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# ASSOCIATIVE LOSS IN UNLEARNING: AN ALTERNATIVE EXPLANATION



Benton J. Underwood and Charles S. Reichardt

Northwestern University

August 1974

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# Associative Loss in Unlearning: An Alternative Explanation

Benton J. Underwood and Charles S. Reichardt

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The memory system may be viewed as a biological system. When viewed in this manner, the system is seen to consist of both anabolic and catabolic processes. The anabolic or building processes are commonly referred to in behavioral language by use of the generic term, learning. Information concerning events in the environment are continually coded and stored (learned), and this information may serve as a basis for at least short-term adaptive behavior. Although there is no evidence that the memory system has storage limits, it appears that catabolic or destructive processes are continually eliminating information from the system. In behavioral language, this is called forgetting. It is not uncommon for theorists to assume that there is no loss from storage of coded information. The so-called forgetting, they may assert, represents a loss in the capabilities of the system to find the coded information; or a loss in the capabil[illegible] to retrieve information. Nevertheless, even this radical position accepts a functional loss of some kind within the system.

The experimental study of forgetting is concerned with the factors responsible for it. In any area of experimental inquiry, great value is attached to procedures which will magnify in amount over a given time period the critical phenomena under investigation. The use of the fruit fly in the study of genetics has prospered because many generations can be compressed into a relatively short time span. In the study of forgetting, the phenomena known as retroactive inhibition and proactive inhibition are of just such nature in that there is a marked acceleration of the catabolic or destructive processes of memory. The paradigms producing these two phenomena may be viewed as representing the paradigms of all forgetting, no matter how slowly that forgetting occurs. It is assumed that if the processes underlying proactive and retroactive inhibition are understood, we will, ipso facto, have a behavioral understanding of all catabolic processes involved in the functioning of the memo system.

The present report is concerned with retroactive inhibition. In particular, it is concerned with the basis for the loss defining retroactive inhibition. Two critical facts are germane. First, it has been shown that very heavy losses of acquired verbal material can be produced in a few minutes by requiring the subject to learn conflicting associations. The paradigm is commonly called A-B, A-D, in which the learning of the conflicting association A-D, following the learning of A-B, results in a heavy loss of A-B. This loss, when measured immediately after A-D learning, by a special procedure called modified-modified free recall (MMFR), is called unlearning, and when so measured probably represents the entire loss called retroactive inhibition, i.e., the measured unlearning in this case is equal to retroactive inhibition.

The second critical point is that the evidence seems to indicate beyond reasonable doubt that in this A-B, A-D paradigm the loss will be observed only when the subject is required to recall or retrieve the response terms (B) of the first task. The loss is minimal in amount, and sometimes not present, when the subject is required only to match the stimulus terms (A) with the response terms (B) when both are provided him. This has led to the interpretation that associative information (the association between A and B) has not been lost as a consequence of having learned the interfering associations. More generally, it is said that processes tested by recognition (as exemplified by the matching task) are not impaired by the interference paradigm; only the capacity to recall is impaired.

In a previous technical report (Underwood, Zimmerman, & Brown, 1973), experiments were reported which in general confirmed the above generalizations, although in one study no retroactive inhibition was observed (for reasons which are still not understood). Nevertheless, the conclusion that unlearning does not involve an associative loss is a difficult one to fit into a theory concerning the consequences of interference, and at the same time retain some degree of theoretical consistency. There are two reasons which are particularly pertinent in this context. First, in another interference paradigm, results have been produced which lead to the conclusion that unlearning is represented by a loss in the integrity of the associations. This paradigm is commonly called A-Br. The two successive lists have the same stimulus terms and the same response terms; they are simply paired differently in the two lists. This paradigm produces an associative loss when the matching (recognition) task is used to assess the loss in exactly the same manner as in the A-D paradigm as described above (Postman & Stark, 1969). No satisfactory theoretical account has been offered of why associative loss should occur in one paradigm and not in the other. Even if it is accepted that a small associative loss may occur in the A-D paradigm (as has been reported in some investigations), the quantitative difference in the amount of loss between A-Br and A-D is a matter of theoretical concern.

