Memory & Cognition
1977, Vol. 5 (1), 123-130

Context effects in recognition memory: The frequency attribute

ROBERT A. MALMI
Northwestern University, Evanston, Illinois 60201

The first experiment determined whether frequency context would affect recognition memory decisions and frequency judgments. In the high-frequency context condition, 5 words were presented at study six times each prior to the section of the list containing the target items. In the low- frequency context condition, 30 words were presented at study one time each prior to the targets. The items tested were the same in the two conditions and were presented one, two, or three times each. Recognition performance and the judged frequency of target items presented once at study was higher in the high-frequency context condition than in the low-frequency context condition, but the opposite was true for items presented three times at study. The results of three subsequent recognition memory experiments suggested that encoding processes were critically involved.

The role of context on recognition memory performance has recently been the subject of considerable theoretical and experimental effort. The research to be reported here was initiated to determine the role of context on recognition memory performance when context is conceived of in terms of frequency information. The guiding theoretical framework is that of frequency theory (Underwood, 1971). According to frequency theory, recognition decisions are mediated primarily by discriminations between the situational frequency associated with old and new items. Items presented for study presumably accrue situational frequency as a result of perceptual and semantic responses made by the learner. The theory contends that the difference in phenomenal frequency of old and new items is evaluated and the result of the comparison translated into a recognition decision by application of the rule that items with greater frequency are called "old" and items with lesser frequency are called "new." Frequency theory has not addressed the role of context formally, and the present report may be considered as a preliminary step in that direction.

Frequency context will be defined in terms of the frequency of presentation of items at study. A description of the two context conditions investigated in Experiment 1 will serve to illustrate the manner in which context is defined here. Each subject was presented a long list of words for study. Words that would be tested later were presented one, two, or three times each in the study list. Eight words were presented with each of the frequencies. The critical difference between the two context conditions was determined by the presentation of items that would not be tested later. In one condition, 30 words were presented one time each prior to the presentation of the target items (Condition 30 x 1). In the other condition, 5 words were presented six times each prior to the presentation of the target items (Condition 5 x 6). Condition 5 x 6 will be considered to have a high-frequency context and Condition 30 x 1 a low-frequency context.

If it is assumed that the frequency of presentation of items at study corresponds roughly to the frequency information represented in memory with the items, then it is apparent that the frequency information about the study list would differ in the two conditions. In Condition 30 x 1, the low-frequency context condition, most of the study items would have frequency information corresponding to one presentation, hence generally lower than that of the tested items. In Condition 5 x 6, the high-frequency context condition, some items would have greater frequency than the tested items. A useful analogy to distinguish between the frequency information presumed to be represented in memory after the presentation of the study list in the two conditions may be that of a statistical distribution. The distribution of items having different frequency information would be skewed toward lower frequencies in Condition 30 x 1 than in Condition 5 x 6.

How might context, as it is defined here, affect recognition memory performance? There seem to be several possibilities, but, at this point, only the general hypotheses that context may affect either decision or storage processes will be entertained. Possible differences between the two context conditions for each of these stages will be briefly mentioned next.

First, subjects in the two context conditions might set different criteria for recognition decisions. For absolute recognition decisions, frequency theory assumes that the situational frequency of an item at the time of testing is evaluated, and, if it is judged to exceed a criterion, the item is reported to have been

The encouragement and criticism by Benton J. Underwood is most gratefully acknowledged. Requests for reprints should be sent to Robert A. Malmi, Department of Psychology, Northwestern University, Evanston, Illinois 60201.

presented in the study list. Since subjects in the high-frequency context condition are presented items with greater frequency than are those in the low-frequency context conditions, this may bias subjects in the high-frequency context condition to set a more stringent criterion. This is to suggest that the frequency information available after the presentation of a list of items may determine the criterion subjects set to make recognition decisions. According to this hypothesis, the frequency information represented in memory about target items would not differ in the two context conditions, but the decision processes would.

