOA	1	3056.25	<1
Pred. X SOA	1	11741.90	1.87
Error	46	6261.62	
Cue Condition	2	22877.20	6.37***
Pred X Cue	2	8405.34	2.34
Error	92	3590.69	
SOA X Cue	2	4645.62	<1
Pred X SOA X Cue	2	9602.58	1.81
Error	92	5284.71	

(b) Percent Error

Source	Df	M.S.	F
Predictability	1	6.42	<1
Error	46	27.62	
SOA	1	107.80	4.40**
Pred. X SOA	1	6.48	<1
Error	46	24.46	
Cue Condition	2	173.73	6.67***
Pred X Cue	2	14.76	<1
Error	92	26.02	
SOA X Cue	2	19.20	<1
Pred X SOA X Cue	2	12.07	<1
Error	92	20.41	

* $p < .10$
** $p < .05$
*** $p < .01$

the thesis that the semantic relationship between the prime and target determines the pattern of facilitation and interference. Also these analyses can clarify the patterns of facilitation and interference at each SOA level.

The first set of analyses examined the effect of list predictability at each level of SOA. In the analysis of the reaction time data from the 250 msec SOA condition, there was a significant effect of cue condition, $\underline{F}$ (2,92) = 4.19, $\underline{p}$ < .05. As shown in Figure 1, a facilitation-dominant pattern was evident in both lists, with no interaction between cue condition and predictability. In the analysis of percent error, the effect of cue condition approached significance, $\underline{F}$ (2,92) = 2.58, $\underline{p}$ < .10. As was noted previously, fewer errors were evident in the related trials. A summary of these analyses is presented in Table 3.

In the analysis of reaction time from the 1050 msec SOA condition, the interaction between cue condition and predictability approached significance, $\underline{F}$ (2,92) = 2.94, $\underline{p}$ < .10. Percent error was analysed

Table 3: ANOVAs on (a) mean reaction time and (b) percentage error for the short SOA condition where predictability is a between-subjects factor and cue condition is a within-subject factor.

(a) Reaction Time

Source	Df	M.S	F
Predictability	1	8497.00	<1
Error	46	86223.60	
Cue Condition	2	15768.70	4.19**
Pred X Cue	2	2954.42	<1
Error	92	3760.70	

(b) Percent Error

Source	Df	M.S	F
Predictability	1	.69E-04	<1
Error	46	22.08	
Cue Condition	2	46.60	2.58*
Pred X Cue	2	1.47	<1
Error	92	18.06	

* p <.1
** p < .05
*** p <.01

in a similar fashion. A significant effect of cue condition was evident, F (2,92) = 5.15, p < .01. Fewer errors were noted in the related than in the unrelated trials. A summary of the analysis is presented in Table 4.

The second set of analyses examined the effect of short and-long SOAs in each type of list. In the analysis of reaction time from the high predictability list, the main effect of cue condition was significant, F (2,46) = 4.21, p <.05. Reaction times were faster in related trials than in neutral or unrelated trials suggestive of a facilitation–dominant pattern. Analysis of percent error showed a significant effect of cue condition in the high predictability list, F (2,46) = 4.73, p < .05. Also, the SOA X cue condition interaction approached significance, F (2,46)= 2.53, p < .10. The number of errors increased across related, neutral and unrelated trials especially in the long SOA condition, as is shown in Figure 1. A summary of the analyses is presented in Table 5.

In the analysis of reaction time from the low predictability list, the effect of cue condition was significant, F (2,46) = 4.54, p < .05. Also, the

Table 4: ANOVAs on (a) mean reaction time and (b) percentage error for the long SOA condition where predictability is a between-subjects factor and cue condition is a within-subjects factor.

(a) Reaction Time

Source	Df	M.S	F
Predictability	1	3728.9	<1
Error	46	100477.0	
Cue Condition	2	11754.10	2.29
Pred X Cue	2	15053.50	2.94*
Error	92	5114.74	

(b) Percent Error

Source	Df	M.S	F
Predictability	1	12.90	<1
Error	46	30.00	
Cue Condition	2	146.30	5.15***
Pred X Cue	2	25.37	<1
Error	92	28.37	

* $p < .1$
** $p < .05$
*** $p < .01$

Table 5: ANOVAs on (a) mean reaction time and (b) percent errors for the high predictability data where SOA and cue condition are within-subjects factors.

