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Evidence for lexical access in a simultaneous matching task

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Reaction times in a simultaneous visual matching task were obtained for four types of letter strings: high-frequency words, low-frequency words, orthographically legal nonwords, e.g., CRAWN, and random letter strings. Two findings supported the notion that the matching of word items involves lexical access. First, words were processed faster than legal nonwords, indicating that the analysis of words uses an additional source of information apart from the constraints imposed by orthographic rules. Second, high-frequency words were processed faster than low-frequency words, indicating lexical search. It is proposed that three levels of identification and comparison operate simultaneously in the matching task: at a word level, a letter cluster level, and a letter level. The results of a second experiment give some support to the idea that these levels operate for "different" items as well as "same" items. Whether familiarity effects will be observed for "different" items will depend on the amount of identification and comparison of the two letter strings which is necessary before a difference is detected.

Words have been found by several investigators to be processed faster than random letter strings (Eichelman, 1970; Krueger, 1970b; Reicher, 1969; Wheeler, 1970). However, it is not clear from these studies whether the perceiver makes use of his knowledge of existing words in the English language, or merely his knowledge of permissible letter sequences. This is because the faster processing of words such as CROWN compared with random letter strings such as CWONR may be due to the fact that CROWN has familiar letter clusters like CR or WN, or it may be because CROWN has a stored representation as a word. To clarify this point, an extra set of items must be included, namely, letter sequences which conform to the rules of English orthography, but which are nonwords, e.g., CRAWN. These items are referred to as *legal nonwords*. An adequate experiment to assess the role of familiarity in the recognition of letter sequences should thus compare words, legal nonwords, and random letter strings (i.e., *illegal nonwords*).

The results of experiments which *have* included a legal nonword condition are conflicting. Baron and Thurston (1973), in a forced-choice tachistoscopic identification task, found that word items such as CARS were not processed more accurately than legal nonwords such as CORS. They concluded that orthographic legality accounted for the superiority in performance on word items over illegal nonwords found in the previous studies by Reicher (1969) and Wheeler (1970). In contrast, Krueger (1970a) found that a letter target was located faster in a word display than a legal nonword display. Krueger interpreted this difference as being due to the retrieval of stored information about words during the encoding of the stimuli. Similarly, Barron and Pittenger (1974) have reported that words are matched faster than legal nonwords in a simultaneous matching task. If the tasks used in the Baron and Thurston (1973), Barron and Pittenger (1974), and Krueger (1970b) studies all require the subject to encode the stimuli at a linguistic level of representation, then one would expect this similarity to be reflected in the results of all tasks.

A further comparison relevant to determining whether words as such are analyzed faster than legal nonwords is the comparison of high- and low-frequency words. If evidence is found that words are processed faster than legal nonwords, one must assume that this facilitation is the result of information about the word being found in the lexicon (that part of long-term memory where representations of words are stored). If access of the lexicon is taking place, then one would also expect high-frequency words to be processed faster than low-frequency words, as there is much recent evidence to support the notion that the lexicon is organized so that information about high-frequency words is accessed faster than information about low-frequency words. This evidence comes from lexical decision tasks (e.g., Rubenstein, Garfield, and Millikan, 1970) which obviously involve lexical access, and from articulation or naming tasks (Berry, 1971; Forster & Chambers, 1973) which, it is argued, also involve lexical access.

In tasks which less obviously require lexical access, the evidence for a word frequency effect is limited and conflicting. In a matching task in which the subject had to decide if two words such as TORE/TORE were the same or different, Eichelman (1970) found no significant correlation of word frequency and matching time. Krueger (1970a, b), in a series of experiments where word displays were searched for letter targets, found conflicting results as regards a word frequency effect. He compared a group of high-frequency and low-frequency words and found in one experiment

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(Krueger, 1970a, Experiment 3) clear evidence that high-frequency words were searched faster than low-frequency words. However, in a subsequent series of experiments using similar tasks, Krueger (1970b) failed to find a significant word frequency effect, although the effects were all in the predicted direction.

So, one has the results of Baron and Thurston (1973) and Eichelman (1970) on the one hand, which may be interpreted as supporting the idea that the familiarity of the letter sequences is sufficient to account for the apparent faster processing of words. On the other hand, Barron and Pittenger's (1974) and Krueger's (1970a) results support the idea that words are processed faster than legal nonwords because of *word* familiarity.

As this issue is important to a theory of word recognition, it was considered necessary to carry out an experiment in which a strong test of word frequency was made, as well as a comparison of words with legal nonwords. The matching task used by Eichelman (1970) was chosen, with a comparison of performance on high-frequency words, low-frequency words, legal nonwords, and illegal nonwords. On the assumption that *word* familiarity is an important variable in this task, words should be matched faster than legal nonwords, and there should also be a frequency effect within words. In addition, if letter sequence familiarity is used in the processing of nonwords, legal nonwords should be matched faster than illegal nonwords.

An issue of major importance in the study of the word-superiority effect is whether the results of the experiments may be generalized to the whole population of words being sampled. As Clark (1973) points out, most analyses fail to establish generality over both items and subjects simultaneously, since items are usually treated as a fixed, rather than a random, effect. The three studies most closely related to the present experiment (Baron & Thurston, 1973; Barron & Pittenger, 1974; Eichelman, 1970) are all deficient in this respect, and it could be argued that the conclusions drawn by these investigators are valid only for the particular samples of items used in each study. In fact, as Clark points out, when a small fixed sample of items is used for each subject, it is highly probable that different results will be found with different samples of items. Hence, the conflicting results found in the related studies may be due to limited item sampling.

In the present paper, the statistical analyses which are carried out ensure that the question of item and subject generality is adequately treated. This involves using the min F′ procedure suggested by Clark (1973), where

$$\min F' = F_1 F_2 / (F_1 + F_2)$$

F_1 being the F ratio based on a Treatment by Subjects error term, and F_2 being the F ratio based on a Treatment by Words Within Treatments error term. A significant min F′ ratio guarantees that both the F_1 ratio and the F_2 ratio are significant, but is a more stringent test than either of the latter ratios. Using the min F′ procedure requires that a relatively large number of items be included in each condition, and accordingly, in the present paper, it was decided to include at least 20 items in each of the major conditions.

A further methodological criticism of several studies investigating the word superiority effect involves the use of the same sets of stimulus items repeatedly for the same subject. The only difference between word and legal nonword items is assumed to be that words have stored representations but nonwords do not. Increasing the familiarity of nonwords by presenting them repeatedly must ultimately give these items some kind of representation in the lexicon, and hence will diminish the possibility of observing a word-legal nonword difference. Such a trend is apparent in the results for "same" items in the Barron and Pittenger (1974) study, where the superiority of word items over legal nonwords tends to diminish in later test sessions. Since the present study is concerned mainly with the role of lexical information in the identification of letter strings, none of the items were repeated.

