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ABSTRACT

In an earlier study, subjects who were shown the two words "inside" and "consult" at two different points in a study list of two syllable words were willing to accept the word "insult" as having been on the study list. It was concluded that each syllable had a representation in memory over and beyond the semantic factors which are normally represented with words. The two experiments described in the present study take the theoretical position that the syllable was represented in memory as a visual-phonetic-articulatory frequency unit. In the first experiment, two independent words were presented for study with varying lags, the test being for the two words having meaning as a pair. In the other, elements of compound words were presented separately with the test being on the compound word. The subjects had to decide whether the two words had or had not been presented together on the study trial. The original position, that the syllables were represented in memory as a visual-phonetic-articulatory-frequency unit, was supported. (TS)

THE INTEGRATION OF DISCRETE VERBAL UNITS IN RECOGNITION MEMORY

Benton J. Underwood, Susan M. Kapelak, and Robert A. Malmi

Northwestern University

September, 1975

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The two experiments examined factors underlying false alarms on recognition tests when the elements of the test items were presented alone for study at different points in time, and when the elements were parts of different two-element units during study. In the former case lag between presentation of the two elements was varied. In one experiment two independent words were presented for study with varying lags, with the test being for the two words as a pair. In the other, elements of compound words were presented separately

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered) with the test being on the compound word. The subjects had to decide whether the two words had or had not been presented together on the study trial. Lag was not found to be a relevant variable and this fact, plus the findings on a special test of temporal discrimination, led to the conclusion that temporal judgments were not involved in the false alarms observed. Because it seems unlikely that a meaning response, evoked on the study trial, was also evoked on the test trial, the false alarms observed were attributed to the visual-phonetic-articulatory responses of the elements which were evoked on both the study and test trials.

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The Integration of Discrete Verbal Units in Recognition Memory

The study of errors in recognition memory is one way to determine the types of information which constitute memories. If the subject accepts an event as one which had been experienced earlier when in fact it had not been, inferences about the information in memory may be made under certain circumstances. More specifically, by appropriate manipulations certain types of information may be inserted into memory as a means, so to speak, of misleading the subject. A positive outcome requires that the false alarm rate be greater for the experimental items than for control items, since the causes for false alarms in the latter case are usually unknown. In the present studies the false alarms of interest were those which reflect the acceptance by the subject that two events had occurred together in time when in fact they had not.

In an earlier study (Underwood & Zimmerman, 1973) it was shown that each syllable in a two-syllable word had independent representation in memory. Subjects shown the two words inside and consult at two different points in a study list of two syllable words were willing to accept the word insult as having been on the study list with a greater frequency than their acceptance of control words. Because the false alarms to such derived words could not have been due to commonality in meaning with the study words, it was concluded that each syllable had a representation in memory over and beyond the semantic factors which are normally represented with words. The theoretical position taken was that the syllable was represented in memory as a visual-phonetic-articulatory frequency unit. In the present studies this position was examined when the unit of interest was a word which was likely to produce a meaningful response (as opposed to the relative lack of such responses for many syllables, such as sult in the above illustration).

In the first experiment false alarms were examined for word pairs which were quite meaningful as a pair (e.g., key figure) but which had been presented for study as individual words. Certain design problems were faced. The first had to do with implicit associative responses. If, to continue the above illustration, figure occurs implicitly when key is presented alone for study, it could be argued that phenomenally the two words had occurred together in time. To eliminate this interpretative confounding only pairs were used which had a very low likelihood of being associatively related in the sense that one would elicit the other in word-association tests.

It was presumed that when the words were presented singly for study, each would produce its distinctive meaning response which would be different from the meaning response produced when the pair was tested. That is, the response to key and to figure as individual words would be quite different from the meaning response to <u>key figure</u> as a pair. To result in a false alarm, therefore, the memory for each of the words as single words must be sufficiently compelling to cause the subject to disregard the meaning of the pair as a pair when presented on the test trial. The fact that the words presented singly must be separated in time raises the possibility that temporal information (of whatever this may be constituted) for each word could be used to reach a decision that the two words had not been presented together on the study phase. Two steps were taken to evaluate this possibility. First, the distance or lag between the two words was systematically varied. If temporal information plays a distinguishable role, the greater the lag the fewer the false alarms. Second, subjects were given an independent test of temporal discrimination. The belief was that if a systematic lag effect was found in the recognition experiment, those subjects with the best temporal discrimination scores on the test would show a more pronounced lag effect than would be subjects with poor temporal discrimination test scores.

Experiment 1

The general plan of the experiment called for a study list in which single words and pairs of words were mixed together. On the test only pairs were shown and the subject made YES-NO decisions as to whether the two words in each pair had been presented together on the study list (YES) or had been presented separately

(NO). The test list consisted of true old pairs, of pairs formed by combining two words which had been presented singly for study (E Pairs), and of new pairs for determining a control rate for the false alarms (C Pairs). Within the E Pairs the lag between the two words on the study list was varied at four levels, namely, 0, 5, 10, and 20 intervening words.

Lists. Newspaper stories were used from which to select a total of 80 word pairs, each pair having occurred together in a sentence. Some examples of the pairs are: last week, sudden decision, main prize, vital link, tightly closed, lying behind. No word was repeated among the 80 pairs. A study list consisted of 40 pairs presented as pairs, and 20 pairs presented as single words, for a total of 80 positions. There were five pairs (presented as single words, of course) at each of the four lags. In sequencing the single words within the list, the first word in the pair always preceded the second. Each lag was represented once in each fifth of the study list but obviously with a lag of 20 there was overlap. From the subject's point of view the list was simply 80 positions, occupied by a random mixture of pairs and single words.

The test list consisted of 70 positions, hence 70 pairs. Of the 40 old pairs presented for study, only 30 were tested. Beyond these, there were 20 E Pairs and 20 C Pairs. With minor variations, the order of presenting the pairs on the test corresponded to the order presented on the study list for the old pairs and for the E Pairs. Four C Pairs occurred within each fifth of the test list, randomly mixed with the old pairs and with the E Pairs.