Second, the representation of frequency information in memory for the target items may differ in the two context conditions. There are several possibilities for the manner in which encoding of target items could differ in the two context conditions. One is suggested by the attenuation of attention hypothesis proposed to account for the higher recall of items repeated in a distributed as opposed to a massed fashion (Shaughnessy, Zimmerman, & Underwood, 1974). One of the assumptions of this hypothesis is that processing time is related to the amount of redundant information available from the presentation of an item. According to this notion, less processing time is devoted to redundant information. The probability that an item's presentation will make available redundant information, that is, a repeated presentation of the same item, is higher in the high-frequency context condition than in the low-frequency context condition. The persistence for encoding redundant information may differ in the two conditions because a tendency not to devote as much processing to redundant information may generalize throughout the list, and so affect the processing of the target items differently in the two context conditions. A second way in which encoding processes may differ in the two context conditions is suggested by adaptation level theory (e.g., Helson, 1964). According to this notion, the perception of an event is determined by the context in which it is perceived. Context is defined here as the frequency with which items are presented at study. Items are presented with greater frequency in Condition 5 x 6 than in Condition 30 x 1. Thus, items presented the same number of times in the two conditions may differ in accrual of frequency information because the frequency of occurrence of an item is perceived relative to the frequency information accrued for other items in the list. An item presented three times may have less apparent frequency in a context in which some items are presented six times (Condition 5 x 6) than in a context in which most items are presented only one time (Condition 30 x 1).

Experiment 1 was initiated to explore what effect, if any, frequency context would have on absolute recognition performance and on judgments of frequency. Frequency judgments were measured because, if the assumption that recognition decisions are mediated by frequency information is to be maintained, performance on the frequency judging test must correspond to that on a recognition test. Specifically, judged situational frequency should be at a higher level when the level of correct recognition performance is higher, and frequency should be judged lower when correct recognition performance is lower. This assumption is particularly important here, since context is being defined in terms of the frequency information presumed to be represented in memory after the presentation of the study list.

EXPERIMENT 1

Method

Design and lists. The factorial design consisted of the combination of the two context conditions (30 x 1 and 5 x 6), two types of test (absolute recognition and absolute judgments of frequency), three forms of the study list as between-subjects variables, and three frequencies (one, two, and three) with which the target words were presented for study as a within-subjects variable.

The study list consisted of 90 positions. The first 30 positions defined the frequency context conditions. Subjects in Condition 30 x 1 were presented 30 different words one time each, and subjects in Condition 5 x 6 were presented 5 words six times each. The remainder of the list was identical for both conditions. Positions 31 to 78 contained the words which would be tested. Within those positions, 8 words were presented once, 8 twice, and 8 three times. Twelve items served as a recency buffer and occupied Positions 79 to 90 in the list. Three forms of the list were constructed such that each of the 24 target words was presented once at each frequency level.

The test list consisted of the 24 target words and 24 new items. Target items appeared on the test in approximately the same order as on the study list. With that restriction, old and new items were presented in a random order. Subjects in both conditions received the same test list.

All items used were two-syllable, five-letter, common (A or AA in Thorndike & Lorge, 1944) words. Assignments of words to function and list position were made in a random fashion. All repetitions of items, including the repetitions of targets and the items defining context conditions, were distributed, with the lag separating presentations of the same item varying from 2 to 10 positions.

Procedure and subjects. The study list was presented on a memory drum at a 1-sec rate. All subjects were given general learning instructions which included a warning that the words would be presented rapidly and that the list would contain repetitions, but did not mention the type of test to follow. The recognition or frequency judging test followed immediately after the presentation of the study list. The test was paced at a 3-sec rate. The subject called out his response for the experimenter to record. Recognition responses were either "yes" or "no." Subjects making frequency judgments were told that each item in the test list could be classified into one of four categories and that they were to indicate the category in which each item belonged. The subject called out "zero" if the item had not appeared in the study list, "one" if it had occurred one time, "two" if it had occurred two times, and "three" if it had occurred three times. Subjects were required to give a response, and were told to make their "best guess" if unsure.

Ninety-six students from a Northwestern University introductory psychology class contributed data. Assignment to experimental condition was determined by a block-randomized

schedule and the order of the student's appearance at the laboratory. All subjects were tested individually.

Results

The performance of subjects making recognition decisions and that of subjects making frequency judgments will be considered in turn. The analyses will be followed by a comparison of performance on the two types of tests. The criterion for statistical significance in this and the following experiments was set at $p < .05$.

Recognition. It will be recalled that the test list contained eight target items at each of the three frequency levels (one, two, and three) and 24 new items. The mean percentage of "yes" responses for the items in the two context conditions is depicted in Figure 1. The points for frequencies of one, two, and three represent correct recognition responses, and those at frequency of zero represent erroneous responses to new items, or false alarms.