EXPERIMENT I

Method

Subjects. The subjects were 20 undergraduate and graduate male and female students from Monash University. They were paid for the session which lasted about 20 min.

Construction of Items. The four types of items used were pairs of high-frequency words, low-frequency words, legal nonwords, and illegal nonwords where the members of the pair were identical or different. A complete list of the items is given in the appendix, together with the mean RT found for each item. The high-frequency words were chosen from words having an AA or A count in the Thorndike-Lorge (1944) word count. The low-frequency words had a count of less than 20 per million words. The words were all one syllable nouns with equal number of items having four or five letters. As can be seen from the appendix, each high-frequency word pair, e.g., FOOT/FOOT was paired with a low-frequency word pair, e.g., FERN/FERN with the same initial letter. From the letters of these four words, a legal nonword pair, e.g., FOON/FOON and an illegal nonword pair, e.g., FTRE/FTRE were made. Thus, any differences between the words could not be due to the particular letters chosen.

There were 40 examples of each type of item, making a total of 160 items. Of these items there were 80 pairs where the letter strings matched ("same" items) and 80 pairs where the letter strings differed ("different" items). For the "different" pairs, half the items began with the same initial letter, e.g., BALL/BELL and half began with a different initial letter, e.g., PIPE/CARD. This manipulation was designed to examine the effect of similarity of the "different" letter strings items on the processing of the four types of item. In order to equate the similarity of "different" items, the number of common letters in identical serial positions for each type of item was held constant. There were seven items with no common letters, e.g., NECK/SOUL, seven with one common letter, e.g., CAKE/HAND, three with two common letters, e.g., LAKE/LIFE, and three with three letters in common, e.g., DOME/DOVE. By error, the number for illegal nonwords was six, eight, three, and three items with respectively zero, one, two, and three letters in common. No word was used more than once in the experiment. Sixteen additional items were constructed in a similar way to be used for practice items, each type of item being equally represented.

The stimulus items were typewritten in upper case, one word directly above the other. They were then photographed and mounted as slides, with white lettering on a dark background.

Apparatus. A Kodak Carousel 35-mm projector was used to present the stimuli. The stimuli were projected onto a screen in front of the subject about 60 cm away at a visual angle of approximately 3 deg in both the horizontal and vertical dimensions. The projector was fitted with a shutter which moved across the light beam during the time the slides were changed. When the stimulus was projected, light fell onto a photocell which triggered a timer. The timer was stopped when the subject signaled his decision by pressing one of two keys, one for "same" and one for "different" decisions. The response time was measured to the nearest millisecond. Half the subjects held the "same" key in their preferred hand and the other half in the nonpreferred hand.

Procedure. The subject was instructed to attend to the pair of letter strings, to decide as fast as possible, without error, whether the two letter strings were identical or not, and then to press the appropriate response key. The subject was informed if the response was incorrect. The experimenter recorded the RT and if an error was made. The experimenter then signaled that the next item was about to be displayed, and the subject heard the slide dropping into position. The stimulus item remained in view until the experimenter indicated that another trial was about to begin. The intertrial interval was appoximately 10 sec. After the practice block, the subject was presented with 10 blocks of 16 trials. In each block all types of item were represented once, in a random order. Five different orderings of the items were constructed. Each order was given to four subjects.

Results

The mean RT for each individual subject was calculated, together with cutoff values falling 2 SD above and below the mean. Responses lying beyond these cutoff limits were replaced by the relevant cutoff value. This adjustment affected less than 3% of responses and was made so that the effect of unusually long or short RTs would be minimal. Incorrect responses were analyzed separately. The scores were then used to calculate means for each subject in each condition, averaging across items, and, when analyzing item means, averaging across subjects for each item.

The mean RT over subjects for "same" items for each condition is shown in Figure 1 as a function of the number of letters in the item. Overall, the fastest matching times were obtained for high-frequency words (649 msec), followed by low-frequency words (687 msec), legal nonwords (755 msec), and illegal nonwords (841 msec). These differences were all significant: for high-frequency words vs. low-frequency words, $\min F'(1,34) = 5.72$, $p < .05$; for low-frequency words vs. legal nonwords, $\min F'(1,40) = 9.53$, $p < .005$; for legal nonwords vs. illegal nonwords, $\min F'(1,40) = 8.21$, $p < .01$.

As can be seen in Figure 1, four-letter items (708 msec) were matched faster than five-letter items (759 msec), $\min F'(1,67) = 8.51$, $p < .01$. The effect of an increase in length tended to be greatest for illegal nonwords and least for words, but the interaction between item type and length approached, but did not reach significance, $\min F'(3,121) = 2.06$, $p > .05$.

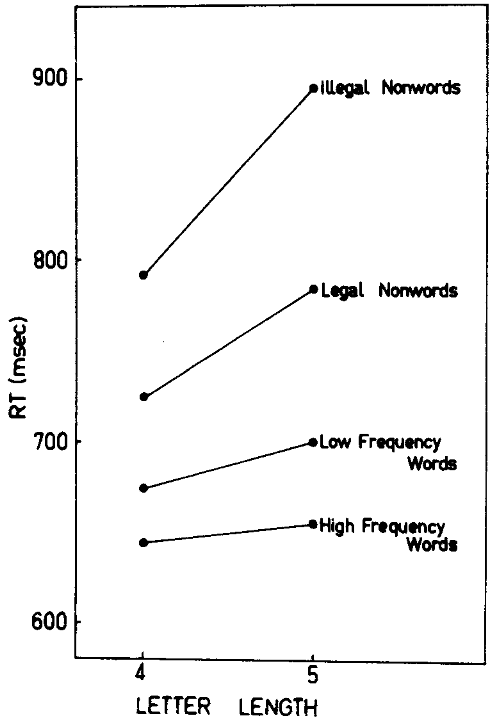

Figure 1. RT (in milliseconds) for high-frequency words, low-frequency words, legal nonwords, and illegal nonwords as a function of the number of letters in the item.

Few errors were made in any condition (less than 2%) except for the illegal nonwords with five letters (6%). There were no significant differences between the conditions for error scores, either for type of item or length of letter string.

The results for "different" items contrast sharply with those for "same" items. For these items, the detection of the difference was just as fast for illegal nonwords (724 msec) as for legal nonwords (716 msec), low-frequency words (721 msec) and high-frequency words (724 msec), $\min F' < 1$; and there were no significant differences between any of the conditions in the number of errors made (less than 2% for all conditions).

Discussion

The results for the "same" items clearly indicate that in a matching task, lexical information is being used to process the word items. The two results suggesting this conclusion are: first, the finding that high-frequency words are matched faster than low-frequency words, and second, that words are matched faster than legal nonwords.