Four study and corresponding test forms were constructed such that across forms each pair served as a C Pair only once, as an E Pair at a given lag only once, and as an old pair no more than twice. Within these restrictions the assignment of the 80 pairs to particular functions was carried out randomly. Of particular importance is that across all forms 20 different words were used at each lag. Since the results were uninfluenced by forms, it will not appear as a factor in the statistical analysis.

Procedure and subjects. The study and test lists were presented at a 3-second rate on a memory drum. Before the study list was shown the subject was instructed that he would be presented a long list of single words and pairs of words and that he should learn as many of the words and as many of the pairs as possible in preparation for a memory test. The subjects were not explicitly instructed to associate the two words presented as pairs. The nature of the test was not described until after the study list was shown. The instructions for the test emphasized that only pairs would be tested, and that a YES response was to be used only if the two words had been presented together as a pair on the study list. The instructions specified that a decision must be made for each pair within the 3 seconds allowed. If a subject failed to respond the experimenter returned to the pair after the test was completed and required a decision. This was very infrequently necessary.

A total of 96 college students served as subjects, 24 being assigned to each form by a block randomized schedule.

Temporal test. After the completion of the recognition task, all subjects were given the same test, a test designed to measure temporal discrimination ability. The subjects were presented a list of 32 words at a 3-second rate. An unpaced test followed in which 12 pairs of words were listed on a sheet, with the numbers 0 through 14 following each. The subject circled the word in each pair which he believed occurred later or more recently in the list, and then circled one of the numbers to indicate the number of other words which he believed fell between the two words being judged when they were presented for study. The 12 pairs constituted three cases each of lags 0, 1, 5, and 10. Half the time the word occurring first in the pair on the test sheet had occurred before the other on the study list, and half the time it had occurred after the other word. Pairs representing the four lags were block randomized on the test list but because the subject was not required to respond in order, this was probably of small consequence. Words occupying positions 1, 2, 15, 21, 22, 30, 31, and 32 on the study list were not tested.

Each subject was given four lists, the test for each occurring before the next was presented for study. The subject was fully instructed about the nature of the test requirements prior to presenting the first list. All lists had 32 words and the tests were identical except that different words were involved. Across the four lists, therefore, a subject made judgments on 12 pairs at each lag. The words consisted of a random sample of 128 four-letter words from a pool of 315 such words drawn randomly from the Thorndike-Lorge (1944) tables. The 128 words were assigned randomly to lists and to positions within the lists, and all subjects were given the four lists in the same order.

Results

Graphical presentations will be based on percentage scores to allow easy comparisons across studies. However, most statistical tests used raw scores, with the significance level set at .05. The essential recognition results for the first experiment are shown in Figure 1, in which the false alarms are plotted for the E Pairs for each lag, and with the dotted line showing the level of false alarms for the 20 C Pairs. It is apparent that more false

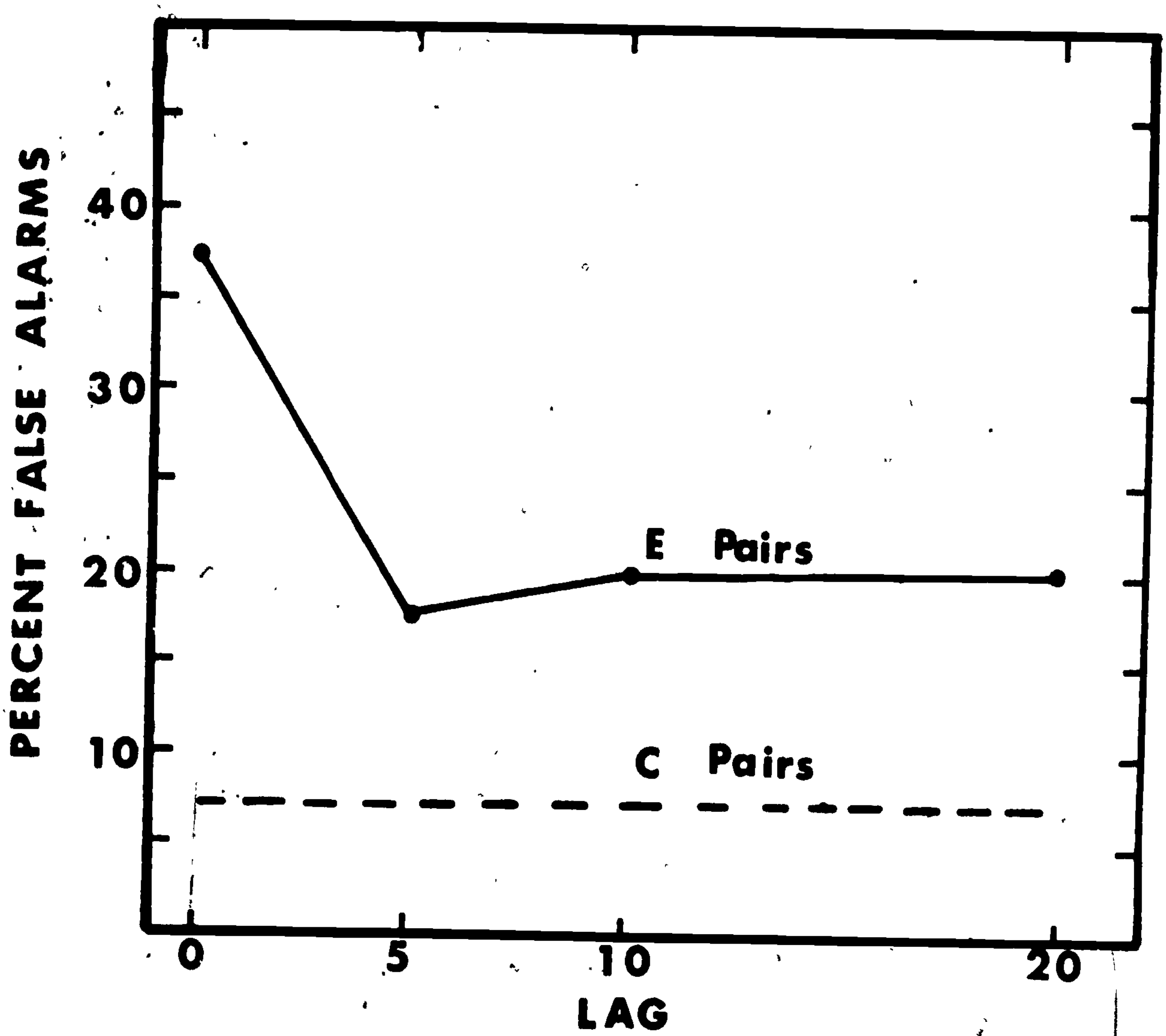

Figure 1. False alarms on E Pairs as a function of lag with the base rate shown for C Pairs.

