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Richard C. Galbraith and Benton J. Underwood

Northwestern University

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ON THE INDEPENDENCE OF ATTRIBUTES OF MEMORY

Richard C. Galbraith and Benton J. Underwood[1]

Northwestern University

The evidence seems to indicate that memories may be considered to be constituted of different types of information or different attributes (Underwood, 1969). Two broad problems are defined by this framework. First, there is the matter of identifying the various attributes which constitute the memories and the conditions under which the attributes do and do not become a part of a memory. The second problem concerns the role which the attributes play in memory functioning (in performance). These two problems are conceptually distinct but the inability to devise experimental paradigms which will reflect this separation is a fundamental source of controversy. The issue may be stated in more specific terms. It may be shown that the attributes A and B are a part of the memory for a task when performance is tested by a technique devised for this purpose, e.g., the Wickens (1970) release-from-proactive-inhibition technique. But if another memory test is used which does not allow this determination, it is difficult to discover whether A alone, B alone, or both A and B were responsible for the performance. Additional comments are necessary to provide a broader perspective to the issue.

It can be seen that if some attributes of memory are irrelevant in the performance of a task, it is another version of the classical distinction between learning and performance. A discrepancy between learning and performance in memory functioning could exist for two

[1]We wish to thank John J. Shaughnessy and Alan S. Brown for their many helpful comments on an initial draft of this paper.

reasons. First, the components of the memory test may be so changed from those existing at the time the memory was established that the appropriate stimuli for some attributes are absent. The extent to which this happens is essentially unknown, although speculations about the role of context change in memory functioning are aimed at this problem.

The second reason why there may be an apparent discrepancy between the attributes of memory and the utilization of the attributes in performance lies in the control which the subject may exercise over the utilization. This is to suggest the possibility that a subject may utilize attributes in a selective way depending upon his perception of the demands of the task. Subject control is the central issue of the present report, and initially it must be referred back to the two basic problems stated at the outset.

Attribute control may exist during the storage phase or during the performance phase. Referring to storage, certain attributes inevitably become a part of memories so long as perception at a rudimentary level occurs. Understanding a spoken message requires acoustic discriminations and the acoustic attribute, therefore, must become a part of the memory although either its permanence or its dominance among other attributes, may be questioned. Occurrence information or event frequency appears to be another obligatory attribute. There are, however, other attributes which appear to be under some volitional control and may or may not become a part of the memory. Certain transformational encoding processes, such as changing RCH to RICH, seem clearly to rest on volitional processes and thereby influence the composition of the memory. Other procedures, however, which are intended to influence the composition of memories cannot be easily interpreted as representing attribute control of storage. Instructions to form images when noun stimuli are used in a paired-associate list enhances performance (e.g., Paivio, 1971). This could be interpreted as changing the composition of the memory. Yet, it is quite possible that the instructions merely aid the subject in selecting the attributes which determine the performance and that the nature of the storage did not differ as a function of the instructions. This same problem of interpretation exists when performance differs as a function of the expected type of memory test (e.g., Carey & Lockhart, 1973). It would seem reasonable that different expectations could lead to different memory compositions but it may be that they lead to differences in attribute selection at the time of performance. Of course, both composition and selection may be influenced.

Differences in assumptions concerning attribute selection during the performance phase has been productive of theoretical disagreement. Some of these disagreements may be noted. The question of whether or not recognition tests involve retrieval mechanisms (associative attributes) did not arise because of differences in assumptions about the attributes constituting the memory. Rather, disagreements developed because of differences in opinion concerning the attributes which mediate performance. The issue concerning the contribution of acoustic attributes and semantic (or associative) attributes to short- and long-term memory functioning does not basically hinge on the presence or absence of the attributes in memory but on differences in beliefs concerning their role in performance. In verbal-discrimination learning, associations develop between the units in each pair. The two units also have differential frequency. The theoretical problem does not revolve around the question of whether or not these attributes are a part of the memory but rather around their functions in the subject's performance.

It has been implied that a subject has the capacity or skills to select attributes from among those forming the memory for a task and to mediate or produce his performance thereon. It seems beyond doubt that some control of attribute usage must be possible. The question asked by the present experiment is directed at the precision with which the subject may control attribute selection depending upon performance demands. For reasons which will become apparent as the rationale is given, the conditions were devised in such a way that unless attribute selection was complete and uninfluenced by other attributes, it could be detected in the performance scores.

Rationale

The subject was presented sets of A-B, A-C pairs, that is, pairs with common stimulus words and different response words. One of these pairs in each set (A-B) was arbitrarily called a correct pair, the other (A-C), an incorrect pair. This information was given to the subject as each pair was presented by the presence of a plus sign (A-B+) or a minus sign (A-C-). Sometimes A-B was presented more frequently than A-C, sometimes the reverse, although over all of the pairs presented the plus sign appeared more frequently than did the minus sign. Before the long list of pairs was presented, the subject was explicitly informed that he would be tested for his knowledge of the frequency with which each pair was presented (frequency attribute). Second, he was told that he would be tested for the rightness or wrongness of the pairs. Thus, the instructions made it clear that the memory should consist of the frequency attribute and an associative attribute. The exact nature of the associations involved cannot be specified. The pair, or at least the response term, may become associated with plus sign or with minus sign, or with rightness and wrongness. But it is also possible that two affective categories may have been involved. Whatever the nature of the association which developed to mediate classification performance, it will be spoken of as the associative attribute.

