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Factors Involved in the Negative Transfer from Isolated Learning to Simultaneous Learning

Benton J. Underwood and Arnold M. Lund

Northwestern University

July 1980

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Personnel & Training Research Programs
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Six experiments were intended to characterize more completely a phenomenon described in an earlier technical report (Underwood & Malmi, 1977). This phenomenon was found when lists were first learned in isolation and then placed together for simultaneous learning. The subjects learned three lists, each list clearly distinguishable from the other. One of the lists was recalled, another was tested for frequency information, and the memory for the third was tested by recognition procedures. The findings of

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered) interest occurred in moving from isolated learning to simultaneous learning. Recall performance was essentially uninfluenced, whereas both recognition performance and frequency judgments were degraded. In the case of frequency information, the effects for some experiments indicated that no residue of the isolated learning remained. In the present work replications were undertaken and certain variables were manipulated to see if the magnitude of the phenomenon could be changed. One of the experiments also dealt with transfer from simultaneous learning to isolated learning, and another showed that associative learning occurred for items presented together for study in simultaneous learning.

Degree of level of isolated learning had only a small effect on the negative transfer observed in subsequent simultaneous learning; the higher the degree of learning the less the negative effect. However, this was not consistent in all experiments. Indeed, the phenomena involved seemed particularly sensitive to what would normally be considered minor variables and there were inconsistencies both within and between experiments. Transfer from simultaneous learning to isolated learning resulted in high positive transfer. Recall did not differ for simultaneous and isolated learning whereas recognition and frequency judgments were poorer in simultaneous than in isolated learning. Items from different tasks appearing together in simultaneous learning became strongly associated. This finding led to the speculation that associative learning occurring in simultaneous learning may have been responsible for the negative transfer originally observed.

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Simultaneous learning involves the acquisition of two or more verbal lists at once. For example, we might have a list of 30 animal names and a list of 30 vegetable names. To form a list for simultaneous learning, the 30 words in the two lists would be paired randomly. Then, on a study trial, the subject is shown a pair of words, one from each category, then another pair, and so on, for 30 presentations. On the test the subject recalls each list independently.

In earlier work we had used simultaneous learning as a means of studying differential encoding (Underwood & Malmi, 1977). The subjects were given three lists to learn simultaneously. They recalled one of the lists, made frequency judgments for another, and were tested by recognition on the third. These different tests did not come as a surprise to the subjects; the subjects were fully informed about the different materials and the different kinds of tests. For reasons which are not germane here, in one of the experiments we gave the subjects a study-test trial on each of the three lists alone before the lists were combined for simultaneous learning. It was found that there was heavy positive transfer from the trial given in isolation to simultaneous learning for the recall task, but that there was substantial negative transfer for recognition and for frequency judgments. To say this another way, performance on the first simultaneous learning trial for recognition and for frequency judgments was below the performance measures for the isolated trial given initially.

These findings were judged to have systematic implications along two lines. First, the negative effects were not observed for recall but were observed for recognition and frequency judgments. This suggests a fundamental difference between the processes underlying recall and those underlying recognition. In our way of theoretical thinking, frequency judgments and recognition decisions are said to be based on much the same information in memory. Other investigators have also reached this conclusion (Harris, Begg, & Mitterer, 1980). Therefore when we speak of fundamental differences between recall and recognition we are at the same time implying a fundamental difference between recall and frequency judgments. In any event, the findings of our earlier experiment suggested a new approach to the study of the differences between recall and recognition.

The second implication has to do with the idea of verbal context changes. When a list is given a study-test trial in isolation, there is a very clear change in verbal context when this list is combined with two others for simultaneous learning. Change in context is an idea that is used frequently as a theoretical notion. It appeared to us that studies manipulating various factors in moving from isolated learning to simultaneous learning, and the reverse, might provide some needed empirical evidence about verbal context change.

We are not aware of other work dealing with the negative transfer observed in moving from isolated to simultaneous learning. The operations have some similarity to the classical part-whole problem. To illustrate a case of part-whole learning, let us assume that the learning task is a list of 20 paired associates. In the part-whole procedure, the subjects are given practice on each of two groups of 10 paired associates and then the 20 pairs are combined for whole learning. Total time to learn the 20 pairs is compared for the part-to-whole procedure with a whole procedure instituted at the beginning of practice.

It is probably correct to say that part learning has had very little influence in overall learning; the critical variable appears to be the total time spent in practice, not the way the practice is divided up (e.g., Postman & Goggin, 1966). Furthermore, as can be seen, the operations for part-whole learning are appreciably different from those used in producing the negative transfer in our experiments.

The neoclassic part-whole phenomenon is associated with free recall and was discovered by Tulving (1966). Subjects were given eight study-test trials on 18 words, and then for further trials these 18 words were mixed with 18 new words. It was observed that compared with a control (not having the prior practice on the part list) performance became worse on the whole list after the first few trials. This finding, of course, is just the opposite of our findings for recall where the subject greatly benefited by a single preliminary trial on the free-recall list.

This lack of background literature for the phenomenon under scrutiny will have been corrected in a modest way by the experiments to be reported. During the course of our experiments we felt it necessary to replicate our earlier experiment. We will report the replication as Experiment 1.

Experiment 1

Method

Lists. There were three sets of materials, each of which was used to form a separate list. The recall task consisted of 24 pairs of words for which the left-hand name was a male name, the right-hand name a female name (e.g., James-Ellen). On a study trial, each pair was presented twice. For obtaining measures of frequency assimilation, animal names were used. There were eight names that occurred once, eight twice, and eight three times. On the test, eight additional names (zero frequency) were added and the subjects made absolute frequency judgments for the 32 names. The animal names were printed in capital letters on the memory drum tape, whereas only the first letter of each name for the name pairs was capitalized. The third class of materials consisted of two-word phrases, the two words being connected by a hyphen (e.g., income-tax). There were 24 such phrases, each presented once. The phrases were presented in lower case type. On the test, 24 additional phrases were used as new items, being mixed with the old 24.

When the lists were presented alone, each of the 24 name pairs occurred twice, just as in simultaneous learning. So also, the frequencies given the two other classes of items were exactly the same in isolated learning as given in simultaneous learning. It can be seen that there were 120 stimuli presented for simultaneous learning, there being 48 male-female name pairs, 48 animal names, and 24 two-word phrases. There were always three stimuli per presentation in simultaneous learning, hence it required 40 presentations for the entire list. Stimuli were assigned to the 120 positions at random, subject to the restriction that a given stimulus could not occur more than once among the three used for a given presentation.

<u>Procedure and subjects</u>. As an alternative way of writing about isolated and simultaneous learning, we will speak of A (alone) learning or A trials when lists are learned singly, and T (together) learning or T trials when simultaneous learning is involved. There were only two conditions in the experiment, each condition represented by a different group of subjects. Group TT was given two study-test trials on simultaneous learning. Group ATT was given a study-test trial on each of the three lists alone (A) before being given two study-test trials of T learning.

The subjects were initially instructed about all steps in the experiment, about the different classes of materials, the different tests of memory, and so on. The general instructions were to learn as many items in all lists as possible.

The presentation rate for the lists when presented alone was 4 sec. The order of giving the single study-test trial on each list separately was the same for all subjects, namely, recall, frequency estimation, and recognition. Recall was written on a prepared sheet containing 24 blanks. For the frequency judgments the 32 words were randomized on a separate sheet with a blank after each. The subjects were asked to write a number in each blank to indicate the number of times they thought the item occurred on a study trial. An item that was judged not to have occurred on the study trial was to be given a value of zero. For the recognition test the 48 phrases (24 old and 24 new) appeared in random order on the test sheet with the words YES and NO after each. The subjects were instructed to circle YES if they believed the phrase had been in the study list and to circle NO if they believed the phrase had not occurred in the study list. The subjects were required to reach a decision on all 48 items, guessing if necessary.

Rate of presentation for simultaneous learning was 12 sec. After the first study trial the subjects were first tested for recall of the paired names, then for frequency knowledge, and finally for recognition of phrases. The same test order was used on the second simultaneous learning trial. All other matters on the second trial were exactly the same as on the first.

Each of the two groups consisted of 34 college students assigned to conditions by a block-randomized schedule.

Results

Recall. For statistical decisions, the 5% level of confidence was used. Recall of the name pairs was scored stringently in that both words had to be given together for an item to be counted correct. The results are plotted in Figure 1 with trials identified as A and T trials. It is apparent that the A trial produced positive transfer to the simultaneous-learning trials. An analysis of the two simultaneous trials (with trials and groups as entries) showed that overall performance was better for Group ATT than for Group TT, $F(1, 66) = 4.00$, $MS_e = 33.01$, and that the interaction was reliable, $F(1, 66) = 18.02$, $MS_e = 3.76$. The reason for the interaction is not immediately obvious (although it was also observed in the earlier study). The interaction was not due to a ceiling, and it did not occur in experiments to be reported later. Actually, the two groups differ very little on the second T trial, but the scores are reaching a level where free-recall performance increases very slowly with trials.

Frequency judgments. The number of hits was used as the measure of

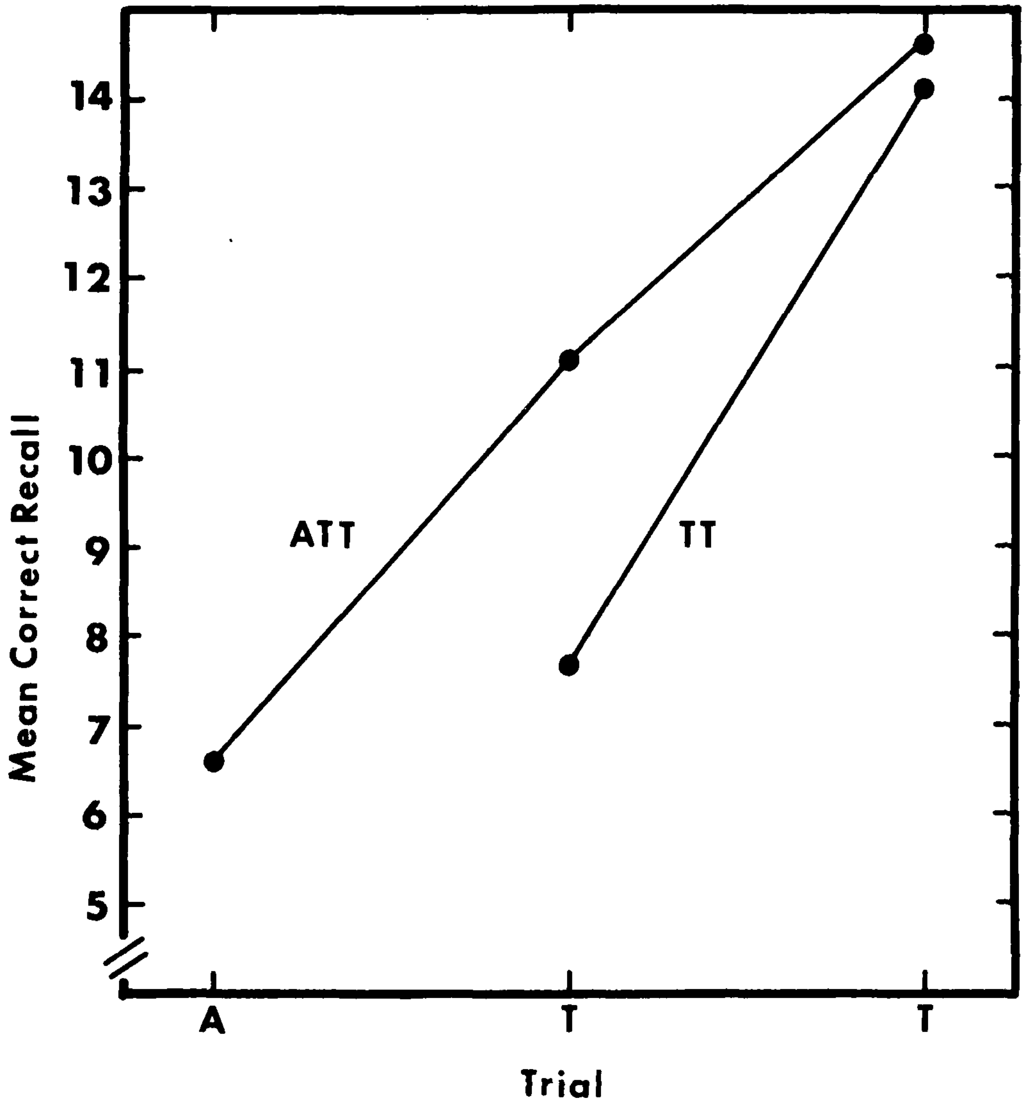

Figure 1. Recall in simultaneous learning with (ATT) and without (TT) an isolated study-test trial. Experiment 1.

accuracy of frequency judgments. This measure is simply the number of times the subjects assigned the correct frequency. Because there were eight words at each of four frequencies, the maximal number of hits was 32. The means are plotted in Figure 2. The first fact of note is the loss of frequency discrimination in moving from the A lists to the T lists. A drop of one or more hits was shown by 31 of the 34 subjects in Group ATT. This drop was highly reliable, of course, $\underline{t}(33) = 5.93$. Also, the negative transfer was statistically complete if the performance of Group TT was used as a base. An analysis of variance involving scores for the two T trials for the two groups showed that no factor was reliable. It can be seen that Group TT did not improve between trials 1 and 2. This failure of frequency judgments to improve across trials has been noted under a number of different conditions in research reported earlier (Underwood & Malmi, 1977). The results for the frequency judgments replicate the earlier finding; clearly there is a severe negative effect on frequency judgments in going from A learning to T learning.

Recognition. The mean number of misses and the mean number of false alarms are shown in the two panels of Figure 3. Looking at the misses (bottom panel) it can be seen that they increased sharply for Group ATT from the A trial to the first T trial. The increase was reliable, $\underline{t}(33) = 4.08$. However, the increase was not of a sufficient magnitude to reach the level of Group TT. An analysis, which included the two groups and the two TT trials showed a significant difference between the two groups, $\underline{F}(1, 66) = 8.01$, $MS\underline{e} = 10.91$.