alarms occurred for the E Pairs than for the C Pairs. Of the 96 subjects, 79 showed more errors on the E Pairs than on the C Pairs, 10 showed an equal number, and for seven subjects more errors were made on C Pairs than on E Pairs. The statistical test showed a reliable lag effect, $\underline{F}$ (3,285) = 23.63, $MS_{\underline{e}}$ = .70. Yet it is obvious that the only appreciable source of variance for this effect arises from zero lag. It will be argued later that this condition represents a special case and that the lack of differences among lags 5, 10, and 20 is to be interpreted to mean that temporal information does not serve as a discriminative cue in decisions as to whether the two words had or had not occurred together during the study trial.

The number of false alarms appears to be greater for the E Pairs than for the C Pairs, even omitting the false alarms at lag zero from consideration. A percentage score was determined for each subject indicating the proportion of false alarms on the 20 C Pairs and a corresponding value was determined for the 15 E Pairs (eliminating the false alarms for the 5 pairs at zero lag). The mean percent difference was 12.4%, and the $\underline{t}$ was 8.44 (95), $\sigma_{\underline{diff}}$ = 1.47. Although of no particular import for the present study, it should be mentioned that the misses on the 30 old pairs averaged 34.7%.

Temporal test. On the temporal test the subjects made two decisions. First, they made a decision as to which of the two words in a pair occurred more recently in the list, and second, a decision as to the number of other words by which the two were separated. Both decisions proved difficult for the subjects to make. The results for the 96 subjects, summed across the four lists, are shown in Figure 2. The upper panel shows the number of correct responses (choosing the more recent word), and although all points are above chance, even with 10 intervening items performance was poor. It should be noted that performance with zero lag is a little better than that with a lag of one. The difference is small but occurred in exactly the same magnitude for the subjects in Experiment 2. As will be discussed later, this appears to be related to the recognition results with zero lag. The lower panel of Figure 2 displays the mean separation judgments. In an absolute sense, the discrimination is very poor but that there is a slope seems unmistakable. A test of the differences in the upper panel yielded $\underline{F}$ (3,285) = 7.10, $MS\underline{e}$ = 2.60, and for the lower panel, $\underline{F}$ (3,285) = 34.71, $MS\underline{e}$ = 112.67, both tests representing reliable effects.

As stated earlier, the intent had been to use scores on the temporal test to correlate with subjects' false alarms on the E Pairs on the recognition test, if recognition had been related to