(a) Reaction Time

Source	Df	M.S.	F
SOA	1	1408.56	<1
Error	23	7932.41	
Cue Condition	2	17640.50	4.21**
Error	46	4182.75	
SOA X Cue Condition	2	2885.71	<1
Error	46	6378.26	

(b) Percent Error

Source	Df	M.S.	F
SOA	1	30.71	1.35
Error	23	22.72	
Cue Condition	2	144.56	4.73**
Error	46	30.50	
SOA X Cue Condition	2	30.84	2.53*
Error	46	12.20	

* $p < .10$
** $p < .05$
*** $p < .01$

SOA X cue condition interaction approached significance, $F(2,46) = 2.71$, $p < .10$. An interference dominant pattern was evident especially in the long SOA condition. In the analysis of percent error, a main effect of SOA approached significance, $F(1,23) = 3.18$, $p < .10$. More errors were noted in the long SOA condition. A summary of these analyses is presented in Table 6.

In addition to the above analyses, the net effect (see below for a complete description of net effect) in msec of related (neutral - related) and unrelated (neutral - unrelated) cues was analysed as per Neely (1977). In these analyses, list predictability was a between-subjects factor and SOA and net effect were within-subjects factors. The results of these analyses were consistent with the above reported results.

A full analysis of prototypicality level and word cue condition is difficult to justify because critical related word trials were not coupled with specific critical neutral or unrelated word trials as was the case in den Heyer et al. (1985). As a first approximation, however, the net effect of prototypicality was examined to clarify the source of

Table 6. ANOVAs on (a) mean reaction time and (b) percent errors for the low predictability data where SOA and cue condition are within-subjects factors.

(a) Reaction Time

Source	Df	M.S.	F
SOA	1	13389.60	2.91
Error	23	4590.83	
Cue Condition	2	13642.10	4.54**
Error	46	2998.63	
SOA X Cue Condition	2	11362.5	2.71*
Error	46	4191.2	

(b) Percent Errors

Source	Df	M.S.	F
SOA	1	83.57	3.18*
Error	23	26.21	
Cue Condition	2	43.93	2.03
Error	46	21.53	
SOA X Cue Condition	2	.43	<1
Error	46	28.63	

* $p < .1$
** $p < .05$
*** $p < .01$

interference in the related word condition. Net effect is the difference between the mean reaction time of related trials and the mean reaction time of the neutral trials. To calculate the net effect, data from the low predictability lists were separated into high, medium and low prototypicality levels for each subject. Then the net effect was determined for each subject.

Table 7 shows the mean net effect for the three levels of prototypicality in the short and long SOA conditions. This table also shows the standard error of the mean net effect and the number of individuals who showed a positive net effect. Two-tailed tests show a significant facilitory effect with the high and medium prototypicality related pairs in the short SOA trials. For the long SOA trials, only the high prototypicality related pairs had a significant positive effect, while the medium and low prototypicality related pairs had significant negative net effects. This pattern was also reflected in the number of subjects showing positive net effects.

In summary, the global analysis of mean reaction time indicated an effect of cue condition reflecting a difference in the related, neutral and unrelated

Table 7: Net effect (in msec) of prototypicality level for short and long SOA conditions.