It is apparent from inspection of Figure 1 that frequency context did affect recognition performance. The correct recognition responses for the target items were treated with an analysis of variance. The interaction of context condition with the frequency with which items were presented at study was reliable [$F(2,92) = 5.89$, $MSe = 1.49$]. Descriptively, the interaction is characterized by better performance on target items presented once and worse performance on targets presented three times by subjects in Condition 5 x 6 than by subjects in Condition 30 x 1. Another way to describe this interaction is to consider the amount of improvement in recognition performance as the frequency of the target items increases from one to three presentations. Subjects in Condition 5 x 6 recognized an average of 61% of the once-presented targets and 79% of the thrice-presented targets, for an increase in correct performance of 18%. Subjects in Condition 30 x 1 recognized 53% of the once-presented items and 86% of the thrice-presented items, for an increase in performance of 33%. The main effect of frequency was, of course, reliable [$F(2,92) = 31.37$, $MSe = 1.49$]. The main effect of conditions was not, however ($F < 1$).

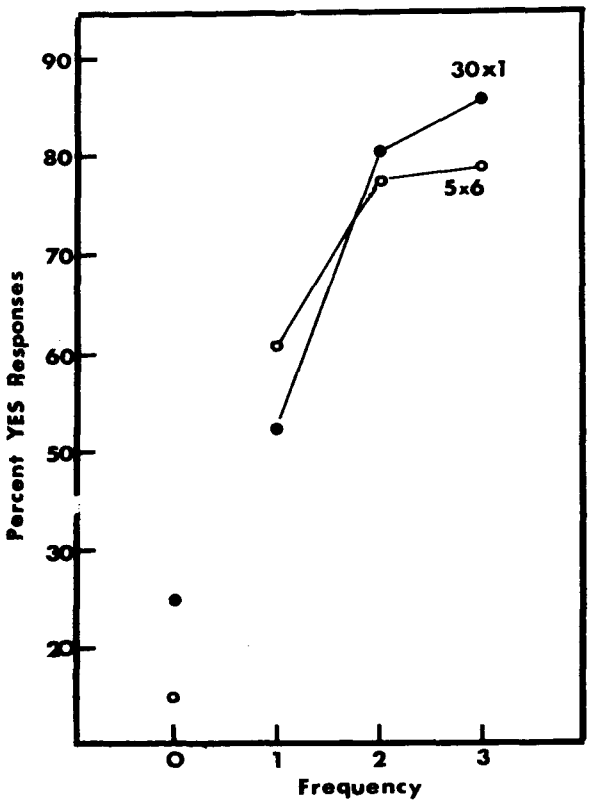

Figure 1. Recognition performance in Experiment 1.

As can be seen in Figure 1, subjects in Condition 5 x 6 made fewer false alarms than did the subjects in Condition 30 x 1, but the reverse was true for correct recognition of items presented once at study. Underwood (1974) has suggested that sensitivity and criterion differences may be determined by subjecting false alarms and misses on items presented once at study to an analysis of variance. A significant main effect of conditions would indicate differences in sensitivity. A significant interaction of conditions with error type would indicate differences in criterion. The proportion of possible false alarms and misses on items presented once at study were treated by analysis of variance. The main effect of conditions was reliable [$F(1,46) = 18.46$, $MSe = 171.96$], but the interaction of conditions with error type was not ($F < 1$).

Frequency judgments. Frequency theory would predict that the character of performance on the frequency judging test would correspond with that on a recognition test. Specifically, judgments of greater frequency should be observed where better recognition performance is observed, and the judgments of lesser frequency should be observed where recognition performance is poorer. The mean frequency judgments for the 24 new items and the target items which occurred one, two, and three times at study is shown in Figure 2.

The interaction of context condition with frequency observed in recognition performance seems to be reflected in the frequency judgments. The mean judgments on the target items were treated by an analysis of variance. The interaction of condition with frequency was found to be reliable [$F(2,92) = 3.87$, $MSe = 7.94$]. The character of this interaction appears to be the same as that of the interaction observed for recognition decisions. Target items presented once at study are judged to have greater frequency in Condition 5 x 6 than in Condition 30 x 1, but the opposite is true for items presented three times at study. As was the case for the recognition decisions, the amount of the increase in the frequency judgments