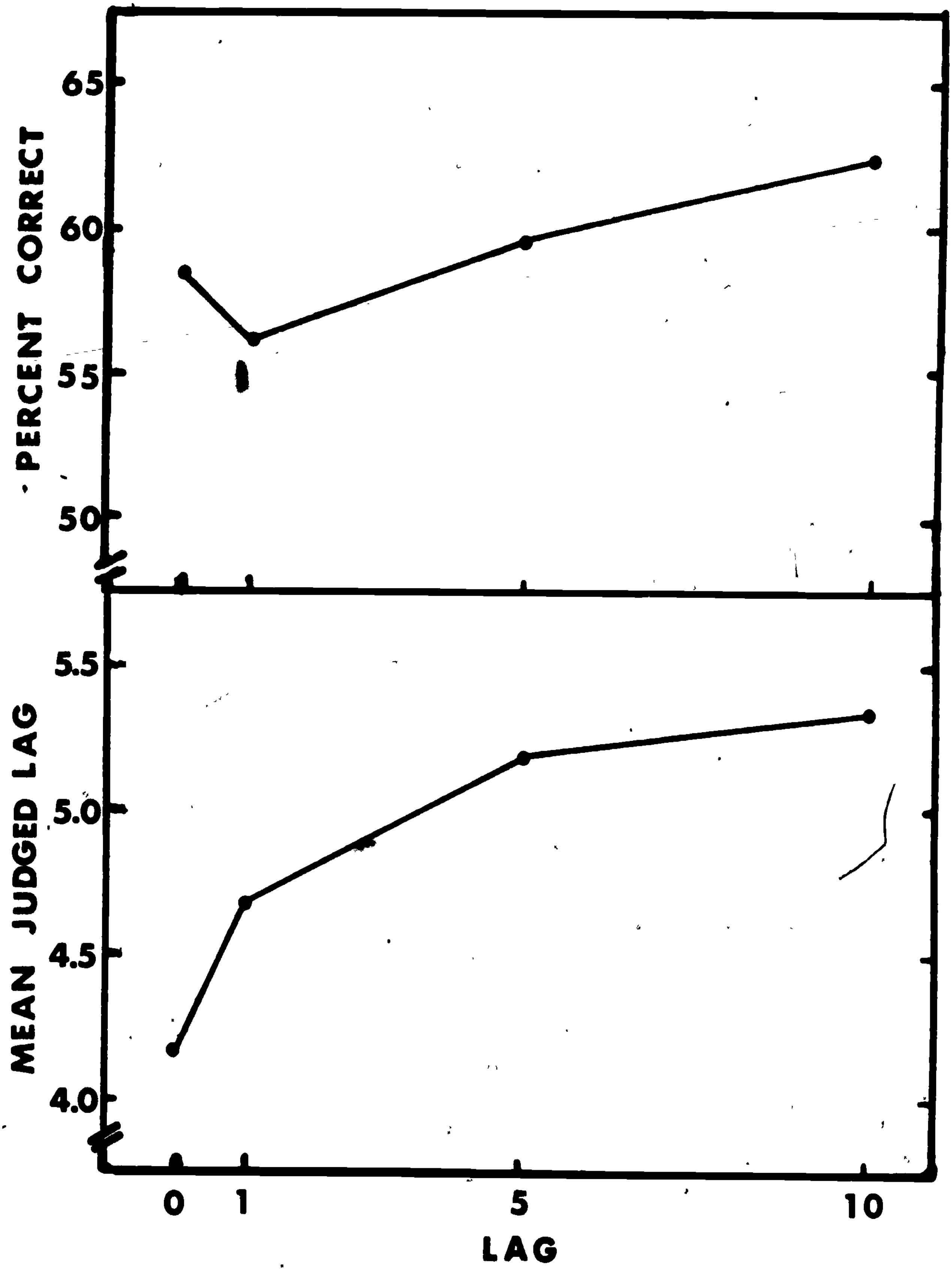

Figure 2. Percent correct responses (upper panel) and mean judged lag (lower panel) for the 96 subjects taking the temporal test.

lag. Except for the case of zero lag, false alarms were not related to lag. Since the data in Figure 2 do show a lag effect for temporal judgments, it would seem reasonable to conclude that a temporal-discrimination skill was not involved in influencing the false alarms. On the other hand, the change in the temporal judgments between lags 5 and 10 is not great and the individual differences approach might still be worthwhile. Unfortunately, the reliability of the temporal test was not high. The product-moment correlation between the number of correct responses on Lists 1 and 2 combined, and on Lists 3 and 4 combined was only .39 for the 96 subjects. Although this value is highly reliable statistically, it has little power for predicting individual performance. A slope measure was used to reflect the lag (separation) judgments. This was calculated for each subject as the sum of the judgments for lags 0 and 1 divided by the sum of the judgments for lags 5 and 10. A ratio of one would indicate no discrimination, with discrimination increasing as the ratio decreases below one. Correlating these slope measures for Lists 1 and 2 combined against those for Lists 3 and 4 gave a value of .29. Across the four lists combined the two measures (number correct and slope) correlated .36.

It is conceptually possible to separate a correct response and a lag judgment on the test. That is, one might know that two events were widely separated in time but not know which was most recent. As the above correlation indicates, this was not true in general; rather, subjects who had many correct responses also tended to have positive slopes reflected in their lag judgments. There were many exceptions noted in the individual records as would be inferred from the modest relationship between the two measures. A rather curious finding emerged from other analyses of the test data. It might seem that a subject would induce a rather sharp lag function based on his confidence of the correctness of his choice of one of the two words in a pair. If the subject had no idea which of the two words had been more recent, he would conclude (therefore) that the two words must have been close together in the list and as a consequence he would assign a short lag. On the other hand, if he was quite confident of his choice, he might also conclude that the two words had been widely separated in the list and assign a long lag value. The data show that this correlation did not exist. A lag function was determined only for items that were incorrect and another function only for items which were correct. The lag function for the erroneous choices was essentially flat with a mean of 5.0. The lag function for the correct response must, as a consequence, have a rather sharp slope since lag judgments for wrong responses would be removed from the curve in Figure 2. The mean lag judgments were 3.8, 4.7, 5.4, and 5.5, for the four lags in order.

As a modification of a strict individual differences approach, the subjects were divided into two subgroups based upon the scores on the temporal test. One subgroup had 30 correct responses or more, the other had 29 or less correct responses. The question was whether these two subgroups differed on the recognition test. Two recognition measures were used. One was a sensitivity measure consisting of the sum of misses on the old pairs and the false alarms on the C Pairs. The other was number of false alarms on the C Pairs subtracted from the number of false alarms on the E Pairs (E-C). The first measure presumably should not be predicted by the temporal test since it does not involve distinguishing events as a function of lag. The second measure might be predicted by the temporal test if the number of false alarms on the E Pairs is in any way determined by the ability to distinguish lag differences. Two other points should be made about the second measure. First, it has substantial, although not high reliability. The correlation between the number of false alarms on E Pairs for lags 0 and 1 combined and lags 5 and 10 combined was .46 for the 96 subjects. Second, subtracting the false alarms for the C Pairs from that of the E Pairs should adjust for individual differences in criterion settings for responding.

The two subgroups consisted of 41 subjects having 30 or more correct responses and 55 having 29 or less. The mean number of misses plus false alarms on C Pairs was 11.22 ($\sigma_{\underline{m}}$ = .67) for the high group, and 12.33 ($\sigma_{\underline{m}}$ = .67) for the low group ($\underline{t}$ = 1.17). On the E-C measure the corresponding means were 3.49 ($\sigma_{\underline{m}}$ = .45) and 3.22 ($\sigma_{\underline{m}}$ = .38) and the $\underline{t}$ was .46. The number of correct responses on the temporal test did not distinguish between these two subgroups on the recognition measures. As a second step the 96 subjects were divided into two subgroups on the slope measure and again the mean scores on the recognition test evaluated. In neither case did the difference approach significance. Whatever is being measured by the temporal test seems to have no counterpart in the tendency to integrate discrete verbal units on the recognition test.

<u>Discussion</u>

The data have shown that the number of false alarms on the E Pairs did not vary as a function of the lag between 5 and 20. This evidence, plus that from the temporal test, indicates that temporal information, however constituted, is of little relevance in preventing false alarms on pairs of words which had been presented as single words for study. It is believed that the large number of false alarms which occurred at zero lag is a special case. It seems highly probable that when two words, such as <u>key</u> and <u>figure</u>, occur in adjacent positions in the study list they will be rehearsed together and therefore phenomenally occur together in the series. The second experiment will allow a test of this in that at a lag of one such rehearsal should not occur. It is also of interest that the temporal test showed what appears to be a similar effect for zero lag in the correct response measure. If two adjacent items are rehearsed together, it appears to help to a small degree in distinguishing the order of the two words in the series.