On the test the subject was presented the sets of A-B, A-C pairs without the plus and minus signs present. In one case he was asked to identify the more frequently presented pair of the set, and in the other to identify the class (plus or minus) to which each pair belonged. Consider the situation which faced the subject on the test. The magnitude or strength of the two attributes should be correlated. The greater the frequency of the pair the greater should be the strength of the classification learning. If, when requested to make a classification decision, the subject is unsure, and if the two attributes are not functionally independent, the classification decision should be influenced by frequency information. More particularly, since over all of the pairs the correct symbol (+) occurred more frequently than did the incorrect symbol (-), the subject should identify the more frequent pair as belonging to the correct category. The question, then, is the degree to which the subject can handle correlated information in performing the two tasks.

In the experiment, the frequency of the A-B+ pairs was held constant for all sets, but the frequency of A-C- pairs was varied at three levels, being less than, equal to, and greater than A-B+. Two possible outcomes, representing independence and complete dependence of attributes, are sketched in Figure 1. Logically, if there is dependence, the associative information could influence frequency judgments or frequency information could influence the classification decisions. However, because of the stability and fidelity of frequency judgments shown in previous work, it was anticipated that if dependence was present it would be shown by the frequency information influencing the classification decisions and not the opposite. The expected outcome for the frequency decisions is represented by the dashed line in Figure 1. If the number of times A-B was chosen as belonging to the correct category is completely dominated by the frequency information, the outcome (decreasing solid line) should be the same as that for the frequency judgments. When A-B has greater frequency than A-C, the fre-

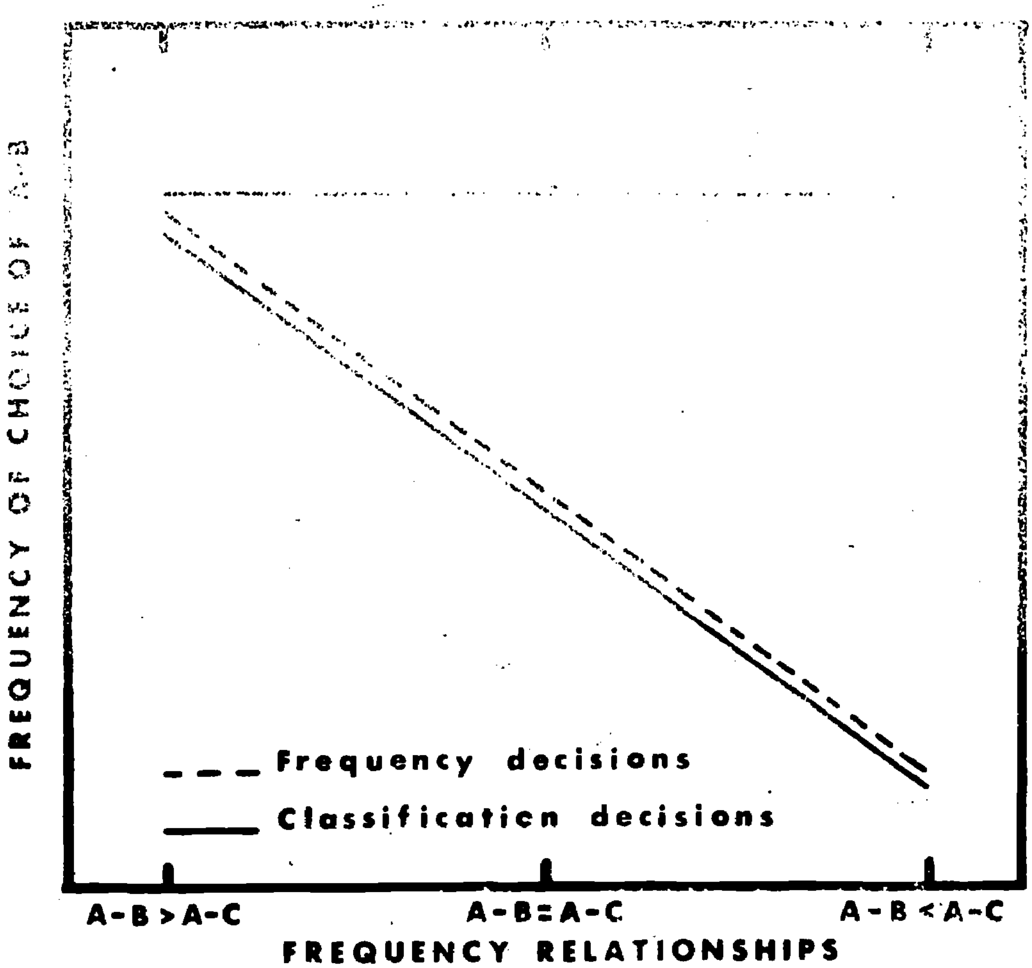

Figure 1. Two possible outcomes of the test of the independence of memory attributes. Frequency judgments were expected to show good discriminations. If the associative attribute required in learning the classification response is completely dependent upon the frequency attribute, the slope of the line will be the same as for the frequency judgments. If the two attributes are controlled independently, the horizontal line will result for the classification learning, although the level is indeterminate.