The word frequency finding conflicts with Eichelman's (1970) finding of no correlation between the response time and the word frequency count of the word items used in the study. The present finding, which was significant across both subject and item means, may have been observed because two very distinct frequency groups were compared, viz, common and rare words. The second finding, that words are matched faster than legal nonwords, confirms the findings recently reported by Barron and Pittenger (1974), and the fact that the results in the present experiment permitted simultaneous generalization to the population of items and subjects show that the previous finding was not due to accidental sampling errors.

Before outlining a model of how the identification process may be operating, we need to establish that two other interpretations of the results are inapplicable.

The first, which we refer to as the "comparison" explanation, argues that the differences between the matching times for the four types of item are due solely to the process responsible for *comparing* the two letter strings of an item, rather than being due to the process used for *identifying* the items. Thus, the rate of identifying words and nonwords is assumed to be the same, but the number of units which are compared differ for each type of item. The response time will be a function of the number of units which make up each item, and which must be compared in order to reach a decision. For a "same" item (for which a complete comparison of the two letter strings must be made), an illegal nonword item which consists of two strings of unrelated letters would require a comparison of each individual letter in both strings. If legal nonword items are compared in terms of letter clusters, then the number of comparisons required will depend on the number of letter clusters forming the letter strings. Obviously fewer comparisons would be needed since the number of letter clusters would be less than the number of letters composing each letter string. Thus, the faster matching of legal nonwords than illegal nonwords could be based on the varying number of necessary comparisons. If word items are compared as "whole" letter sequences, then only one comparison would be necessary. Thus one would expect word items to be matched faster than both legal nonwords and illegal nonwords. However, one would not be able to account for the word frequency finding since it would be *most* unlikely that low-frequency words are composed of more units than high-frequency words.

The second explanation, the "sequential redundancy" explanation, might suggest that the results are due to the words being formed of more familiar letter sequences than the legal nonwords, and that this familiarity enables faster processing to be carried out. To check if the words and legal nonword items did differ in average trigram or digram frequency, the appropriate frequencies were calculated using the tables prepared by Mayzner and Tresselt (1965) and Mayzner, Tresselt, and Wolin (1965).

For the "same" items, the mean trigram and digram frequencies were as follows. Among four-letter items, the means for high-frequency words were 16 and 211, respectively; low-frequency words, 21 and 207; legal nonwords, 12 and 237. For five-letter items, the corresponding means were 33 and 212 for high-frequency words; 25 and 192 for low-frequency words; 28 and 172 for legal nonwords. There were no significant differences between the item types according to trigram and digram frequencies. Similarly, there was no significant correlation between the digram or trigram counts and the response times for individual items. The correlation of response times and the digram frequency of items for words was $r(38) = -.108$, $p > .05$; and for legal nonwords, $r(38) = .012$, $p > .05$. Similarly, the correlation between the trigram count and response times was not significant, $r(38) = .123$, $p > .05$ for words and $r(38) = .276$, $p > .05$ for legal nonwords. It seems unlikely then that the results found for the word and legal nonword "same" items can be attributed to variations in the familiarity of the letter sequences involved.

The results of this experiment seem to be most easily explained by assuming that three levels of identification and comparisons are operating simultaneously. These three levels are the word level, the letter cluster level, and the individual letter level. At the lowest level, an attempt is made to identify each of the letter strings in the pair as a sequence of individual, unrelated letters. At the next level, an attempt is made to identify both of the letter strings in terms of the orthographic structure of the letter string which tentatively, we will assume, is based on larger units than the individual letters and for convenience we will call those units letter clusters. Finally, at the highest level, an attempt is made to identify both letter strings as words using lexical information. It is proposed that as soon as an identification is complete at any one of these levels of analysis, a comparison of the information currently identified from the two letter strings takes place. The time taken to make a decision about any particular item will thus be a function first of which level of analysis is the first to be completed, and second of the number of identifications and comparisons necessary to make a decision.

Analysis at the word level involves a search through the lexicon until a lexical entry is found which has the same orthographic features as the letter string being analyzed. It is suggested that the analysis at the letter cluster level might involve a search through a list of English letter clusters until an entry is found which has the same orthographic features as a segment of the stimuli. Similarly, the individual letter level of analysis involves a search through a list of single letters until a satisfactory match is made for each letter in the string.

As aspects of the stimulus item are identified at one level, it is proposed that this information is made available to the other levels of analysis. Thus, for example, if the lowest level identifies the first letter as C, then the search process at the letter cluster level can be narrowed down to clusters beginning with C. Similarly, the lexical search may be limited to words beginning with C.

This multilevel analysis is attempted for both members of the stimulus item. For a "same" item, where the two letter strings match, the processing of both letter strings must be completed at one of these three levels of analysis at least, so that a correct decision can be made. When the items are words, the processing at the word level is assumed to be completed first, and the comparison involves testing whether both letter strings are the same word or not. For high-frequency words, the identification is completed earlier, since it is assumed that the order of searching lexical entries is partly determined by the frequency of the word. When both letter strings are legal nonwords, the word level of analysis would be ineffective as no lexical entry would be found. It is assumed that for these items processing at the letter cluster level is finished first, and that the comparison involves testing whether the two letter strings contain the same sequence of letter clusters. Since it is assumed that identification of several letter clusters takes longer than one identification at the word level, the response times for legal nonwords are longer than for words. Finally, the response times for illegal nonwords are the longest of all item types since the identification process is unable to take advantage of any familiarity either with the whole sequence or with parts of the letter string. In this case, each letter string has to be identified as a sequence of unrelated letters, and the comparison involves testing whether both letter strings consist of the same sequence of unrelated letters. It is assumed that the several letter identifications and comparisons necessary for a "same" response for an illegal nonword item would take longer than the two higher levels of analysis which can be used to analyze words and legal nonwords.

However, when the above model is applied to the case of a "different" item, the expected outcomes are quite different. In this case, a complete identification and comparison of the two letter strings may not be necessary (Bamber, 1969; Egeth, 1966; Nickerson, 1967), since these processes may be terminated as soon as any comparison reveals a mismatch. Thus, if all the letters differ between the two letter strings, then the very first comparison (be it a comparison of two individual letters, two letter clusters, or two words), would yield a correct "different" decision. In these circumstances, there is no longer any reason to assume that processing at the word level will be the fastest method of reaching a decision about two words, since this would require that the time taken to identify and compare two words is less than that taken for two individual letters. In fact, the results for "different" items in the first experiment suggest that processing at the individual letter level was the fastest method of processing for *all* items , since "different" RTs did not vary as a function of item type.

