1976

The word familiarity effect as a function of the number of response alternatives.

Robert Laurence Cohen
University of Massachusetts Amherst

THE WORD FAMILIARITY EFFECT AS A FUNCTION OF THE NUMBER OF RESPONSE ALTERNATIVES

A Thesis Presented

By

Robert Laurence Cohen

Submitted to the Graduate School of the
University of Massachusetts in partial fulfillment
of the requirments for the degree of
MASTER OF SCIENCE
August 1976
Psychology

THE WORD FAMILIARITY EFFECT AS A FUNCTION OF THE NUMBER OF RESPONSE ALTERNATIVES

A Thesis Presented

By

Robert L. Cohen

Approved as to style and content by:

Arnold Well, Chairperson of Committee

Alexander Pollatsek, Member

Katherine V. Fite, Member

Bonnie Strickland
Chairperson
Department of Psychology

ABSTRACT

The Word Familiarity Effect as a
Function of the Number of Response Alternatives

(August 1976)

Robert L. Cohen
B.A., Western New England College
M.S., University of Massachusetts

Directed by: Professor Arnold Well

It has long been known that experience with words influences performance in certain visual tasks. What is not clear is the extent "wordness" influences processing at an early perceptual (extraction) level before memory or response variables exert an effect. Various studies have offered conflicting evidence as to whether a word familiarity effect (WFE) can be found at a stage of processing that could be labeled perceptual.

One study, Bjork and Estes (1973), yielded results which indicated that the WFE found in other studies was caused by an uninteresting response bias and not perceptual facilitation. Evidence is offered in this thesis that the results of Bjork and Estes' study were due to an artifact of their experimental design. The present study was designed to provide a valid test of the problem Bjork and Estes dealt with.

The results of the present study indicated that Bjork and Estes' results were indeed due to problems in their experimental design and that experience can influence

perceptual processes in a way that allows familiar material to be processed faster.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

It has long been known that experience with words influences performance in certain visual tasks. Cattell (1886) found that subjects could report more letters from a briefly presented word than from a similarly presented nonword. More recently, Howes and Solomon (1951) found that the visual duration threshold (VDT: Determined by progressively flashing a word for increasingly longer intervals until S correctly reports) of a word was a function of the relative occurrence of that word in written English.

Solomon and Postman (1952) manipulated experience with alphabetic stimuli by varying stimulus frequency. Subjects in this experiment read aloud three syllable nonsense words from one to twenty-five times. VDTs to these words and unpracticed nonsense words were measured. The result was a linear relationship between VDT and the log of the frequency. Miller, Bruner, and Postman (1954) found that more letters could be reported out of a string of eight letters when the sequence of letters resembled the sequence in English words than when it did not.

While these studies indicate that familiarity with words or induced familiarity with sequences of letters enables subjects to report the words, familiar strings, or their component letters with greater accuracy than with unfamiliar strings, it is not clear that the effect is perceptual. The subject might have seen the unfamiliar stimuli just as well as the familiar ones, but might have been able to use his knowledge of the regularities of the familiar stimuli to make a more accurate guess (Neisser, 1967).

The fact that superior performance with words may lie in a post-perceptual stage does not by itself make the effect uninteresting. Rather, it is the speed of the operation involved that distinguishes between interesting and uninteresting mechanisms (Baron, 1975). This is based on the assumption that the main reason for being interested in a word familiarity effect is out of an interest in the processes involved in reading rather than out of an interest in demonstrating how familiarity may influence performance in certain specific visual tasks.

Smith and Spoehr (1974) present a very good conceptual framework in which to deal with the processing of letter strings. Their basic hypothesis is that the processing of a letter string includes two distinct and sequentially organized stages. The first stage involves the extraction of information from the input string (Extraction Stage); and the second stage the assignment of this information to some stored category (Interpretation Stage). The information extracted in the first stage is in the form of visual features. The interpretation stage may contain as many as three sequentially organized component processes: (1) a matching process, (2) a decision process, and (3) a translation process.

Smith and Spoehr use an example of a single letter (R) to further explain their two stage model (Figure 1). The output of the extraction stage is a feature description of the input in terms of line segments, angles, and curves. The matching process of the interpretation stage consists of a comparison of this input description to stored visual representations of all twenty-six possible letters (categories). The output of this process is a restricted set of categories, each of which matches the input to some degree. The decision process makes a selection of one category from this restricted set according to some decision rule, e.g., the frequency of occurrence in English. The single category of this output may then be translated into its acoustic equivalent.

In the context of the Smith and Spoehr model, "perception" may best be thought of in terms of the extraction stage. It is clear that any facilitation of letter extraction in words would be fast enough to operate in reading. Whether or not facilitation in the interpretation stage is important would depend, as stated previously, on the speed at which the word facilitation was accomplished.

The results of the Howes and Solomon, Solomon and Postman, and Miller, Bruner and Postman studies previously cited are open to explanation in terms of a subject response strategy. Three types of response strategies that could