The false alarms also increased between the A trial and the first T trial, $\underline{t}(33) = 3.78$. The difference between the two groups on the simultaneous trials was not reliable, $F(1, 66) = 2.39$, $MS_e = 10.35$. It must be concluded that recognition was influenced negatively when moving from isolated learning to simultaneous learning. This result too was much the same as found in the earlier study.

Discussion

The data show that recall performance was influenced very little by moving from A learning to T learning, whereas frequency judgments and recognition decisions were negatively influenced almost to the point where the isolated learning was a waste of time. Generally speaking, these results replicate those of an earlier study (Underwood & Malmi, 1977).

In trying to understand the nature of the transfer involved for both recall and recognition, some parametric studies were undertaken. These will be reported as Experiments 2 and 3.

Experiment 2

Two variables were manipulated. It was earlier noted that in a gross sense, learning a task in isolation followed by simultaneous learning represents a change in verbal context. If simultaneous learning is given first, followed by isolated learning, a change in context would also be involved. The former case is sometimes spoken of as context addition, whereas the second case is called context deletion. The first question asked by Experiment 2 was whether or not the phenomena observed in Experiment 1 were independent of the nature of context change. Would context deletion produce a negative effect as was found with context addition.

As a second variable, degree of learning of the first task was manipulated. In one case the level of learning of the A task was varied before

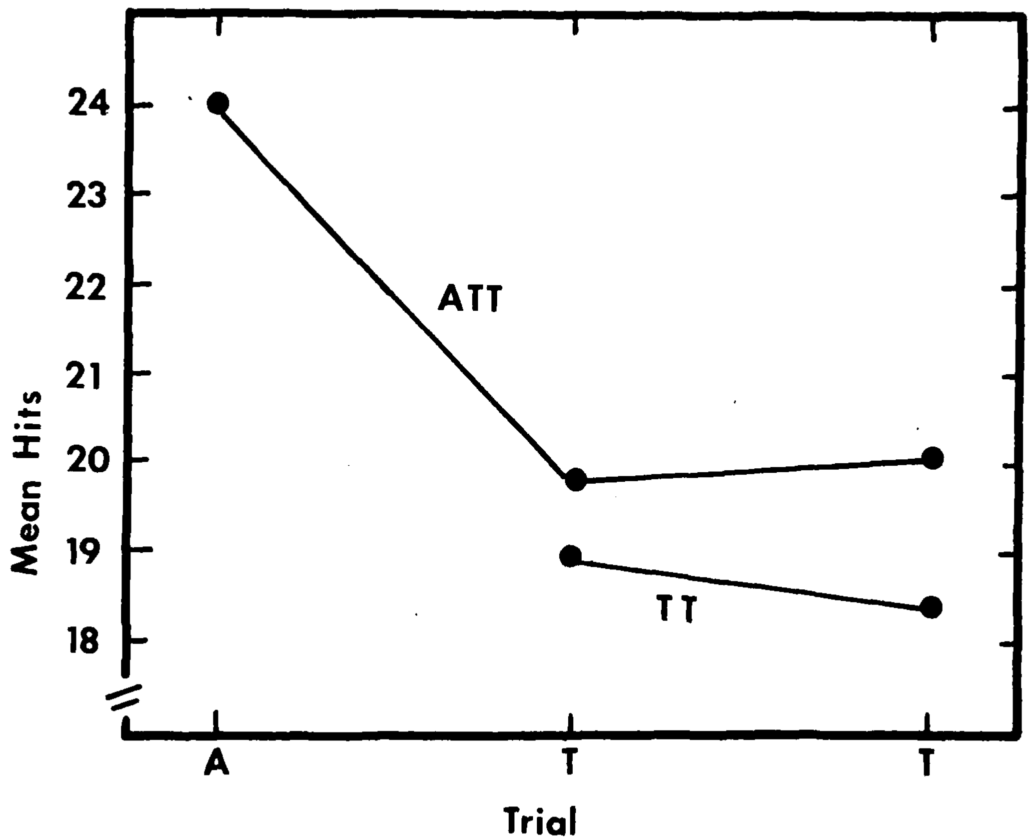

Figure 2. Mean hits on frequency judgments with (ATT) and without (TT) an isolated study-test trial. Experiment 1.

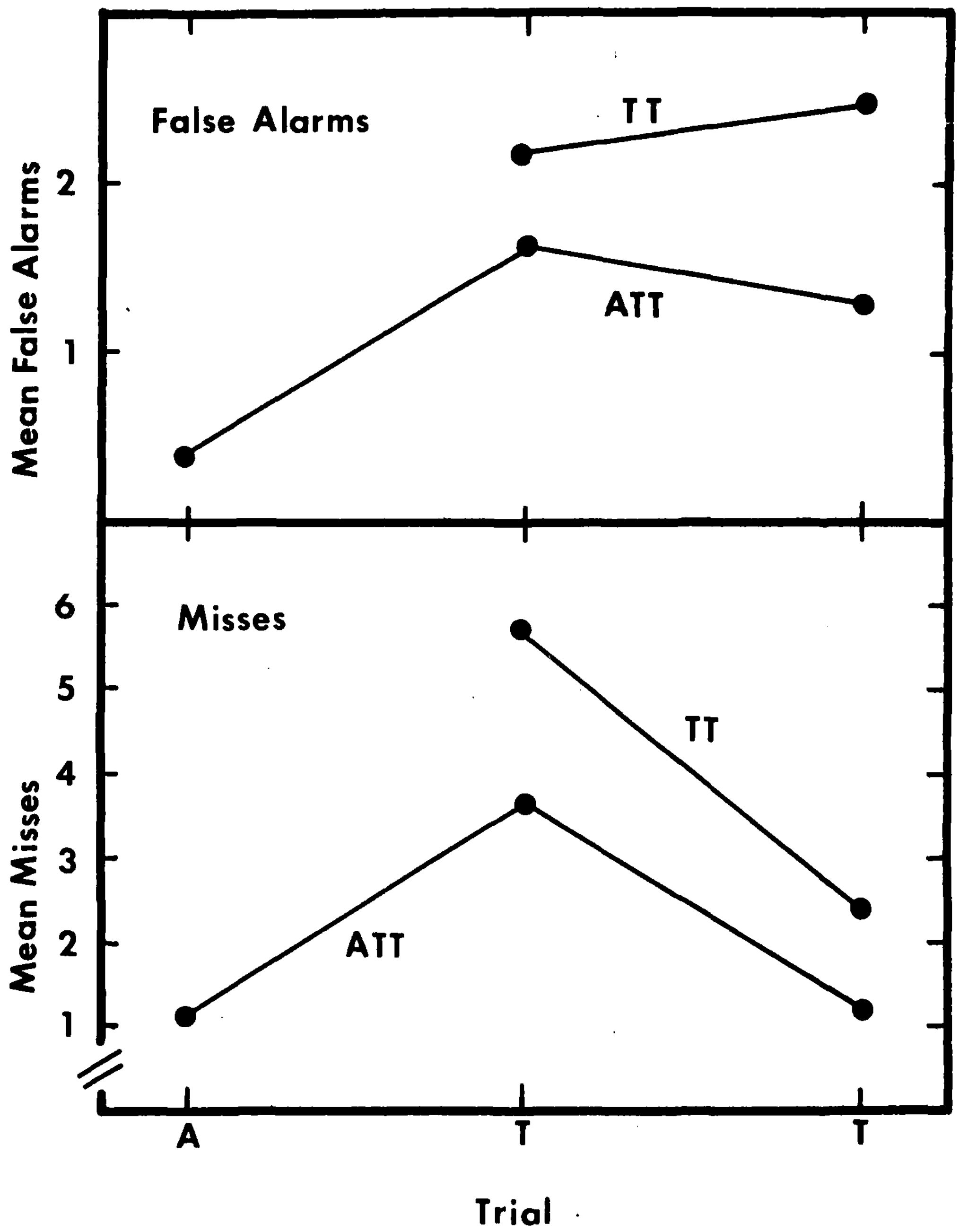

Figure 3. Recognition scores (false alarms and misses) with (ATT) and without (TT) an isolated study-test trial. Experiment 1.

transfer to T learning, and in another the level of T learning was varied before transfer to A learning. A basic reason for manipulating degree of learning was the belief that the higher the degree of learning the more likely it would be that a learned task would be removed from contextual constraints. To say this another way, it seems that those tasks which we know well are essentially independent of a particular context.

Method

Conditions. There were three conditions used to examine transfer in moving from A to T. One of these was Condition AT and, with a higher degree of A learning, Condition AAAT. The control condition was TTTT. The second T in the sequence of four T trials for Condition TTTT served as a control for Condition AT, and the fourth T trial was a control for Condition AAAT.

Three conditions were also involved in the transfer from T learning to A learning. These three conditions were designated TA, TTTA, and AAAA. It should be clear that in all cases the A trial represented the study and test of each of the three lists in isolation, one tested by recall, one by frequency judgments, and one by recognition. The T trial, on the other hand, represented the simultaneous learning of all three lists, with each being tested separately.

Lists. The three lists were modified somewhat from those used in Experiment 1. For the simultaneous list there were 42 presentations and on each presentation one item from each list was shown. There were 21 pairs of male-female names. Each was presented twice on a study trial and these pairs always served as the recall task. There were 42 two-word phrases (printed in lower case type) each occurring once. These phrases were tested for recognition by mixing them with 24 new phrases. Animal names printed in capital letters were used for examining frequency assimilation. There were seven words occurring once, seven occurring twice, and seven occurring three times. On the test seven additional words were added as zero-frequency words. The 42 items for each of the three lists were placed randomly in the presentation units subject to the restriction that no more than one item from a list could occur in a presentation unit for simultaneous learning.

Procedure and subjects. The rate of presentation for A trials was 2 sec, and for T trials it was 6 sec. Thus, the presentation rate was more rapid than in Experiment 1. Recall was written on prepared sheets. On the recognition tests the subjects made YES-NO decisions for each item by encircling either YES or NO. A decision was required for all 66 phrases. For the frequency judgments the subjects circled one of four numbers (0, 1, 2, or 3) to indicate the frequency with which they thought each item had been presented.

Under A learning the order of learning and testing was always recall first, then recognition, and then frequency judgments. The same order of testing was used for T learning. All tests were unpaced, although for recall the subjects were allowed only as much time as they felt they needed to "exhaust" recall possibilities. Instructions were not complete in the sense that the subjects were not informed initially about all of the trials that would be given. They were, of course, fully informed about the "next" trial and they were always urged to learn as many correct responses as possible. The order of the items on the study trials was exactly the same from trial to trial and the subjects always knew this.

The six conditions may be repeated: AT, AAAT, TTTT, TA, TTTA, and AAAA. Twenty subjects (college students) were assigned to each condition from entries on a block-randomized schedule.

Results

Recall. There were no statistical differences among the six conditions for the recall of the paired names. This means that performance was as high under T learning as under A learning, and that transfer from A to L learning was essentially complete, as was the transfer in the reverse direction.

Frequency judgments. Mean hits made in estimating the frequency of occurrence of the animals names are shown in Figure 4. The total possible score was 28. The left panel plots the scores for transfer from A to T, while the right panel shows the results for transfer from T to A. In the case of recall it was noted that learning was about the same whether it was a T trial or an A trial. It is quite obvious from Figure 4 that that was not true for frequency estimations; performance on the A trials was much better than on the T trials.

There is a discrepancy in the data in Figure 4. It can be seen that the line for Condition AAAT is essentially flat, while for Condition AAAA there is a rather sharp increase across the first three trials. There is no reason why these two conditions should differ on the first three trials. The difference is reliable in the sense that the increase from Trial 1 to Trial 2 is statistically significant for Condition AAAA, $t(19) = 3.48$. We have no accounting for this.

Looking now only at the left panel, it is seen that a loss (negative transfer) was present for Condition AT in moving from the A to the T trial, and the loss was reliable, $t(19) = 4.06$. This would appear to confirm the results of Experiment 1. However, in Experiment 1 the two groups had almost equivalent performances on the first T trial, whereas in the present case there is a large gap between the first T trial for Conditions AT and TTTT.

We may ask if there was an effect of degree of learning by comparing the drop between Trials 1 and 2 for Condition AT with the drop between Trials 3 and 4 for Condition AAAT. The drop was greater for Condition AT, but when tested directly the difference in the magnitude of the two drops was not statistically reliable, $t(38) = 1.77$.

The data in the right panel, reflecting the outcome when the subjects moved from the T task to the A task, indicate no negative transfer. In fact, the transfer is heavily positive for Conditions TA and TTTA, and is nearly complete when Condition AAAA is used as a base. The difference in degree of learning appeared to have little influence as seen by the fact that the change in moving from T to A was about the same for both conditions TA and TTTA. Thus, these data show that transfer was heavy and positive for frequency information when moving from the T task to the A task, and this clearly distinguished the two types of context changes (addition versus deletion).