quency information and the associative attribute are coordinate. When the freq[illegible] of A-C is greater than the frequency of A-B, A-C should be chosen as correct if frequency dominates this decision. If, however, the subject can respond on the basis of one attribute without being influenced by the other, the frequency of choice of A-B as the correct item should result in the horizontal solid line seen in Fig. 1. This outcome would be taken as evidence for complete independence. In view of the fact that A-C frequency increases from left to right (with A-B frequency constant), classification performance may in fact increase correspondingly. This outcome would still be interpreted as representing independence. Of course, if classification performance produced a slope which fell between the slopes shown by the two solid lines in Fig. 1, partial dependence of the two attributes would seem to be the appropriate conclusion.

Method

Design. The rationale sketched the basic outlines of the experiment. Several additional decisions were necessary to implement the design. In considering the use of correctness and incorrectness as the basis for a two-category classification task, it seemed possible that this particular classification might not be neutral in the sense that it could imply reward and punishment. Therefore, with other groups of subjects, the correct-incorrect classification was replaced with neutral classes, namely an asterisk and a number sign (*,#). The asterisk was simply substituted for the plus sign on A-B pairs, the number sign for the negative sign on A-C pairs. The basic design, therefore, called for four groups:

Group CI: Correct-incorrect (+ or -) classifications of the A-B, A-C sets on the test.

Group CI-FJ: Relative frequency judgments of the two pairs within each A-B, A-C set.

Group AN: Asterisk-number sign classifications of the pairs.

Group AN-FJ: Relative frequency judgments of the pairs within the asterisk-number sign sets.

Differential frequencies of the A-B, A-C pairs within the sets were, of course, manipulated as a within-subject variable. In a given list there were 24 A-B, A-C sets. For 12 of these sets, A-B was presented twice. For eight of these, A-C occurred once (2:1), for two A-C occurred twice (2:2), and for the final two sets, A-C occurred four times (2:4). For the other 12 sets, A-B was presented four times. For eight of these, A-C occurred once (4:1), for two sets A-C occurred four times (4:4), and for two sets, eight times (4:8). Thus, for each of the two base frequencies of A-B (2 and 4), A-C was presented less frequently, with equal frequency, and with greater frequency.

The asymmetry in the number of pairs at each frequency combination was used as a means of having the correct pairs and asterisk pairs occur with greater frequency overall than the incorrect and number-sign pairs. The number of different sets which could be used in a list was necessarily limited if appreciable learning was to be expected. However, the number of sets at each frequency combination was increased to a minimum of six by using three different lists.

One further matter should be mentioned by way of explaining the nature of the lists. It would have been possible to conduct the experiment using single-word presentation. However, given a certain outcome of the study (which in fact did not occur) there was an intent to relate the findings to paired-associate learning and to issues related to negative transfer. Therefore, the A-B, A-C paradigm was used. A discerning subject might learn to classify and to sum frequencies only on the basis of the response terms for this paradigm. Two steps were taken to minimize this possibility. First, the subject was required to pronounce each word in the pair during the study trial, and second, some filler pairs forming A-B, C-B paradigms were included to counteract any tendency to attend only to response terms. Words used in these A-B, C-B pairs were, of course, different from those used in the A-B, A-C pairs.

Lists. The 252 words used represented a random sample of two-syllable words within the 1-10 frequency range in the Thorndike-Lorge (1944) tables. All assignments to be described were made randomly except that no two words were paired if they had the same initial letters. Each of the three lists was made from 84 different words. There were 24 sets of A-B, A-C pairs (72 words) and four sets of A-B, C-B pairs (12 words). For all of these latter sets, A-B was presented four times (accompanied by a plus sign or an asterisk) and C-B was presented twice (with minus sign or number sign). A total of 148 positions, 124 for the A-B, A-C pairs and 24 for the A-B, C-B pairs, was required. For all pairs within the list the plus (correct) sign for Groups CI and CI-FJ occurred for 60% of the positions, as did the asterisk for Groups AN and AN-FJ. The first six positions and the last six positions contained A-B, C-B pairs, the other 12 positions required for this paradigm being within the body of the list. The spacing of the pairs constituting an A-B, A-C set was based on the total positions in the body of the list. Thus, when A-B was presented twice and A-C four times, one of the six occurrences was in each sixth of the body of the list. Otherwise, the positioning was random, i.e., whether A-B or A-C occurred first in the list or last in the list was determined randomly.

To reduce the likelihood that the results would be biased by particular pairings, four different forms of each of the three lists were constructed, with the function of a particular word varying from form to form.

Procedure and subjects. Prior to presenting the first list, the subject was explicitly instructed that on at least one of the tests in the series he would be tested for his knowledge of the frequency with which each pair was presented, and also his knowledge of the class to which each pair belonged. Sample cards illustrated the nature of the pairings (A-B, A-C and A-B, C-B) and the classification symbols. The subjects in Groups CI and CI-FJ were told in addition that the plus sign meant correct, the minus sign, incorrect.