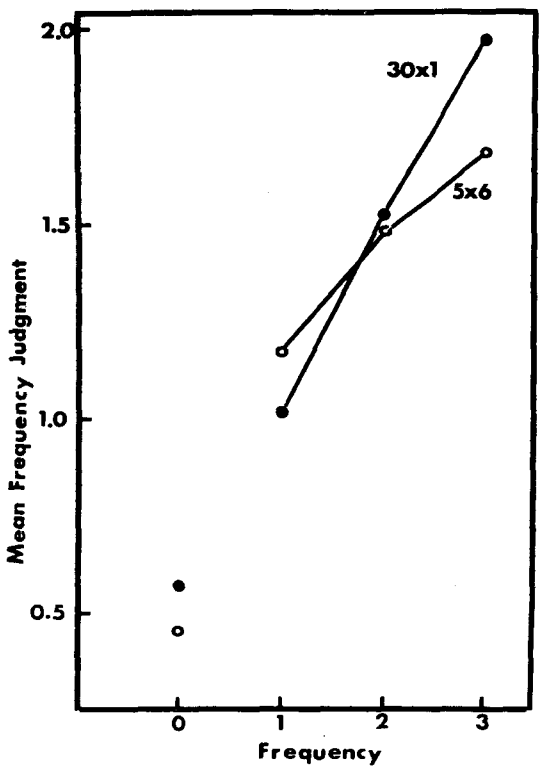

Figure 2. Mean frequency judgments in Experiment 1.

as presentation frequency increased was less in Condition 5 x 6 than in Condition 30 x 1. The main effect of frequency was reliable [$F(2,92) = 48.76$, $MSe = 7.94$], but the main effect of conditions was not ($F < 1$). The results of the frequency judging test seem to correspond closely with the recognition performance. The apparent correspondence will be further examined next.

Recognition and frequency judgments compared. Recognition performance may be directly compared to performance on a frequency judging test by scoring the frequency judgments as if they were recognition responses. A frequency judgment of greater than zero would be equivalent to a "yes" recognition response, and a frequency judgment of zero would be equivalent to a "no" response. The frequency judgments for each subject were rescored in this manner. The mean percentage of correct recognitions for the rescored frequency judgments was 74%, 89%, and 96%, for items presented one, two, and three times, respectively, in Condition 30 x 1. The mean percentage correct was 76%, 87%, and 90%, for target items presented at study one, two, and three times, respectively, in Condition 5 x 6. The mean false alarm rate was 37% in Condition 5 x 6 and 43% in Condition 30 x 1. As was observed for both recognition decisions and judgments of frequency, the values reflect a higher level of performance on items presented once at study by subjects in Condition 5 x 6 than by those in Condition 30 x 1, with the reverse being true on items presented three times at study.

The rescored frequency judgments and the true recognition responses for the target items were then treated by the same analysis of variance. The difference between the types of measures (recognition and frequency judgments rescored as recognition) was reliable [$F(1,92) = 23.55$, $MSe = 2.59$]. The higher level of correct recognition performance for the rescored frequency judgments than for the true recognition decisions is most probably the result of a more lenient criterion set by subjects making frequency judgments. This is suggested by the false alarm rates for the two types of measures. The average false alarm rate was 20% for the recognition decisions, but was 40% for the rescored frequency judgments. The interaction of context condition with frequency was reliable [$F(2,92) = 6.06$, $MSe = 1.25$], but the interaction of type of judgment, condition, and frequency was not reliable [$F(2,184) = 1.65$, $MSe = 1.25$]. The latter null result is predicted by frequency theory.

Discussion

Experiment 1 was initiated to explore the role of frequency context in recognition memory. The major result is the interaction observed between the two context conditions and the frequency with which the target items were presented at study. Recognition performance was higher on target items presented once at study in Condition 5 x 6 than in Condition 30 x 1, but the reverse was true for target items presented three times at study. For convenience, this interaction will be referred to as the frequency context effect.

The major assumption underlying the present research is that recognition decisions are mediated by frequency information. If this is the case, then correspondence between recognition decisions and frequency judgments must be predicted. It is inelegant that the prediction is for a null result; in any case, that is what was observed. Target items presented once at study were judged to have greater frequency in Condition 5 x 6 than in Condition 30 x 1, but the reverse was true for target items presented three times. Assuming that items judged to have greater apparent frequency are more likely to be recognized, the result corresponds with the recognition performance observed. When the frequency judgments were rescored as for recognition decisions, the frequency context effect did not differ for true recognition decisions and the rescored frequency judgments. The conclusion from the present results is that the assumption that recognition decisions are mediated by frequency information has not been rejected. Attention will subsequently be directed solely to recognition performance.

An explanation of the frequency context effect will not be attempted at this point because too little is

known about the relevant parameters of the design of Experiment 1. The experiments to be reported are intended to diminish this ignorance. They may be considered both as empirical attempts to isolate the relevant variables involved, and, at a more theoretical level, attempts to determine whether encoding or decision processes are critically involved in the frequency context effect.