		Prototypicality Level		
		High	Medium	Low
SOA 250				
	RT	65.41	35.10	-26.32
	SEm	25.25	22.82	40.34
	n	19	15	13
	t(23)	4.86 p<.001	2.61 p<.02	1.95 ns
SOA 1050				
	RT	38.95	-104.54	-145.3
	SEm	28.71	70.83	79.45
	n	21	10	6
	t(23)	2.89 p<.01	7.77 p<.001	10.8 p<.001

Net effect is the difference between related and neutral trials at both SOAs for high, medium and low typicality levels. SEm is the standard error of the mean for net effect data. _n_ is the number of subjects out of 24 which show a facilitatory effect of related trials. A two tailed t-test of differences was utilized to compute the level of significance.

word trials. The error variance in the present study was very high which obscured the overall results of analyses. Subsequent analysis of list predictability and SOA did suggest that specific dominance patterns were emerging. A facilitation-dominant pattern was significant in the short SOA condition and there was asuggestion of a facilitation-dominant pattern with the high predictability list in the long SOA condition. In the long SOA condition with the low predictability list context, an interference-dominant pattern was suggested. In the low predictability list context a difference between high, medium and low typicality levels was evident in related word trials.

Discussion

The purpose of the present study was to examine patterns of facilitation and interference in the lexical decision task with respect to two important variables: the time course of processing and list context. With the exception of two recent studies (den Heyer et al., 1985, den Heyer, 1986), there has been no attempt to examine both variables in a single study. The current study begins to show ways in which the perspectives offered by the two-process view and the two-strategy view can be reconciled. The results support a fast-acting automatic process at a short SOA which is compatible with the two-process view. At the longer SOA, the effects of strategic intervention are evident, which is consistent with some version of the two-strategy view.

The two-process view has emphasized the time course of processing, suggesting that item processing during short SOAs is automatic without strategic intervention and that at longer SOAs, strategic processes are evident. In the present study, short SOA results show the same pattern in high and low predictability lists where reaction times on related word trials are generally faster than on neutral or unrelated word trials. This pattern is suggestive of an automatic process and is similar to results from other studies supporting the two-process view (Neely, 1977; Balota, 1983). At the long SOA, the trends suggest that interference develops in low predictability lists, but not in high predictability lists. These results are similar to those studies (Becker, 1980; den Heyer et al., 1985) supporting the development of an attentional strategy at long SOAs.

Since the completion of the present experiment, den Heyer et al. (1985) replicated Becker's (1980) Experiments 1 and 2 and included a short SOA condition. Their results were similar to those of the present study, suggesting the presence of automatic processing at short SOAs and attentional processing at long SOAs. den Heyer (1986) has further clarified the time course results. He examined facilitation in prime-target pairs which were repeated six times in short or long SOA conditions. He demonstrated that facilitation increases over trial blocks with a long SOA, but not with a short SOA. He argued that the increase in facilitation resulted from the development of an attentional strategy during the long SOA trials.

The results of the present study and those of den Heyer and his colleagues support an automatic process influencing word identification at short SOAs. At longer SOAs the strength of the semantic relationship between the cue and target influences how a target will be identified. The strength of the cue-target relationship results in the development of attentional strategies which can either facilitate or interfere with word identification.

Becker's (1980) conception of the role of list context is that it allows the subject to develop either specific predictions or general expectations of a potential related target word set. However, Becker's (1980) study confounded the type of semantic context in the list (antonyms vs categories) with the strength of the semantic relationship between the cue and target. The results of the present study, using only categorical materials, suggest that the overall strength, not the type, of semantic relationship between the prime and target in the list determines strategy selection.

When the list context was highly predictable, responses to related items were facilitated. No interference was associated with the processing of unrelated items. Nor did cue condition interact with SOA in the analysis of the high predictability list data. Apparently the time course did not substantially affect subjects' performance. There are two possible interpretations of these results. First subjects may have adopted Becker's (1980) prediction strategy and generated short lists of target words to facilitate target processing. Since strategy development requires time, this strategy could only work in long SOA conditions. An alternative possibility is that the targets which had been activated by the automatic process were passively maintained by the subjects, as suggested by Posner (1982). Of the two possibilities, the passive maintenance explanation is more parsimonious than the prediction strategy explanation. Generating a short candidate set would be redundant because the potential targets have already been activated by the automatic process.

Interference was evident in the processing of unrelated word targets at a long SOA when the lists were of low predictability. Interference at long SOAs is characteristic of both the two-process view and the two-strategy view. The differentiating factor is the presence or absence of facilitation on related word trials. The two-process view predicts facilitation arising from attentional processing directed towards the target. The two-strategy view predicts no facilitation because the semantically-defined set is large. The potential benefits of the use of the expectancy strategy are lost because of the increased time to search for and identify the target item.