The pairs were presented at a 1.5-second rate on a memory drum with the subject instructed to pronounce the words in each pair. It was expected that the rate used and the pronounciation requirement would diminish the possibility of the subject rehearsing pairs shown earlier in the list. After the presentation of the first list, the test on this list was administered. The test booklet consisted of a randomized ordering of the sets of pairs. Subjects in Groups CI and AN were required to mark each pair in the set with its appropriate label. Groups CI-FJ and AN-FJ ranked the frequency of each pair in a set by placing a "1" next to the more frequent pair in the set, and a "2" next to the less frequent pair. The A-B, C-B pairs were also tested but not scored.

After the test for the first list was given, the second list was presented for study, tested, and then the third list was presented and tested. After each of the first two lists was tested, the subject was informed that on the following list he might be tested for either his frequency knowledge or his classification knowledge. However, a given group was tested in the same manner (classification or frequency judgments) on all three lists. Following the test on the third list, the subject was given another test booklet and was asked to make the other type of decision. Those having frequency judgments thus made classification decisions on the third list after having made the frequency judgments, and those who first had the classification test made frequency judgments as a second test on the third list.

Each of the four groups consisted of 40 college students. They were assigned to a group by a block-randomized schedule which also included the four forms of each of the three lists.

Results

The response measure was the number of times the A-B pair of the A-B, A-C sets was selected as being correct (Group CI), as belonging to the asterisk class (Group AN), or as being the more frequent of the two pairs (Groups CI-FJ and AN-FJ). The values for the six different A-B, A-C frequency combinations were summed across the three lists and converted to percentages. The results for the sets when A-B had a frequency of two are shown in the left panel of Figure 2, and in the right panel when A-B frequency was four. A comparison of these results with the two possible outcomes shown in Figure 1 indicates that the results match precisely the outcome which indicates independence of the two attributes, or at least, the independence of the two performances. The essential facts may be pointed out. The percentage of times A-B was chosen as being more frequent decreases appropriately across the three frequency combinations, with the accuracy being greater the greater the frequency difference between A-B and A-C (left panel versus right panel). The two dashed lines essentially fall on top of each other indicating that the nature of the symbol appended to the pairs (plus-minus versus asterisk-number sign) had no differential influence on the frequency judgments. This is true in spite of the fact that, as will be shown shortly, classification performance differed as a function of the classification symbols. Classification decisions were independent of the frequency relationships between A-B and A-C, although performance on the classification tests increased as the frequency of A-B increased