EXPERIMENT 2

Although the most critical difference between Conditions 5 x 6 and 30 x 1 in Experiment 1 seemed to be the frequency context arising from the study of the list, the conditions also differed in the number of unique items presented for study. Subjects in Condition 5 x 6 were presented 41 different words, and subjects in Condition 30 x 1 were presented 66 different words, in the study lists. The issue may be raised as to what an appropriate comparison condition to Condition 5 x 6 should be. Experiment 2 was conducted to examine the effect of the number of different items presented for study.

Condition 30 x 1 was included in Experiment 2 and was compared to Condition 5 x 1, in which five words were presented at study once each prior to the presentation of the targets. The five items preceding the targets at study in Condition 5 x 1 were the same items that preceded the targets in Condition 5 x 6 in Experiment 1. The only difference between Condition 5 x 1 and Condition 5 x 6 was the frequency of presentation of the five items preceding the target items at study. Shulman (1974) has shown that recognition performance is affected by the number of items studied, but it is not apparent how this would produce the frequency context effect. If the frequency context effect was due to the number of different items studied, and not due to the frequency with which the items were presented, then the effect should be observed in Experiment 2.

Method

Design and procedure. The factorial design consisted of the combination of the two conditions (5 x 1 and 30 x 1) and three forms of the study list as between-subjects variables, and three frequencies (one, two, and three) with which the target items were presented for study as a within-subjects variable.

Condition 30 x 1 was the same as that condition in Experiment 1. Condition 5 x 1 differed from Condition 5 x 6 in Experiment 1 only in that the five words preceding the presentation of the targets during study were presented one time each instead of six times each. All other design and procedural details, as well as materials, were the same as in Experiment 1. The test was for absolute recognition.

Subjects. Forty-eight subjects, from the same source as in Experiment 1, contributed data. Assignment to experimental condition was by a block-randomized schedule and the order of the student's appearance at the laboratory.

Results and Discussion

The test in Experiment 2, which was the same as in Experiment 1, contained 24 new items and 8 items which had been presented one, two, and three times, respectively, at study. The mean percentage of correct recognition responses for target items presented one, two, and three times at study was 54%, 76%, and 82%, respectively, in Condition 30 x 1, and was 63%, 72%, and 87%, respectively, in Condition 5 x 1. The average percentage of false alarms was 25% in Condition 30 x 1 and 23% in Condition 5 x 1.

Correct recognition responses to target items were examined by an analysis of variance. The main effect of the frequency of the targets' presentation was reliable [$F(2,92) = 50.76$, $MSe = 1.08$], but neither the interaction between condition and frequency [$F(2,92) = 2.87$, $MSe = 1.08$] nor the main effect of conditions ($F < 1$) was reliable. The results suggest that the number of different items studied had very little effect on performance. This does not mean that the variable is not of any import, but does mean that it is not relevant within the parameters of the present research.

EXPERIMENT 3

Experiment 3 is an attempt to determine whether the frequency context effect observed in Experiment 1 involves differences between context conditions at the encoding or the decision stage. It will be recalled that the items defining the frequency context conditions in Experiment 1 preceded the presentation of the target items during study. It may be that the presentation of these items prior to the targets at study influenced the encoding of the target items. In the present experiment, the presentation of items defining frequency context conditions followed the targets during study. If the locus of the frequency context effect is at the encoding stage, then the effect should not be observed. This is because the target items would have been encoded before the items defining context conditions are encountered by the subject. The representation of frequency information associated to the target items in memory should not differ among the context conditions.

If, however, the locus of the frequency context effect is at the decision stage, then the placement of the context-condition defining items after the targets at study may enhance the frequency context effect. This would follow from the fact that when the context-defining items follow the targets at study the retention interval for the items would be less than in Experiment 1, where the items preceded the targets during study. The memory for the context-defining portion of the study list may be better in Experiment 3 than in Experiment 1, and so affect the decision process to a greater extent.

Method

Design and procedure. The three different frequency context conditions of Experiments 1 and 2 were represented in Experiment 3; the only difference was that the order of presentation of the sections of the study lists were reversed. For each condition, the study list began with the 12 items previously used as recency buffers. The same target section as previously used was then presented. For Condition T5 x 6, the list

ended with the presentation of 5 words six times each; for Condition T30 x 1, the list ended with 30 words being presented one time each; for Condition T5 x 1 the list ended with 5 words being presented one time each. To make the retention interval equivalent for all conditions, a 25-sec unfilled delay separated the end of the study list in Condition T5 x 1 and the test.