The second reason for being concerned about the presumed lack of associative loss in the A-D paradigm is that the acceptance of the statement at its face value runs into a contradiction. It was pointed out earlier that for the A-D paradigm, unlearning is found in the inability of the subject to recall the B terms when the A terms are afforded him. Based upon the grounds that recall or retrieval must necessarily involve associations, why should not the associative loss also be present when the recognition test is used -- when the subject is asked to pair the A and B terms appropriately. One resolution that has been offered is to assume that a very "weak" association is sufficient to mediate correct recognition whereas a strong association is needed to produce recall. This position assumes an associative loss in the A-D paradigm but uses strength as an auxiliary explanatory notion. This seems like a very reasonable solution to the problem. But, recent work has called into question the idea that the association is fundamentally involved in recognition decisions. We will now turn to this work, following which a statement of the problem for the present research will be developed.

The evidence of importance is the fact that differences in the strength of associations between words in a pair has little if any consequence on recognition of pairs of words (Underwood, 1974). Strength in this case refers to normative associative strength as measured by word-association procedures, with experimental frequency held constant. If a highly associated pair, e.g., <u>spool-thread</u>, is presented for study once, the errors in recognition will be as great in number as when there was no initial association between the words, e.g., <u>spool-icy</u>. This suggests the possibility that the failure to find associative unlearning by recognition procedures results from the fact that associative informat ' is not critical for recognition decisions. If this is the case, the recognition procedures which have been used to reach conclusions about associative unlearning are simply inappropriate procedures for reaching this conclusion. An alternative approach is needed. The one to be pursued here is to offer an alternative account of recognition tests, one that does not involve associations and associative strength, and then see if the consequences can be supported.

Without belaboring the matter, we may assert that a considerable amount of evidence indicates that frequency information is fundamentally involved in recognition decisions, both for the recognition of individual words and for the recognition of pairs of words (Underwood, 1974). Let us examine this theory to see how it might account for the appropriate pairings of A-B when a matching test is given following the learning of A-D. The two words in each pair in the list will have, as a consequence of the original learning trials, presentation in memory in terms of joint frequency. To say this another way, it may be assumed that the two words as a unit have frequency representation in memory. On the recognition test the subject arranges the words in pairs according to joint or pair-unit frequency. If it is assumed that A-D learning leaves such information intact, the matching would be expected to be carried out without errors.

It might seem that this approach merely substitutes joint or unit frequency information for an association. However, other results given in a technical report (Galbraith & Underwood, 1973) showed that associative information and frequency information can have quite independent representation in memory, and that the subject can use these two types of information independently, depending upon the demands of the task. Given these facts, it seems reasonable to propose that the matching task on A-B following A-D learning involves the use of frequency information and not the use of associative information.

Direct tests of the above propositions have not seemed possible. The theory presumes that the procedure used to produce unlearning in the A-D paradigm leaves the frequency information of the A-B pairs intact. But it also assumes that frequency information is used by the subject in making his recognition decisions. Suppose that the subjects in a control group (learning A-B only) were asked to make frequency judgments of A-B pairs following the learning of the list, and the subjects in a group having A-D in addition to A-B were asked to make the same decisions. If the judgments were equally precise, it would indeed suggest that the A-B frequency information following the learning A-D was intact. It was judged to be far better, however, to use a situation in which recognition performance was expected to differ. If, in such a case, it could also be shown that there were corresponding changes in frequency information, the theory would receive indirect support. It would not, unfortunately, "prove" that the subjects used frequency information in making the recognition decisions.

It was pointed out earlier that a true so-called associative loss is demonstrated by the matching test for A-B in the A-Br paradigm. Viewed in terms of frequency theory, this means that for this paradigm there is a loss or distortion of the frequency information for A-B. Therefore, it must be predicted by frequency theory that the frequency information for the A-B pairs will be less precise when the A-Br paradigm is used than when the A-D paradigm is used. The present experiment tests this expectation.

For all groups, the A-B pairs were presented for learning in a continuous task, with different pairs occurring with varying frequencies. The second list was presented by the usual discrete-trial method. Frequency judgments were then requested. It was also necessary to employ other groups to measure unlearning by recall and recognition to be sure that the typical findings for the A-D and the A-Br paradigms were present when the continuous-presentation method is used in A-B. Therefore, two groups were given MMFR and matching tests.