In contrast to both predictions, interference was evident in the processing of related word trials in the low predictability list at the long SOA. Further examination of the results revealed facilitation for high typicality pairs only, and substantial interference effects in the processing of medium and low typicality word pairs. While interference in related word trials is not a typical finding, the pattern of net effects of high, medium and low word trials is consistent with network models of memory as outlined below.

In network models of memory, when the cue is presented, a logogen is automatically activated and this activation spreads through the memory network affecting closely related logogens. The effects of spreading activation decline as the target logogens become less typical of the cue logogen. The pattern of results in the present study is consistent with this. The high typicality pairs showed facilitation regardless of SOA. Low typicality pairs were never facilitated. The results of Becker's (1980) Experiment 5 would also support this. In that experiment, high typicality related word trials showed a facilitation dominant pattern but not the low typicality related word trials.

den Heyer et al. (1985) suggested that the proportion of related word trials could influence the pattern of results. As the proportion of related word trials increases, facilitation and interference increases. The present results could have been influenced by the greater proportion of highly related word trials in the high predictable list. In the high predictable list context, all related pairs were high typicality items. In the low predictable list context, 33% of the pairs were high typicality.

The above, however, does not explain why medium and low typicality items were actually processed more slowly than unrelated items in the low predictability list at the long SOA. That is, the net interference effect for unrelated trials was -60.9 msec, which is considerably less than the net interference effect for medium and low typicality items of -104.5 and -145.3, respectively. One possible explanation is that the effects of an expectancy strategy only become evident for those items that are not affected by a passive maintenance strategy (e.g., medium and low typicality items).

Assume that cue presentation lowers the activation threshold of closely related target nodes and activates the major attributes of the category. If the target is not immediately processed by the passive maintenance strategy (e.g., high typicality targets), a strategy similar to the expectancy strategy would process the target. A semantically-defined set would be generated by the cue similar to the expectancy strategy. However prior to an exhaustive search, the target is examined for category membership. The category decision could be based on a quick check of attributes rather than a long search process. If the cue and target are related, the target is checked through an exhaustive search of a long candidate list. If the cue and target are unrelated, the search process is not implemented and recognition proceeds according to the sensory-defined feature set. If the cue is a row of X's, the category decision is not necessary. In this case subjects can act on the sensory-defined set as soon as it becomes available. The reaction times for the medium and low typicality related trials are longer than unrelated trials in the present study because of the extensive search.

In the present experiment the lexical decision times were quite long and quite variable. The difference in lexical decision times between the present study and similar studies (den Heyer et al, 1985; Becker, 1980) is in the 100 to 200 msec range. Subject factors may be one source of difficulty here. The subjects in the present study were largely first-year university students who were tested during their first semester. These subjects may have been more cautious in responding than more experienced students leading to slower and more variable reaction times.

While subject selection may have been problematic in the present study, most of the lexical decision studies have more general problems which need to be addressed. One problem is that typicality has been defined in terms of production frequency, not prototypicality. The common source for most category selection is the Battig and Montague (1969) production frequency norms. Uyeda and Mandler (1980) suggest that typicality is only partially related to production frequency. They examined the first 30 exemplars from 28 of the Battig and Montague (1969) norms. Subjects were asked to rate the typicality of each exemplar of the category. Spearman correlations between production frequency and prototypicality ranged from .064 for the Toy category to .869 for the Country category. The variations in these correlations suggest that investigations of the effects of typicality may be influenced by category selection.

A second class of problems concerns procedural differences between lexical decision studies. For example, some studies (Becker, 1980; Eisenberg and Becker, 1982) limit the amount of time a subject is allowed to make a decision. The time to make the word or nonword decision is limited by not allowing a subject to respond after the cutoff criterion. Other studies (Neely, 1977; Balota, 1983; den Heyer et al, 1985; den Heyer, 1986) did not use a cutoff. Shoben (1982) suggests that the utilization of a cutoff criterion has the effect of reducing the mean reaction time, especially where the mean would be greater with no cutoff.