This explanation of the "different" response times predicts an interaction between item type and the number of letters matching between the items being compared. For example, when three of the letter pairs are the same, for example, SHEET/SHIRT, then processing at the letter level will clearly be much slower than when none of the letter pairs are the same, for example, SHEET/WORLD. In the first case, depending on the order in which the letter pairs are compared, there could be as many as *four* letter pairs which have to be compared, whereas in the latter case, only *one* pair need be compared no matter what the order of comparison. Thus, as the number of pairs which need to be compared increases, so the probability decreases that the decision will be controlled by the letter level of analysis.

The second experiment examines this hypothesis more closely, manipulating both the number of matching letter pairs and the location of the nonmatching pairs within the letter strings.

EXPERIMENT II

The purpose of this experiment was to test the hypothesis that the word superiority effect will only be observed for "different" responses when several letters in the item pair are the same. In the studies which have included such items, the evidence supporting the hypothesis is either inconsistent [being as predicted for four, but not six, letter items in the Eichelman (1970) study], or tenuous, being based on an inspection of the results of studies with too few of these items [one in the study by Barron & Pittenger (1974) and three in the first experiment reported here]. In studies where most of the "different" items had less than three letters matching, no familiarity effect has been found (Egeth & Blecker, 1971; the first experiment of the present paper).

Bamber (1969) and Egeth (1966) have proposed that the mechanisms responsible for detecting sameness and difference are quite distinct, and Egeth and Blecker (1971) have further postulated that only the sameness detector is sensitive to the familiarity of the stimulus. According to this view, there should be no between-item effects for "different" items, no matter how many letters are the same.

However, according to the multilevel model outlined earlier, as the number of matching letters is increased, the relative efficiency of the letter level of processing will decrease, creating the possibility that higher levels of processing will be completed first. To make this point quite clear, let us consider a concrete example, using a set of hypothetical values for the various components of response time. Suppose that on the average, each individual letter takes, say, 50 msec to identify, that each letter cluster takes 75 msec to identify, and that each word takes 200 msec to identify. Further, assume that *any* comparison, no matter what level it occurs at, requires 50 msec. We can now estimate the identification and comparison components of the same-different classification times (ignoring the decision components). For five-letter "same" items, the time required to reach a decision at the letter level is (10 X 50 msec) + (5 X 50 msec) = 750 msec, for the letter cluster level (assuming that the items contain three letter clusters), the time is (6 X 75 msec) + (3 X 50 msec) = 600 msec, and for the word level, the time is (2 X 200 msec) + 50 msec = 450 msec. In these circumstances, there will be marked differences between the three types of items, as found in the first experiment, with words being processed faster than legal nonwords, which are faster than illegal nonwords. However, when *all* letters *differ*, the amount of processing required at the word level remains constant (450 msec), but decreases sharply at the letter level, since only one letter from each string needs to be identified, and only one comparison made, which produces a time of 150 msec. The letter cluster level occupies an intermediate position, requiring 200 msec. Thus decision time for all types of items will be controlled by the letter level, since this reaches a decision first, and hence no between-item effects are to be expected.

But manipulation of the number of comparisons necessary to reach a "different" decision can produce other outcomes. For instance, suppose three letters in each string must be compared before the difference is detected, as opposed to, say, 1.5 letter clusters. The word level of processing still takes 450 msec, compared with 300 msec for the letter cluster level, and 450 msec for the letter level. This would predict that items which can be processed at the letter cluster level (i.e., legal nonwords and words) will produce shorter times than items which cannot be processed at this level (illegal nonwords). However, words gain no special advantage, since the word level is not as fast as the letter cluster level.

Since processing time at the word level is constant despite variations in the number of matching letters, it should obviously be possible to construct items which require enough comparisons at either the letter level or the letter cluster level to eventually make the word level the fastest of the three. Under these conditions, the results for "different" items will show the same pattern as for "same" items.

In order to decide between the two-process model of same-difference detection described by Egeth and Blecker, 1971), and the one-process multilevel model described here, it is necessary to determine whether between-item effects can be altered by changing the number of letters common to both letter strings. The following experiment was designed to test this hypothesis, comparing words, legal nonwords, and illegal nonwords which differ on all, or only one letter. If our interpretation is correct, there will be no difference in the "different" response times when all letters differ, since the letter level is likely to be the fastest method of processing for all items. Where only one letter differs, it would be expected that one of the higher levels of processing would be faster, thus making illegal nonwords the slowest of the three types of items. Whether words will also be processed faster than legal nonwords is difficult to predict in advance, without knowing the relevant parameters.

The "different" items which differed by only one letter were constructed so that the difference occurred in the first, third, or fifth serial position. It might be expected that if an analysis is completed at the word level, then the serial position of the different letter would be unimportant since it is assumed that such an identification and comparison is completed using the complete word unit. At the letter cluster and letter levels of analysis it is predicted that differences in response times may be found according to the serial position of the letter difference, if there is any systematic order for identifying and comparing either the letter clusters or the letters forming the letter strings.

The "same" items also contained samples of words, legal nonwords, and illegal nonwords, and these items constituted a replication of the conditions of the first experiment, except that word frequency was not explicitly varied. In addition, these items provided a strong test of the hypothesis that the word superiority effect is due to variation in digram or trigram frequencies, since the legal nonwords were constructed so that they had markedly *higher* average digram and trigram frequencies than the word items with which they were compared. If the word items are still matched faster than the legal nonwords, then a clear *word* superiority will have been demonstrated.

Method

The subjects were 20 students, male and female, from Monash University. None had participated in the previous experiment.

Construction of items. Three types of items were used: words, legal nonwords, and illegal nonwords. All items were five letters in length. The words were chosen from AA and A words in the Thorndike-Lorge (1944) word count. Unlike the word items in the first experiment, verbs and adjectives were included besides nouns. The legal nonwords were constructed so that each legal nonword was paired with a word item, the legal nonword as far as possible having a higher digram and trigram count than the word item. The mean digram and trigram counts were determined using the Mayzner and Tresselt (1965) and Mayzner, Tresselt, and Wolin (1965) counts. The mean digram count for legal nonwords (325) was higher than for words (240), $t(119) = 7.341$, $p < .001$. Similarly the mean trigram count for legal nonwords (79) was higher than for the words (44), $t(119) = 6.605$, $p < .001$. The illegal nonwords were constructed from the same pool of letters as the word items. Letters were randomly drawn to form five letter sequences, with the restriction that if a legal sequence was drawn, it would be replaced. There were 80 examples of each type of item, making a total of 240 items. As before, half the items were "same" items, half were "different" items. For each type of item, the "different" items included 10 items in which the first letter differed, e.g., FLOOD/BLOOD, 10 items in which the third letter differed, e.g., HORSE/HOUSE, 10 items in which the fifth letter differed, e.g., CROWD/CROWN and 10 items in which all the letters differed, e.g., CHILD/BROWN. The three types of item had the same letters differing in any one serial position, e.g., FLOOD/BLOOD was paired with the legal nonword item FRONE/BRONE and the illegal nonword item FHNTL/BHNTL. The actual items are shown in the appendix, together with the response item for each item.[1] The items were all typed, as before, in uppercase, one above the other.