## Method

Lists. The lists consisted of 12 pairs, with the A terms being four-letter nouns, the response terms two-syllable adjectives. The continuous paired-associate task used for the presentation of the A-B pairs consisted of 96 positions, i.e., 96 pair presentations. There were two pairs at each of six frequency levels; 3, 5, 7, 9, 11, and 13. This variable will be identified by these numbers, although it must be clear that the possibility of the subject correctly anticipating a response term occurred only after the first presentation. Therefore, the numbers of possible correct responses were 2, 4, 6, 8, 10, and 12. The positions of the successive occurrences of a pair were determined roughly by dividing the 96 positions into blocks the size of which was determined by the number of presentations. For example, a pair presented five times occurred once within each successive fifth of the 96 positions. However, this plan was restricted by first assigning each pair once to the last 12 positions (84-96) in the list. This method of distributing the occurrences of an item necessarily results in an inverse relationship between the length of lag between occurrences and number of occurrences.

Since the second lists were to be presented by the usual paired-associate procedure using discrete trials (one blank space between each trial), it was decided to use such breaks in the continuous task in order that context differences would not be present which might reduce unlearning. Therefore, a break was inserted in the A-B list after each 12 positions.

The pairings of the A and B terms was carried out randomly subject only to the restriction that the two words in a pair not have the same first letters. Three forms were constructed, and across the three forms the same pair was never used at the same frequency level. Therefore, a given frequency level was represented by six different pairs.

The A-D and A-Br lists were formed by randomly assigning words to the stimulus terms, again following the rule that the initial letters of the two words not be the same. Of course, for the A-Br list, it was also necessary to assign a different response term to a given stimulus from that used in A-B.

Procedure and subjects. Anticipation learning was used throughout, with a 2:2-sec. rate. For A-B learning the subjects were instructed that whenever they recognized a stimulus term as having been presented earlier, they should try to give the appropriate response. Following A-B learning, the instructions indicated the slightly changed nature of the presentation for the second list. The A-D and A-Br lists were presented until the subject correctly anticipated all response terms on a single trial, and then eight additional trials were given. The subject was informed that he was to be given trials beyond the point at which he could get all responses correct.

Two groups, one for each paradigm, were given an MMFR test immediately after second-list learning. The stimulus terms were listed in alphabetical order, with two blank spaces after each. The subject was instructed to insert the correct response from the first list in the first blank, the correct response from the second list in the second blank. The instructions urged guessing if the subject was in doubt. After the completion of the MMFR test, a matching test for the A-B pairs was given. The stimulus terms were listed on a new sheet, with a blank after each, and to the right were the 12 response terms. The subject was asked to fill in each blank with the appropriate response term.

For the other two groups (one for each paradigm), judgments of frequency were requested. For each A-B pair, another pair was formed by using the response term from the other pair in the list that had been given equivalent frequency during A-B learning. Thus, if gang-verbal and code-yonder had been presented three times in A-B learning, on the test these two pairs occurred along with gang-yonder and code-verbal. Thus, each word in both the correct and incorrect pairings had been presented an equal number of times in A-B, but in only two of the four pairs had the words occurred together and thereby could be expected to have a joint or unit frequency. The 24 pairs were randomized on the test form, with a blank after each. The subject was instructed to place a number in each blank to represent the number of times that the two words had occurred as a pair in the first list. The instructions further informed the subject that if the two words had not been presented together, a value of zero should be inserted in the blank. By these instructions a subject was required to fill in each blank, but he was not required to fill in only 12 blanks with a number above zero.

The four groups each consisted of 30 college students, 10 to each of the forms used for A-B learning. They were assigned to conditions and to forms by a block-randomized schedule.

## Results

A-B learning. The mean total number of correct anticipations for the four groups on A-B varied between 48.4 and 54.3 (out of 84 possible). An analysis, which included forms, and also treatment differences to occur after A-B learning, showed no reliable effect except for one interaction with forms. The interpretation of this is not clear since subjects and forms were confounded.

An examination was made of the number of correct responses given on each of the first two anticipation trials as a function of total trials the pairs were to receive (3, 5, 7, 9, 11, 13). The two pairs at each frequency level were combined, and since there were three forms, each frequency level was represented by six different pairs. Figure 1 shows the mean values. It is seen that there were systematic differences on the second anticipation trial as a function of the frequency levels. As pointed out earlier, lag between occurrences was inversely related to frequency. The relationship with lag was continuous from 3 through 11 presentations, but was obviously reversed for pairs presented 13 times. A part of the performance on the pairs with a frequency of 13 seems to have been due to the fact that one of the pairs presented 13 times was presented as the first pair in the list, resulting in a primacy effect. However, this will not account for the entire effect since performance on the other pair presented 13 times was higher than for pairs occurring 11 times.