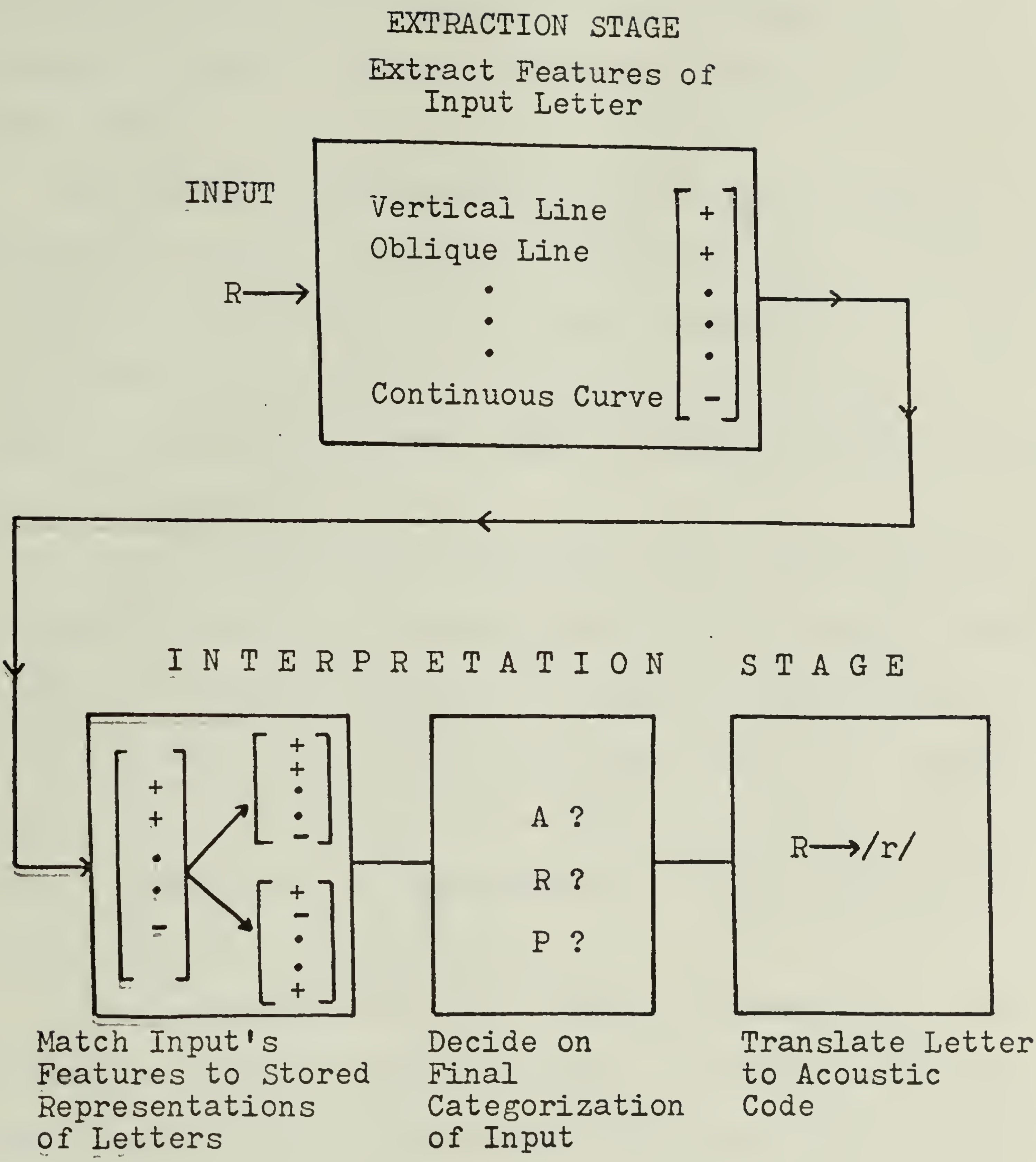

Figure 1

Smith and Spoehr (1974) Model of Letter String Processing have been employed by subjects in these studies are pure guessing, sophisticated guessing, and criterion bias (Broadbent, 1967).

In the pure guessing model, the subject is able to completely extract a proportion of the stimuli correctly and guesses in some or all of the remaining trials. If, given his knowledge of English, he guesses more frequently on common words than uncommon words, he might by chance improve his performance.

In the sophisticated guessing model, even though the information that has been extracted is not complete, there is enough information available to restrict the possible number of alternatives, given that the subject sees the stimulus presentation as a word. The subject now selects a response from a limited set of alternatives and thus increases the probability of a correct choice.

The criterion bias model involves a biasing of the subject to accept a smaller amount of information before deciding in favor of a probable word rather than an improbable word. If a subject utilizes this strategy, a facilitation for words will result.

Recently, various paradigms have been devised which attempt to minimize response bias. One of these is the simultaneous matching task. Eichelman (1970) tested subjects' ability to match pairs of words and pairs of nonword strings formed by scrambling the same letters that appeared in the words. Subjects responded faster to words than to nonwords. A hypothesis that subjects were able to respond faster because they were reading the words and name matching was rejected by Eichelman by adding a condition in which some of the words were printed in different cases. A large difference in response time was found between different case and same case pairs for both words and nonwords. If subjects were name matching words, it should have made no difference if word pairs were presented in the same or different cases. Thus, with Eichelman's experiment it appears that subjects were able to perform a perceptual task better when the stimuli were words rather than nonwords.

Reicher (1969) employed a probe recognition procedure, which is the procedure we will primarily be concerned with in this paper. In Reicher's study, four letter words, four letter nonwords, and single letters were presented followed by a field containing (1) a visual noise mask that covered the region in which the letters had been presented, and (2) two probe letters adjacent to a particular letter position. The subjects had to decide which of these two letters had appeared in the probed position. Subjects were more accurate with words than with nonwords or single letters. Accuracy did not differ significantly between nonwords and single letters. An important aspect of Reicher's experimental design was that in the word condition both the correct and incorrect response alternatives would form a word if placed in the probed position. This manipulation served to reduce a possible cause of response bias in favor of words. In an attempt to reduce memory effects, Reicher added a condition in which the two alternatives were also verbally given in advance of the stimulus presentation. Giving subjects the response alternatives before the stimulus display as well as after caused an impairment of performance in the word, nonword, and letter conditions, but word superiority remained.

Reicher's findings were replicated by Wheeler (1970) who proposed, tested, and rejected five hypothesis (other than one of perceptual facilitation) to account for Reicher's results.

One alternative explanation of Reicher's findings is that of feature redundancy (Thompson and Massaro, 1973; Massaro, 1973; Bjork and Estes, 1973). Baron (1975) gives a good description of this uninteresting form of the sophisticated guessing theory:

> Let's say that the word FOLD is presented and the subject gets enough information to say with confidence that the second letter is a vowel, the last letter is a consonant, and the third letter has a horizontal line at the bottom, which means it must be E, L, or Z. If he now assumes that the stimulus is a word, a reasonable assumption to make when he already knows that a lot of the stimuli are words, he can with considerable confidence now say that the third letter must be an L. In other cases, he may narrow down the possibilities to a small set of letters rather than just one. After he makes this decision, we must also assume that he forgets the information on which it was based. In particular, he forgets that one critical piece of evidence was the horizontal line at the bottom. Now let us say that the

alternatives L and R are presented. Clearly he will get it right. If the subject could not use this kind of information about redundancy to help his decision - and clearly he would not be able to use it to advantage for nonwords such as OFLD - he might have guessed that the horizontal line indicated the letter E rather than L. When presented with the alternatives L and R, he might well decide that the R looked more like an E than the L did, and get it wrong. Of course, if he remembered that his guess about the letter identity had made use of his initial perception of the horizontal line, he would still pick L, but we have assumed he has forgotten. In general, then, the subject might use his knowledge of certain kinds of redundancy - the ability to predict the identity of some letters from information about others - to narrow down the set of possible letters before he looks at the alternatives.