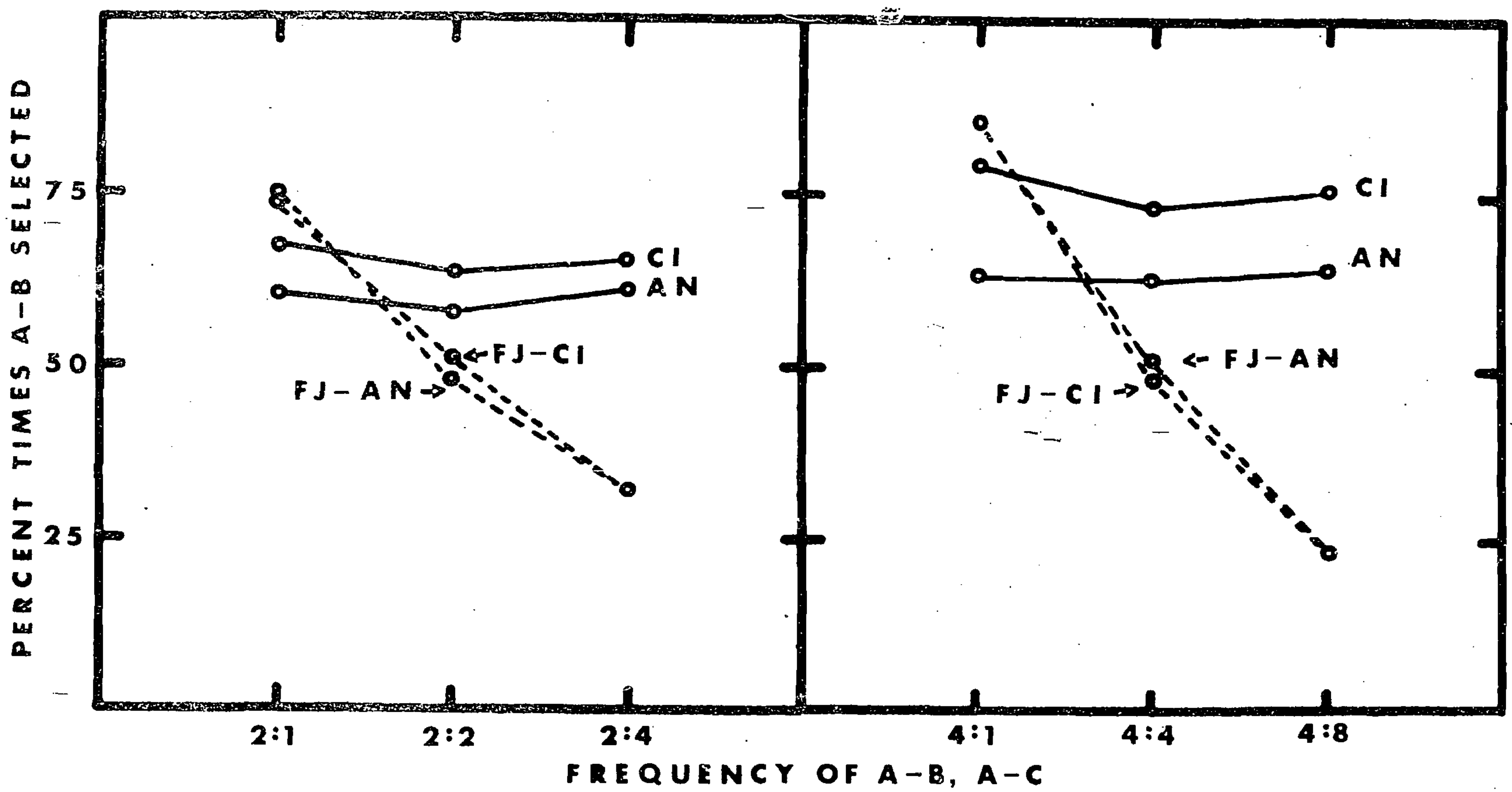

Figure 2. Correct classification responses (Groups CI and AN) and correct frequency judgments (Groups FJ-AN and FJ-CI) as a function of relative frequency differences for A-B and A-C pairs. The base frequency of A-B is two in the left panel, four in the right.

(the level of the horizontal lines increases, although not greatly, from the left panel to the right panel).

The fact that the absolute level of performance on the classification tasks was not great provides striking secondary support for the conclusion of independence. Under circumstances where the subjects must have been unsure of the correct classification on many occasions, the relative frequency of A-B and A-C did not influence their decisions. That is, A-B was not chosen more frequently as belonging to the plus class or asterisk class when it was more frequent than A-C than when the frequency of the two was equivalent, and A-C was not chosen more frequently than A-B than when the frequencies were equal.

The interactions between the frequency judgments and the classification responses were, of course, highly reliable statistically ($F = 45.23$ for the left panel of Figure 2, 112.80 for the right panel). Figure 2 also indicates that classification performance was better for Group CI than for Group AN. An analysis was made of these two groups, including in the analysis the base frequencies (2, 4), type of classification (AN, CI), frequency differences (less than, equal, greater than), and the four forms of the lists. The outcome showed that base-frequency difference was reliable, $\underline{F}$ (1, 72) = 24.31, $\underline{p} < .01$, indicating that classification performance was better the greater the number of presentations of the A-B pairs. Figure 2 indicates that classification performance for subjects dealing with the plus-minus symbols was better than for the groups dealing with asterisk-number sign symbols, and the difference was reliable, $\underline{F}$ (1, 72) = 9.38, $\underline{p} <.01$. Furthermore, there was an interaction between symbol type and base frequency, $F(1, 72) = 4.30$, $p < .05$, indicating that the improvement in classification performance increased more rapidly over presentations for the groups dealing with the plus-minus symbols than for those dealing with the asterisk-number sign symbols. Finally, the near complete lack of any effect of the frequency differences on classification performance was evidenced by the F of .69.

The data used for Figure 2 were based on the sum of the performance for each subject across three lists, and a given subject had only one type of test. It is proper to ask whether or not these data can be taken to mean that a subject carried both frequency information and associative information as a part of the memory for the task. That is, it might have been that after the first test the subject only "stored" the information that was tested on the first task. This does not seem to be the case. The basic relationship shown in Figure 2 held on each of the three lists, including the first one, and on the first test the subject had no reason to expect one type of test over the other. The most critical data on this matter derive from the third list where the subjects, after being given one type of test, were then given the other type. The data on this second test for the third list may be displayed in the same manner as were the data in Figure 2. To increase stability, the data for the groups having the different types of classification labels have been combined. The plot is shown in Figure 3.

It can be seen that generally speaking, independence is maintained on the second test. Classification remained uninfluenced by frequency differences at both base-frequency levels. The only evidence of disturbance occurred for the frequency judgments for the base frequency of four as seen in the right panel. The choice of A-B as being more frequent than A-C was appreciably above 50% when they were equal in frequency. Too, choice of A-B as being more frequent was about 40% when the ratio was 4:8 in favor of A-C. The corresponding value in Figure 2 was approximately 25%. These data indicate that the phenomenal frequency judgments changed following a classification test. Taken at face value this would indicate that the classification decisions influenced the immediately following frequency judgments. However, if this is true, there appears to be little generality since it did not occur for a base frequency of two. The act of taking the classification test could well influence the apparent frequency of the pairs so that a subsequent test of frequency discrimination would reflect this. Further, there was a relatively small number of pairs determining the values at the point of equality (4:4) and at the point where A-C was more frequent than A-B (4:8). It seems reasonable to conclude that the shift in frequency judgments (using the data of Figure 2 as a reference) shown in the right panel of Figure 3 should not be allowed to obscure the basic generalization; a subject is quite capable of making successive decisions, one requiring associative information, the other frequency information, with at best but little "slippage" between the two types of information.