Although a small lag effect might have been anticipated, a variation of from 60% to 22% (second anticipation trial) was quite unexpected. These lag effects were not the concern of this study, but their implications for it must be pointed out. In effect, the differences in levels of learning attained as a function of the different levels of frequency actually presented are blunted by the lag effect. Of course, across all trials of A-B, there is a clear correlation between number of anticipation trials and number of correct responses. On the last occurrences of the pairs, the percent correct anticipations were 60, 71, 79, 84, 83, and 90 for the 120 subjects for the pairs presented 3 through 13 times, respectively. The relatively poor performance on the second anticipation trial for frequency-level 11 seems to be reflected also on the last trial. In short, the evidence suggests that performance differences as a function of frequency inputs may have been attenuated by lag differences.

A-D and A-Br learning. The second list was presented until the subject achieved one perfect trial, and then eight additional trials were added. The mean total trials was 19.75 for the two groups given A-Br, and 16.24 for the two groups given A-D, $F$ (1,108) = 11.19, $p < .01$. The two groups within each paradigm did not differ reliably. The better performance under A-D than under A-Br is as normally found, although it is not known whether the two second lists were or were not equal in difficulty.

MMFR and matching. The MMFR and matching scores are shown in Figure 2, expressed in percentages. For the MMFR test, about 40% of the A-B items were lost, and this was essentially equivalent for both