A detailed discussion of the factors underlying the false alarms for the E Pairs will be given following the report of Experiment 2.

Experiment 2

In the Underwood-Zimmerman (1973) study described earlier, false alarms occurred when a test word was formed by joining two syllables from two different words presented for study. Experiment 1 showed that a similar effect was produced when two words, presented for study singly, were tested as a pair. In the present experiment, an examination was made of false alarms for an in-between case, namely, the case where subjects were tested on a compound word (e.g., keynote) when the constituent, short, or more elementary words (key and note) had been presented singly for study. Furthermore, it was found possible within the same experiment to approximate the procedures used for the syllable-integration study noted above, but with each syllable constituting a common word. This may be illustrated. The subject was presented two compound words such as toothbrush and heartache widely separated on the study list. On the test list a YES-NO decision was required on the word toothache, a word which is constituted of two shorter words from the compound words given on the study list.

Essentially, then, Experiment 2 consisted of two experiments done simultaneously. In describing the experiment it will be necessary to keep the two sets of procedures distinct. One set implements the test of whether single words presented for study will be accepted as having occurred together as a compound. This part of the experiment will be identified as SC procedures (single to compound). In the other set of procedures, two compound words were presented on the study trial and from them a new compound word derived for the test. These procedures will be identified as BC (between compounds). Several considerations determined the nature of the design.

1. The lags used for the SC procedures were 1, 5, and 10 intervening items. If the findings for zero lag in the first experiment represent a special case, no lag effect should be found.

2. Again the problem of implicit associational responses had to be faced if the interpretation was not to be clouded. It seemed a distinct possibility that in the SC procedures a word such as base, presented for study, might elicit ball implicitly. The

interpretation of a false alarm on baseball would therefore become ambiguous as to origin. At the same time it seemed of some importance to determine if implicit associational responses were involved. As a consequence, for one group of subjects the single words were presented as indicated above (base followed by ball), and for another group the order was reversed (ball followed by base). The assumption was that an appropriate implicit associational responses might occur in the first case, but would be very unlikely to occur in the second.

3. For the BC (between compounds) procedures it was possible to assess the influence of a testing effect as was done in the Underwood-Zimmerman (1973) experiment in which syllable integration was studied. The procedures for this may be illustrated. Assume that toothbrush and heartache were used as inducing words during study to produce a false alarm on toothache. If the recognition for the two inducing words were also tested, the false alarms on toothache should be more frequent if the two inducing words were tested prior to the BC word (the derived word) than if tested after the BC word. This follows from the notion that in the act of testing the inducing words there is an additional frequency input for the two elemental words which will subsequently be tested as a BC word. If the BC word is tested before the inducing words are tested, this frequency increment would not be present. Therefore, for half the BC words, the inducing words were tested before, for half they were tested after the BC words.

4. Finally, because it seemed possible that compound words from which other compound words can be derived might constitute a special class of compound words, it was judged necessary to use such words as C Words for the BC procedures. As a consequence, each of the two procedures was entirely self contained in that the SC part of the experiment had E Words, C Words, and old words, and the BC part of the experiment had completely different items representing these three classes.

Method

Study and test lists. The words used for the SC tests will be described first. A total of 72 compound words was brought together. There were no duplications among the 144 shorter words constituting the 72 compounds. Most, but not all, of the short words were single syllables. These 72 words were assigned randomly to one of five functions: 8 words for lag 1, 8 for lag 5, 8 for lag 10, 24 presented as compound words and tested as such (old words), and 24 used as new compound words on the test (SC-C Pairs). The 24 words used for the lag manipulation were, of course, presented as 48 short words for study. A second form was created by a new randomization subject only to the restriction that the same word could not serve the same function in the two forms. Across the two forms, therefore, there were 16 different words used at each lag.

For the BC manipulations 16 pairs of compound words were assembled. For each pair a new compound word could be derived by using the first element (short word) of one and the second element of the other. The 16 pairs were divided randomly into two groups. For one form eight pairs were used as inducing words and eight served as BC-C Pairs in that the eight new compound words that could be derived from them were used as C Pairs. For the other form, the function of the two subsets of eight pairs was reversed. In presenting the two inducing words on the study list, the lag between them was never less than 10 items. Furthermore, the first element of the first presented inducing word always became the first element of the derived word and the second element of the second inducing word became the second element in the derived word.

The composition of the study list for the BC and SC manipulations may now be summarized. There were 48 positions occupied by the short SC words used to study the lag function, 24 SC compound words tested as old words, and 16 inducing compound words for the BC part of the experiment.

In allocating the items to position the 88 positions were divided into successive eighths. Essentially, each lag for the SC words was represented once in each eighth. Three compound words occurred in each eighth (these words to be tested as old SC words), and two inducing words for the BC manipulation occurred in each eighth. Both forms had the same structure. For each form a backward version was made up, backward in the sense that the short words used to study lag were interchanged. For example, in the forward version, neck occupied position four, lace position six (lag 1). In the backward version, lace occupied position four, neck position six. In both cases the test word was necklace. Only the 48 short words were interchanged to form the backward version; all control items and all BC items retained the same positions on both the forward and backward forms.

The test lists required 104 positions as follows: 24 compound words presented as short words on the study list and used to study lag (SC-E Words); 24 old compound words; 24 new compound words (SC-C Words); 16 inducing words for the BC part of the experiment and which, on the test, constituted 16 additional old compound words; 8 BC experimental words (BC-E Words), and 8 BC control words (BC-C Words).

Four of the eight BC inducing pairs were placed in the first half of the test list (again with at least 10 positions separating the two words in each pair) and their corresponding BC-E Words were placed in the second half of the test list. The other four pairs of inducing words were placed in the second half of the test list and their corresponding BC-E Words were placed in the first half. A BC-C Word was placed in a position adjacent to each of the BC-E

Words. After these placements were made, the remaining 72 words were assigned randomly to the remaining 72 positions.