In the present study category selection was dependent upon prototypicality not production frequency. Also outliers were determined instead of using a cutoff criterion. Both of these factors could have affected the results but further experimentation would be required to clarify the effects of these factors. Since significant differences in these studies are measured in milliseconds, methodological considerations take on increased importance. Some methodological conventions are required for data handling and material selection so as not to interfere with interpretation.

In conclusion, the results of the present experiment where SOA was a within-subjects variable are consistent with the recently published findings from den Heyer et al. (1985) where SOA was a between-subjects variable and den Heyer (1986) where SOA was varied both within- and between-subjects. The collective findings suggest that with short SOAs word recognition is automatic and reflects the effects of spreading activation in a semantic network. The cue presentation results in a lowered activation threshold of closely related nodes. At longer SOAs, strategies come into play. Strategy development depends upon the strength of the semantic relationship between the prime and target. If the cue-target pairs are closely related then subjects can utilize this relationship to make decisions faster. This may well take the form of passively maintaining the automatic process. When the cue-target pair is not closely related, subjects engage in a slow serial search through a cue-generated list, similar to Becker's expectancy strategy.

REFERENCES

Balota, D. A. (1983). Automatic semantic activation and episodic memory encoding. Journal of Verbal Learning and Verbal Behavior, 22, 88-104

Battig, W. F., & Montague, W. E. (1969). Category norms for verbal items in 56 categories: A replication and extension of the Connecticut category norms. Journal of Expermental Psychology Monograph, 80, Pt 2.

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

Becker, C. A. (1982). The development of semantic context effects: Two processes or two strategies?, Reading Research Quarterly, 17, 482-502.

Carroll, J.B., Davies, P. & Richman, B. (1971). The American heritage word frequency book. New York: Houghton Mifflin.

den Heyer, K., Briant, K. & Smith, L. (1985). Automatic and strategic effects in semantic priming:

An examination of Becker's verification model. Memory and Cognition, 13, 228-232.

den Heyer, K. (1986). Manipulating attention-induced priming in a lexical decision task by means of repeated prime-target presentations. Journal of Memory and Language, 25, 19-42.

Eisenberg, P., & Becker, C. A. (1982). Semantic context effects in visual word recognition, sentence processing, and reading: Evidence for semantic strategies. Journal of Experimental Psychology: Human Perception and Performance, 8, 739-756.

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

Jonides, J., & Mack, R. (1984). On the cost and benefit of cost and benefit. Psychological Bulletin, 96, 29-44.

Koriat, A. (1981). Semantic facilitation in lexical decision as a function of prime-target association. Memory and Cognition, 9, 587-586.

Morton, J. (1970). A functional model for memory. In D. A. Norman (Ed), Models of human memory, (pp.203-254). New York: Academic Press.

Morton, J. A. (1979). Facilitation in word recognition: Experiments causing change in the logogen model. In P. A. Kolers, M. E. Wrolstad, & H. Bouma (Eds), Processing of visible language, Vol. 1 (pp. 259-268). N.Y.: Plenum Press.

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

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

Posner, M. I. (1978). Chronometric explorations of the mind: The third Paul M. Fitts lectures. Hillsdale, N.J.: Erlbaum.

Posner, M. I. (1982). Cumulative development of attentional theory. American Psychologist, 37, 168-179.

Posner, M. I., & Snyder, C. R. R. (1975a). Attention and cognitive control. In R. L. Solso (Ed.), Information processing and cognition: The Loyola symposium. (pp. 55-85). Hillsdale, N.J.,: Erlbaum.

Posner, M. I., & Snyder, C. R. R. (1975b). Facilitation and inhibition in the processing of signals. In P. M. A. Rabbitt & S. Dornic (Eds.) Attention and Performance V. (pp. 669-682) New York: Academic Press.

Shoben, E. J. (1982). Semantic and lexical decisions. In C. R. Puff (Ed) Handbook of research methods in human memory and cognition, (pp. 287-314). New York: Academic Press.