Massaro (1973), and Thompson and Massaro (1973) designed their studies to eliminate the effect of redundancy. This was done by keeping the response alternatives constant (P, R, C, or G), the word presentations constant (APE, ARE, ACE, AGE), and the nonword presentations constant (VPH, VRH, VHG, and VCH). Each stimulus presentation contained one of the four response alternatives. Subjects responded by identifying the response alternative which appeared in the stimulus presentation. These studies yielded results different from those of Reicher (1969). In Thompson and Massaro, subjects were more accurate during letter presentations than during word presentations. Massaro replicated this finding and in addition found no significant difference in subjects' accuracy between the word and nonword displays.

Bjork and Estes' (1973) study was also designed to reduce the effect of redundancy in a forced choice detection procedure. Only two target letters (R and L) were used and subjects were told the target letters prior to the onset of the experiment. Each stimulus presentation contained a target letter. Each of the four trial blocks of seventy-two displays contained an equal number of words, nonwords, and single letters.

The letter strings were arranged so as to control for certain possible effects of redundancy. This was done by constructing the word displays so that exchanging the nonpresented target letter for the presented target letter changed one-half of the word displays into nonword displays and kept one-half of them as word displays. Similarly, exchanging the nonpresented target letter for the presented target letter changed one-half of nonword displays into word displays and kept one-half of them as nonword displays.

Bjork and Estes tested ten groups of four subjects each at various combinations of masking fields and display durations. No significant difference in accuracy between words and nonwords was found for any of these groups. The discrepancy between the results of this study and Reicher's (1969) was attributed to the more complete elimination of the effects of redundancy on response selection.

RATIONALE FOR THE PRESENT STUDY

Various experiments have shown that a subject is capable of altering his perceptual strategy to fit the task. Aderman and Smith (1971) found no effect for spelling patterns when subjects were led to expect sets of unrelated letters. In Johnston and McClellands' (1974) study subjects performed better in a forced choice procedure on words when they were instructed to see the whole word than when they were instructed to fixate on just the probed position. With strings of unrelated letters the reverse was true: fixating on the critical serial position improved performance. The results of this study suggest a different interpretation of the results of Massaro (1973), and Thompson and Massaro (1973): the word familiarity effect disappeared with the restricted stimulus lists employed in these studies because subjects stopped looking at whole words and looked at just the critical middle letter.

A possible effect of limiting the number of response alternatives as Bjork and Estes did can be seen in comparing the results of Krueger (1970), and Gibson, Tenney, Barron, and Zaslow (1972). In Krueger's experiment the subject saw a target letter and then searched through the displayed word or nonword responding yes or no. The target letter appeared once or not at all in a given display, and the target letter changed with every display. Search time was found to be lower for word than nonword displays.

Gibson, et al., had subjects search for a single target letter (N) through (1) letter strings that were orthographically well structured though not English words and (2) letter strings that were poorly structured and unpronounceable. Subjects did not differ in scan rate between the pseudoword strings and unpronounceable strings.

Gibson, et al., considered the contradiction between their results and Krueger's and concluded it was due to the fact that they kept the same target letter throughout the experiment while Krueger changed the letter with every trial. Gibson, et al., state, "His [Krueger's] Ss, unlike ours, did not have the opportunity to learn to search for the distinctive graphic features of a single target letter." Krueger attributes his results to the fact that subjects in his experiment were not restricting their attention to the letter shape being sought but were engaging in a somewhat broader encoding operation perhaps similar to reading. Gibson, et al., state, "Our Ss were not [their italics] engaged in a coding operation similar to reading in the usual sense."

The explanation of Gibson, et al., to explain the difference between their results and Krueger's was not supported in a recent study by Krueger and Weiss (1976). Here, as in the Gibson, et al., study, the target letter was kept fixed over a series of trials. However, search was found to be faster through words than through nonwords.

Krueger and Weiss hypothesized that Gibson, et al., failed to find significantly faster letter search through familiar letter sequences because they simply used a less sensitive, between subjects experimental design.

Using a similar procedure, but changing the target on each trial, Krueger, Keen, and Rublevich (1974) found a 49 msec. time savings for words which was significantly greater than the 22 msec. found in Experiment 1 of Krueger and Weiss. While keeping the target letter constant did not eliminate a word familiarity effect, it apparently can reduce it.

We now have two alternative explanations for Bjork and Estes' results. The first is the explanation of Bjork and Estes that they eliminated redundancy and therefore a word superiority effect. The second is that subjects were more apt to search just for the graphic features of R and L. They may have performed a more peripheral kind of processing, encoding the stimulus less completely, only far enough to determine whether an R or L was present. Consequently, they would have been less likely to identify the other letters, and hence the effect of "wordness" could have been reduced far enough not to yield significant results.

In the present study, Bjork and Estes' procedure was modified so as to force more complete processing of the stimulus, i.e., more features of each letter would have to be extracted to reach a decision as to whether or not that letter is a member of the target set. In order to accomplish this, the target set was increased to four letters.

A possible problem in increasing the target set is a differential memory effect -- memory comparison in words being more efficient than comparison in strings. If this is the case, then increasing the number of alternatives will increase the advantage of words over strings. Krueger (1970) varied the size of the target set from one to four letters in a search task and found that search time increased as much for words as nonwords -- the time savings for words over strings staying constant. Therefore, using a target set size of four should not confound memory effects with a perceptual facilitation for words.

As a control, Bjork and Estes' use of two target letters was replicated. If Bjork and Estes are correct in saying that eliminating redundancy from the decision process eliminates a word familiarity effect, then no difference between words and strings in the two or four target condition should be found. However, if Bjork and Estes' results were a function of perceptual strategy and if using four target letters forces the subject to process more features of each letter, then there should be a difference between words and strings if familiarity does indeed affect the feature extraction stage.

METHOD

Subjects. Twelve male and eight female University of Massachusetts undergraduate and graduate students served as Ss. The undergraduates received course credit for their participation. Each S participated for a single one hour session.