Apparatus. The items were presented in an Electronics Developments two field tachistoscope, with a horizontal visual angle of 1.4 deg and a vertical visual angle of 1.3 deg. The illumination level was held constant in both fields.

Procedure. The first field displayed a small cross aligned to the middle of the stimuli display. At the beginning of each trial, the experimenter said "Ready" and initiated a system which presented a 200-Hz tone at 7 dB for 1 sec over headphones to the subject while the subject watched the fixation point. Then the stimulus item was displayed on the second field for 1,500 msec. During this time, the subject pressed one of the response keys according to his decision. The time, in milliseconds, from the onset of the stimulus item until the subject's response, was recorded.

A practice block of 24 items was presented first. Then two blocks of 120 items were presented in an order which ensured that "same" and "different" items, and the various types of item were represented equally in each block of 24 items. Four different orderings of the 240 items were used, five subjects seeing any one order.

Results

Mean times for each subject in each condition, and for each item were computed as in Experiment I. The subject means are shown in Table 1.

Considering first the results for "same" items, it can be seen that the findings of the first experiment are replicated, with words being matched faster than legal nonwords, $\min F'(1,58) = 29.44$, $p < .001$, even though the average trigram and digram frequencies of the legal nonwords were much higher than for words. Also, legal nonwords were matched faster than illegal nonwords, $\min F'(1,46) = 28.43$, $p < .001$. As in the first experiment, the trigram and digram frequencies were uncorrelated with response times, the obtained product-moment correlations for the word items being .066 ($p > .05$) and .054 ($p > .05$), and for legal nonwords, .020 ($p > .05$) and $-.134$ ($p > .05$).

Table 1

Mean RTs in Milliseconds for Word, Legal Nonword, and Illegal Nonwords for "Same" and "Different" Items

		"Different" Response			
		Position of Letter(s) Different			
	"Same" Response	All Letters	First Letters	Third Letters	Fifth Letters
Words	747	677	748	815	851
Legal Nonwords	873	673	727	844	886
Illegal Nonwords	1007	686	791	1007	1041

The results for "different" items provide partial support for the model proposed earlier. As predicted, the means in Table 1 show that when all letters differ, there were no differences between the three types of letter strings, $\min F'(2,15) = .248$, $p > .05$. However, when only *one* letter differs, item type exerts an effect, with illegal nonwords being responded to slower than legal nonwords and words, and with words tending to produce faster response times than legal nonwords when the different letter occurs later in the string. The respect in which the data fails to completely support the hypothesis is that for none of the three sets of items where one letter differed was there a significant difference between words and legal nonwords. For the first serial position, the only significant comparison was between legal nonwords and illegal nonwords, $\min F'(1,19) = 4.89$, $p < .05$; for the third serial position, the only significant comparisons were for legal nonwords and illegal nonwords, $\min F'(1,17) = 12.52$, $p < .01$, and words compared with illegal nonwords, $\min F'(1,14) = 17.55$, $p < .001$; the same two comparisons were significant at the fifth serial position, $\min F'(1,30) = 17.66$, $p < .001$ for the legal-illegal nonword comparison, and for the word-illegal nonword comparison, $\min F'(1,30) = 24.08$, $p < .001$.

The data in Table 1 also show that the speed with which the difference between the letter strings is detected is a function of serial position, with an approximately linear effect being obtained for each type of item. The effect of serial position was significant, $\min F'(2,155) = 25.01$, $p < .001$, but this effect was not equal for the three item types, as revealed by an interaction between item type and serial position, $\min F'(4,134) = 2.53$, $p < .05$. The effect of serial position was most pronounced for illegal nonwords, least for words, although the effect was still present for word items, as indicated by the significant difference between Positions 1 and 5, $\min F'(1,19) = 9.20$, $p < .01$.

Finally, "different" response times were markedly faster when all letters differed, there being a significant effect due to number of letters differing for words, $\min F'(1,16) = 7.47$, $p < .05$, legal nonwords, $\min F'(1,28) = 6.26$, $p < .05$, and illegal nonwords, $\min F'(1,18) = 9.81$, $p < .01$.

Discussion

The results for "same" items provide a strong confirmation of the results of the first experiment, indicating clearly that words are matched faster than legal nonwords, despite the fact that the legal nonwords were composed of more frequently occurring letter sequences than the words.

The results for the "different" items provide partial support for the proposal that the processes underlying judgments of sameness and difference are the same. An essential feature of this model is that the pattern of between-item effects should change as the number of comparisons which have to be made at the letter level increases. As expected, when *all* letters differed, there were no differences between the items, since the decision in each case was controlled by the letter level, which treats all items alike. However, when only one letter differed, both words and legal nonwords were processed faster than illegal nonwords, although there were no differences in performance on words and legal nonwords. These results suggest that the letter cluster level of processing detected the difference faster than both the letter and the word level. Why it should have been faster than the word level of processing is not entirely clear, since the number of letter clusters which must be identified and compared to detect the difference under these conditions would not be markedly less than for four-letter "same" items, for which a word superiority effect *was* obtained in Experiment I. Inspection of the means in Table 1 shows that there is at least a trend for word items to be responded to faster when the items differ in the third and fifth position, and perhaps all that is required is a repetition of the experiment, using a larger number of items of this type.

The fact that the serial position of the different letter influenced "different" response times suggests a serial left-to-right identification and comparison of the elements of the letter string. The fact that the slope of this function was higher for illegal nonwords than for legal nonwords further suggests that comparison time at the letter level is greater than at the letter cluster level. This could indicate either that letters take longer to compare than letter clusters, or that the number of comparisons is fewer when letter clusters are being compared rather than letters. It was anticipated that there would be no effect of serial position for words, but this was not the case, although the slope of the function was rather less than for legal nonwords. The existence of a serial left-to-right comparison procedure for the word items is further evidence that the words were being processed at the letter cluster level, although this would not explain the reduction in slope for words. One possibility is that processing at the word level was *occasionally* faster than at the letter cluster level, producing a slight but nonsignificant word superiority at the later serial positions, and a general flattening of the serial position effect.

One problem remains. If the comparison process is left-to-right, then why are "different" decisions faster when *all* letters differ, compared with the condition in which just the *first* letter differs? There are three possible interpretations of this effect. First, there may be a "wholistic" comparison process which compares the entire letter strings, reaching a relatively fast "different" decision when all letters differ. Second, the comparison process may proceed past the first comparison (seeking further confirmation that the letter strings are indeed different), and the "different" decision may be slowed down as a result of the fact that subsequent matches are encountered. Third, the comparison process may only be left-to-right on the average. That is, the order of comparison varies somewhat, and on some trials, the difference in the first pair of letters is not always detected first. However, when *all* letters differ, the very first comparison always yields a "different" decision, no matter what the order of comparison. The present experiments do not provide a basis for choosing between these three alternatives.