Two facts require further comment. It was noted that the subject could deal more effectively with plus-minus symbols than with asterisk-

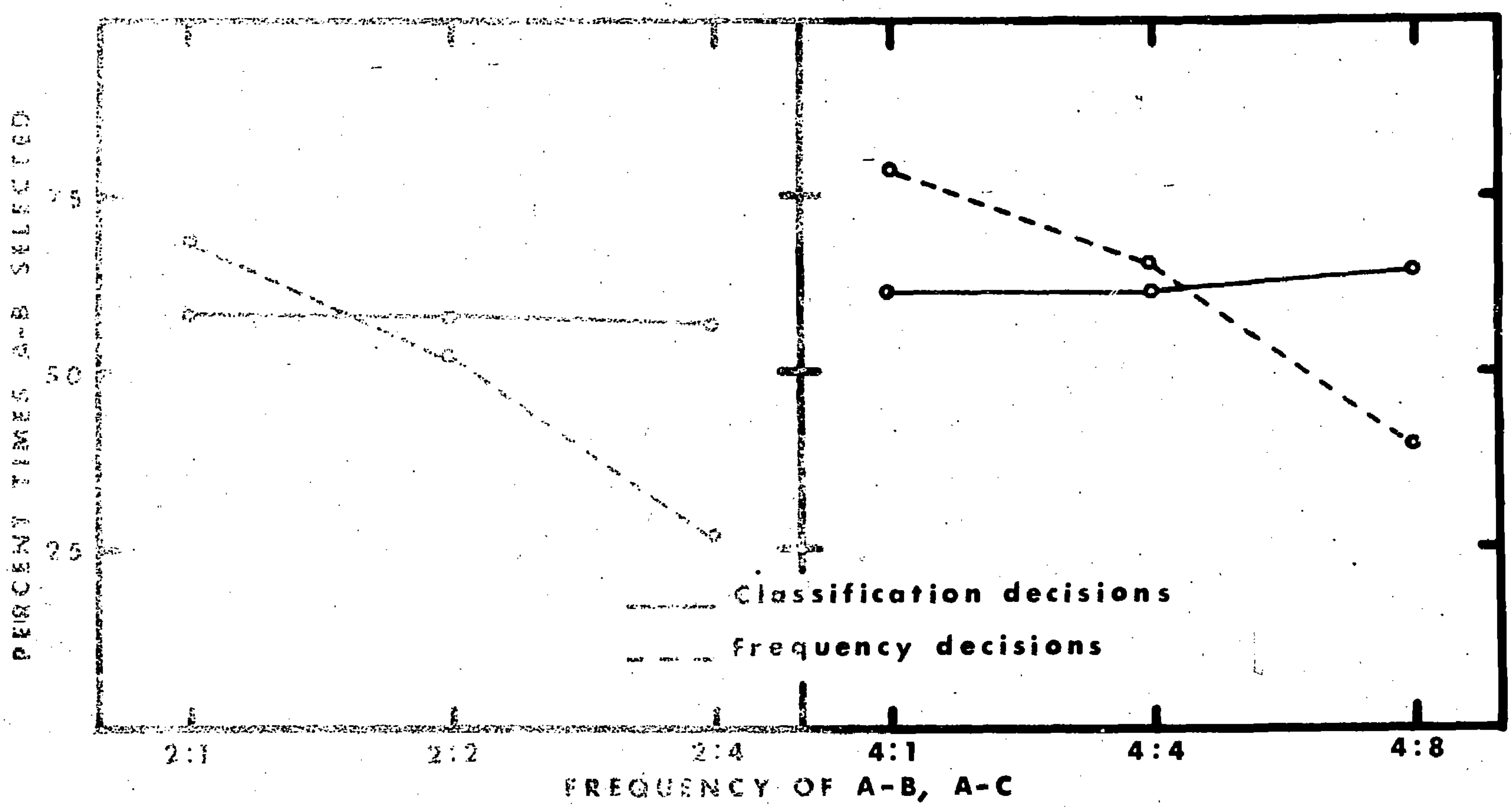

Figure 3. Performance on the second test of the third list. Groups having different classification symbols have been combined.

number sign symbols. It will be remembered that the plus-minus symbols were representative of rightness and wrongness. It is likely that the subject is more practiced in using right-wrong categories than in using asterisk-number sign categories. In effect, the two symbol classes represent different levels of meaningfulness, and the learning rate might be expected to differ because of this.

The second fact concerns the classification performance as a function of A-C frequency. The data in Figures 2 and 3 showed that the accuracy of classification did not differ as a function of A-C frequency. Knowledge of the appropriate classification of A-C should increase as the number of presentations increases. It would seem that it should automatically follow that the classification of A-B should be better the higher the A-C frequency. This did not happen; why it did not is not clear. There are a number of possibilities. First, as judged by the differences associated with base frequencies two and four, classification performance increased very slowly with the increases in frequency of presentation of the pairs. This was particularly true for the classification based on the asterisk-number sign labels. The rate of presentation was rapid and the subject was required to pronounce the words in each pair. Both would be expected to produce a slow rate of change in classification performance over presentations. Another possibility is that the subject made no attempt to learn the classification of A-C; rather, he attended only to the classification ascigned A-B. This might be a possibility for the plus-minus labels, but it is certainly not clear why it would occur for the asterisk-number sign labels. Another possibility is that some of the subjects did show increasingly better performance on the classification task as A-C frequency increased, but that the other subjects made classification decisions based on frequency (indicating a lack of independence between the attributes). Two considerations argue against this interpretation. First, to obtain the horizontal lines for the classification performance (as seen in Figures 1 and 2) would require a very delicate balance between the two opposing factors. Second, and perhaps more critical, there should be bimodality in the performance scores if the two opposing factors are operative. An examination of the scores gave no hint of bimodality.