All other procedural and design details were the same as in the previous experiments. Three forms of the study list were presented such that each target item was presented once at each frequency level. The test was the same as before and was for absolute recognition decisions.

Subjects. Fifty-four students from the same source as in Experiments 1 and 2 contributed data. Assignment to condition was by a block-randomized schedule and the order of the student's appearance at the laboratory.

Results and Discussion

The mean percentage of correct recognition responses for the eight target items presented one, two, and three times, respectively, and the mean percentage of false alarms on the 24 new items on the test are given in Table 1. It seems clear from inspection of Table 1 that the frequency context effect, the interaction of condition with frequency, was not observed. This was confirmed by the statistical analysis. The correct recognition responses to target items were examined by an analysis of variance. The interaction of condition with frequency was not found to be reliable ($F < 1$). The main effect of conditions was not reliable [$F(2,51) = 2.00$, $MSe = 3.47$], but the main effect of frequency was reliable [$F(2,102) = 66.73$, $MSe = 1.67$].

The results of the experiment seem quite unambiguous. The frequency context effect observed in Experiment 1 was not observed in Experiment 3. The only difference between the experiments, other than the inclusion of Condition 5 x 1 in Experiment 3, was the position of the items defining the frequency context conditions, relative to the targets, during study. It seems likely that, if decision processes are involved, the frequency context effect should be observed, regardless of the order of presentation of the sections of the list. In fact, it seemed likely that the frequency context effect might be enhanced when the items defining frequency context conditions were closer in time to the test. This prediction was obviously not supported.

The lack of support for the decision hypothesis suggests that the frequency context effect is the result of differences between context conditions at the encoding stage. The conclusion cannot be stated with certainty, however, because it depends upon the acceptance of a null result. Experiment 4 was a further attempt to determine whether encoding or decision processes are critically involved in the frequency context effect.

Table 1
Percentage of "Yes" Responses to the Target Items and the False Alarm Rate in Experiment 3

Condition		Frequency 0	1	2	3
T5 x 6	Mean %	18	42	67	81
	SD	10	22	28	14
T30 x 1	Mean %	24	54	75	84
	SD	12	20	23	12
T5 x 1	Mean %	21	55	77	87
	SD	09	22	16	17

EXPERIMENT 4

In the previous experiments, recognition decisions were absolute in nature. Items were shown one at a time during the test and subjects were required to give a response to each item. Within the framework of frequency theory, the decision would require the comparison of the frequency information associated to the test item with some general level of phenomenal frequency information arising from the experimental situation. The subject must set a criterion to enable a determination of which level of frequency information is acceptable to result in a positive recognition response.

The decision process would be different, however, when comparative recognition decisions are required. In that case, subjects may be shown a pair of items on the test and be asked to decide which one was presented in the study list. A criterion would not enter into the decision. The rule would simply be to judge which item in the test pair had the greater frequency, and the item would be judged to have been presented in the study list. For absolute judgments, the subject must determine some level of frequency information that must be exceeded to result in a positive recognition response. The level, or criterion, would not enter into the comparison of the information available from the items in the test pair.

In Experiment 4, subjects were asked to make comparative recognition decisions after the presentation of the study lists of Conditions 5 x 6 and 30 x 1 used in Experiment 1. If decision processes are critically involved, then the frequency context effect will not be observed when the recognition decisions are comparative. The encoding hypothesis, however, contends that the information represented in memory differs in the two context conditions. If this is so, then the frequency context effect should be observed when decisions are comparative. Experiment 4 was conducted to examine these predictions. It was also deemed wise to attempt to replicate the frequency context effect when decisions were absolute in nature, so the two conditions of Experiment 1 were included with the test for absolute recognition.

Method

Design. Subjects were presented the three forms of the study lists of Condition 5 x 6 or Condition 30 x 1 used in Experiment 1 and were then given either an absolute recognition test or a comparative recognition test.

The absolute recognition test was the same as was used in Experiment 1. The comparative test was formed by randomly pairing the 24 target items with the 24 new items from the

absolute test. As was the case for the absolute test, the order of appearance of a target item on the test was approximately the same as in the study list. Pairs were presented such that the target item was the left or right member of the pair in a random fashion.

Procedure and subjects. The procedure was identical to that of Experiment 1 in all respects, except for the instructions to subjects making comparative recognition responses. After the study list had been presented, these subjects were told that they would see a pair of items, one of which had been presented for study and one of which had not, and that they would have 3 sec to call out the word that was in the study list. They were instructed to make their "best guess" if unsure of a response. None of the subjects had difficulty making a response in the time available.