Recognition. The misses observed on the recognition test are shown in Figure 5. The data in the left panel again deal with A to T transfer, those in the right panel with T and A transfer. Condition AT does not show a negative effect in moving from A to T learning, although the positive effect is very small. As was true for the frequency judgments, performance on the T trial of Condition AT is far better than performance on the first

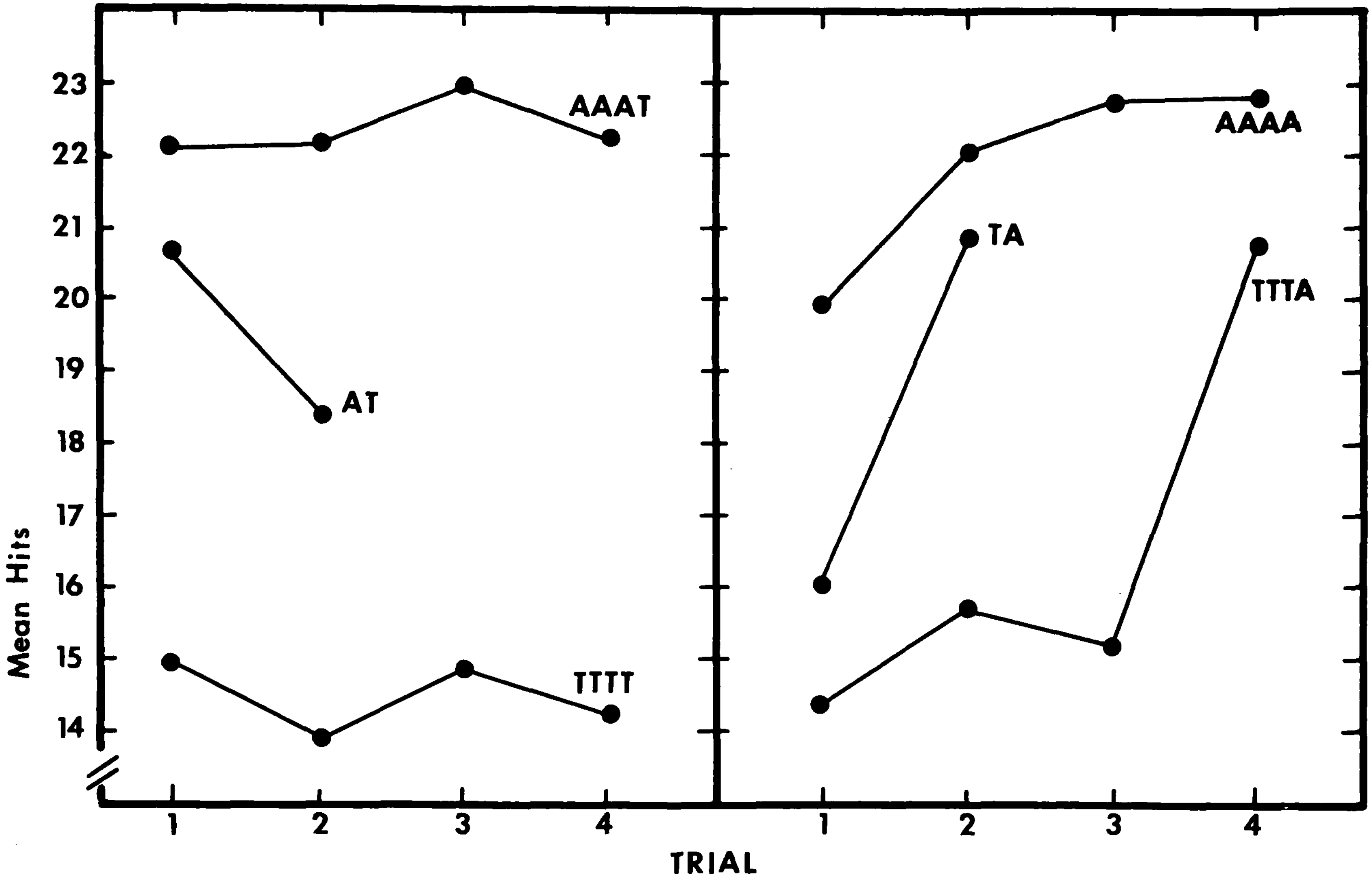

Figure 4. Mean hits for frequency judgments as a function of the pattern of alone (A) trials and simultaneous (T) trials. See text for complete explanation. Experiment 2.

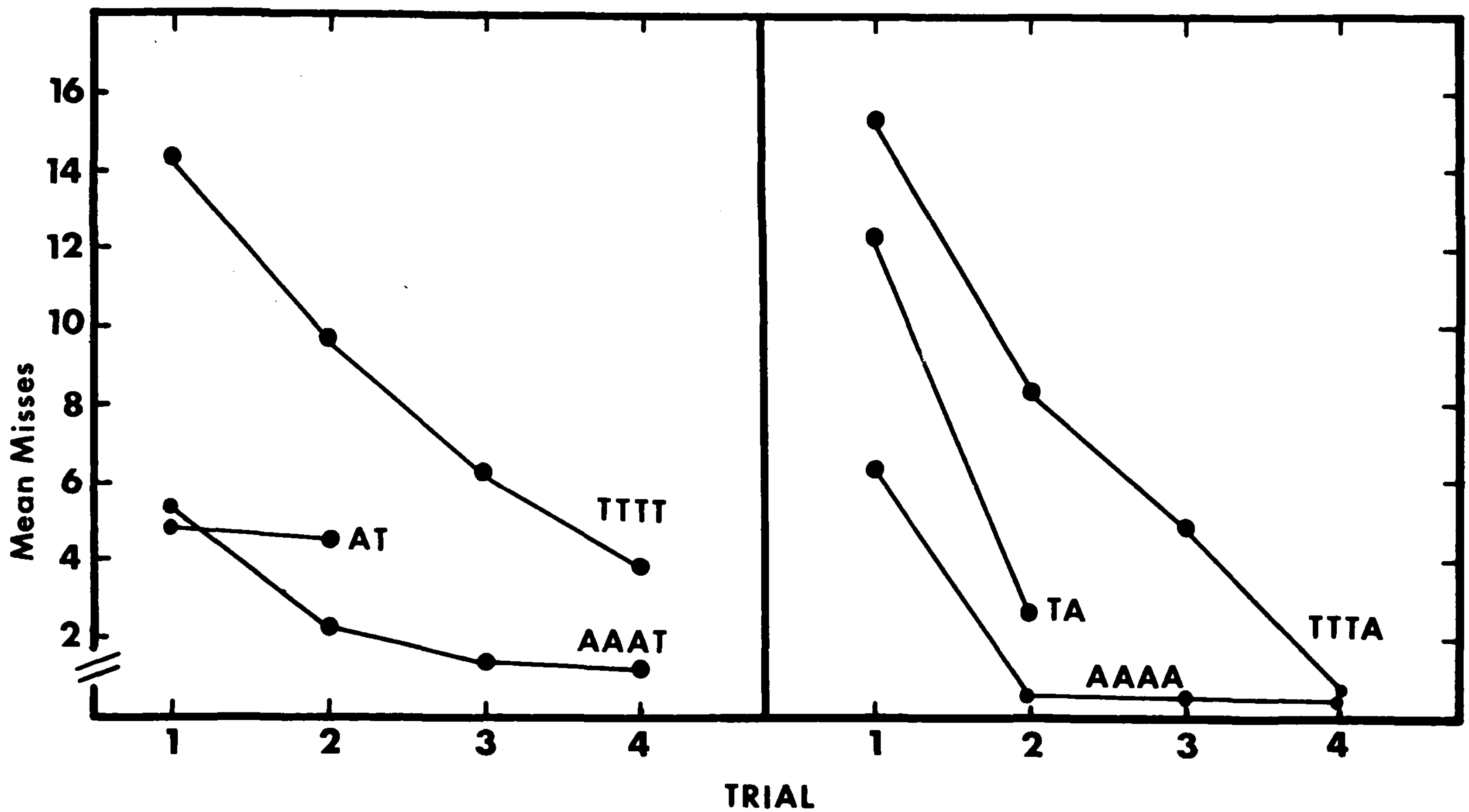

Figure 5. Mean misses on recognition tests as a function of the pattern of A and T trials. Experiment 2.

T trial of Condition TTTT. This was not true for the results of Experiment 1. There is no clear evidence in Figure 5 that degree of learning is of consequence. In fact, the slope of the line relating the two trials for Condition AT is about the same as the slope for the line between Trials 3 and 4 of Condition AAAT. The right panel of Figure 5 shows that transfer was very heavy and positive in moving from T learning to A learning.

We examine next the false alarms as plotted in Figure 6. A very clear negative effect is present in Condition AT, $\underline{t}(19) = 3.89$, and the size of the loss is about the same as that observed in Experiment 1 (Figure 3). However, the negative effect appears to be much less for this experiment because performance under Condition TTTT is so poor. It can be seen that there is an effect of degree of learning in that there is no loss between trials 3 and 4 for Condition AAAT; thus the loss is less with the higher degree of learning.

The data in the right panel indicate again that the transfer is asymmetrical in that there were no negative effects in moving from T learning to A learning. The data for Conditions TA and TTTA indicate that the positive transfer is essentially 100%, and does not differ as a function of the degree of learning. Again there are some anomalies in the data. Conditions TTTT and TTTA should be equivalent on the first three trials but they are not. Further, if we used Trials 1 and 2 of Condition AAAA as a control for the change seen in Condition AT, we would be forced to conclude that the so-called negative effect for Condition AT is not due to the fact that the second task consists of simultaneous learning. Perhaps the most important conclusion suggested by these discrepancies is that the negative effects in this experiment are, in an absolute sense, very small for recognition.

Discussion

Some summary points need to be made. First, we found that recall under simultaneous learning at a 6-sec rate was about equivalent to isolated recall when study was at a 2-sec rate. For frequency judgments and recognition, on the other hand, performance was far poorer under T learning than under A learning. This again points to the likelihood that there are some fundamental differences in recall and recognition.

There was no evidence for negative effects in moving from T learning to A learning. Studies of recognition that have used the addition and deletion operations for studying changes in verbal context have found that context deletion has a negative effect whereas context addition has no effect (Underwood & Humphreys, 1979); this is just the opposite of the present findings.

The results for Experiment 2 were in some sense disturbing. There were anomalies in the results; the negative effects of moving from A to T learning were much less apparent than in Experiment 1. For example, there was no negative transfer in the misses on the recognition test, although there was an effect for false alarms. In some sense the phenomenon of interest seems a bit ephemeral. We shall see this same pattern emerges again in the next experiment.

Experiment 3

The major intent of Experiment 3 was to determine what role rate of presentation plays in determining the phenomenon of interest. In Experiment 1 the rate of presentation was 4 sec for A learning and 12 for T learning. The corresponding values for Experiment 2 were 2 sec and 6 sec. The negative

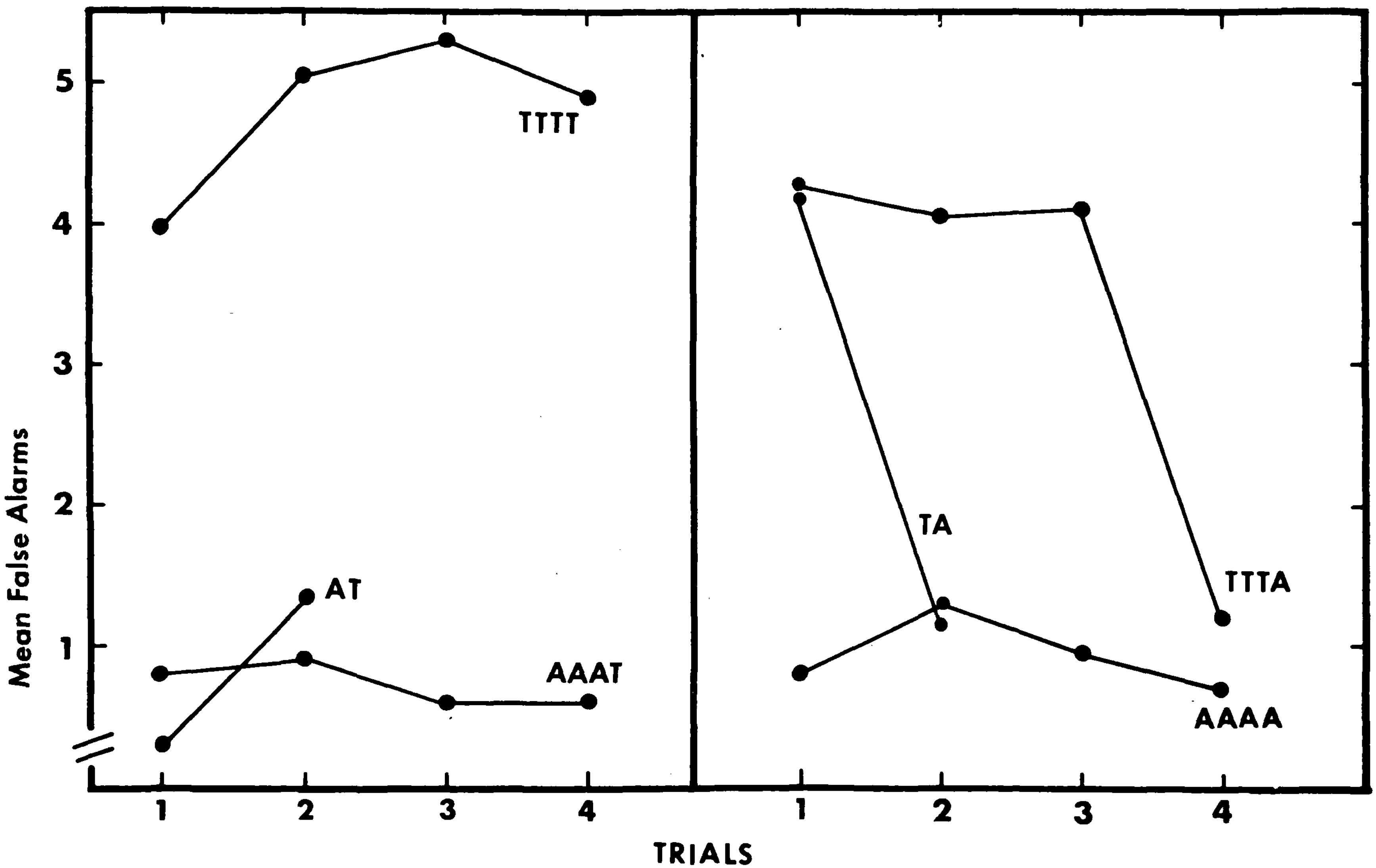

Figure 6. Mean false alarms on recognition tests as a function of the pattern of A and T trials. Experiment 2.

transfer for frequency judgments and recognition were much more apparent in Experiment 1 than in Experiment 2. It seemed necessary to make a direct test of the rate variable. This conclusion was reached in spite of the fact that variation in the degree of learning (as manipulated in Experiment 2) may be expected to simulate the conditions of learning when study time per trial was varied. In any event, in Experiment 3 we varied both study time and degree of learning.