Clearly, the analysis for "different" decisions is far more complex than for "same" decisions. What is clear is that legal nonwords are processed for difference faster than illegal nonwords, a finding already suggested by the results of Barron and Pittenger (1974) and Eichelman (1970). Since this contrast involves a manipulation of familiarity (i.e., familiarity of letter sequences), we would have to reject Egeth and Blecker's (1971) suggestion that familiarity has no effect on difference judgments. It is also clear that it is difficult to demonstrate that differences can be detected faster in words than legal nonwords, and there appears to be no simple explanation of this fact. Incidentally, it should be noted that this result does not contradict the results obtained by Henderson (1974), who found that "different" responses for "illegal" letter strings that nevertheless had lexical representations, such as USSR, were faster than for illegal nonwords such as VPMC. This result is equivalent to the word-illegal nonword difference found in the present experiment, if words and strings such as USSR are both thought of as letter strings with lexical representations. Extrapolating from the results of Experiment II, one might predict that if Henderson had included legal nonwords such as BIST, he might have found that "different" responses for items such as USSR were actually *slower* than for legal nonwords. It is also worth noting that Henderson's suggestion that a word/illegal-nonword difference can only be obtained using blocked presentation of items appears to be incorrect, since the present experiments used mixed presentation conditions.

One implication of the model we have outlined is that "same" decisions should always be at least as slow as, or slower than "different" decisions. Yet, in Table 1 it can be seen that "same" responses were *faster* than "different" responses when the fifth letter only differed, a result which parallels those of Bamber (1969), Egeth (1966), and Nickerson (1967). However, rather than count this result as a disconfirmation of the model, we would prefer to argue that the direct, absolute comparison of "same" and "different" response times is potentially quite misleading. For example, it is possible that the two kinds of judgments involve different decision components. In the "different" case, in which some of the letters match and some do not, the evidence will always be contradictory, some of it suggesting that the items are the same (especially when the first four letters are the same in the two strings), some of it suggesting that they are different, and the decision-making system may take time to resolve this conflict. No such conflict is involved for "same" responses, where all the evidence points to the same conclusion. If this argument is correct, then the only relevant comparison is between "same" responses and "different" responses when *all* letters differ. Under these conditions, "same" responses are certainly slower than "different" responses (see Table 1).

The difficulties involved in interpreting the evidence obtained from "different" responses should not be allowed to obscure the pattern for "same" responses, where the picture is very clear. These results demonstrate unequivocally that lexical information is involved in the simultaneous matching task. This is no small matter, since it is not known whether the previously reported word superiority effects (Barron & Pittenger, 1974; Henderson, 1974) would be significant under the requirement that both item and subject generality be demonstrated (Clark, 1973). If we accept the interpretation that these results demonstrate that words are identified faster than legal nonwords, then we must ask why no such effect is found in the tachistoscopic identification task used by Baron and Thurston (1973). It could be that the answer to this question lies in the fact that the matching task and the tachistoscopic identification task involve quite different underlying processes. The strongest claim that could be made is that the matching task is inappropriate, since it confounds identification and comparison processes. Up to a point, this is a valid observation, since the word/legal-nonword difference *may* be due to the greater number of comparisons required for legal nonwords, but as we have already argued, the difference between high- and low-frequency words observed in Experiment I cannot be explained in this way. This effect can only be interpreted as showing that high-frequency words are identified faster than low-frequency words, from which it seems reasonable to infer that high frequency words (at least) must be identified faster than legal nonwords.

On the other hand, it could be that Baron and Thurston did not adequately test the word superiority hypothesis. The forced-choice recognition procedure that they employ may be less sensitive to the effect in question than the matching task, and it may not be possible to show a word/legal-nonword difference unless: (a) relatively high-frequency words are used (some of the words used by Baron and Thurston were of very low frequency, e.g., BOAS and PARS), (b) a larger number of items per condition are used, and (c) the effects are not minimized by repetition of the nonwords.

So far, we have offered no explanation of why words should be processed faster at the word level than legal nonwords can be processed at the letter cluster level. The simplest suggestion is that the faster processing results from the fact that stored lexical information can be used to speed up the identification process. For example, Rubenstein, Garfield, and Millikan (1970) postulate that lexical search is initiated after only some of the letters have been identified. If the correct lexical entry is found before *all* letters have been identified, then the remaining unidentified letters may be examined to determine whether their visual features (i.e., distribution of lines, angles, curves, etc.) are *consistent* with the orthographic information specified in the lexical entry. If the criterion for consistency is reached, then the identity of these letters is inferred from the lexical entry, not the visual stimulus, thus producing phenomena such as the proofreader's error. The matching task is then carried out by comparing the obtained orthographic specifications, which might even be done in a serial fashion. The advantage of words over legal nonwords then, arises from the fact that an accurate orthographic representation of words can be determined more rapidly than for legal nonwords. Of course, the process may be considerably more complex. For example, the matching of words may require the comparison of more than just the orthography, leading to the prediction that "different" response times might be affected adversely by similarity of meaning (Barron & Pittenger, 1974, appear to adopt this view), or even similarity of pronunciation.

One might be tempted to use the same kind of argument to explain why legal nonwords are matched faster than illegal nonwords. Just as one could search for a word beginning with C, one could search for a familiar letter cluster beginning with C, assuming that the familiar letter clusters are stored in much the same way as words. A familiar initial cluster CL will then be identified more rapidly than a "noncluster" such as CX. However, if this were the case, then it would be expected that the average digram and trigram frequencies would be correlated with response times within the legal nonword condition. In both Experiments I and II, this was not the case. That is, legal nonwords which consisted of high-frequency letter sequences were processed no faster than legal nonwords which contained low-frequency letter sequences.[2] This is a surprising result, since it is usually accepted without question that sequential redundancy is intimately involved in the identification process. In the context of the matching task, one could still explain the superior performance for legal nonwords by pointing out that fewer *comparisons* need be made if it is possible to analyze the letter string into clusters, even if these clusters are identified at the same rate as the individual letters. But this explanation would hardly suffice for other tasks, such as the tachistoscopic identification task (Baron & Thurston, 1973), or the letter search task (Krueger, 1970a), where legal-illegal nonword effects have been found. Perhaps it is not the *frequency* with which the letter cluster occurs that is important but rather whether it occurs *at all*. Clearly, this issue requires closer examination.

APPENDIX

The items used in the first experiment are listed below together with the mean RT in milliseconds found for each item. The items are arranged in groups of four, the first a high-frequency word, the second a low-frequency word, the third a legal nonword, and the fourth an illegal nonword pair.