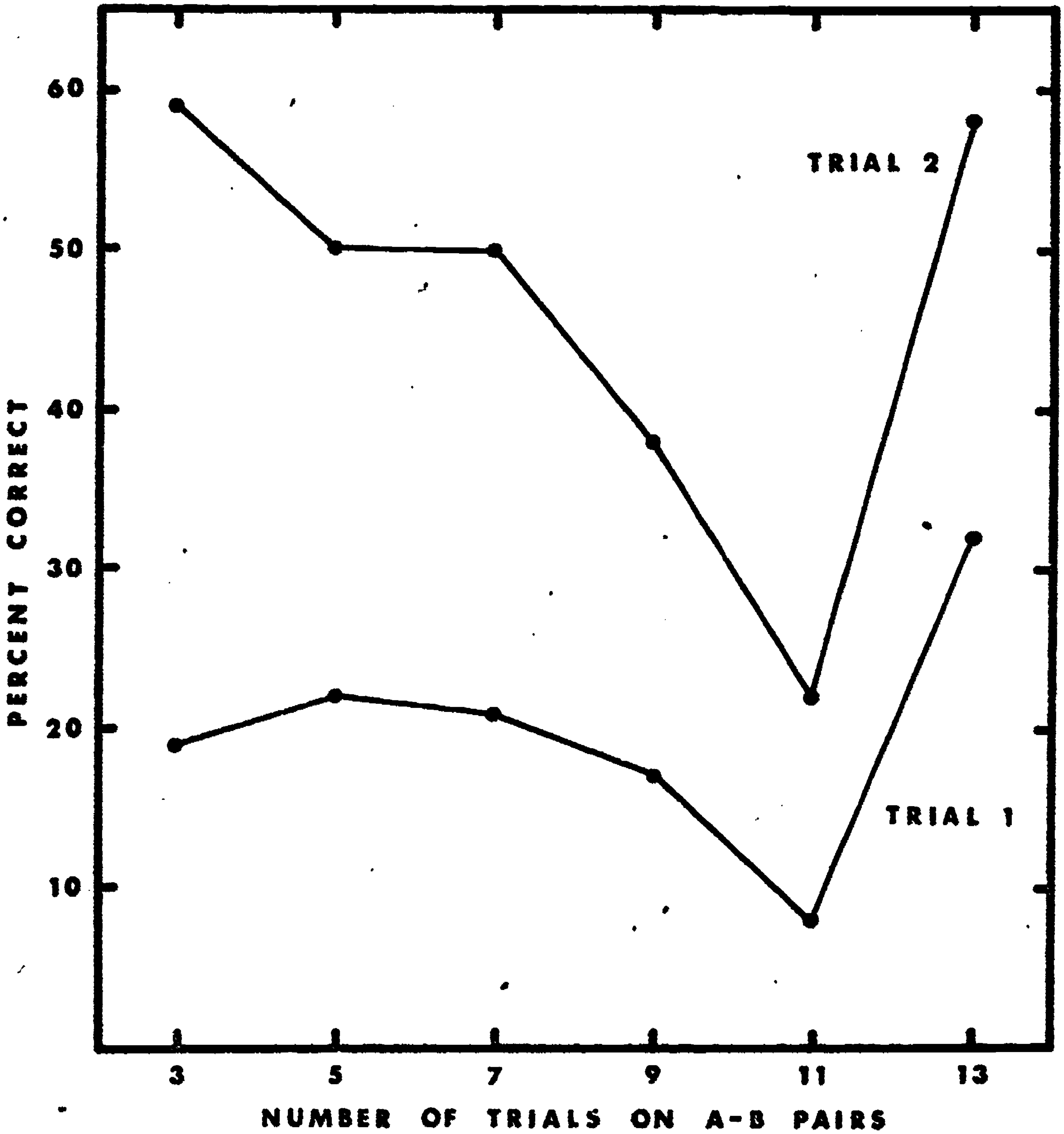


Fig. 1. First- and second-trial performance for A-B pairs which were given the frequencies shown along the baseline. The differences in performance are believed related to the lag between successive occurrences of the pairs, since lag and frequency were inversely related.

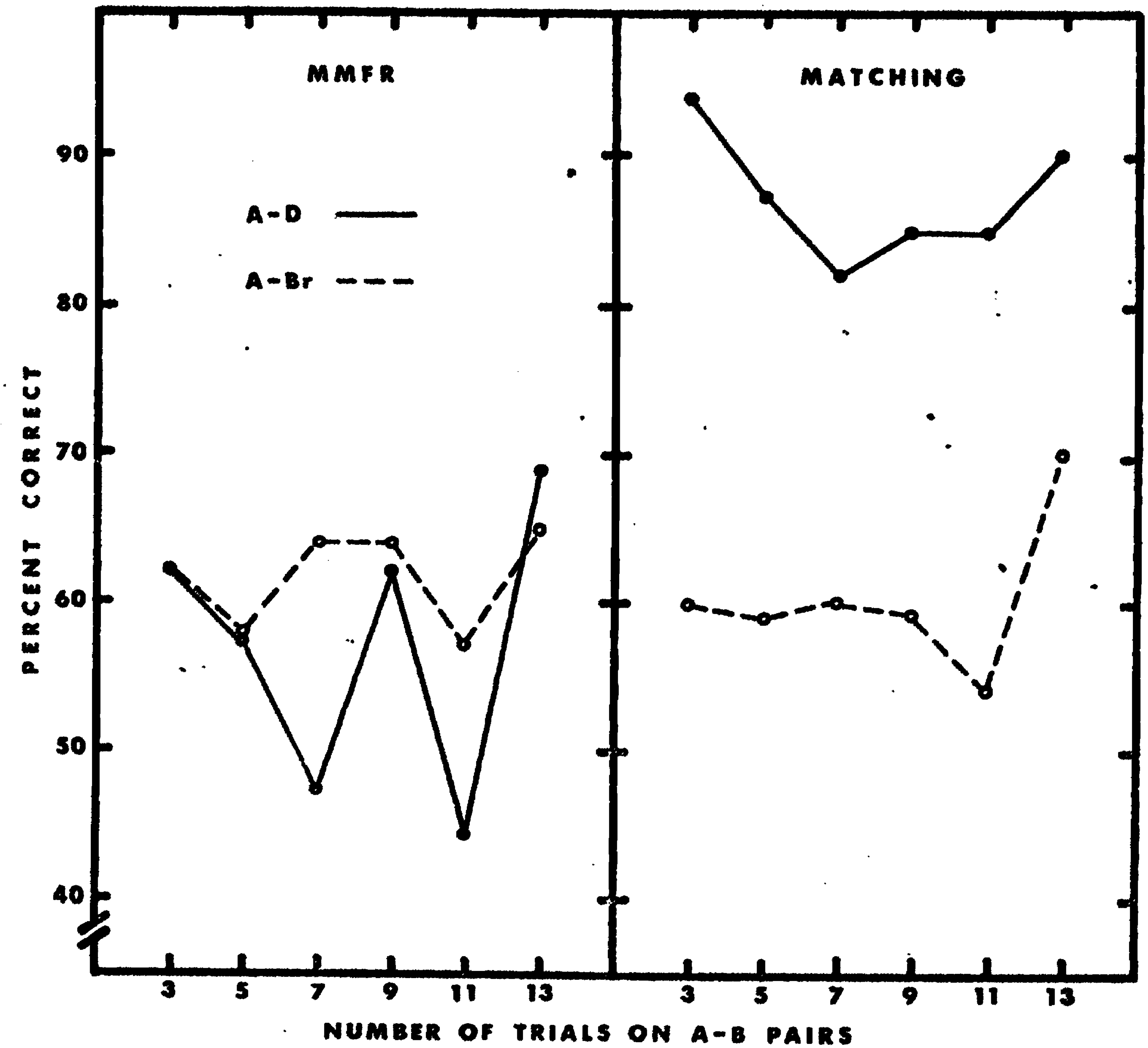


Fig. 2. Recall (MMFR) and matching performance under the two paradigms.