Method

There were six conditions which may be identified as follows: 6ATT, 6AAT, 6TTT, 12ATT, 12AAT, and 12TTT. The number refers to the rate of presentation under simultaneous learning. The lists were the same as those used in Experiment 2 as were all other details of the procedure including the fact that 20 subjects were assigned to each condition.

Results

Recall. Recall by trial is shown in the two panels of Figure 7. Three facts are to be noted. First, learning occurred more rapidly with the 12-sec rate than with the 6-sec rate (compare the two panels). Second, although there were small differences as a function of A and T, the basic fact remains that learning was essentially equivalent for A and T trials for both rates. Third, at the 6-sec rate, there is a crossover of Conditions AAT and TTT between Trials 2 and 3, and this interaction was reliable, $F(1, 38) = 6.94$, $MS_e = 1.73$. This is the only evidence we have found of a negative effect involving recall in moving from A to T trials, and we are inclined to dismiss it.

Frequency judgments. The essential data are exhibited in Figure 8. As with recall, performance was higher with the 12-sec rate than with the

6-sec rate, $\underline{F}(1, 114) = 7.19$, $MS\underline{e} = 92.80$. A second general point is that performance under the A conditions was much higher than that under the T conditions on the first trial. This is true for both rates, and this finding was also apparent in Experiment 2. The results for Conditions ATT and TTT are much like those found in Experiment 1 (see Figure 2), but the negative effect is larger than found in Experiment 2 under the same conditions.

The frequency judgments allow a generalization about the role of degree of learning when viewed either in terms of learning trials or exposure time. The generalization is that the higher the degree of learning under A trials the less the negative effect in moving to T trials. The evidence for this will be pointed out without necessarily seeking statistical support. The negative effects in moving from A to T is greater for Condition ATT than for Condition AAT. This holds true for both rates. The negative effects are greater for the lists presented at a 6-sec rate than for those presented at a 12-sec rate. Because learning is higher or faster with the 12-sec rate, the level of learning seems to be the critical variable rather than rate per se.

Recognition. The false alarms are plotted in Figure 9. The data for the 6-sec rate show a sharp negative effect for Condition ATT in moving from A to T. The negative effect is less between trials 2 and 3 for Condition AAT. With the 12-sec rate the effects are generally attenuated. For example, under Condition ATT there is a small increase in false alarms between trials 1 and 2, but for Condition AAT there is no change between Trials 2 and 3.

The misses observed in recognition are plotted in Figure 10. At the

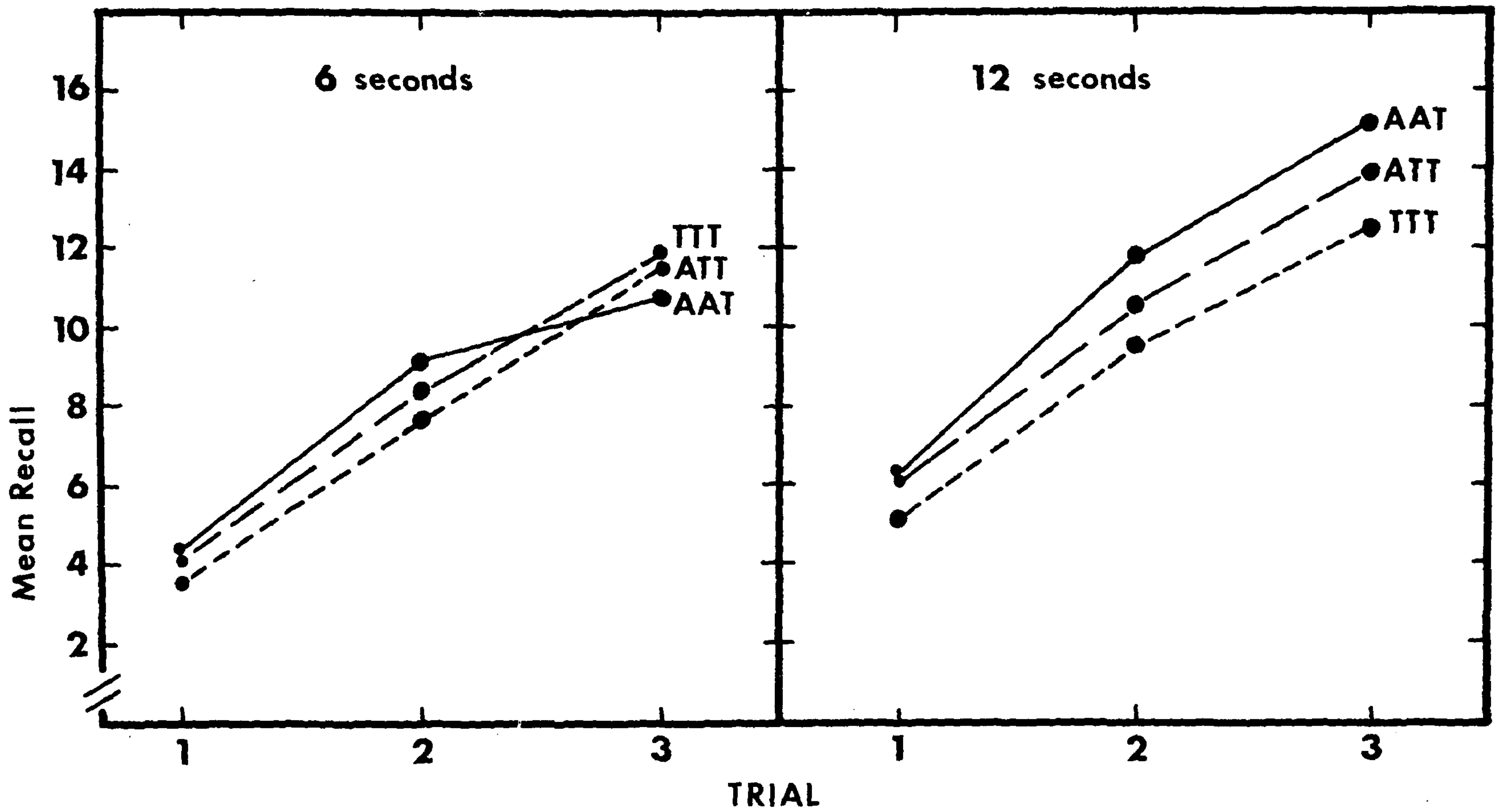

Figure 7. Mean recall as a function of the pattern of A and T trials and the exposure duration on the T trials. Experiment 3.

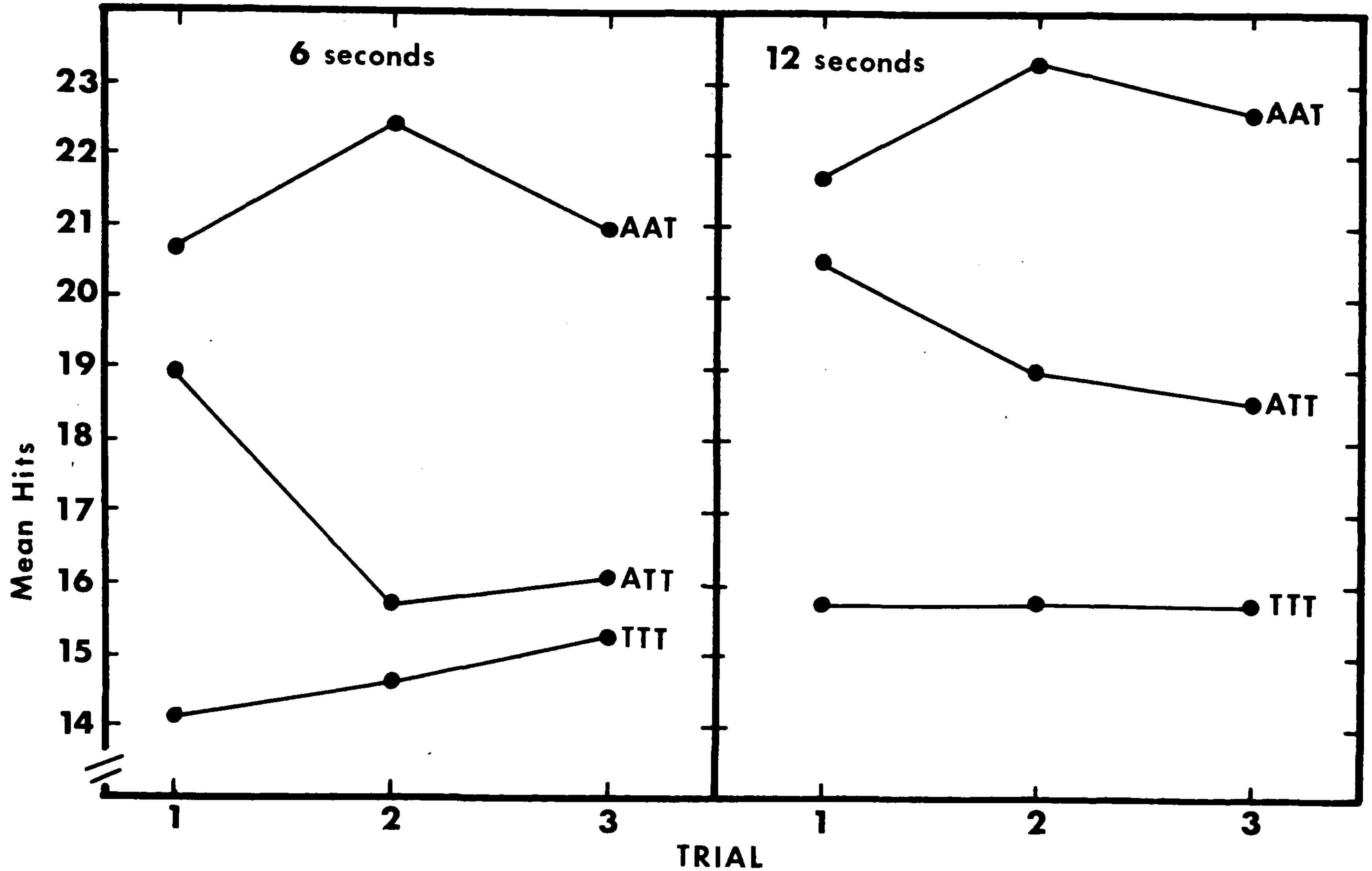

Figure 8. Mean hits on frequency judgments as a function of the pattern of A and T trials and the exposure duration on the T trials. Experiment 3.

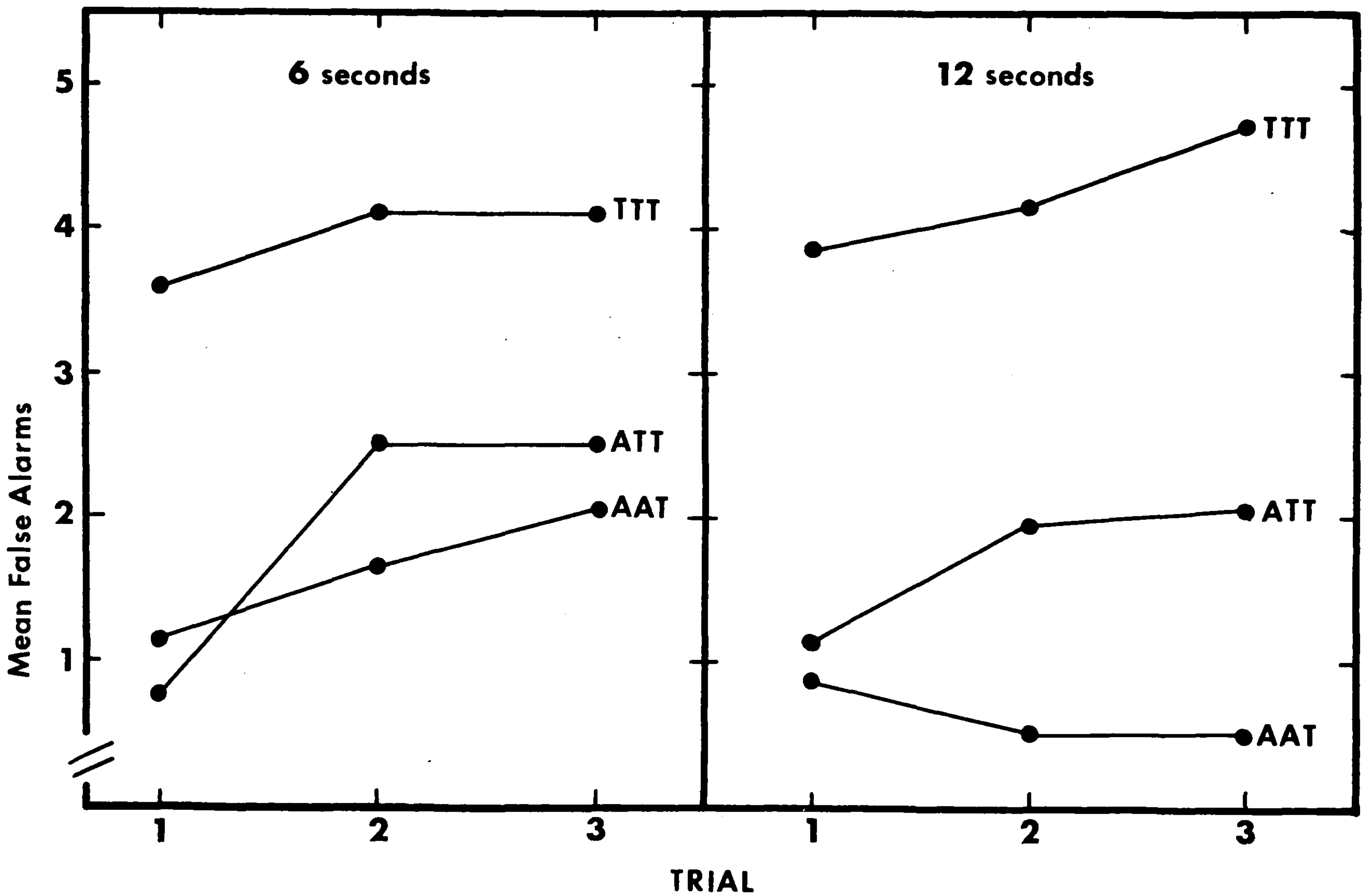

Figure 9. Mean false alarms on recognition test as a function of pattern of A and T trials and the exposure duration on T trials. Experiment 3.