Fifty-four students contributed data. They were assigned to experimental conditions by a block-randomized schedule and the order of their appearance at the laboratory.

Results and Discussion

Absolute test. The mean percentage of correct recognition decisions on the eight target items presented at study one, two, and three times, respectively, is depicted in the left panel of Figure 3. The mean percentage of false alarms on the 24 new items is not shown, but was 21% for Condition 5 x 6 and was 24% for Condition 30 x 1.

From inspection of Figure 3, it appears that the frequency context effect observed in Experiment 1 was replicated; the statistical analysis confirmed this. The interaction between frequency context conditions and the frequency of the target's presentation at study was reliable [$F(2,68) = 4.15$, $MSe = 1.21$]. The interaction may be described as before. Recognition performance was better on once-presented items in Condition 5 x 6 than in Condition 30 x 1, but the reverse was true for items presented three times at study. The main effect of conditions was not reliable ($F < 1$). The main effect of frequency was again reliable [$F(2,68) = 14.04$, $MSe = 1.21$].

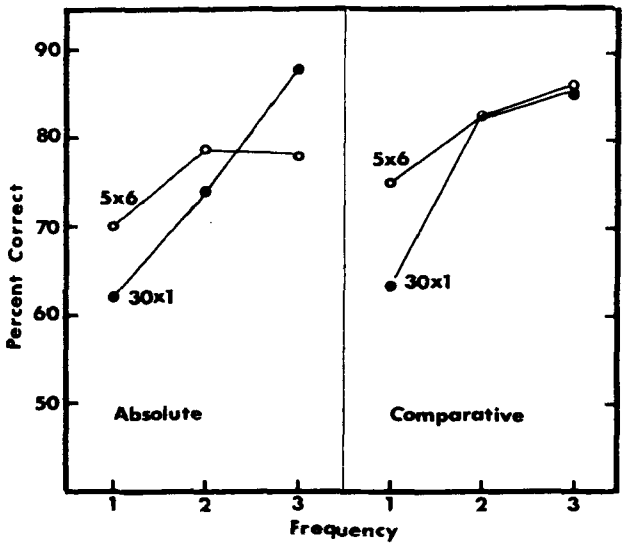

Figure 3. Performance on the absolute recognition test (left panel) and on the comparative recognition test (right panel) in Experiment 4.

Comparative test. The percentage of correct recognition decisions on the target items for subjects given the comparative recognition test is depicted in the right panel of Figure 3. As can be seen, recognition performance was higher on once-presented items in Condition 5 x 6 than in Condition 30 x 1, but the performance in the two conditions does not seem to differ otherwise. The interaction of context conditions with frequency was reliable [$F(2,68) = 3.25$, $MSe = .77$]. The main effect of condition was not reliable [$F(1,34) = 1.48$, $MSe = 2.01$], but the main effect of frequency was reliable [$F(2,68) = 23.29$, $MSe = .77$].

It will be recalled that eight items were presented and tested at each frequency level, so correct recognition performance of 88% represents the recognition of seven out of eight items. It may be that the measurement of performance in Condition 30 x 1 on items presented three times was constrained by an upper boundary. The mean percentage of correct recognition decisions on items presented three times was 86% for Condition 30 x 1 and 87% for Condition 5 x 6. This represents correct recognition decisions on an average of 6.9 items of the possible 8. Although performance could have improved, it may be suggested that it did not because of a ceiling effect. If this notion is accepted, then it may be argued that the frequency context effect was observed for the comparative recognition decisions. In any case, it is clear the performance in the frequency context conditions did differ. This observation renders the decision hypothesis extremely doubtful.

GENERAL DISCUSSION

The results of the present studies lead to the conclusion that the frequency information represented in memory differed as a function of the presentation of the items defining the frequency context conditions. This is also to say that decision processes are not of critical importance in the observation of the frequency context effect. The bulk of the evidence to support these statements is provided by the results of Experiments 3 and 4.

In Experiment 3, the items defining frequency context conditions followed the targets at study, and no differences between conditions were observed. If decision processes were involved in the frequency context effect, then it seems that the placement of items defining context conditions closer in time to the test would, if anything, enhance the effect observed in Experiment 1. It also seems reasonable to assume that, if encoding processes differed in the two conditions because of the presentation of items defining conditions, then the items must precede or, perhaps, be mixed in with the target items at study. The frequency context effect was observed only when the items defining

conditions preceded the targets at study, and not when they followed the targets at study.