1. "Same" Items

Four-Letter Items

BIRD/BIRD	624	BEEF/BEEF	651	BIRF/BIRF	741	BDEE/BDEE	775
COAT/COAT	613	CONE/CONE	711	COAN/COAN	785	CTOE/CTOE	797
FOOT/FOOT	570	FERN/FERN	673	FOON/FOON	658	FTRE/FTRE	762
GOAT/GOAT	625	GERM/GERM	732	GRAT/GRAT	853	GMOE/GMOE	754
MILK/MILK	610	MOTH/MOTH	659	MOLK/MOLK	709	MKHO/MKHO	772
POLE/POLE	648	PORK/PORK	614	PELK/PELK	648	PREO/PREO	764
SHOE/SHOE	604	SWAN/SWAN	677	SHAN/SHAN	829	SHWO/SHWO	757
STAR/STAR	713	SASH/SASH	749	SART/SART	715	SHSA/SHSA	871
TOWN/TOWN	726	TUSK/TUSK	621	TOSK/TOSK	678	TWNU/TWNU	865
WOOL/WOOL	648	WAND/WAND	687	WOON/WOON	668	WDLA/WDLA	793

Five-Letter Items

TEETH/TEETH	675	TORCH/TORCH	617	TORTH/TORTH	818	TEEHC/TEEHC	890
CLOTH/CLOTH	608	CREST/CREST	644	CLOST/CLOST	780	CRTEH/CRTEH	923
BLOOD/BLOOD	645	BRINE/BRINE	777	BRONE/BRONE	818	BDIOL/BDIOL	870
CHAIR/CHAIR	620	CREED/CREED	668	CHADE/CHADE	750	CRREI/CRREI	883
QUEEN/QUEEN	640	QUILL/QUILL	667	QUILE/QUILE	699	QLNEU/QLNEU	931
WHEAT/WHEAT	687	WRIST/WRIST	661	WREAT/WREAT	883	WHTIS/WHTIS	841
GLASS/GLASS	588	GNOME/GNOME	780	GLOME/GLOME	732	GLLDA/GLLDA	816
HEART/HEART	623	HEATH/HEATH	760	HATHE/HATHE	862	HRTAE/HRTAE	936
PORCH/PORCH	704	PLANK/PLANK	704	PRONK/PRONK	730	PLCAH/PLCAH	971
CROWN/CROWN	680	CHART/CHART	704	CRAWN/CRAWN	762	CRHOT/CRHOT	848

2. "Different Items

(A) Items Beginning With Different Letters

Four-Letter Items

NECK/SOUL	604	NODE/STAG	687	NEEK/STOG	624	NDCO/SLVA	668
HAND/CAKE	641	HARP/CORK	614	HARN/CERK	638	HDPA/CKOA	679
MOON/PATH	675	MONK/PILL	722	**MOOK/PILT**	656	MNON/PLHA	645
WIFE/ROPE	643	WART/ROOK	712	**WEAF/ROOP**	658	WTRI/RKED	649
PIPE/CARD	695	PINT/CASK	679	**PITE/CRAD**	641	PNPI/CKSA	633

Five-Letter Items

CREAM/STONE	704	CRANE/SHACK	679	CRAME/STECK	620	CMRAB/SNHAO	702
SHEET/TRAIN	701	SPOOL/TRIPE	674	SHOOL/TRAPE	722	SPTEE/TNIIR	575
MOUTH/WORLD	711	MARSH/WHARF	675	MORSH/WARLD	651	MHUAT/WHOFR	747
CLERK/FRUIT	657	CRUMB/FINCH	622	CRULB/FRINT	695	CEKRM/FHCIU	632
GRAIN/CHILD	729	GLAND/CHALK	717	GLAIN/CHILK	745	GDRNA/CDAHL	743

Items used in the second experiment. The items are arranged in groups of three, the first a word item, the second a legal nonword item, and the third an illegal nonword item.

(B) "Different" Items Beginning With the Same Letter

Four-Letter Items

BALL/BELL	929	BEAD/BEAK	888	BEAL/BEEL	1032	BKLA/BDLA	996
TENT/TREE	866	TRAM/TALC	700	TRAN/TRAL	876	TTME/TCEE	760
LAKE/LIFE	680	LUNG/LOBE	682	LUNK/LIBE	625	LGEA/LFIE	700
ROOF/ROOM	802	RAFT/RIND	796	ROFT/RION	717	RTFA/RDMO	684
DESK/DOOR	681	DOME/DOVE	753	DOKE/DROE	885	DSME/DVOO	649

Five-Letter Items

BIRTH/BEAST	740	BIRCH/BADGE	767	BRITH/BEDGE	692	BCRHI/BSTAA	812
CLOCK/CLOUD	741	CLOWN/CHOIR	716	CLOND/CHIRK	688	CLWOU/CLCOO	797
SHEEP/SWORD	744	SHAWL/SHEAF	829	SHEEL/SHORD	790	SPWHA/SFWEA	986
BRAIN/BREAD	785	BROOM/BROTH	762	BROON/BRATE	724	BMRAI/BDROH	726
FIELD/FLESH	804	FLUTE/FUDGE	779	FLIDE/FLUGE	800	FTLUE/FSHDE	846

ADD TEXT

1. "Same" Items

WHEAT/WHEAT	778	BLOUT/BLOUT	774	ETRNO/ETRNO	1100
GUARD/GUARD	841	SONTH/SONTH	904	RKNLI/RKNLI	1040
SMOKE/SMOKE	686	GRAIM/GRAIM	967	HLSAE/HLSAE	1036
LEARN/LEARN	758	PIGHT/PIGHT	983	FODTN/FODTN	1028
FRUIT/FRUIT	794	SELCH/SELCH	815	ETSPT/ETSPT	1139
CATCH/CATCH	770	MINCH/MINCH	674	GNEGO/GNEGO	854
BRUSH/BRUSH	690	FLEEP/FLEEP	834	LWEOR/LWEOR	999
DRINK/DRINK	785	STARP/STARP	963	EDEWI/EDEWI	1005
FIGHT/FIGHT	848	THEST/THEST	797	DDAID/DDAID	969
SLEEP/SLEEP	748	RILSE/RILSE	869	DEDNC/DEDNC	888
VOICE/VOICE	659	CHESK/CHESK	855	EEAEQ/EEAEQ	1173
KNIFE/KNIFE	836	HILCH/HILCH	834	HCSOI/HCSOI	923
BUILD/BUILD	757	THOVE/THOVE	806	IMRTA/IMRTA	1006
FAITH/FAITH	763	DRASH/DRASH	879	TNPRT/TNPRT	1064
GUESS/GUESS	760	SLART/SLART	987	TLSUA/TLSUA	1081
SHORT/SHORT	760	FRIND/FRIND	958	CUHRP/CUHRP	1150
SPEND/SPEND	716	SMACE/SMACE	922	OSRTA/OSRTA	1005
STAGE/STAGE	734	BLACE/BLACE	939	RASNR/RASNR	1030
STAND/STAND	724	BLING/BLING	847	TNGPU/TNGPU	940
WHITE/WHITE	677	THEEN/THEEN	878	HSHTE/HSHTE	1056
PORCH/PORCH	806	SHISK/SHISK	739	RKSAU/RKSAU	1022
PRIDE/PRIDE	742	CHAND/CHAND	842	TTNSE/TTNSE	858
STATE/STATE	832	BLONG/BLONG	795	EIIEL/EIIEL	1012
QUEEN/QUEEN	758	CHALL/CHALL	847	UHDBW/UHDBW	1048
PAINT/PAINT	723	STIRE/STIRE	946	OAAES/OAAES	990