The answer to the puzzle -- the puzzle of why classification performance did not increase with the increase in A-C frequency -- remains to be discovered. However, given the fact that there was no bimodality in the distributions, the conclusion concerning the independence of the attributes in determining performance remains firm, and should not be modified by the failure of the performance on the classification task to increase as A-C frequency increased.

Discussion

The results of this study are interpreted as a demonstration that under certain conditions there is complete independence of memory attributes in determining performance. It was as if the subject could select appropriate memorial information for making decisions requested without these decisions being influenced by other memorial information known to be a part of the memory. This was true in spite of the fact that in the present study there was a built-in small but positive correlation between the two attributes and performance on the two tasks. That is, always choosing the more frequent pairs would have produced above chance performance on the classification task. So too, always choosing the more frequent symbol would have given above chance performance on the judgments of frequency. The evidence indicated that the subjects did not behave in this case on a probabilistic basis. The task demands dictated the choice of attributes and the subject seemed perfectly capable of keeping one attribute functionally isolated from the other.

The present study is to be viewed as a demonstration of independence, not as an analytical study which explored the conditions under which independence does and does not obtain. For example, the instructions to the subjects that he would be tested on both tasks may have reduced the level of his performance on both tasks as compared with instructions that he would be tested on only one task. The classification task was not rapidly learned, so that some form of time-sharing between the two types of attributes is a distinct possibility. The present experiment simply was not intended to answer such questions. To repeat, the experiment simply demonstrated that rather complete independence is possible.

The experiment reported involved only two attributes of memory. It would not be expected that all attributes could be so functionally isolated as they appeared to have been in the present study. Hintzman and Block (1970) showed some independence between frequency estimations and the judgment of successive repetitions (which may represent a duration judgment) but it was by no means complete. Essentially the same conclusion was reached in a different study (Hintzman, 1970). It seems beyond doubt that conditions could be devised in which independence would break down. For example, if two attributes can both mediate performance for, say, 90% of the items, and if the two attributes are in conflict (would produce different responses) on the other 10%, it seems likely that there would be an interplay between the two attributes on the items constituting the 10% of the total. This should be most likely when performance is at a low level but the overall correlation between the two attributes in determining performance has also been perceived. To conclude (as has been concluded above) that independence can be shown is not to say that it will always be shown. Nevertheless, a number of implications and speculations about memory are suggested by the possibility of independence. Some of these will be considered.

Assume that a task is such that two (or more) attributes are perfectly correlated in the sense that either could mediate correct performance effectively. As noted in the introduction, these situations can be sources of theoretical disagreement. It seems clear that the present study makes three facts manifest about such situations. First, for a theorist to assume that the performance is mediated by one of the attributes exclusively is perfectly reasonable in view of the demonstrated independence which can be maintained in the utilization of attributes. Second, if a theory which emphasizes the exclusive role of a particular attribute in performance successfully survives experimental tests it must not be concluded concomitantly that the other attributes are not a part of the memory for the task. The distinction between learning (the attribute composition of memory) and performance (utilization of attributes) must be maintained in such situations. Third, generally speaking, such situations are not going to result in theoretical resolution if the theories disagree as to the attribute utilized in performance. It is probably not even possible to tell when one attribute is utilized as a checking device on the decision mediated by another attribute. The situation in which two or more attributes are near perfectly correlated is a relatively impotent one in the search for theoretical arbitration by experiment. Theoretical arbitration will be most likely to occur, it will now be argued, when conditions are sought which will cause a breakdown in theoretical expectations, thereby restricting the range of phenomena to which it is applicable.

Experimental work of recent years has resulted in a broadly expanded conception of memory in terms of the many different types of information which are now accepted as constituting a memory. In a manner of speaking, memory may be likened to a highly flexible instrument with many systems, some of which are independent operating units in mediating performances. A theory which chooses one of these systems as an exclusive (or even major) determinant of all performances reflecting the operation of memories must assuredly be on the wrong track. To choose one attribute or operating unit as being fundamentally involved in producing the performance on certain types of tasks has some chance of being useful. Theoretical purchase will be obtained on memory functioning by determining the limits of the role of particular attributes. To show a breakdown of the performance-mediating capabilities of a given attribute may in fact add to its usefulness as a theoretical device in a circumscribed set of tasks. An illustration will be given.