Apparatus and Stimuli. A Hewlett-Packard 2114B computer was used to display rows of capital letters on an HP-1300A X-Y display oscilloscope. Each letter was formed by illuminating the appropriate pattern of points in a matrix 13 points high by 9 points wide. The computer recorded responses. The Ss were run individually, and sat approximately five feet from the oscilloscope screen in a dimly lit sound-damped room.

The display for a single trial consisted of a single four letter string. Each of the letters in a string was .34 inch wide and .39 inch high, and there was .08 inch between letters. Each string was therefore 1.6 inches wide by .39 inch high. These dimensions corresponded to visual angles of 1.52° in the horizontal and $.38^{\circ}$ in the vertical.

The two target condition was a direct replication of the Bjork and Estes study. The target letters were R and L. Half the letter strings were words and half nonwords. The word displays were constructed so that exchanging the nonpresented target letter for the presented target letter changed one-half of the word displays into nonword displays and kept one-half of them as word displays. Similarly, exchanging the nonpresented target letter for the presented target letter changed one-half of the nonword displays into word displays and kept one-half of them as nonword displays. Thus, two types of word displays were used, which may be denoted word-word and word-nonword respectively, depending upon whether the display remained a word or became a nonword when the presented target letter was replaced by the nonpresented target letter. Similarly, two types of nonword displays were used: nonword-nonword and nonword-word.

Pairs of word-word and word-nonword displays were constructed first and then used to construct pairs of nonword-nonword and nonword-word displays respectively. Given a pair of word-word displays (e.g., PLAY and PRAY) a pair of nonword-nonword displays was constructed by randomly rearranging the letters of the word-word pair. However, the target letter maintained the same serial position and the consonent-vowel structure was preserved in the created nonwords. For example, YLAP and YRAP would be a nonword-nonword display derived from the word-word display PLAY-PRAY.

The nonword-word display was constructed by presenting the alternative of a word-nonword display. For example, a NW-W display derived from the W-NW display SLED would be SRED.

There were 192 experiment trials divided into six blocks of thirty-two. Any one block of 32 trials contained equal numbers of each display type (word-word, word-nonword, nonword-word, nonword-nonword) with R and L appearing equally often in each serial position in each display type.

The construction of the two target condition stimuli is outlined in Table 1. The words were selected from Kucera and Francis (1967).

It was impossible to construct four target letter stimuli which exactly met the constraints employed by Bjork and Estes in the construction of the two target letter stimuli. D, M, N, and P were selected to be the target letters in the four target condition through the following procedure. First, a list was made of all four letter words contained in Kucera and Francis (1967). Beginning with the fourth serial position, groups of words which would meet the word-word constraint (i.e., all target letters forming a word) were searched for. It was found that insisting that an entire set of four target letters form a word in a given serial position would make it impossible to generate enough stimuli using four targets. Therefore, in the four target condition, the word-word constraint was modified such that replacing the presented target letter with two of the three nonpresented target letters would keep the stimulus a word.

This modified word-word constraint yielded some possible target letter combinations. The most promising target letter combinations were then checked at the other serial positions to see how many word-word stimuli could be constructed using

TABLE 1

TWO TARGET LETTER DISPLAY TYPES

Display Type	Display Presented	Outcome of Incorrect Guess
Word-Word	LOCK	ROCK
Word-Nonword	TRIM	TLIM
Nonword-Word	WALM	WARM
Nonword-Nonword	NAER	NAEL

these target groups. D, M, N, and P were found to yield the most word-word stimuli in the first, third and fourth serial positions.

The second serial position proved to be a problem for all possible target letter combinations. The lack of four letter words with D, M, N, and P in the second serial position required that in this serial position (1) the word-word stimuli be kept words by one of the three nonpresented target letters, and (2) there be fewer examples in this serial position. This necessitated repeating these items in order to keep the number of tests at the second serial position the same as the other serial positions.

In the four target nonword-word stimuli, any of the nonpresented target letters formed a word with the exception of the second serial position. Here, one of the three incorrect target letters formed a word and there were fewer examples in this serial position. This necessitated repeating items as was the case in the word-word condition.

In the four target word-nonword stimuli, replacing the presented target letter with a nonpresented target letter turned the display into a nonword.

The four target nonword-nonword stimuli were derived from the word-word stimuli in the same manner as was done with the two target stimuli. Replacing the presented target letter with a nonpresented target letter kept the display a nonword.

In the four letter condition, there were 192 experimental trials divided into six trials of thirty-two. Each trial block contained an equal number of the four stimulus types. In any one trial block, each target letter appeared equally often in each serial position. The construction of the four target stimuli is outlined in Table 2.

Procedure. Ten Ss were run in the four target condition followed by ten Ss in the two target condition. Each S was shown a total of 224 four letter strings grouped in seven blocks of thirty-two during a single one hour session. The first block was a practice block. The remaining six experimental blocks were randomly ordered for each S.

Each S viewed the following instructions as E read them aloud:

> In this experiment you will be shown 224 four letter strings. Half of these strings will be words and half random letter strings. The target letters are R and L (for Ss in four target condition different instruction sheet read D, M, N and P). A trial will follow this sequence.
>
> $$$$ pre stimulus masking field
> WORD stimulus
> $$$$ post stimulus masking field
>
> The post stimulus field will remain on until you have responded. Respond by pressing the appropriate key on the response board corresponding to the target letter which appeared in the string. One and only one of the target letters will appear in each string. Response time is not measured in this experiment. Try to be as accurate as possible. You initiate each trial by pressing any one of the keys on the response board. The trials will be grouped in seven blocks of thirty-two. The first block is a practice block. Do you have any questions?

The pre-stimulus field ($$$$) lasted for two seconds.

TABLE 2

FOUR TARGET LETTER DISPLAY TYPES

Display Type	Display Presented	Outcome of Incorrect Guess
Word-Word	MICE	DICE, NICE, PICE
Word-Nonword	LUNG	LUDG, LUMG, LUPG
Nonword-Word	WIME	WIDE, WINE, WIPE
Nonword-Nonword	LCAD	LCAM, LCAN, LCAP

The stimulus was displayed for a period of 30 to 90 milliseconds, the actual time being varied by blocks in 15 millisecond intervals in order to keep accuracy on words at about 75%. Pilot subjects indicated that Ss should be started initially at 90 milliseconds with four alternatives and 75 milliseconds with two alternatives, and that Ss would show a sizable practice effect. If Ss approached 85% accuracy on a given block, the display time was reduced by 15 milliseconds for the following trial.