Subjects and procedure. There were 100 subjects. Of these, 50 had the forward version of the study list (25 on each form) and 50 the backward version (25 on each form). Assignment to one of the four subgroups was from a block-randomized schedule. Forms will not be included in presenting the results since their purpose was to increase the number of different words used for each function.

The procedures for presenting the study and test lists were exactly the same as for Experiment 1. All subjects were given the temporal test following the recognition test.

Results

Single to compound (SC). Independent groups of 50 subjects each were used to assess the influence of the forward-backward variable. An inspection of the data indicated that this variable was of no consequence in determining false alarms, F (1,198) = 2.24, MS_e = 2.50. Therefore, the lag effects may be discussed for the 100 subjects combined. The lag function (percent of false alarms at each of the three lags) is plotted in Figure 3, with the dotted line indicating the false alarm level for the 24 SC-C Words. Lag was not a significant source of variance, F (2,196) = .07, MS_e = 1.03, and did not interact with the forward-backward variable, F (2,196) = 2.23, MS_e = 1.03. It is perhaps obvious that the number of false alarms differed for the C Words and E Words ($\underline{F}$ = 134.20). Of the 100 subjects, 83 made more false alarms on the 24 E Words than on the 24 C Words, 11 made an equivalent number, and four subjects had more errors on the C Words. Again, while of no consequence for the present problem, it may be noted that the misses on the old words averaged 35.6%.

A comparison of Figure 3 with Figure 1 shows very high correspondence if the results for lag zero of Experiment 1 are eliminated from consideration. In both experiments the false alarms on the E items exceeds that for the C items by 10-12%. The failure of lag to show an effect in the present experiment supports the notion that the zero lag represents a special case of associative learning in which the words were, in effect, presented simultaneously for study.

Between compounds (BC). In this portion of the experiment false alarms were examined for compound words when the words were formed from two short words taken from compound words presented for study. Further, testing effects were examined under the presumption that if inducing words occurred twice (once during study, once during test) before the derived word was tested, false alarms should be more frequent than if the inducing words had occurred

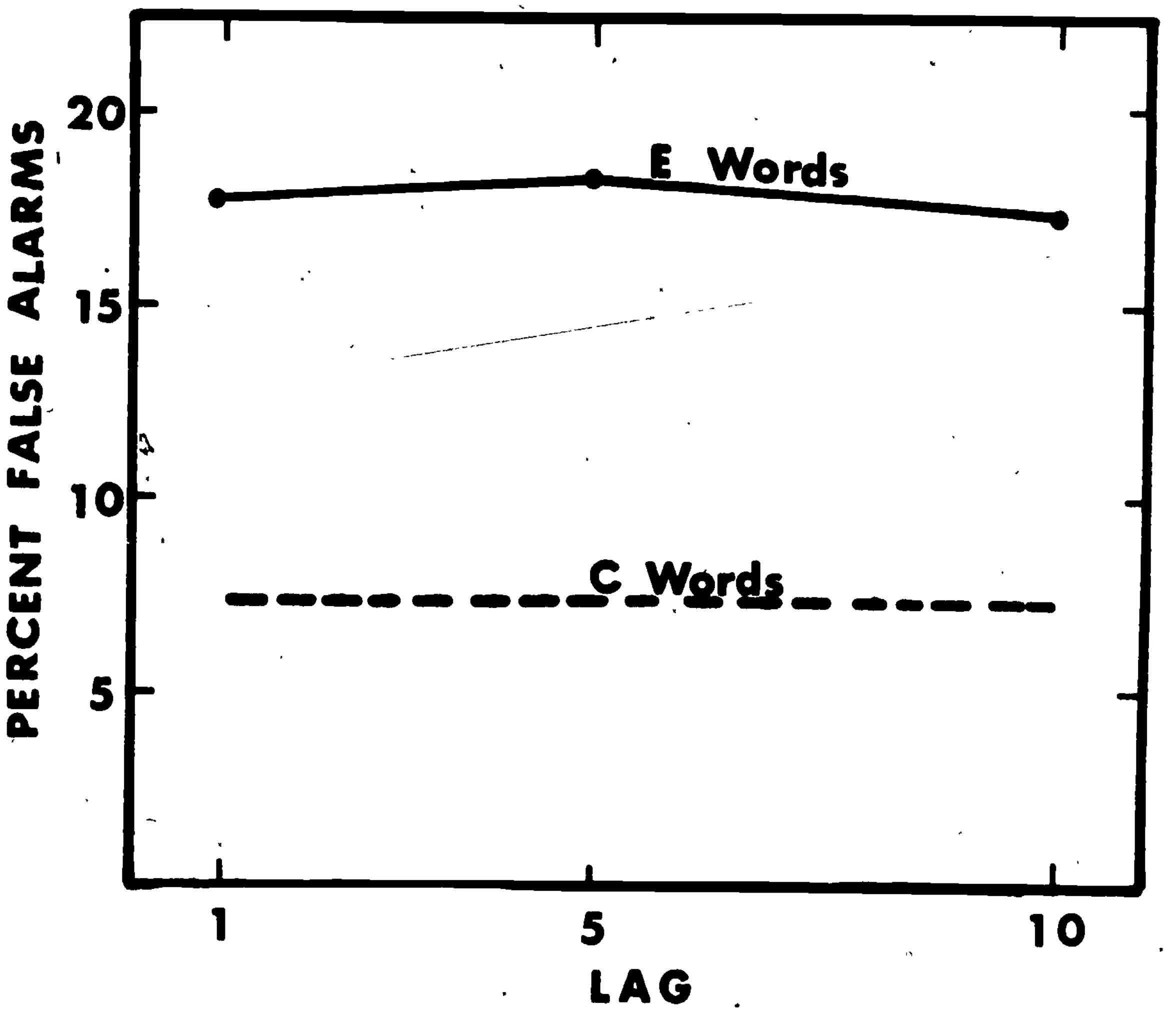

Figure 3. False alarms on E Words as a function of lag with the base rate shown for C Words (SC procedures).

only once (were tested after the derived words were tested). Derived words tested in the first half were based on inducing words which occurred only once, those tested in the second half followed two presentations of the inducing words. The outcome is shown in Figure 4.