Uyeda, K. M., & Mandler, G. (1980). Prototypicality norms for 28 semantic categories. Behavior Research Methods and Instrumentation, 12, 587-595.

APPENDIX A

List of critical and filler stimulus material used to generate high and low predictability word lists

High Predictability List: critical stimulus material

Category	Exemplars		
Animal	horse	wolf	lion
Beverage	milk	water	lemonade
Bird	dove	robin	sparrow
Body	head	legs	hand
Building	roof	door	wall
Clergy	priest	minister	reverend
Cloth	cotton	wool	silk
Clothing	pants	shirt	dress
Color	blue	yellow	green
Country	france	england	italy
Dwelling	house	home	cottage
Fruit	apple	pear	banana
Furniture	chair	table	couch
Instrument	piano	violin	flute
Metal	iron	steel	copper
Money	dollars	dimes	pennies
Sport	baseball	tennis	soccer
Tool	hammer	nails	drill
Toy	doll	rattle	ball
Tree	pine	redwood	birch
Utensil	knife	spoon	fork
Vegetable	carrot	spinach	brocolli
Vehicle	auto	truck	motorcycle

Weapon	pistol	rifle	knife

High Predictability list: filler stimulus material

Category	Exemplars			
Crime	murder	assualt	robbery	theft
Dance	waltz	twist	jerk	monkey
Disease	cancer	mumps	measles	polio
Distance	mile	foot	inch	yard
Fish	trout	bass	shark	herring
Flower	rose	tulip	daisy	violet
Insect	ants	mosquito	spider	beetle
Profession	doctor	lawyer	teacher	dentist
Relatives	aunt	uncle	father	mother
Ship	sailboat	submarine	battle	cruiser
Spice	salt	pepper	sugar	garlic
Time	hour	minute	second	year

Low Predictability list: critical stimulus material

Category	Exemplars		
Animal	horse	sheep	squirrel

Beverage	milk	cocoa	punch
Bird	dove	crow	vulture
Body	head	back	trunk
Building	roof	hall	wood
Clergy	priest	monk	sister
Cloth	cotton	velvet	jersey
Clothing	pants	shoes	gloves
Color	blue	gold	olive
Country	france	brazil	africa
Dwelling	house	motel	shack
Fruit	apple	melon	tomato
Furniture	chair	chest	radio
Instrument	piano	drums	cymbals
Metal	iron	zinc	sodium
Money	dollars	cents	bonds
Sport	baseball	racing	hunting
Tool	hammer	screws	plumb
Toy	doll	wagon	rope
Tree	pine	spruce	locust
Utensil	knife	glass	sink
Vegetable	carrot	cabbage	rice
Vehicle	auto	train	tank
Weapon	pistol	bomb	stick

Low Predictability list: filler stimulus material

Category	Exemplars			
Crime	murder	theft	assualt	beating
Dance	waltz	minuet	ballet	modern
Disease	cancer	malaria	cold	virus
Distance	mile	millimeter	kilometer	acre
Fish	trout	whale	carp	crab
Flower	rose	lily	petunia	poppy
Insect	ants	wasp	ladybug	worm
Profession	doctor	engineer	professor	clerk
Relatives	aunt	nephew	niece	wife
Ship	sailboat	yacht	canoe	raft
Spice	salt	cinnamon	cloves	lemon
Time	hour	decade	week	score

Appendix B

Mean reaction time and percentage error data (in brackets) for short (SOA 250 msec) and long (SOA 1050 msec) SOA conditions for the high and low predictability lists. The data presented in this table are the same as those presented in Figure 1.

SOA 250 msec.

Cue Predictability	Cue condition		
	Related	Neutral	Unrelated
High	721.69 (.69)	756.8 (2.42)	772.16 (2.77)
Low	722.76 (1.04)	742.32 (2.08)	741.75 (2.78)

SOA 1050 msec.

Cue Predictability	Cue condition		
	Related	Neutral	Unrelated
High	728.57 (.69)	754.52 (2.42)	748.8 (5.55)
Low	752.13 (2.42)	724.45 (3.53)	785.42 (4.51)