As outlined in the instructions given Ss, the post-stimulus field ($$$$) remained on until S had responded by pressing the appropriate key on the response board corresponding to the target letter which appeared in the stimulus. S controlled the rate of trial presentation and was not told whether or not a response was correct.

RESULTS AND DISCUSSION

The overall results are given in Table 3. Subjects performed significantly better on words in both the two and four alternative conditions. The difference in performance between conditions was found to be not significant.

Serial position effects are shown in Figures 2 and 3 for the two and four alternative conditions respectively. In neither case was there a difference in performance in the first or second serial positions. Superior performance on word displays was found in the third and fourth serial positions.

The fact that significant overall differences were found in both the two and four alternative conditions does not support the hypothesis that Bjork and Estes' results were solely a function of subjects altering their strategy by merely searching for the critical features of the two alternatives: i.e., the stimuli not being encoded far enough to allow an effect, if any, of wordness to be important on a perceptual level.

A possible explanation for the differing results follows the same logic employed by Krueger and Weiss (1976) in explaining the difference between their results and those of Gibson, Tenney, Baron, and Zaslow (1972). It might have been the case that Bjork and Estes' design was simply not sensitive enough to show a word familiarity effect even if one was indeed present.

TABLE 3

PERCENTAGE OF CORRECT DETECTION BY NUMBER OF ALTERNATIVES

Group	N	No. of Alternatives	Display Type		Difference
			Word	Nonword	
1	10	4	74.4	64.6	9.8*
2	10	2	78.3	72.2	6.1**