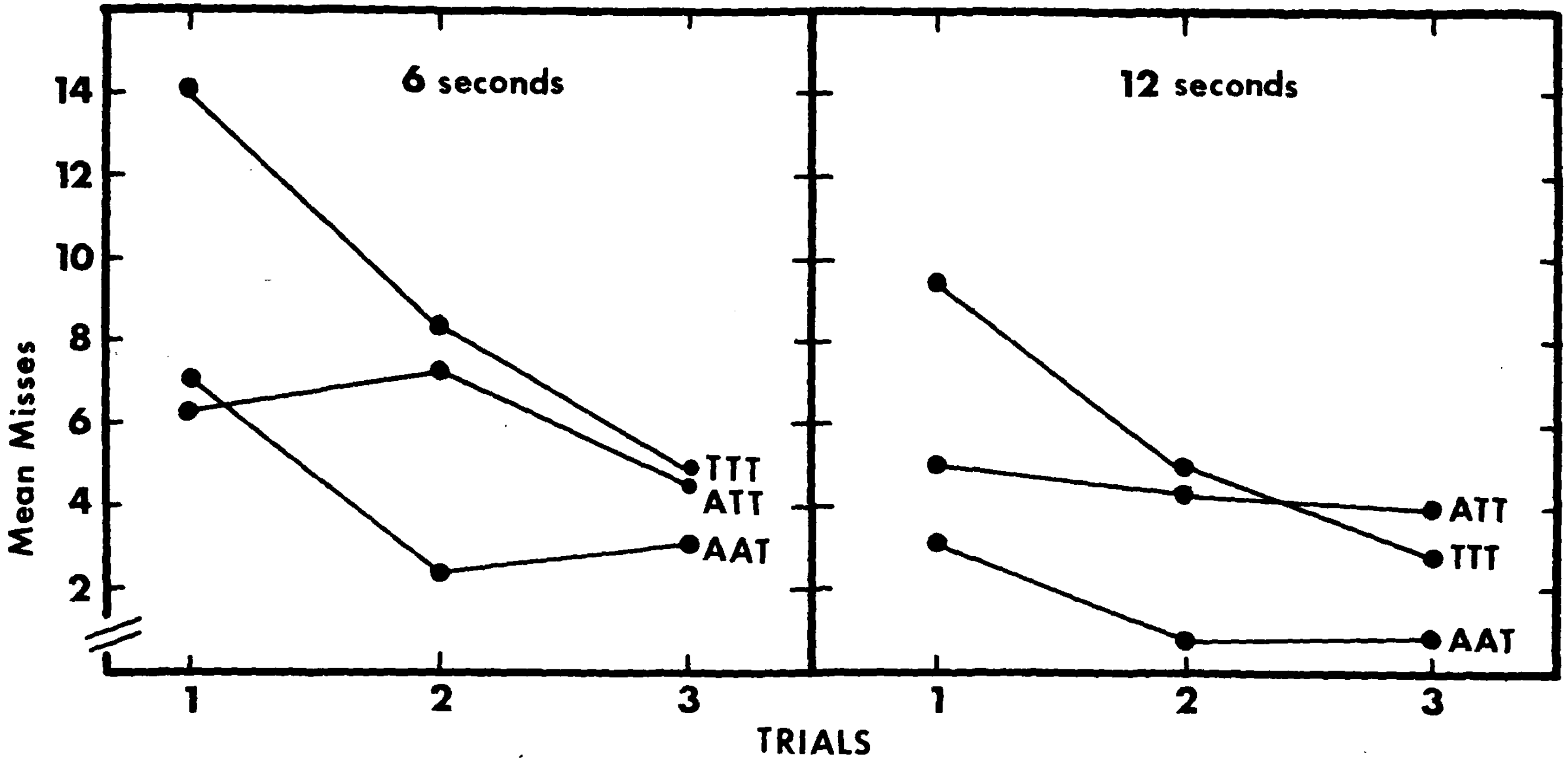

Figure 10. Mean misses on recognition test as a function of pattern of A and T trials and the exposure duration on T trials. Experiment 3.

6-sec rate Condition ATT shows a small increase in misses between Trials 1 and 2, but the absolute number on Trial 2 (the first T trial) is far below the number made on the first T trial of Condition TTT. It is to be noted that for Condition AAT there is only a slight increase in misses between Trials 2 and 3. Again, with the 12-sec rate the effects of moving from A to T are minimal.

Discussion

The evidence from Experiment 3 makes it appear that the level of A learning prior to the transfer to T learning is a critical variable in producing the phenomena under consideration (the negative transfer for recognition and frequency judgments). Nevertheless, there are some very odd aspects of these findings which force us to review them for all three experiments. By so doing we will assess more pointedly the state of affairs with regard to degree of learning manipulated by changing study time.

In Experiment 1 a 12-sec rate was used and the negative effects in moving from A to T were severe for recognition and frequency judgments. After one isolated learning trial, performance on the first simultaneous learning trial was almost as low as if the subjects had not had the A trial. But in Experiment 3, a 12-sec. rate gave only weak evidence of the negative effects. In the same experiment a 6-sec rate showed larger negative effects than was observed with the 12-sec rate, but with a 6-sec rate in Experiment 2 the negative effects were small. Experiment 3 was consistent in showing that the negative transfer was inversely related to the degree of A learning. The small negative effects in Experiment 2 made it difficult to draw any firm conclusions about the effect of degree of learning but what evidence there was would support the above principle. However, the puzzle remains with regard to Experiment 1. Because a 12-sec rate was used in Experiment 1, the negative transfer should have been relatively small if the results across all experiments are to show consistency. It should be remembered that Experiment 1 was a repeat of an earlier study and both experiments produced essentially the same negative effects. It does not seem, therefore, that we can ignore the inconsistencies across experiments.

We reviewed the procedures for the three experiments to determine what differences could be identified (over and beyond subject differences). These will be listed:

1. There were some differences in the number of stimuli used, although the basic materials were the same. There were 24 pairs of male-female names used in recall for Experiment 1, and there were 21 such pairs in Experiments 2 and 3. There were 24 two-word phrases presented for study with 24 new phrases used on the recognition test in Experiment 1. In Experiments 2 and 3 there were 42 phrases presented for study (one time each) with 24 new phrases on the test. In Experiment 1 there were eight animal names at each frequency level, whereas in Experiments 2 and 3 there were seven at each level.

2. In the list used for simultaneous learning for Experiment 1, each presentation did not include one item from each of the three lists. This occurred because only 24 two-word phrases were used for the recognition study list. In Experiments 2 and 3 all three lists were represented on each presentation of the T list.

3. In Experiment 1 the subjects made absolute frequency judgments by filling in a blank after each word. In Experiments 2 and 3 the numbers 0, 1, 2, and 3 occurred after each word and the subject encircled a number

to indicate his judgment.

4. In Experiment 1 the order of testing was always recall, frequency, and recognition. In Experiments 2 and 3 the order was recall, recognition, and frequency.

5. In Experiment 1 the subjects were informed at the beginning of the session what all of the steps were to be for the entire experiment. That is, they knew that T trials would follow A trials. In Experiments 2 and 3, the instructions pertained to only the next step (next trial) and the subject was given no perspective of the entire session.

It would seem that one or more of these differences in procedure must be responsible for the differences in the results, differences which in one case are quite robust and in another very weak. Just how such differences in procedure could interact with rate to produce the results we have reported is beyond our comprehension as yet. Nevertheless, we did not believe we should leave the matter at this point, although any systematic attempt to run down the critical procedural differences among the experiments was simply not possible within the time frame of the projected research. Certain of the differences seemed unlikely candidates for the critical difference. For example, it did not seem plausible that the differences in recording frequency judgments could influence recognition performance. And how could the order of testing be of consequence? Without a strong rationale for doing so, we decided to ascertain whether or not the differences in the materials were critical. It seemed possible to us that the 42 study items versus 24 (in recognition) might be a relevant difference. If this were true, it then became possible that the differences in the handling of the frequency judgments could influence the negative transfer for frequency. In fact, it seemed quite possible that having the subjects circle a number between 0 and 3 to indicate a frequency decision might well restrict the range of judgments and be responsible for the attenuation of negative effects.

Experiment 4

In this experiment we used the materials prepared for Experiments 2 and 3. On all other counts, the procedure was the same as for Experiment 1. That is, with respect to the differences discussed in points 3, 4, and 5 above, the procedures identified with Experiment 1 were used in Experiment 4. Thus, Experiment 4 was judged to be an exact replication of Experiment 1 except for the differences in the materials.

Method

The methods used have been indicated. Group TT was given two T trials, and Group ATT was given one A trial followed by two T trials. There were 30 subjects in each of the two groups.

Results

Recall. The mean numbers of pairs recalled are shown in Figure 11. Again recall is seen to be completely transferable from A learning to T learning; it can be seen that recall on the second T trial for Group TT was almost identical to the recall on the first T trial for Group ATT.

Frequency judgments. The relevant data are shown in Figure 12. The negative transfer from the A to T trial is complete in that the performance on the first T trial for Group ATT was identical to the first T trial for Group TT. The subjects in Group TT actually performed a little better than did those in Group ATT on the second T trial.

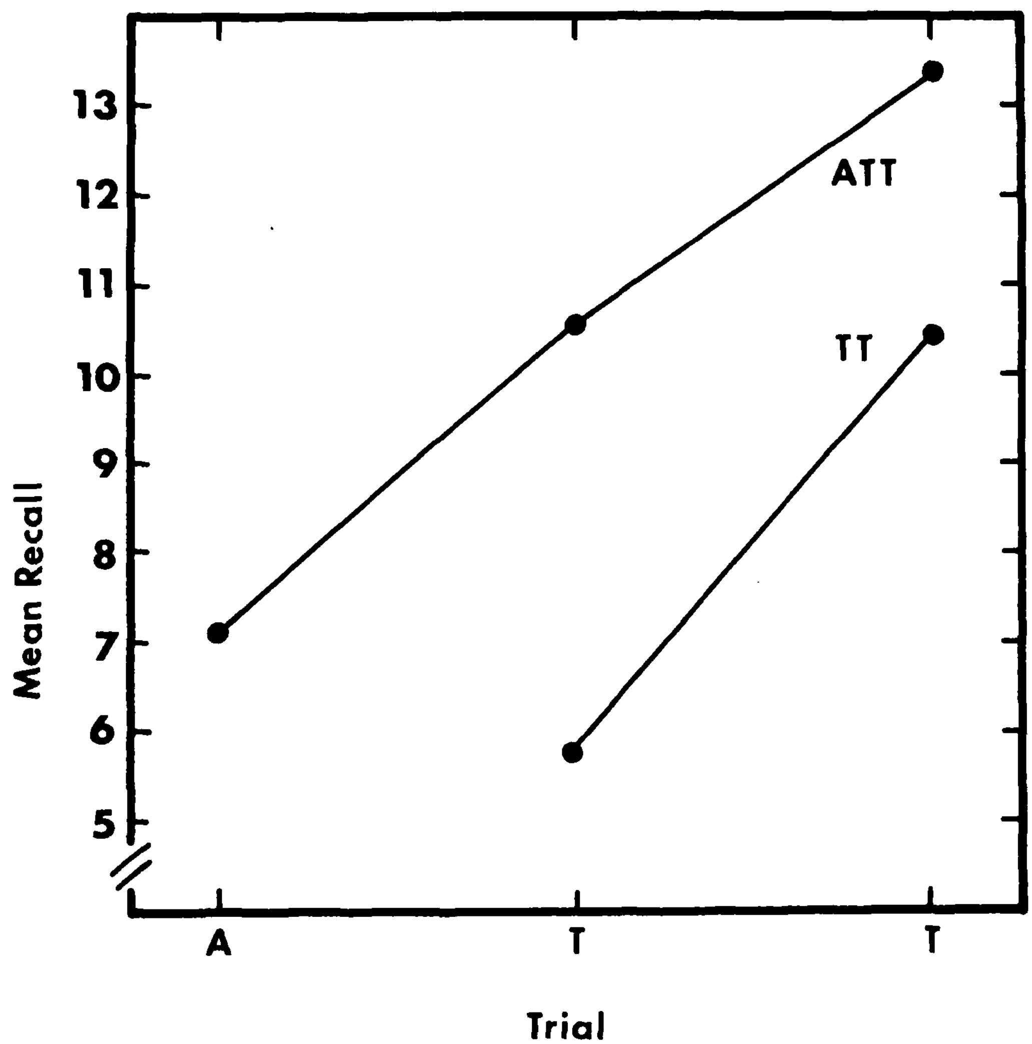

Figure 11. Recall in simultaneous learning with (ATT) and without (TT) an isolated study-test trial. Experiment 4.