paradigms. It can be seen that there is considerable variation in the means, particularly for the A-D paradigm. An analysis showed that the number of A-B trials was the only reliable source of variance, $F$ (5,270) = 2.46, $p < .05$, but the lack of any systematic trend does not allow a meaningful interpretation. In a further analysis, the scores for 3, 5, and 7 A-B trials were combined, as were those for 9, 11, and 13 trials. No source of variance approached statistical reliability. It is frequently found that unlearning, as measured by MMFR is greater in the A-Br paradigm than in the A-D paradigm (Postman & Stark, 1969). This was obviously not the case here. Whether this was due to the nature of the inputs in A-B or to some other factor is not known.

On the matching test, performance for the subjects having the A-Br paradigm did not improve over the performance level shown on MMFR. The subjects given the A-D paradigm, on the other hand, showed a sharp increase in the number of correct responses from MMFR to matching. The only source of variance which was reliable for the matching test was paradigm, $F$ (1,54) = 19.59, $p < .01$. Without a control group (having only A-B) it cannot be determined whether the matching performance for the A-D paradigm involves a loss. There is likely a small loss which, according to the usual interpretation, means an associative loss. However this may be, the critical finding is the wide difference in the performance levels for the matching test for the two paradigms. It is this difference which, according to the theory developed in the introduction, reflects a difference in available frequency information.

Frequency judgments. Several measures of frequency information for A-B pairs will be considered. It will be remembered that in addition to the 12 intact A-B pairs for which the subject was requested to assign values representing frequency of presentation, 12 additional pairs were present consisting of mispairings. As pairs, these latter 12 items should have been assigned values of zero for correct responding. The mean frequency judgments at each frequency level (including the zero level) are shown in Fig. 3. It is first noted that discrimination of the zero pairs from all others is quite good, although positive values were assigned to some of the pairs. We will return to this matter shortly. Overall, for pairs with positive frequencies, the nature of the relationship between presented frequency and judged frequency conformed in general to previous findings, namely, that the lower frequencies were overestimated, and the higher frequencies were underestimated (Underwood, Zimmerman, & Freund, 1971). However, the magnitude of these effects is far larger than usually found in that there is a minimum amount of discrimination across successive frequencies. Nevertheless, statistically speaking, there is an upward slope to the lines. With the zero items omitted from the analysis, the effect of A-B frequency was reliable, $F$ (5,270) = 8.61, $p < .01$. Neither paradigm, nor the interaction between paradigm and frequency, yielded reliable differences.

The variability of judgments around a given frequency level would reflect differences in the precision of frequency information. For each judgment made by a subject on the 12 items with A-B frequency,