Figure 4 shows that whereas false alarms on the C Words decreased slighly across the test halves, those on the E Words increased in number. It is also quite apparent that more false alarms occurred for the E Words than for the C Words. Test half was not a significant source of variance, $\underline{F}$ (1,99) = 3.16, MS$\underline{e}$ = 58; the E versus C difference was reliable, $\underline{F}$ (1,99) = 103.47, as was also the interaction, $\underline{F}$ (1,99) = 6.45, MS$\underline{e}$ = .42. Of the 100 subjects, 77 had more false alarms on E Words than on C Words, 17 had an equivalent number, and for six the direction was reversed. The number of misses on the inducing words was 29.3%, somewhat less than the number on the old words for the SC part of the experiment (35.6%).

A comparison of false alarms produced by the BC manipulation (Figure 4) and those produced by the SC manipulation (Figure 3) shows that the number was appreciably larger for the former. The difference was almost entirely due to differences in false alarms

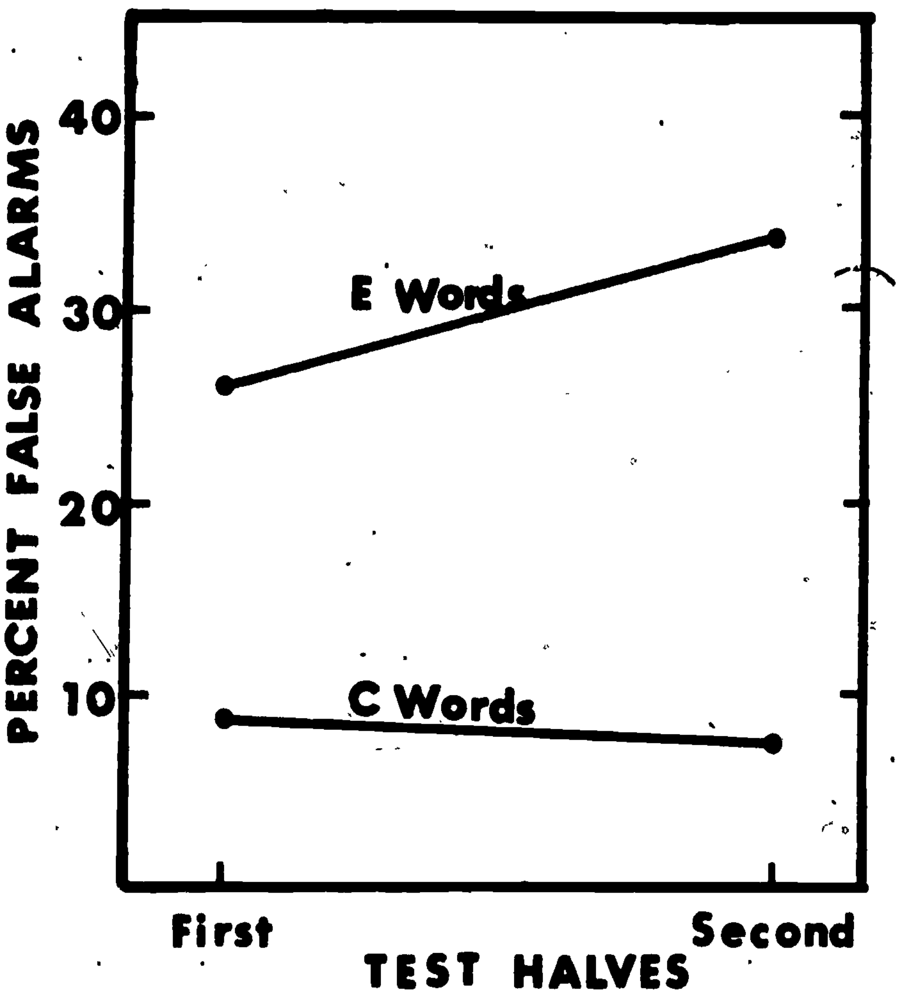

Figure 4. False alarms on E Words and C Words as a function of test halves (BC procedures).

on the E items, since the number on the C items was much the same for the two procedures. However, there was some commonality underlying the false alarms in the two cases because the correlation between the number of false alarms on the SC-E Words and on the BC-E Words for the 100 subjects was .42.

Temporal test. The complete absence of a lag effect in Figure 3 would seem to deny the possibility that a temporal judgment enters into the occurrence or nonoccurrence of false alarms. The number of false alarms should decrease as lag increases if this were the case. It is always possible that some other factor correlated with lag influences the frequency of false alarms in a direction opposite to that expected for lag increases, although that these two factors would be rather precisely in balance for two experiments seems unlikely. In any event, it was felt worthwhile to search again for possible relationships between recognition performance and scores on the temporal test.

A plot of number of correct responses across subjects on the temporal test, and their lag judgments, produced results which were almost arithmetically identical to those shown in Figure 2. Again there was a slight decrease in the number of correct responses from lag 0 to lag 1. The reliability of the test was about the same for correct responses as found in Experiment 1 ($r = .40$), the reliability for the slope measure somewhat less ($r = .15$).

The 100 subjects were divided into two groups, those who obtained 30 or more correct (N = 47), and those who obtained less than 30 correct (N - 53). The mean of the sum of the misses (on old items) and false alarms (on SC-C Words) was used as a measure of sensitivity. The E-C measure for false alarms on lag items was also used again. The subjects with high scores on the temporal test had a mean sensitivity measure of 8.98 ($\sigma_{\underline{m}}$ = .65), those with low scores a mean of 11.55 ($\sigma_{\underline{m}}$ = .60), and the $\underline{t}$ (2.92) indicated that these means were reliably different. However, the means for the E-C measure were 2.28 ($\sigma_{\underline{m}}$ = .31) and 2.70 ($\sigma_{\underline{m}}$ = .30) for the high and low subjects, respectively ($\underline{t}$ = .98).