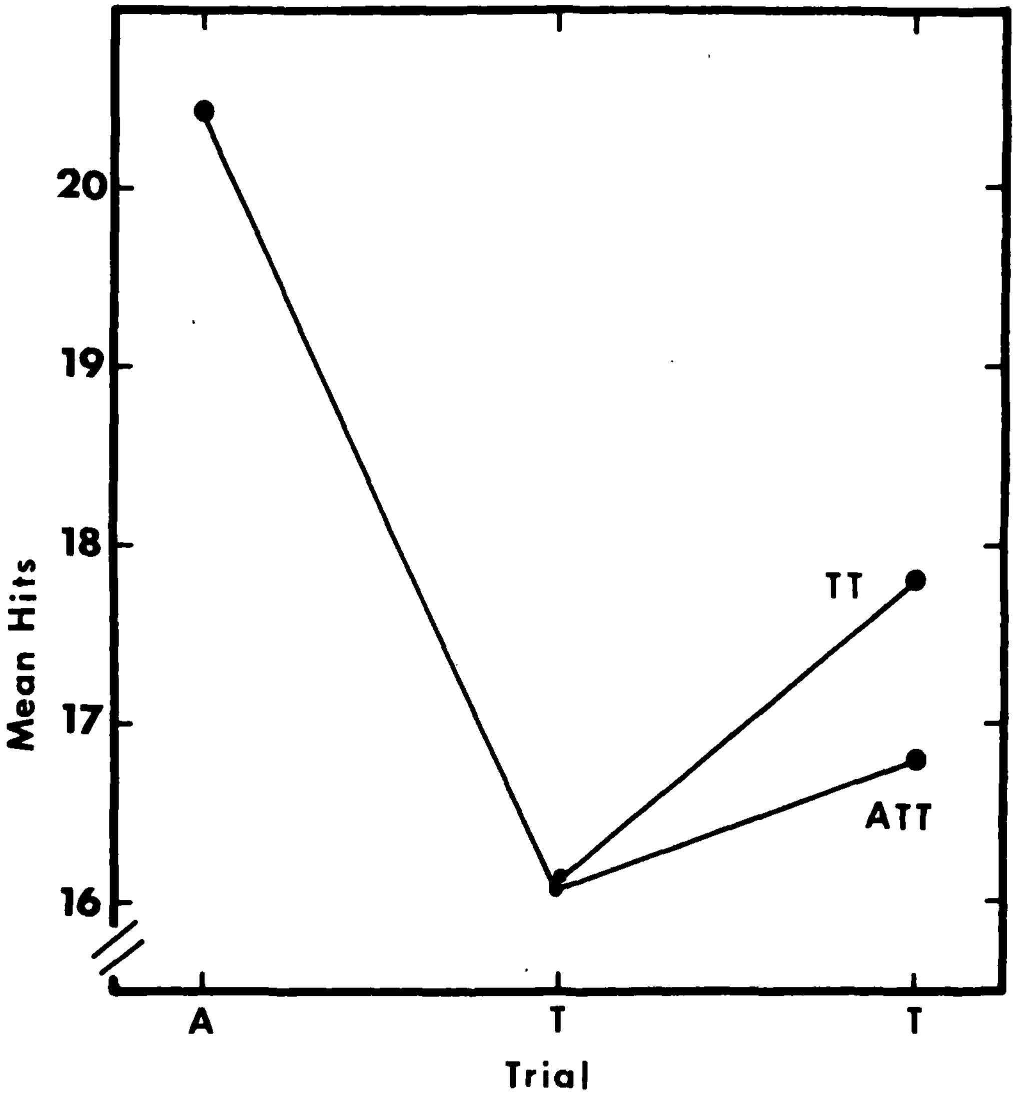

Figure 12. Mean hits on frequency judgments with (ATT) and without (TT) an isolated study-test trial. Experiment 4.

Recognition. The misses and false alarms are plotted in Figure 13. In the case of misses, we see an increase in the number for Group ATT between the A and the T trial. However, the negative transfer was not complete. An analysis of variance of the two T trials for the two groups showed Group TT to have lower performance than Group ATT, $F(1, 58) = 4.46$, $MS_e = 38.77$. In the case of the false alarms the negative transfer was statistically complete in that the two groups did not differ on the two T trials ($F < 1$).

Discussion

The negative transfer for recognition and for frequency estimations observed in this experiment were the most severe we have found in any of the studies. The fact that the negative effects were as great as those found for Experiment 1 eliminates the material as a reason for the failure to find severe negative effects in Experiments 2 and 3. The outcome of the experiment requires a conclusion that the negative effect is critically influenced by one or more of factors 3, 4, and 5 as listed earlier.

Experiment 5

Experiment 4 established again that large negative effects for frequency judgments and for recognition can be produced by isolated learning of the tasks prior to simultaneous learning. In Experiment 5 we attempted to test one possible reason for this negative effect, ignoring for the time being those factors associated with the procedural differences discussed earlier.

For both recognition and for frequency judgments new items were introduced on the tests for isolated learning. As a consequence of these tests, for the second and third trials (the simultaneous-learning trials) the new items are no longer new. The subjects may, therefore, show an increase in false alarms in recognition in moving from the A trial to the T trials. Figure 13 seems to support this expectation. The effect on the misses of the new items becoming old is less evident. However, in general the discriminability between the correct and incorrect items could become less as new items become old as a consequence of testing. For frequency judgments, the effect of testing may be to increase the apparent frequency of all items and the number of hits is reduced thereby.

The above considerations suggest that if the subjects are not tested following the study period on the A trial, there would be less negative transfer in recognition and in frequency judgments on the first T trial. By not testing the subjects after the A study trial, new items remain new for the test after the first T trial. These outcomes would be expected if the only cause of the negative transfer from A learning is due to the new items becoming old as a consequence of the test trial. Furthermore, it would be expected that the recall performance should be reduced if the subjects are not given a recall test following the A trial. The evidence is quite consistent in showing that a test trial for free recall increases performance about as much as does a study trial (e.g., Birnbaum & Eichner, 1971).

There is some evidence in the data we have already presented which would not support the idea that the negative transfer which has been observed in recognition and in frequency judgments in moving from A to T trials is due to new items becoming old. Generally speaking, the performance for subjects in Group TT does not decrease between the two trials. Figure 12, for example, shows an improvement for frequency

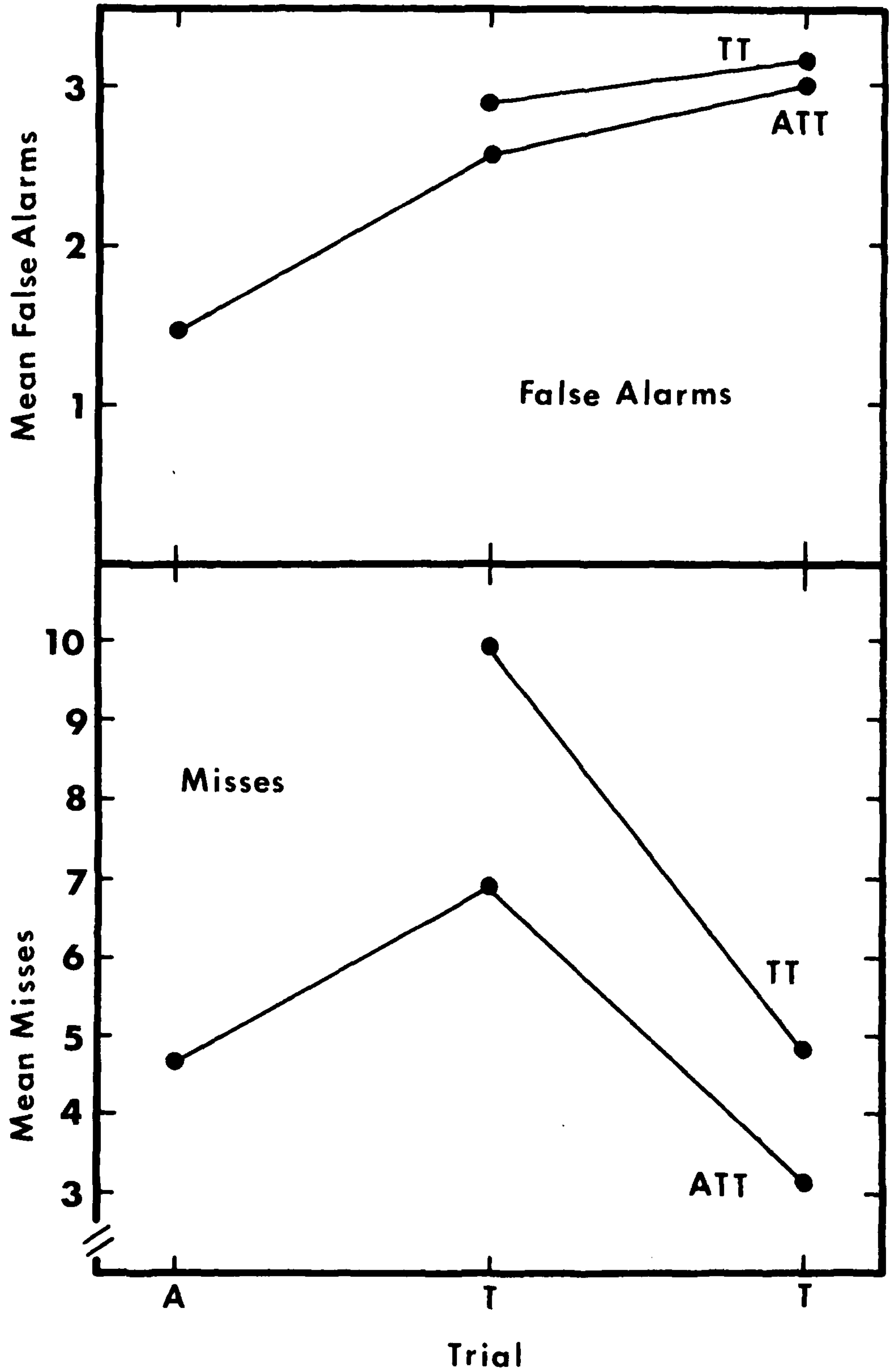

Figure 13. Mean misses and false alarms in simultaneous learning with (ATT) and without (T) an isolated study-test trial. Experiment 4.

judgments as does Figure 13 for recognition misses. If the only factor lying behind the negative transfer is related to the new items becoming old as a consequence of testing, then negative transfer should have been found between the two simultaneous learning trials. Still, it is possible that simultaneous learning per se involves some factor which counteracts the negative transfer although we do not know what such a factor could be. Whatever the case may be, we were led to carry out Experiment 5 to determine if the tests given following the A study trial are responsible for any part of the negative transfer shown for recognition and frequency judgments.

Method

There were three groups. Group ATT and Group TT were the same as those used in the previous study. Group NTT was a new group; the subjects in this group were treated exactly the same as those in Group ATT except that no (N) tests were given on the three lists following the isolated (A) study trial. The time given to testing the subjects for Group ATT was used by having the subjects in Group NTT work multiplication problems. All other conditions were the same as for Experiment 4. Each of the three conditions contained 20 subjects assigned to conditions by a block-randomized schedule.

Results

Recall. The recall results are shown in Figure 14. A comparison of Conditions ATT and TT with the corresponding conditions in Figure 11 shows considerable disparity. The data in Figure 11 indicate that transfer was essentially complete between the A and T trials for Group ATT, whereas there was little transfer in the present study. It had been anticipated that the performance under Condition NTT would be poorer than that under Condition ATT. This expectation was not supported. In fact, an analysis of variance showed that the three groups did not differ on the two simultaneous learning trials ($F < 1$).

Frequency judgments. The results for the frequency judgments are quite unambiguous. Figure 15 indicates that severe negative transfer occurred in Condition ATT. However, under Condition NTT this negative transfer also occurred, apparently, because the performance of the two groups is essentially equivalent on the first simultaneous learning trial. The three conditions do not differ statistically on the two simultaneous learning trials ($F = 1.07$).

Recognition. The recognition data are plotted in Figure 16. The fact that Conditions ATT and NTT produced much the same number of false alarms on the two simultaneous learning trials indicates that having taken the recognition test following the A study phase is not a causal factor in the number of false alarms subsequently observed. The number of misses (lower panel) looks more favorable toward the idea that taking the test following the A study phase is responsible for the negative transfer. This is indicated by the fact that on the first simultaneous learning trial there are fewer misses for the subjects in Condition NTT than for those in Condition ATT. However, the difference is of borderline statistical reliability, $t(38) = 2.12$.

Discussion

We will dismiss the idea that the negative transfer phenomenon on which this report has centered is due to new items becoming old as a result of the test given following the A study phase. If the testing

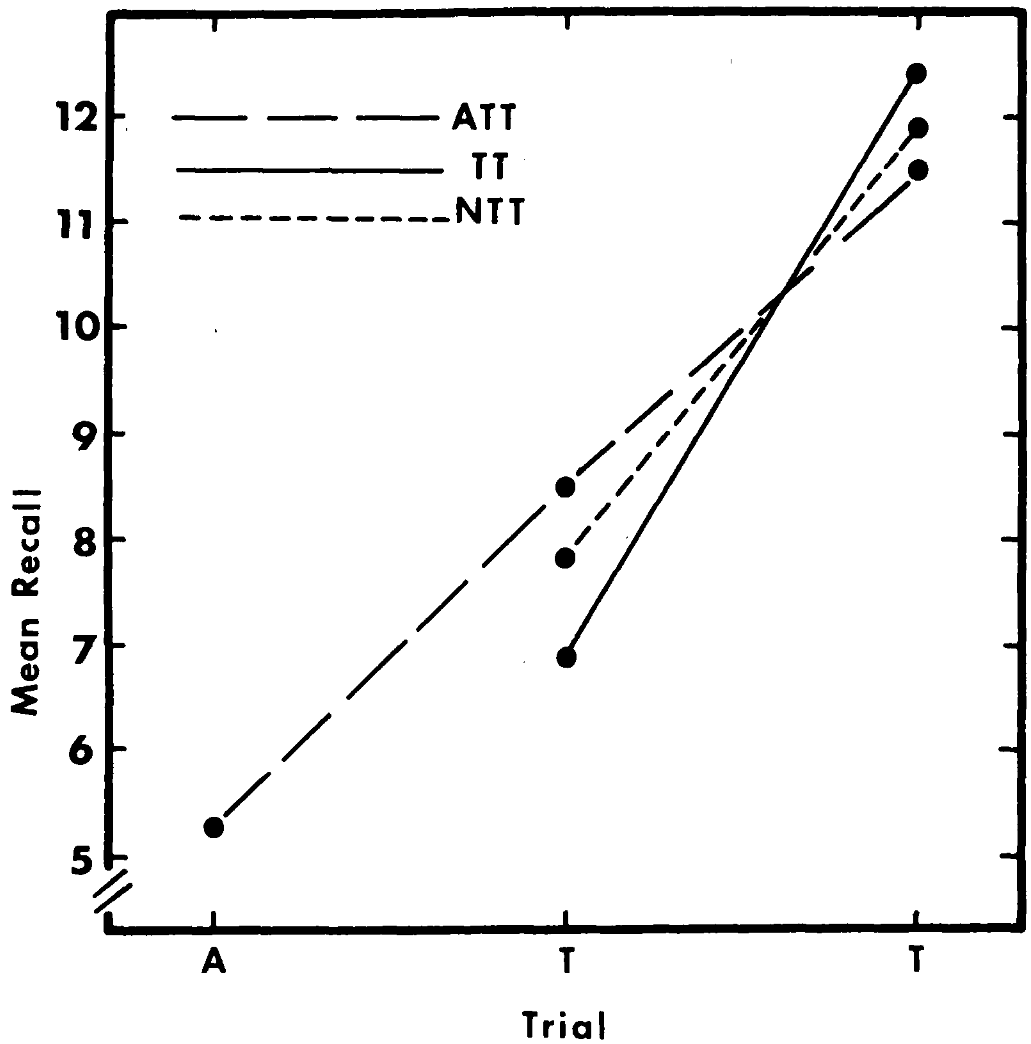

Figure 14. Recall in simultaneous learning with and without an isolated trial before simultaneous learning. Group ATT had an initial study-test trial in isolation, Group NTT had the study but no test, and Group TT did not have the isolated learning or test. Experiment 5.