* $F=15.64$, $df=1/9$, $p<.005$

** $F=21.08$, $df=1/9$, $p<.005$

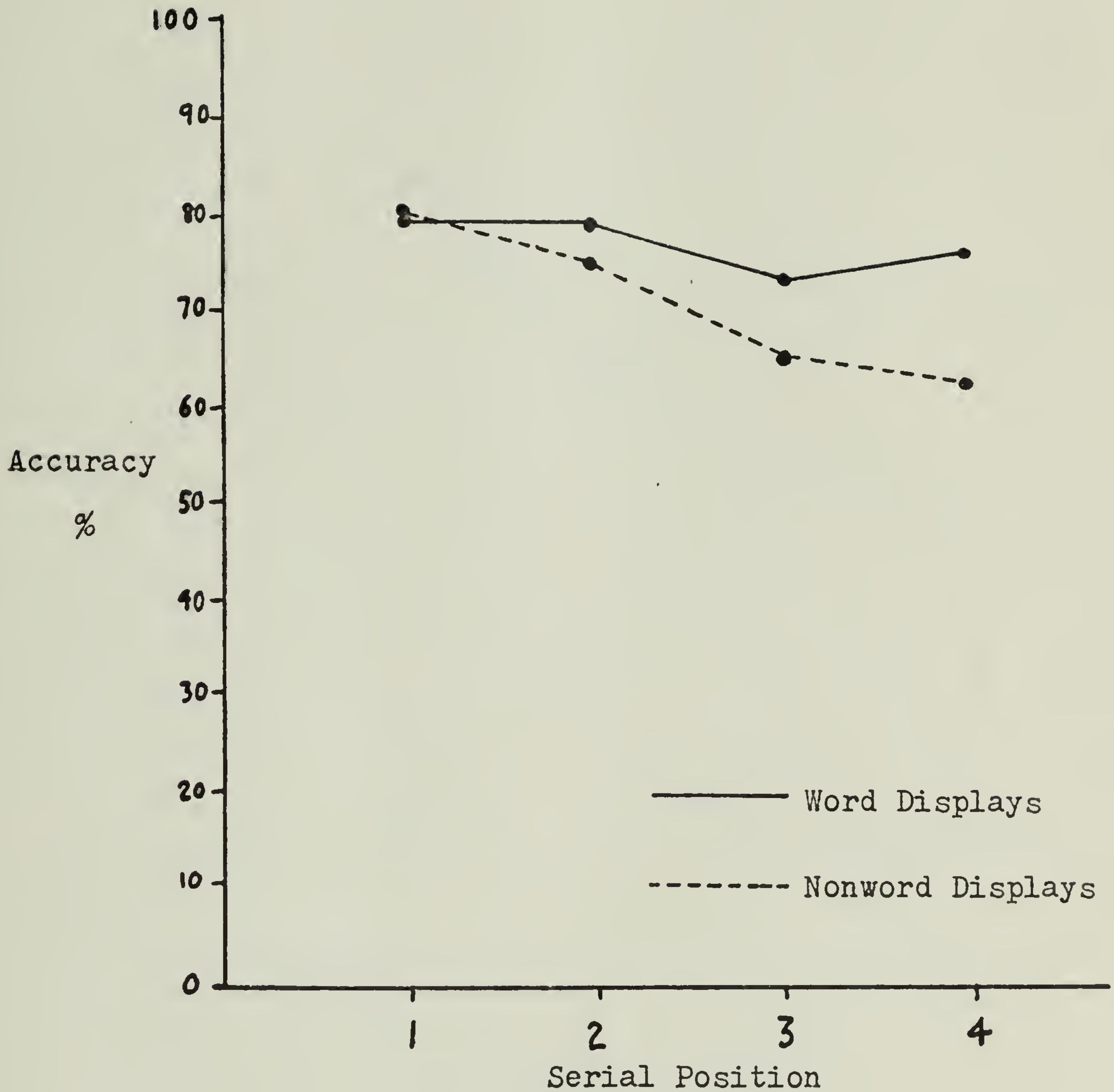

Figure 2

Serial Position Effects: 2 Alternatives

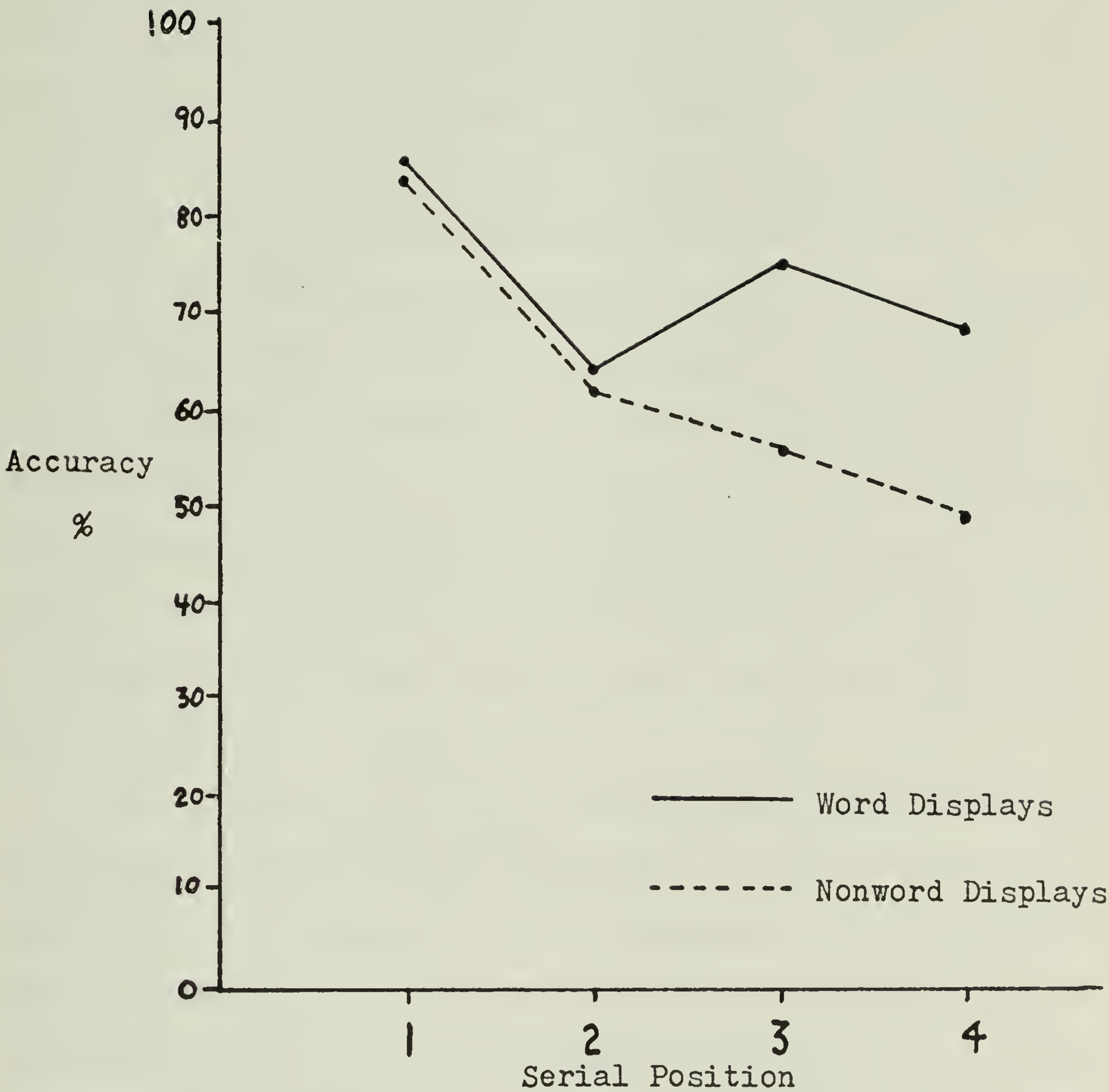

Figure 3

Serial Position Effects: 4 Alternatives

This hypothesis of a lack of sensitivity being the reason for Bjork and Estes' results is based on the following observations. First, in three of the groups Bjork and Estes used a # as a pre- and post-mask. This was found to be a weak mask, as was later verified in Estes, Bjork, and Skaar (1974). This might have allowed a post-stimulus response strategy to have more of an effect for these groups.

Of the seven remaining groups, two had accuracy rates below 60%. Given that to provide maximum sensitivity to find a word effect, one should have subjects operate between perfect performance and chance, i.e., about 75%, this might have lessened the sensitivity of the procedure for these two groups. So, we are left with five groups that on the basis of masking and stimulus duration had some chance of finding an effect.

One of Bjork and Estes' groups showed a difference of 5% which was not found to be significant. With four subjects per group, and assuming an error component of the same magnitude as the present study, a power calculation yielded a probability of .55 for detecting a difference of 5%. This power might actually have been lower because the same error component as the present study was assumed. One of the reasons display time was varied by blocks in the present study was to keep subjects operating close to the same accuracy throughout the experiment, thus reducing within subject variability. Subjects show a sizable practice effect in this kind of task. By using constant display durations, Bjork and Estes might have had a sizable within subject source of error.

Support for the hypothesis of differing perceptual strategies as well as the observations concerning the lack of sensitivity is provided by comparison of the present study with that of Estes (1975). In this study Estes sought to determine at what level the context of a word influences the visual processing of that word. He in fact states the problem in terms of Smith and Spoehrs' model: does context modify the extraction stage or only the interpretation stage?

In Experiment 1 of the Estes study, the design introduced by Bjork and Estes (1973) was used. However, here Estes notes that in either the word-word or nonword-nonword display types, if subjects fail to perceive the critical letter but make their choice on the basis of context in an effort to complete a word, the probability of guessing correctly will be .5 on the average. Further, in the word-nonword displays, the critical letter is embedded in a word, but the alternative makes the string into a nonword. In the nonword-word display, the critical letter is in a nonword but the alternative converts it to a word. In these displays, if a subject fails to perceive a target letter but responds according to a bias to form words, he will always be correct on the word-nonword displays but never correct on the nonword-word displays. So, if context affects the extraction stage then accuracy should be higher for word-word displays than nonword-nonword displays; and if context affects the interpretation stage accuracy should be higher for word-nonword displays than for nonword-word displays.

This argument is equally valid for the four target condition of the present study. The difference is that the probability of a correct guess on word-word or nonword-nonword displays is .25; but they are equal, which is the critical factor. The probability of a correct guess on the word-nonword or the nonword-word displays is the same as with two targets: 1 and 0.