The 100 subjects were then divided into two groups of 50 each based on the slope measure derived from the lag judgments on the temporal test. Again, the difference between these two groups on the sensitivity measure was highly reliable, the means being 12.24 ($\sigma_{\underline{m}}$ = .64) and 8.44 ($\sigma_{\underline{m}}$ = .54) for shallow and steep slopes respectively ($\underline{t}$ = 4.52). The groups did not differ on the E-C measure ($\underline{t}$ = .47), with the means being 2.40 ($\sigma_{\underline{m}}$ = .26) and 2.60 ($\sigma_{\underline{m}}$ = .34) for subjects with steep and shallow slopes. None of the conclusions about the false alarms was changed if all false alarms (those on BC items as well as those on SC items) were included.

The above results are somewhat more convincing than were the comparable ones described for Experiment 1. In Experiment 1 the subgroups determined by scores on the temporal test did not differ on either recognition measure, a finding which might be attributed to the low reliability of the test. In Experiment 2, however, both measures from the temporal test segregated two groups which did differ on the sensitivity measure (misses on old items plus false alarms on C-Words) of recognition, although neither measure of distinguishing subgroups was correlated with differences in false alarms. It appears that the evidence from both experiments leads to the conclusion that temporal discriminations are not involved in any substantial way in the recognition decisions made when two units, presented singly for study, are brought together on the recognition test.

The temporal test distinguished subjects on the sensitivity measure of recognition of Experiment 2 but not for Experiment 1. It might well be expected that a general learning factor could underlie performance on both the temporal test and recognition, but why a positive relationship would be found in Experiment 2 and not in Experiment 1 is not apparent. This matter should not obscure the more ciritical finding that the temporal test did not predict false alarms on the critical experimental items.

General Discussion

The evidence has been interpreted to support the conclusion that a temporal discrimination which increases as a function of lag between discrete units is not involved in the integration (erroneously) of these units on the recognition test. The explanatory issues must center on other types of information which may be responsible for the false alarms. In dealing with this matter four basic results must be kept in mind.

1. In the previously published study (Underwood & Zimmerman, 1973), many false alarms were observed when the test word contained two syllables, and when the two syllables had been taken from two different words presented for study.

2. In the comparable operations (BC procedures) included in Experiment 2, many false alarms occurred to compound words, each element of the compound having been taken from two different compound words presented for study.

3. In Experiment 1 two words were presented for study at different points in the list. These words were paired on the test and the subject made a decision as to whether they had occurred together on the study trial. False alarms exceeding the number for a control were observed.

4. In Experiment 2 procedures comparable to those in point 3 above were carried out by presenting two short words at separate points in the study list, and then making them into compound word for the test. False alarms were indicated when the subject reported

that the compound word had been presented on the study list.

As a means of simplifying the discussion, it will be assumed that there are two types of information which enter into the memory for each unit presented for study, semantic and nonsemantic. In the former would be included any elaborative responses which give the word its meaning. In the nonsemantic class would be included the more or less raw perceptual responses involving visual-phonetic-articulatory responses. These perceptual responses have some independence for units at least as small as the syllable. There is no reason not to believe that both classes of information were represented in memory as a consequence of the study trial. In one way of thinking about this, it may be said that there is situational frequency for both the perceptual response and the meaning response. This is to say that situational frequency may accrue to a perceptual response and independently to a consistent semantic response (e.g., Jacoby, 1972).

In evaluating the four findings about false alarms listed above, and the procedures which produced them, it seems quite unlikely that the test item would elicit a meaning response that had been elicited during the study trial. Certainly this seems unlikely for the findings 1, 2, and 4. Meaning responses might possibly have occurred independentlv for each word on the test which produced the third finding. That is, when, on the test, the subject is presented key figure, it is possible that a meaning response would occur to key, and quite a separate meaning response to figure, these two responses having occurred when the words were presented separately on the study trial. At the same time, a meaning response to the pair as a pair may not have occurred. If these events had happened, however, the number of false alarms should have been greater than observed, and greater than the number listed as the fourth finding above (two short words being tested as a compound word). All of this leads to the conclusion that the false alarms are primarily produced because the perceptual responses for the elements (syllable, short word) have a frequency representation in memory which leads to affirmative responses in spite of the fact that there is no "match" with the meaning response. The fact that the meaning response made to the test item does not have situational frequency representation in memory very likely prevents the number of false alarms from being far higher than actually observed. Given that a perceptual response must always occur prior to a meaning response, any technique which would reduce the likelihood of the occurrence of a meaning response on the test should increase the number of false alarms.

One further finding must be considered. The number of false alarms produced by the operations for the first two findings listed above was about twice as great as those representing the third and fourth findings. The cause for this difference probably lies in a common perceptual factor that holds for the study and test items in the former but not in the latter. In the procedures producing the first two findings there were always two elements represented in the study and test items (e.g., toothbrush and heartache on the study list leading to toothache on the test list). In the procedures producing the third and fourth findings this was not true in that the study item always consisted of one element, the test item of two elements. In one case the size of the unit changed between study and test, in the other it did not. Such a difference is frequently spoken of as a context difference. In this case it may be identified as a perceptual response having occurred alone on the study trial versus two perceptual responses (one for each verbal element) having occurred in succession on the study trial. In the latter case the context does not change between study and test, in the former it does. This cannot be considered an explanation since it merely represents a more detailed description of the differences in procedure associated with the differences in the number of false alarms. To move somewhat more toward an explanation it might be assumed that the subject learns a two-category classification task on the study trial (one element versus two elements) which serves as a discriminative cue on the test, i.e., the subject responds NO on the test because he remembers that at least one of the elements belonged to the single-element class on the study trial. Although such category learning can occur rather rapidly (e.g., Shaughnessy, 1973), that it was responsible for the so-called context effects in the presenting findings cannot be ascertained.

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