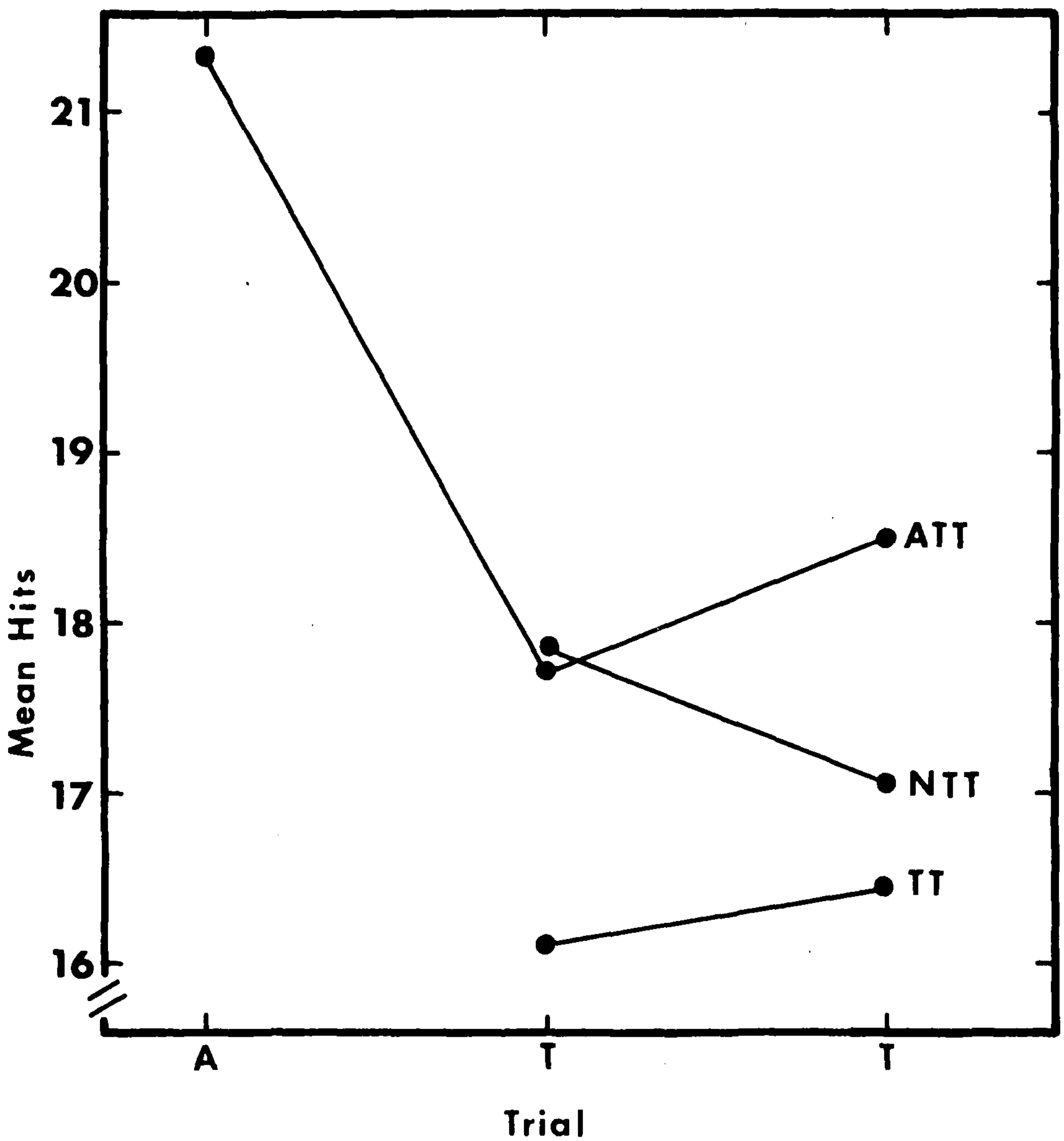

Figure 15. Mean hits on frequency judgments as a function of different study and test procedures on the isolated trial. Experiment 5.

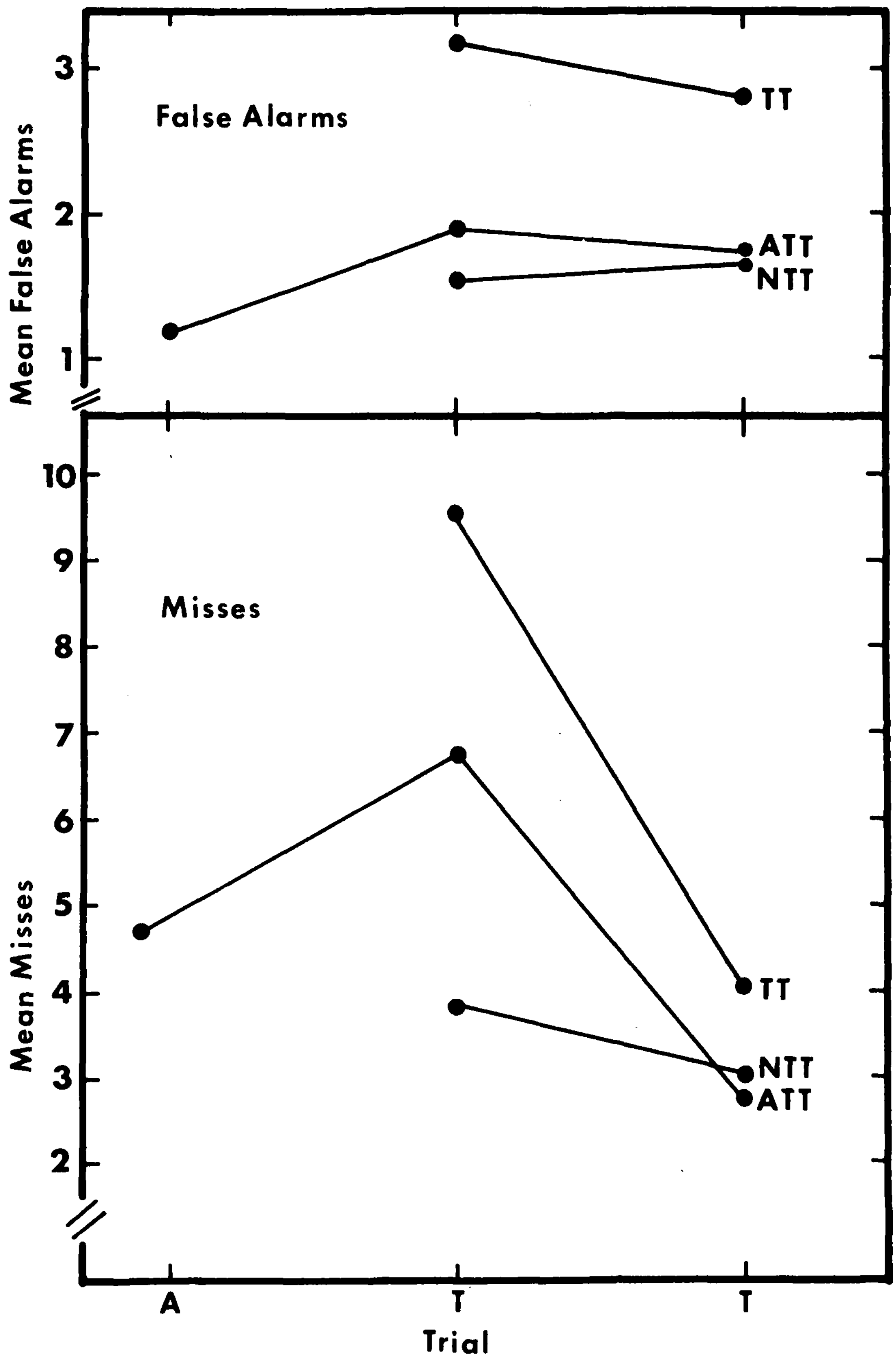

Figure 16. Mean false alarms and misses on the recognition test as a function of different study and test procedures on the isolated trial. Experiment 5.

factor is involved, it is involved in a very small way. It would seem, therefore, that we should look for other factors, in particular, those factors associated with context and context changes.

Throughout this report we have found it necessary to point out again and again discrepancies in the data. Some of these discrepancies are so large that sampling variations cannot easily be suggested as a cause. For example, the difference in the results for recall for Experiments 4 and 5 for Conditions ATT and TT (Figures 11 and 14) were large and obvious, and there is no ready explanation for them. To repeat, we have consistently observed inconsistencies in the results. This may suggest that we are dealing with unstable or fragile phenomena in the sense that they are very sensitive to what may appear to be very minor procedural factors. We indicated some of these possible factors earlier, but there are surely others. Never before in our laboratory (which has been active for over 30 years) have we encountered such sensitivity in any series of experiments.

It may well be that context changes are responsible for our results. Context involves a wide range of variables, from the nature of the physical environment to the emotional state of the subject to the nature of the processes underlying the learning task. One of the problems in the use of context as an explanatory concept is just this diversity. At the same time the diversity should not be allowed to divert one from the use of context as an explanatory notion when it seems appropriate.

It was pointed out earlier that our results seem to be at odds with certain generalizations about context and recognition. Verbal context addition is usually found to have little influence on recognition whereas verbal context deletion has considerable effect. Our results, at least when viewed superficially, seem to speak the opposite. That is, going from isolated learning to simultaneous learning (addition of context) produced larger effects than going from simultaneous learning to isolated learning (deletion). However, there are so many differences in the experiments involved in producing these different sets of conclusions that to try to rationalize them would be of little value. Our interest is in trying to understand how context might be involved in the negative transfer usually observed in going from A learning to T learning. Presumably, an explanation of this phenomenon would also permit us to account for the lack of change in going from T learning to A learning.

The obvious change that occurs when the subject moves from A learning to T learning is the necessity to handle three tasks rather than a single one. Generally speaking, our results indicate that this can be done quite readily for recall, but not for recognition and frequency discrimination. It may be speculated that in A learning the subject goes about each of the three tasks differently. But, upon moving to T learning, these three different "strategies" cannot be easily handled all at once so there is a shift and all the learning or encoding is appropriate for recall. Thus, it might be that the encoding used in A learning for recognition is not compatible with the encoding for recall, and as a consequence the subjects basically start over again when moving from A learning to T learning. Studies on differential encoding for recall and for recognition show rather consistently that studying for recall is quite appropriate for recognition, but that the reverse is not always true (e.g., Hall, Grossman, & Elwood, 1976). Thus, a subject could move from T learning to A learning without a problem, but there could be problems in moving from A learning to T learning if the encoding was different for the three tasks during A learning.

There is another way in which context differences may be involved in our experiments. When the subject moves from A learning to T learning he finds that items from all three tasks occur together on the study phase. Items which occur together in a task where the subject is actively trying to learn something may become associated. Furthermore, if associations develop quickly they may in some way interfere with the use of the information acquired on the A trial which was used for recognition and frequency decisions on the A test trial. In A learning, interitem associations may develop between items in each list but it is quite unlikely that interlist associations would develop. Interlist associations could only develop in T learning. If these associations are in some way inimical to the performance based on information acquired in A learning, the negative transfer we have observed in most of the experiments could be accounted for. If this line of thinking has any validity for trying to understand our results, we need to determine whether or not words which occur together during study on T trials develop associative relationships. The purpose of Experiment 6 was to determine if such associations do develop.

Experiment 6

The logic of the experiment required two stages, one in which simultaneous learning occurred and during which associations could develop, and a second stage where a test was made for associative learning which may have occurred during the first stage. We chose to use a paired-associate list to test for associative learning, the items in the list having previously been a part of the simultaneous learning of two lists by free recall. By using different pairings in the paired-associate list, positive transfer and negative transfer could be anticipated if the words studied together in simultaneous learning did in fact become associated.

Method

Lists. The two lists used in simultaneous learning consisted of 16 four-letter nouns typed in capital letters, and 16 nouns of at least two syllables typed in lower case. The paired-associate list contained 16 pairs, each pair made up of one short and one long noun. The paired-associate list was presented for bidirectional learning, i.e., each word in a pair occurred as the stimulus term half the time, and as the response term half the time. A single paired-associate list was used, with the differences in the transfer paradigms being produced by varying the pairings of the word during simultaneous learning.

Conditions. There were four conditions, differing in the nature of the pairings as they occurred in simultaneous learning and in paired-associate learning. In Condition AP (appropriately paired) the pairings of the words in the test list (the paired-associate list) was exactly the same as the pairings in simultaneous learning. If the two words occurring together in simultaneous learning become associated, positive transfer should occur on the test list for this condition. Condition IP (inappropriately paired) was a contrast to Condition AP in that the two words occurring together in simultaneous learning were never paired on the test list. If associations develop in simultaneous learning they should produce interference as the subjects try to learn the test list in Condition IP. Condition VP (variably paired) was another potential interference condition. There were five simultaneous learning trials and the pairings of the long and short words differed on each of the trials, and a sixth pairing occurred on the test list. Finally, in Condition C (control) the subjects were given simultaneous learning on two lists made up of long and short nouns but none of these words occurred on the test list. This condition serves as a control for nonspecific transfer only.