Frequency theory assumes that apparent frequency of events and apparent frequency differences of events are fundamentally involved (are the major bases) in recognition decisions. Predictions from these relatively simple premises have met with some success. Such success could lead the theoretician to believe that frequency information may also be important for nonrecognition tasks, indeed, for all phenomena of memory. To scotch this heady approach, and at the same time perhaps to make the theory more plausible in the limited area of memory functioning for which it was intended, the boundry conditions for its breakdown need to be established. Broder's (1973) findings established that there is a clear breakdown point for the role of the frequency attribute even in recognition memory. Without detailing his procedures, it can be stated that when both frequency information and associative information (two-category classification) were relatively precise but in partial conflict (32% of the items), the subject did not continue to respond blindly on the basis of frequency information. Rather, performance was determined by associative information in those cases where frequency information was invalid. The subject only responded on the basis of frequency (and was thereby incorrect) when associative learning was at a very low level, and probably the subject would not have responded in many cases had it not been a forced-choice test. Experiments which establish limitations on the role of particular attributes in performance seem necessary if we are to understand the relationship between memory and performance.

Although the above comments were not without speculative overtones, the matters following must be explicitly identified as speculative. The notion that attribute selection is based upon the subject's perception of the task demands has been expressed earlier. It is difficult to specify the amount of the variance in performance scores which result from this variable. One reason why careful instructions are given in the laboratory prior to presenting a task is to minimize variance. It is probably correct to say, however, that it is commonly believed that such instructions influence the composition of the attributes constituting the memory for the task. But it is not at all obvious that instructions influence only the composition of memory. It is possible that the composition may be relatively constant across subjects and that the variance in the performance results from the differences among subjects in the selection of attributes to mediate performance. Instructions may influence selection, not composition. To insist that there are no individual differences in learning or storage of attributes would probably be too strong, but it might not be improper to suggest that individual differences in the selection of attributes to mediate performance may be as great or greater than those involved in learning. This is, of course, another possible version of approaches which place heavy emphasis on retrieval processes and relatively little emphasis on storage. The problem which plagues all such conceptions is that at the present time there seems to be no way to get an experimental discrimination between learning or storage differences and retrieval or attribute-selection differences. Memory composition and attribute selection from memory are sequentially ordered with the latter dependent upon the former; they intervene sequentially between the material given for learning and the performance. With present methods it is difficult to assess the role which each plays in performance because of the variance which may occur in memory composition and the variance which may occur in attribute selection. It is particularly difficult to identify the particular locus of variance when nonobligatory attributes are involved. If the attributes of interest are truly obligatory, a decision is possible.

The basic idea of attribute selection is that the subject may set aside certain attributes of memory when they are perceived as being inappropriate for the performance required. There are two obvious variables which are involved. First, the perception of appropriateness, and second, the capabilities of setting inappropriate attributes aside. The present experiment was pertinent to the operation of the second of the two variables. This variable presumes the operation of the first factor, but just how a subject decides on appropriate and inappropriate attributes is not known. It may be presumed that the developmental history is important in that the subject learns the "art" of attribute selection; he learns that certain attributes are relevant for performance on certain tasks, others are not. If this is true, it would be found that young children would be less capable of demonstrating attribute independence than would adults.

The idea that the subject can set aside attributes which he perceives as being irrelevant or even inimical to performance on a task is not a new idea. Interference paradigms between lists would provide an impossible situation for the subject unless he could in essence classify the earlier task as "wrong", set it aside, and proceed to learn the current task. The A-Br paradigm is particularly difficult because the components of the memory of the first task have heavy representation in the second task; only the specific associative attributes are changed. It is quite possible to construct a task in which the attributes will not mediate correct performance because no attributes can be selected which will provide a valid basis for responding across all items. The double-function verbal-discrimination task is such a task. If learning occurs at all it appears to be due to the fact that the subject learns to apply a unique discriminative attribute for each pair. The unsuccessful subject undoubtedly acquires a highly complex set of memory attributes for such a list but none is appropriate for mediating correct performance.

A positive effect in so-called positive-transfer paradigms is not always found. This would be expected if the subject did not perceive the task demands of a second list as being related to the attributes which mediated the first-list performance. For example, in mediation paradigms, investigators have found it necessary to draw a distinction between the potential for positive transfer existing in the memory for the first list and the utilization of that potential in performing the second list. Over the years, many investigators have expressed uneasiness about the use of transfer tests to deduce the composition of the memory developed in an earlier task. Such uneasiness is fully justified by the notion that the utilization of attributes is heavily determined by the subject's perception of the demands of the transfer task. Studies which have tried to understand serial learning by transfer tests on paired-associate lists may be an extreme case. Even if the serial list is learned by item to item associations, these associations may be perceived as being irrelevant by the subject when given the paired-associate list, and this may be true in spite of instructions to the contrary. The idea that associations, viewed as functional units of memory, are automatically elicited by a stimulus occurring in a task quite different from the one in which it had occurred earlier, has long since been discarded by thoughtful investigators. The lack of automaticity must be attributed to the control which the subject may exercise over attributes composing a memory.

This is all to suggest in many different ways, that: (1) the multi-attribute nature of memory must be recognized; (2) certain attributes are more pertinent to successful performance on a given task than are others; (3) the subject has some control over the selection of attributes in mediating performance; (4) to some extent at least, this selection will depend upon his perception of the demands of the task (the attributes which he believes will mediate successful performance); (5) irrelevant or interfering attributes may be set aside; (6) the subject can handle two attributes simultaneously to perform on tasks requiring different attributes with little or no interaction between the performances. Because of all of the factors, it is necessary to maintain a distinction between the attribute-composition of a memory and the particular attributes mediating performance on a given task.

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