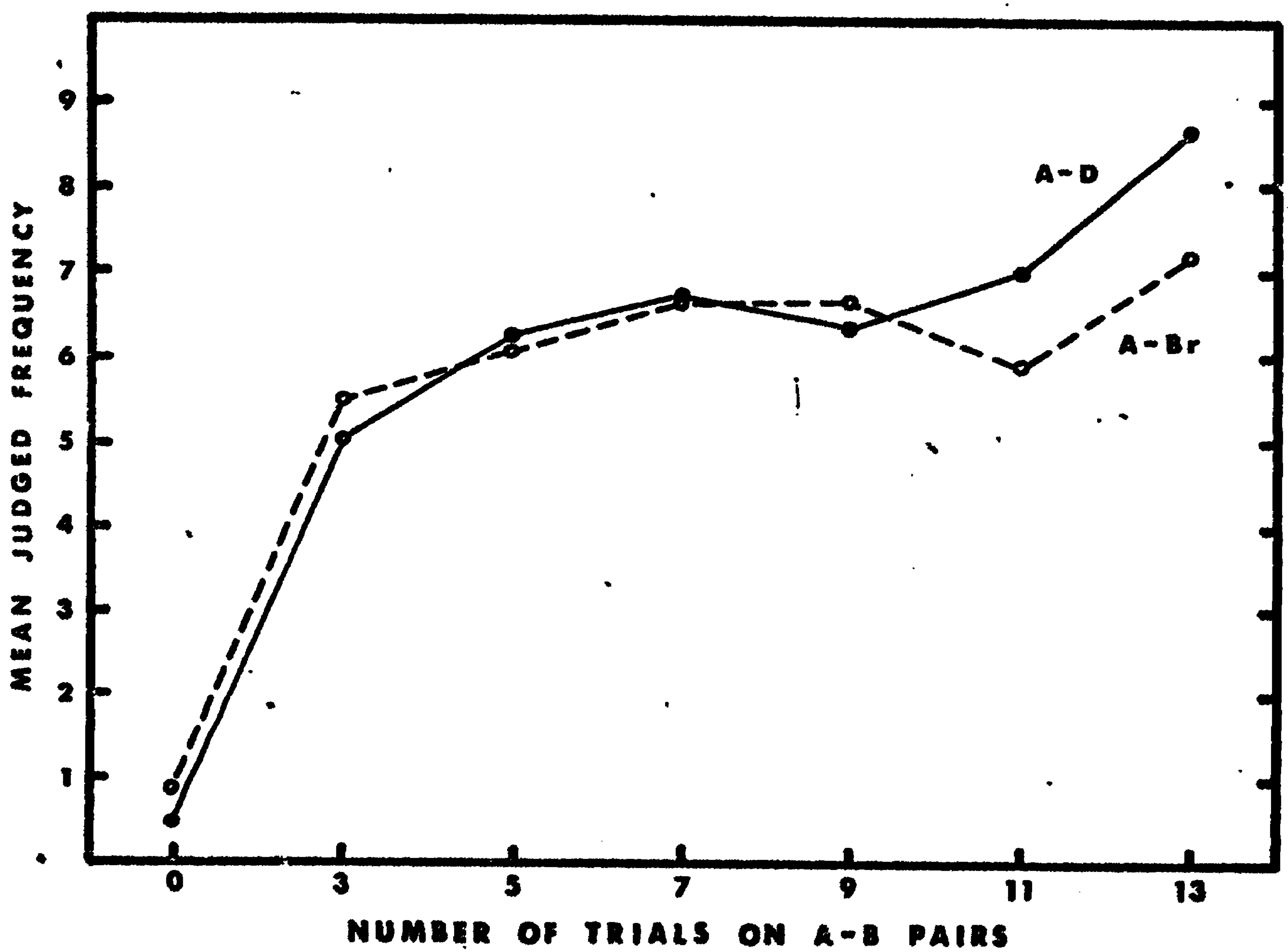


Fig. 3. Mean frequency judgments on A-B pairs as a function of input frequency.

a difference score was determined, this difference score representing the discrepancy between the true frequency and the judged frequency. The standard deviation of these 12 difference scores was used as a measure of variability. The mean standard deviation for the subjects in the A-Br paradigm was 4.48, and for the subjects in the A-D paradigm, 3.58, $F$ (1,54) = 7.86, $p < .01$. By this measure, therefore, learning A-Br produced a greater distrubance in frequency information than did learning A-D.

It will be remembered that the subject was free to assign positive values to as many pairs as he chose, although 12 such values would be proper. Actually, the mean number of assigned positive values was close to 12, being 12.07 (standard deviation = 1.52) for the A-D paradigm, and 11.50 (standard deviation = 2.38) for the A-Br paradigm, $F$ (1,58) = 1.21, $p > .05$.

We may ask about the number of hits when a hit means assigning the true frequency to a pair. It was quite apparent that some subjects assigned only all even numbers in recording their judgments. In order to eliminate this bias in calculating hits, a hit was defined as assigning the true frequency or assigning a frequency within one of the true frequency. The mean number of hits for the subjects in the A-Br group was 2.23, for those in the A-D group, 3.57, $F$ (1,58) = 10.67, $p < .01$. If the scores for each subject were expressed as a percentage of hits per number of positive values assigned, the difference between the two groups (29.4% versus 20.5%) was still reliable (F=6.53).

It might be anticipated that misses (assigning a zero to a pair that was presented in A-B learning) and false alarms (assigning a positive value to a zero pair) would be reciprocally related in that only one of the two pairs with a common stimulus would be assigned a positive value. In fact, this was not always true, so the two measures have some independence. The subjects in the A-Br group had more misses than those in the A-D group. The means were .90 and 2.33, $F\ (1,58) = 8.88$, $p < .01$. The means for the false alarms, on the other hand, did not differ reliably, being .97 for A-D, and 1.77 for A-Br ($F = 2.48$).