Procedure and subjects. The lists for simultaneous learning were presented at a 4-sec rate on the study trial, with the order of the pairs differing on each of the five trials. The list of short nouns was always recalled before the list of long nouns; 60 sec were allowed for the recall of each list on each trial. The paired-associate (test) list was presented for one study and eight anticipation trials at 3:3-sec rate. On any given trial, half the stimulus terms were the short words, half were the long words. Across the trials, each word in a pair served equally often as the stimulus terms and as the response term. The pairs were presented in four different orders. The subjects were fully informed about the bidirectional learning of the test list.

Four groups of 20 subjects each (college students) represented the four conditions. Subjects were assigned to conditions from a block-randomized schedule.

Results

Simultaneous learning. There were five trials of simultaneous learning. The mean numbers correct on the fifth trial varied from 9.70

to 12.50 for the various lists viewed individually. In only five cases out of a possible 160 (80 subjects, each having two lists for simultaneous learning) did the subject get all 16 items correct from one of the lists on the fifth trial. We mention these matters to indicate that simultaneous learning did not reach a high level in the five trials.

Transfer to paired associates. The mean correct by trials for the paired-associate test list is shown in Figure 17. As can be seen, the differences in transfer were large. Heavy positive transfer occurred in Condition AP but in fact the amount is underestimated because of a ceiling effect. Seven of the 20 subjects responded correctly to all stimuli on the first anticipation trial. The performance under Condition C is inferior to that under Condition AP, but it is difficult to judge the exact magnitude of the true difference. There are two reasons for this. First, there is the ceiling problem for Condition AP as just noted, and which indicates that we are underestimating the amount of positive transfer. Second, there is the fact that for Condition C it is necessary for the subjects to learn the items per se in the test list whereas that is not true for the other conditions. The performance under Condition C is some unknown amount lower than would have been the case if item learning was not required. The subjects in the other conditions, of course, learned most of the items making up the paired-associate list when they had simultaneous learning. Still, it seems quite unlikely that if we knew the true differences we would conclude that there was no positive transfer in Condition AP.

There are no qualifications concerning the negative transfer produced by Conditions VP and IP. The amount is great for both. The fact that

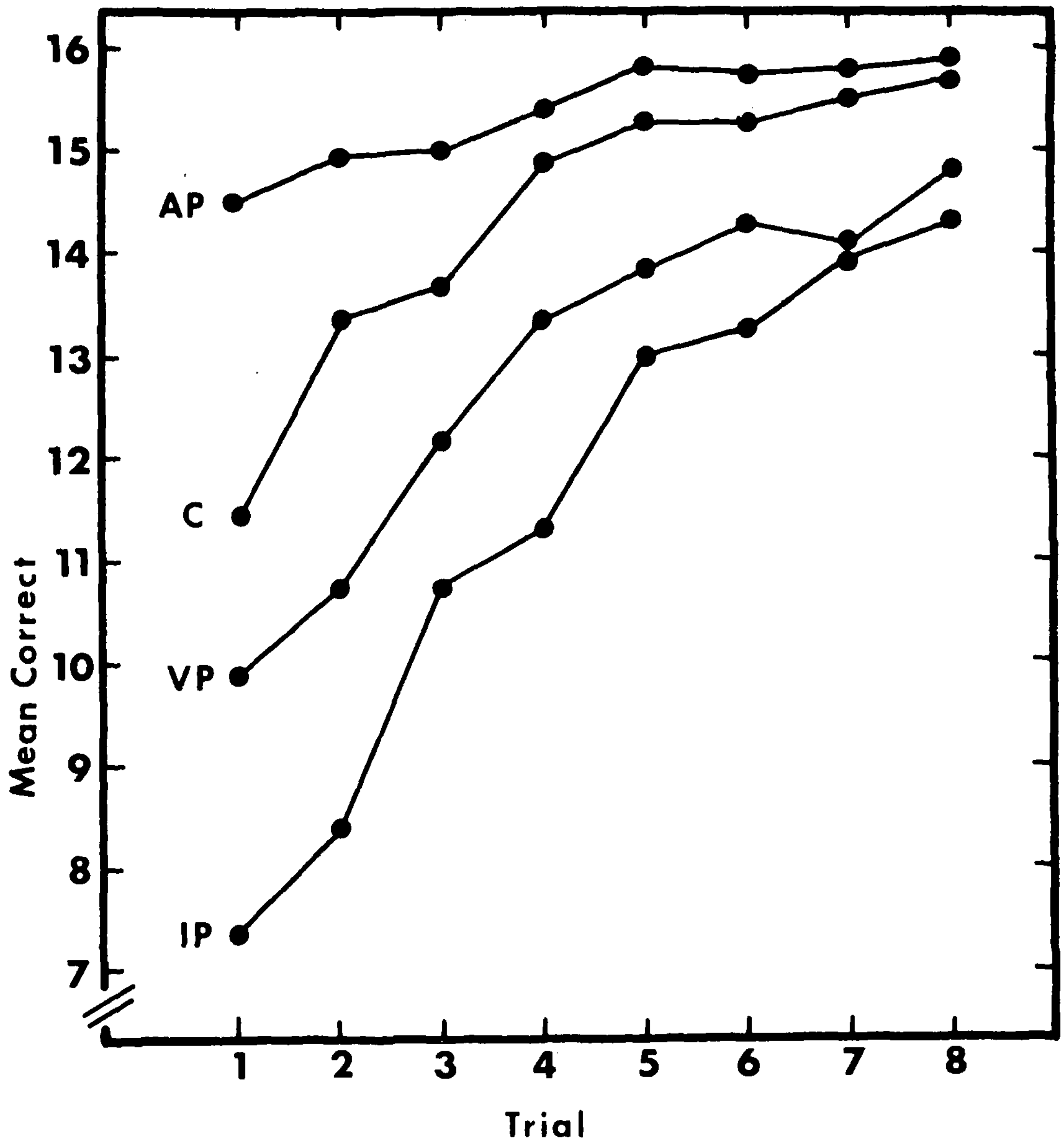

Figure 17. Transfer from simultaneous learning to paired-associate learning. See text for condition descriptions. Experiment 6.

the interference is greater for Condition IP than VP indicates that a single strong associate will produce more negative transfer than several weak associates. Intrustions in the test list reflecting the pairings which occurred in simultaneous learning were numerous in Condition IP, averaging 7.15 for the 20 subjects.

The above evidence leaves no doubt that associations develop between the two words presented together in simultaneous learning, and this is true even if the words are presented together only once. The question that immediately arises concerns the degree of awareness of the subjects in the growth of the associations. Did the subjects deliberately set about to learn the associations or did these associations develop incidentally? Although the experiment was not designed to obtain an answer to this question, we believe that certain of the data are pertinent to the answer.

If subjects deliberately tried to associate the items occurring together in simultaneous learning, they might do so in order to use one word as a cue to produce the other during free recall. If this is true, then it very likely that the output order for the two lists (making up the simultaneous-learning task) should be about the same. We made a determination of the relationship between the output orders of the two lists for Conditions AP, IP, and C on the fifth (last) simultaneous learning trial. The relationship was expressed by a rank-order correlation for each subject. Of course, these correlations could be calculated only for the items which occurred together in simultaneous learning and which were also recalled. Out of the 60 subjects we found only two cases where intentional learning would be clearly indicated. In one case 16 items from both lists were recalled and the order of output for the two lists was identical. This will be illustrated. Let Ab, Cd, Ef, and Gh represent four of the 16 sets of words occurring in simultaneous learning. If in the recall of the four-letter words the output order was E, C, G, and A, and if it was also found that the output order for the long words was f, d, h, and b, the two output orders were said to be correlated perfectly for this subject. The same correlation was found for a second subject who recalled 13 items from each list.

The above two cases were the exceptions. Out of the 60 cases, 26 of the correlations were negative, 34 were positive, thus indicating that overall there was very little relationship between the output orders of the two lists making up the simultaneous task. In turn, this suggests that associations were not learned intentionally in order to use a cueing procedure at recall. It is logically possible, of course, to have associated items used as cues for each other without having the output order of the two lists correlated, but this does not seem likely. It was also determined that the number of times each item was given correctly during simultaneous learning of one of the lists was not correlated with the number of times the item with which it was paired was given correctly. Out of the 60 cases, 23 of the correlations were negative, 37 positive. The average correlation was .10. Again, while these data are not definitive on the matter, they do not indicate that subjects set about to associate the items in order to use the associations to cue the items at recall.

One other finding should be reported. The subjects in Condition C provide a test of the underlying similarities between simultaneous learning of free-recall lists and paired-associate learning. It will be remembered that in this condition the words used for simultaneous learning were completely different from those used in the test list. The correlation between the total number correct for the two tasks across the 20 subjects was .21, far below an acceptable level of statistical significance.

Discussion

This experiment gave a clear answer to the question prompting it. Items occurring together in simultaneous learning do get associated, and strongly so. The amount of negative transfer observed in Condition IP in Figure 17 represents far more negative transfer than is usually found in an A-Br paradigm in the usual two-list transfer situation. In that situation A-B is deliberately learned to a given level prior to learning a second list that is formed by re-pairing the stimulus and response terms of the first list. In the present study the evidence indicates that most subjects did not deliberately try to associate the two words occurring together in simultaneous learning. This may be a key to an account of the large transfer effects. During the test-list learning the subjects would necessarily try to activate situational associations to the stimulus terms. It may be that the subjects simply are not aware of the fact that they had associated items in simultaneous learning, hence they had a difficult time discriminating between the associations learned incidentally and those learned intentionally in the test list. This lack of discrimination is suggested by the intrusion data, data which are particularly sensitive to breakdowns in discrimination.

There are recent experiments (e.g., Glenberg & Bradley, 1979) which show that associations do not develop as a result of the mere contiguity of two words. Nevertheless, if a subject is deliberately trying to learn a central task as per the instructions given him by the experimenter, incidental learning of contiguously occurring items having nothing to do with the central learning task may well occur. This incidental learning appears to occur in verbal-discrimination learning (e.g., Zechmeister & Underwood, 1969), and it seems to have occurred here in simultaneous learning.

General Discussion

The basic findings will be reviewed, although in doing so it must be remembered that the magnitude of some of these effects varied from experiment to experiment for reasons that were not apparent. Performance on a recall task was essentially uninfluenced by the alone-together variable. The learning which occurs in either A or T learning transfers with little loss to the other when recall learning is involved. The number of items recalled is a direct function of study time, and the slope of the function is the same whether the list is given on A trials or on T trials.

Generally speaking, we have viewed the results for recognition and for frequency judgments as showing the same transfer effects. This was not entirely appropriate. The hits for frequency judgments showed no improvement with practice on either A or T trials, but a switch from A to T or from T to A resulted in a rather quick change in performance to a new level. This was most dramatic in moving from T to A, but occurred also in some cases in going from A to T when level of learning under A was low. For recognition the false alarms "behaved" very much as if frequency decisions were being made in that there was very little change in performance on the new items across several A or T trials, although performance was better under A trials than under T trials. When a switch was made from A to T or from T to A, performance moved to a new level after a single trial. For misses, however, the picture was quite different. Performance improved gradually across either A or T trials, and a change from A to T (or T to A) did not result in dramatic changes in performance. The relationships were perhaps best seen in Figures 4, 5, and 6. (We have earlier noted some inconsistencies across experiments; the generalizations made just above cannot always be supported in each experiment).

The above facts suggest that recognition decisions for some of the old items are based on associative learning. This is to say that frequency information (which we assume to be primarily used for recognition decisions) may not enter into some recognition decisions. As has been seen, frequency decisions do not improve gradually across trials (for reasons unknown, but reported in other studies, e.g., Underwood and Malmi, 1978), and neither does the performance on new items in recognition in the present studies. Therefore, frequency information may well lie behind recognition decisions on new items. But, for old items, the gradual change in performance with successive practice trials suggests that associative learning was taking place for items not initially correct.

We have seen in Experiment 6 that items occurring together in simultaneous learning become associated, and that the level or strength of the associations was high after five trials as inferred from the large amounts of positive and negative transfer which was observed. It may be that this associative learning which occurs in simultaneous learning in some way disturbs the utilization of frequency information developed in isolated learning. We do not know just how this disturbance would occur. That it occurs in moving from A to T trials but not in moving from T to A trials could be handled by assuming that frequency information which develops in T learning initially is independent of associative relationships. However, this is quite post hoc and will not be pressed.

Some Implications

Three implications will be noted and discussed briefly.

1. The present data, along with those of many other investigators working with other paradigms, make it necessary to consider seriously the possibility that recall performance and recognition performance are based on different types of information. Although the discussion earlier raised the possibility that recognition of some old items could be based on associative learning (similar to the basis for recall), it is our belief that most of the recognition decisions are based on frequency information. Certainly in our experiments the differences between recall and recognition were marked in that recall was not subjected to the negative factors in moving from A to T as was recognition and frequency judgments.

2. There was an astonishing amount of associative learning that occurred for items appearing together in simultaneous learning. This learning occurred with very little expense in that simultaneous learning of two or more tasks proceeded just about as rapidly as did the learning of single tasks when total time was adjusted. It would be theoretically possible to program a learning situation in order to take advantage of this learning which takes place without expense.

3. The negative effects of moving from A to T learning might be said to be due to change of context. But if this is true, then a puzzle arises as to why moving from T to A does not produce an effect due to change of context. Indeed, simultaneous learning appears to make the tasks learned free of contextual restraints (Experiments 2 and 3). This may be one reason why simultaneous learning leads to better long-term retention than does isolated learning (Underwood & Lund, 1979). The greater the number of different contexts in which an item is acquired or practiced, the less is the memory dependent upon any particular context for its elicitation. With respect to this matter, it should be noted that simultaneous learning could consist of two or more tasks, all of which are recalled. This is to say that the better retention following simultaneous learning than following single-task learning is not dependent upon the use of different types of retention measures for the different tasks.

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