Except for the post-stimulus field, the basic design of the Estes experiment is the same as the present study. Estes wanted to make sure that the subjects had the context available to them when they made their decision. A trial in what he called the continuing context condition was as follows:

....	Warning signal
DREW	Display
D#EW	Post-mask

While this manipulation might heighten the effect on a response level, it should not affect the extraction stage since this stage would operate in this task prior to the onset of the post-mask. The results of Estes continuing context condition as well as the results of the present study broken down into display types is presented in Table 4.

TABLE 4

PERCENTAGE OF CORRECT DETECTIONS BY STIMULUS TYPE

TYPE	Estes (1975)	Difference	Present Study 2 Targets	Difference	Present Study 4 Targets	Difference
WORD-WORD	.86		.77		.75	
		.01		.05		.09***
NONWORD-NONWORD	.87		.72		.66	
WORD-NONWORD	.91		.80		.74	
		.13*		.08**		.11****
NONWORD-WORD	.76		.72		.63	

* $t=2.32$, $p < .05$
** Sandler $A = .188$, $p < .02$
*** Sandler $A = .199$, $p < .02$
**** Sandler $A = .144$, $p < .01$

Unlike Bjork and Estes, Estes found an overall significant advantage for words (88% for words, 82% for nonwords). This result lends support to the argument that Bjork and Estes had insufficient power in their design to have a reasonable probability of finding the effect. Estes used eight subjects per group as opposed to the four per group of Bjork and Estes.

The comparison of word-word vs. nonword-nonword displays yielded no significant differences in the two target letter condition of the present study or in Estes' study. The word-nonword vs. nonword-word comparison was significant in both the Estes study and the two target condition of the present study. So in both studies, with two fixed target letters there is no evidence that context influences feature extraction, but there is evidence that context influences the interpretation stage.

However, in the four target condition of the present study, the differences for word-word vs. nonword-nonword and word-nonword vs. nonword-nonword were both significant. Therefore, with four target letters there is evidence that wordness can influence the extraction stage as well as the interpretation stage.

This finding supports our original hypothesis concerning the forced choice procedure with two fixed alternatives. Keeping the alternatives constant at two apparently can influence perception in a way that lessens the probability of finding a word familiarity effect. What is more important, the results of the four target condition offer evidence that experience can influence perceptual processes in a way that allows familiar material to be processed faster.

REFERENCES

Aderman, D. & Smith, E.E. Expectancy as a determinant of functional units in perceptual recognition. Cognitive Psychology, 1971, 2, 117-129.

Baron, J. The Word Superiority Effect. In Estes, W.K. (Ed.) Handbook of Learning & Cognitive Processes (In Press).

Bjork, E.L. & Estes, W.K. Letter identification in relation to linguistic context and masking condition. Memory & Cognition, 1, 217-223.

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

Cattel, J.M. The time taken up by cerebral operations. Mind, 1886, 11, 220-242.

Eichelman, W.H. Familiarity effects in the simultaneous matching task. Journal of Experimental Psychology, 1970, 86, 275-282.

Estes, W.K. The locus of inferential and perceptual processes in letter identification. Journal of Experimental Psychology: General, 1975, 104, 122-145.

Estes, W.K., Bjork, E.L. & Skaar, E. Detection of single letters and letters in words with changing versus unchanging mask characters. Bulletin of the Psychonomic Society, 1974, 3, 201-203.

Gibson, E.J., Tenney, Y.J., Barron, R.W., & Zaslow, M. The effect of orthographic structure on letter search. Perception and Psychophysics, 1972, 11, 183-186.

Howes, D.H. & Solomon, R.L. Visual duration threshold as a function of word probability. Journal of Experimental Psychology, 1951, 41, 401-410.

Johnston, J.C. & McClelland, J.I. Perception of letters in words: seek not and ye shall find. Science, 1974, 184, 1192-1193.

Krueger, L.E. Search time in a redundant visual display. Journal of Experimental Psychology, 1970, 83, 391-399.

Krueger, L.E. and Weiss, M.E. Letter search through words and nonwords: The effect of fixed, absent, or mutilated targets. Memory & Cognition, 1976, 4, 200-206.

Krueger, L.E., Keen, R.H., & Rublevich, B. Letter search through words and nonwords by adults and fourth-grade children. Journal of Experimental Psychology, 1974, 102, 845-849.

Kucera, H. and Francis, W.N. Computational analysis of present-day American English. Providence, R.I.: Brown University Press, 1967.

Massaro, D.W. Perception of letters, words, and nonwords. Journal of Experimental Psychology, 1973, 100, 349-353.

Miller, G.A., Bruner, J.S. and Postman, L. Familiarity of letter sequences and tachistoscopic identification. Journal of General Psychology, 1954, 50, 129-139.

Neisser, U. Cognitive Psychology. New York: Appleton-Century-Crofts, 1967.

Reicher, G.M. Perceptual recognition as a function of meaningfulness of stimulus material. _Journal of Experimental Psychology_, 1969, _81_, 275-280.

Smith, E.E. & Spoehr, K.T. The perception of printed English: a theoretical perspective. In Kantrowitz, B.H. (Ed.) _Human Information Processing: Tutorials in Performance and Cognition_. Potomic, Md.: Erlbaum Press, 1974.

Solomon, R.L. & Postman, L. Frequency of usage as a determinant of recognition thresholds for words. _Journal of Experimental Psychology_, 1952, _43_, 195-201.

Thompson, M.C. & Massaro, D.W. Visual information redundancy in reading. _Journal of Experimental Psychology_, 1973, _98_, 49-54.

Wheeler, D.D. Processes in word recognition. _Cognitive Psychology_, 1970, _1_, 59-85.