The items defining context conditions preceded the targets at study in Experiment 4 and comparative recognition decisions were required. If one assumes that criterion differences are irrelevant in a forced-choice test, then the frequency context effect should not be observed if decision processes are critically involved. It was concluded that the effect was observed for forced-choice recognition decisions, and the result is contrary to the notion that decision processes are critical. It should also be recalled that differences in sensitivity were observed in Experiment 1, but differences in criterion were not. The weight of the evidence suggests that the presentation of items defining context conditions before the targets at study affected the encoding of the target items, and that the frequency information represented in memory differed for the target items in the two context conditions.

An explanation of the frequency context effect must consider two features of the effect. First, why is performance better on once-presented items in the high-frequency context conditions than in the low-frequency context condition? Second, why does performance improve relatively less as a function of the target's frequency of presentation at study in the high-frequency context condition than in the low-frequency context condition? A speculative explanation will be suggested next.

In the high frequency context condition, subjects were presented five items six times each prior to the presentation of the target items. It is known that the study time devoted to each presentation of an item decreases as the degree of repetition increases for an item (Shaughnessy, Zimmerman, & Underwood, 1972; Zimmerman, 1975). If it is assumed that a decrease in the study time devoted to an item reflects a decrease in processing time, then it may be suggested that the tendency to encode repetitions superficially may have generalized throughout the list in the high-frequency context condition. If this were so, then target items presented more than once may have been encoded more superficially in the high-frequency context condition than in the low-frequency context condition.

The same reasoning may also be applied to the higher recognition performance and the higher frequency judgments on the once-presented items in Condition 5 x 6 than for those items in Condition 30 x 1. If the high-frequency context biased the subject to devote less elaborative encoding operations to repetitions of target items, it may also have served to bias the encoding operations devoted to once-presented items. The first appearance of an item may have received more elaborative encoding in the high-frequency context condition than in the low-frequency context condition.

These notions may best be considered as a form of adaptation level theory (e.g., Helson, 1964). According to adaptation level theory, the perception of an event is determined by its relationship to aspects of the context in which it is experienced. In the present case, one may consider the level of the redundancy of the information encountered upon the presentation of an item at study to be the critical aspect of the context in which items are perceived. The information available from the first presentation of an item in a context in which most presentations offer redundant information, that is, a repeated presentation of an item, may deviate from the level of redundancy to a greater extent than when the level of redundancy is lower, that is, when most items are not repeated. The difference in the level of redundancy of the information available from the presentation of an item and the level of redundant information encountered in the situation from other items may influence the degree of encoding devoted to the item. Nonredundant information may be encoded more elaboratively when the level of the redundancy of information in the situation is high than when it is low. Conversely, redundant information may be encoded more elaboratively when the level of redundancy of information is low than when it is high.

Other explanations are, of course, possible for the frequency context effect. It is clear that the results obtained here do not demand the explanation offered above, and so it must be considered only as a preliminary hypothesis.

REFERENCES

HELSON, H. *Adaptation-level theory: An experimental and systematic approach to behavior.* New York: Harper & Row, 1964.

SHAUGHNESSY, J., ZIMMERMAN, J., & UNDERWOOD, B. J. Further evidence on the MP-DP effect in free-recall learning. *Journal of Verbal Learning and Verbal Behavior*, 1972, **11**, 1-12.

SHAUGHNESSY, J., ZIMMERMAN, J., & UNDERWOOD, B. J. The spacing effect in the learning of word pairs and the components of word pairs. *Memory & Cognition*, 1974, **2**, 742-748.

SHULMAN, A. I. The declining course of recognition memory. *Memory & Cognition*, 1974, **2**, 14-18.

THORNDIKE, E. L., & LORGE, I. *The teacher's word book of 30,000 words.* New York: Columbia University Press, 1944.

UNDERWOOD, B. J. Recognition memory. In H. H. Kendler & J. T. Spence (Eds.), *Essays in neo behaviorism.* New York: Appleton-Century-Crofts, 1971.

UNDERWOOD, B. J. The role of the association in recognition memory. *Journal of Experimental Psychology*, 1974, **102**, 917-939.

ZIMMERMAN, J. Free recall after self-paced study: A test of the attention explanation of the spacing effect. *American Journal of Psychology*, 1975, **88**, 277-291.

(Received for publication April 12, 1976;
revision received July 13, 1976.)