SCORE/SCORE	690	BANCH/BANCH	862	CCTNE/CCTNE	1081
PRICE/PRICE	725	WHOCE/WHOCE	974	VNNEI/VNNEI	1029
SCALE/SCALE	712	BRULT/BRULT	900	CSNEL/CSNEL	929
NOISE/NOISE	669	CHIST/CHIST	903	SCESC/SCESC	912
CLOTH/CLOTH	678	LITCH/LITCH	826	UTDTA/UTDTA	887
SOUND/SOUND	629	PRING/PRING	885	AAPFE/AAPFE	1103
FOUND/FOUND	680	DRING/DRING	888	OETWF/OETWF	1042
WOULD/WOULD	766	THERP/THERP	886	STGIO/STGIO	876
DEATH/DEATH	817	STERK/STERK	896	OOHCC/OOHCC	849
WORTH/WORTH	692	SPING/SPING	838	GHIHL/GHIHL	922
THREW/THREW	909	SHINT/SHINT	774	IHSWF/IHSWF	1123
THREE/THREE	841	WOULT/WOULT	856	RUDTK/RUDTK	918
SPACE/SPACE	663	GLAST/GLAST	884	RREOI/RREOI	1088
PLANT/PLANT	764	PREAT/PREAT	1032	EHPHH/EHPHH	1063
TRAIN/TRAIN	759	BROUL/BROUL	811	BTRIE/BTRIE	1066

2. "Different" Items

(A) Items With a Different Letter in the First Position

BLOOD/FLOOD	780	BRONE/FRONE	711	BHNTL/FHNTL	800
GRAIN/BRAIN	722	GEARK/BEARK	701	GSEHN/BSEHN	691
BEACH/TEACH	698	BRULD/TRULD	707	BSHCO/TSHCO	776
DRESS/PRESS	843	DROUT/PROUT	812	DHCAO/PHCAO	808
CLASS/GLASS	870	COUND/GOUND	784	CMSTD/GMSTD	943
MOUNT/COUNT	666	MOULK/COULK	715	MSRKA/CSRKA	691
YOUTH/SOUTH	671	YOULD/SOULD	642	YCGLW/SCGLW	783
BRAVE/GRAVE	721	BRICH/GRICH	679	BLRCD/GLRCD	763
BLAME/FLAME	744	BRISS/FRISS	756	BMSOA/FMSOA	741
BOUND/ROUND	797	BOULT/ROULT	763	BDSST/RDSST	991

(B) Items With a Different Letter in the Middle Position

HORSE/HOUSE	932	WORCH/WOUCH	937	LNRCT/LNUCT	1013
TRICK/TRACK	793	TRIND/TRAND	906	**CKILV/CKALV**	945
SHALL/SHELL	850	CHARD/CHERD	867	**CSAKI/CSEKI**	1087
SMALL/SMELL	783	STARM/STERM	810	**LHABI/LHEBI**	1026
THINK/THANK	813	THICE/THACE	740	RMISR/RMASR	1031
BLACK/BLOCK	720	FLAST/FLOST	833	ECAGR/ECDGR	1188
MOUTH/MONTH	884	WOUTH/WONTH	951	RKOHA/RKNHA	1075
STICK/STOCK	699	SHING/SHONG	779	ANICR/ANOCR	999
BREAD/BROAD	852	WHESK/WHOSK	902	HCELR/HCOLR	820
FLASH/FLESH	938	CLAST/CLEST	754	RCASL/RCESL	1039

(C) Items With a Different Letter in the Final Position

CHEER/CHEEK	813	THEAR/THEAK	913	EOASR/EOASK	1137
SHEEP/SHEET	976	WHERP/WHERT	967	EHRFP/EHRFT	1139
SHARE/SHARP	852	THIRE/THIRP	849	OOKHE/OOKHP	939
SHOOK/SHOOT	893	DREAK/DREAT	905	RACLK/RACLT	1096
GREEN/GREET	848	BREAN/BREAT	894	EEHSN/EEHST	1012
STORE/STORM	778	COURE/COURM	894	FNOHE/FNOHM	920
CROWD/CROWN	901	THEAD/THEAN	890	AARSD/AARSN	1033
CHAIN/CHAIR	822	SHAIN/SHAIR	854	ATFSN/ATFSR	1037
CLEAN/CLEAR	829	SMAIN/SMAIR	781	CELFN/CELFR	1030
GRAND/GRANT	844	PLARD/PLART	881	HFLHD/HFLHT	1098

(D) Items With All Different Letters

CHILD/BROWN	660	MOUNG/CLOOR	656	GTUMC/IKDTE	632
DREAM/CHIEF	666	COUSE/SHEND	661	GNAEA/RDNTO	697
MARCH/BRING	672	MOUSK/SHICE	646	EHGRS/FCFIE	736
SPEAK/GRASS	699	SHACE/BREET	685	EEOTM/RCMED	706
JUDGE/TOUCH	666	BLEAM/THARE	708	OTRHL/HSCTU	733
SMILE/EARTH	708	STIRM/TRONG	671	LRLCI/WNOHO	602
FIELD/MIGHT	678	SHENT/NOULD	649	DRADR/AHIAI	695
STONE/THICK	664	COUSK/THENG	658	TTHJA/KSEFI	720
HEART/NORTH	672	GRULD/CARTH	747	BHILH/GRREM	656
TEETH/WORLD	694	JANCE/CHOUT	651	DTSPW/BEHIR	681

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NOTES

1. After running the experiment, three small errors in the construction of the items were noted. FIELD/MIGHT should have had no letters in common. ECAGR/ECDGR and RKOHA/RKNHA should have been ECAGR/ECOGR and RKOHA/RKUHA to match the related word and legal nonword items. The results were reanalyzed without these items. Neither the direction nor the level of significance of the reported results differed when these items were omitted.

2. When the trigram frequencies for the word and legal nonword "same" items of the second experiment were analyzed in terms of *relative* frequences (i.e., transitional probabilities), there was still no significant correlation with response times.

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