APPENDIX A. 2 TARGET LETTER STIMULI

Practice	Block 1	Block 2	Block 3
LEVO	DRIP	RIUN	FOUR
VERY	OVEL	WOHL	LUIN
YERU	LAKE	BALE	DAUL
LOSE	PRUM	YEAR	MARE
WOFL	TELI	LIPE	OVAR
MALE	CLUB	LIKE	CRAB
RAKN	FLOM	RION	YNLO
FELT	MRAC	DLIP	ABRE
LANG	CRAM	LEAD	LOAD
BROW	HIAL	WALM	ABLE
PRUG	HORN	RIPE	HALP
LOVE	KORF	BEEL	LAMB
PIAR	HAIL	GULF	SPUR
PAIL	WLOG	TIRE	LABM
FOWR	POOR	HOWL	CLAM
FROM	BOLD	FROM	MRIT
PIER	ROKC	HARP	RICH
PIEL	ROCK	LYDA	RADY
ROSE	GOAL	ROAD	REDI
FLOM	RAMB	ERAE	MOLE
WLBO	CURT	MERG	WARM
RANG	LOOF	FAIL	OVAL
ROVE	RUIN	GOAR	RAKE
BLOW	SUOR	PLUM	PSUR
FOWL	GLOW	GURF	FLAW
PAIR	SCAR	BLED	CRUB
FERT	HOLN	SRIP	TLIM
MARE	LION	OLSA	BRED
MELA	HOWR	HAIR	SCAL
PLUG	TILE	EBLA	PARH
MROF	MORD	EVOR	SOUL
VELY	LAOD	PRAY	GLEU

APPENDIX A. 2 TARGET LETTER STIMULI

Block 4	Block 5	Block 6
LICH	GERM	SPUL
RIHC	TULC	ARSO
LOCK	CULT	LEKA
ALMY	HAER	FORK
ONRY	VEAL	DUAL
BARE	SERO	ALEA
LEKE	RICE	ROOF
RAFT	FRAW	IDLE
BEER	GLUE	BELA
WLAF	CLAB	REAP
PLOD	PROD	ROST
CURE	LIDE	YRAP
FULG	VEAR	FOUL
FOLK	HEAL	LOST
MROE	DLOP	ACRE
SLIP	RIDE	FIAR
YEAL	RESS	PLAY
SOLD	NEAL	FUOL
RUMP	LICE	AREA
COIL	NEAR	RAED
RIKE	LESS	SOLE
POOL	IDRE	LAFT
ARMY	RECI	DUAR
GRUE	SORE	ALSO
LADY	ACLE	MERA
COIR	ONLY	LUMP
NAER	SOUR	OVER
GROW	TRIM	SORD
CULE	AVOL	DLEB
CIOL	BLEW	BREW
FAIR	LUPM	GELM
ECRA	WREB	HEAR

APPENDIX B. 4 TARGET LETTER STIMULI

Practice	Block 1	Block 2	Block 3
BEAD	TEMS	DALE	TIDE
SNAP	NAVY	TIME	REDS
ENIT	EDIT	REED	OLON
PCEK	CLAD	LINS	SONT
WIME	BUDS	LAEM	DOCK
LIMB	PULL	COPE	EDIT
DRUG	TONS	NURE	WILD
PEAT	PASH	SLIM	LEDO
ERNE	LOOD	OPAL	ODUS
WORP	LADY	MELO	NEAD
LAME	HELN	FAWN	IDLE
SPIT	ENIT	SPUG	CLAM
EPON	LCAD	NEAD	ENIT
OMIT	NAED	SMUG	BEAP
IDEI	SNOW	GRIP	DILE
TAPS	SEEN	OMUS	INCH
SEEP	SDUG	MELT	RUIN
PECK	DELE	AMOS	LONE
RAED	ONUS	GRAP	ESED
ECDO	SLUM	TYPE	ONUS
SHID	FAPS	PLOW	DOKE
PASH	OLON	OPUS	HARP
OMES	ADAM	WEEM	IDET
OMIT	SOUP	PLUL	PULP
LUNG	SUDB	LIDE	NATE
DAYS	DEFY	DOST	GUDS
SNUG	JUNK	ELMS	NAER
GAME	MILL	REMO	HORM
EMON	UPOS	RAHP	MONK
SAND	MUKE	UNOS	FANE
PERK	LENO	WEPI	MALT
LSIP	MSUG	IDET	UNOS

APPENDIX B. 4 TARGET LETTER STIMULI

Block 4	Block 5	Block 6
SEED	EDIT	LODE
REMO	GADE	OMUS
LEAM	SDUG	HELM
AMOS	ENIT	WIME
WIPE	COME	RAHD
MICE	WARP	EPIT
ROME	TAPS	DAST
ROAM	MOLE	AVID
OMUS	LUNG	EMIT
DOES	MECK	DILL
SMUG	HARD	UPOS
CRAD	UNOS	LIEN
MEAR	POVE	NAVY
SPUG	ISLM	LAMB
PILL	RODS	LEAM
SPOT	PARE	MSUG
FLOP	DLIL	NICK
PICE	BEAN	SMOG
OPUS	EDGY	DATA
RAHP	MILK	NALE
WEPT	WENI	SLIP
MECI	FOAM	COPY
FAMS	NIKC	PERA
LOON	TEDI	SPUR
AIPS	SHID	TEMI
MSUG	IDET	ESEN
NOTE	RGIP	TEPS
SAPT	ONLY	MLIL
PLIL	HARN	OPUS
COMB	ONUS	CEPE
SLIN	AINS	WORP
UPOS	PAGE	WINE

Appendix C

Errors By Stimulus Type

2 Target Condition

S	W-W	W-NW	NW-W	NW-NW
1	10	4	8	8
2	10	6	14	13
3	10	15	14	12
4	11	14	14	22
5	14	13	11	18
6	9	10	17	10
7	16	9	16	11
8	9	8	14	11
9	13	9	13	13
10	10	9	12	16

Appendix D

Errors by Stimulus Type

4 Target Condition

S	W-W	W-NW	NW-W	NW-NW
1	7	10	19	15
2	15	14	12	12
3	19	15	15	17
4	13	12	22	17
5	13	15	19	17
6	13	11	17	17
7	16	13	20	24
8	11	9	15	15
9	7	10	17	10
10	8	18	21	19

Appendix E

Analysis of Variance: 2 Target Condition

Source	df	SS	MS	F
Subjects (S)	9	323.2	35.91	
Word-Nonword (A)	1	168.2	168.2	21.08*
SA	9	71.8	7.98	

*p < .005

Appendix F

Analysis of Variance: 4 Target Condition

Source	df	SS	MS	F
Subjects (S)	9	358.2	39.8	
Word-Nonword (A)	1	441.8	441.8	15.65*
SA	9	254.2	28.24	

*$p < .005$

Appendix G

Accuracy by Serial Position for Word and Nonword Displays

	Word Serial Position				Nonword Serial Position			
	1	2	3	4	1	2	3	4
2 Alternatives	.86	.65	.76	.70	.85	.63	.57	.50
4 Alternatives	.796	.8	.754	.775	.804	.763	.663	.638