In summary: most of the measures of frequency information indicated that this information was more seriously disturbed for the subjects having learned A-Br than for those having learned A-D. It might be suggested that the measures on which differences were found must necessarily be highly correlated and therefore only a single measure should be reported. Somewhat unexpectedly, it was found that these measures were not highly correlated. For example, the standard-deviation measure and the hits measure were negatively correlated (as would be expected), but the values were only -.37 and -.31 for A-D and A-Br, respectively. The evidence leads to the conclusion that the frequency information for the A-D paradigm was less disturbed by the second-list learning than was true for the A-Br paradigm.

## Discussion

The experiment has shown unlearning for A-Br and A-D when measured by MMFR. When MMFR was followed by matching, performance under the

A-D paradigm increased markedly, while no change occurred in the performance on the A-Br paradigm. The logic of the experiment required this expected outcome. Given this outcome, the question was whether differences in frequency information would be found for the two paradigms. The evidence provided a positive answer. The implications of these findings are indirect with regard to countering previous conclusions that there is little associative unlearning in the A-D paradigm, and a considerable loss in the A-Br paradigm. The indirect nature of the reasoning will be reviewed.

First, it is assumed that pair recognition is primarily based on frequency information as opposed to associative information. Second, it is further assumed that a matching task is a recognition task, and that the correct matches can be made on the basis of frequency information without resort to associative information. It follows that the ability of the subjects to make correct matches of A-B in the A-D paradigm results from the fact that the frequency information is not seriously disturbed; the inability to make the matches in the A-Br paradigm is due to the disturbance of frequency information produced by the learning of the second list. This implies that the possibility remains that there is associative unlearning, perhaps of considerable magnitude; the matching test may simply be an inappropriate technique for determining associative loss.

The argument assumes that the critical frequency information involved is the joint or unit frequency of the pair. That such frequency could have representation in memory is indicated by the relatively small number of false alarms, particularly for the A-D paradigm. All words on the frequency-judging test had a heavy situational frequency, but only appropriately paired words had a high joint frequency. In effect, if a pair had a joint frequency greater than zero, the correct matches could be made, and it is of small consequence whether or not differences in joint frequency could be discriminated. This means that when the A-B list is presented for learning in the usual fashion (where all A-B pairs receive the same input frequency), the discrimination between correct pairings and incorrect pairings could readily be made on the basis of joint frequency information.

The evidence indicated a difference in the integrity of the joint frequency information for the A-B pairs in the two paradigms. Is it possible to translate this difference in a way that would account for the difference in matching performance for the two paradigms? We have not discovered a meaningful way to make such a translation. In retrospect, it seems that such a calculation might have been made had a forced-choice frequency test been used, the forced choices being between the 12 sets of two pairs each which had a common stimulus term. The difference in number of errors should reflect, in at least a proportionate manner, the differences in matching performance.

The indirectness of the arguments advanced in this report must again be emphasized. We have concluded only that the outcomes of the experiment are compatible with the idea that frequency information is used in the matching test, and that, therefore, matching tests do not necessarily implicate associative loss. An obvious contrary argument could be advanced, namely, that there is nothing in the present data which denies the possibility that the matching performances were mediated by associative information and not by frequency information. This is correct; to accept the position that frequency information is fundamental in the matching performance requires the acceptance of data from other areas which suggest that associative strength is not important in recognition decisions, but that frequency is.

References

Galbraith, R. C., & Underwood, B. J. On the independence of attributes of memory. Technical Report, November 1973, Personnel and Training Research Programs, Office of Naval Research.

Postman, L., & Stark, K. Role of response availability in transfer and interference. Journal of Experimental Psychology, 1969, 79, 168-177.

Underwood, B. J. The role of the association in recognition memory. Journal of Experimental Psychology Monograph, 1974, 102, No. 5.

Underwood, B. J., Zimmerman, J., & Freund, J. S. Retention of frequency information with observations on recognition and recall. Journal of Experimental Psychology, 1971, 87, 149-162.

Underwood, B. J., Zimmerman, J., & Brown, A. S. Associative interference and recognition memory. Technical Report, November 1973, Personnel and Training Research Programs, Office of Naval Research.

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