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ABSTRACT

This summary of research performed during the past five and one-half years and dealing with different attributes in memory functioning is organized around four attributes of memory: "Frequency Attribute: Verbal Discrimination" explores the development of the theory dealing with verbal discrimination tasks and lists several papers prepared during the contract period which are used as documentation for the theory. "Frequency Attribute: Classical Recognition" discusses the theory, application of the frequency theory, and a listing of the reports used to summarize the work in this area. "Associative Attribute: Massed versus Distributed Practice" discusses some of the findings in this area and lists some of the articles produced during the investigation. "Associative Class Attribute and Forgetting" discusses the theory and the research that was conducted. Two sections conclude the summary: "General" surveys the general findings and suggests further research, and "Temporal Attribute" reviews some of the unfinished research in this area. (WR)

ATTRIBUTES OF MEMORY: FINAL REPORT

Benton J. Underwood

Northwestern University

November, 1974

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This is the final report summarizing research performed during the past five and one-half years, dealing with different attributes in memory functioning

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Attributes of Memory: Final Report

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The Background

To a near complete extent, the research performed during this contract period was guided by a revised and broadly expanded conception of memory. This conception was developed during the last year of a previous contract and published during the initial months of the present one, namely, in November, 1969 ("Attributes of memory." Psychological Review, 1969, 76, 559-573). This paper resulted from an examination of widely scattered literature, an examination which led to the conclusion that a memory for an event may consist of several distinctly different types of information, the different types being called attributes. Basically, this conception of memory is not a theory, but it provides a framework within which theories may be developed about how the various attributes influence memory functioning. It is not known that all attributes have been discovered but those that have been identified are as follows: frequency, modality, temporal, spatial, orthographic, nonverbal associative (acoustic, imagery, affective, contextual), and various levels of verbal-associative attributes (parallel associates, class associates).

The research goal, viewed in the light of the attribute conception, is to determine how (under what conditions) these attributes become a part of a memory, how they function singly or jointly in memory-test performances, and how they are lost over time (forgetting).

It goes without saying that this enormous enterprise is involving many laboratories, and is being guided in many cases by theoretical formulations. Not all of these formulations, of course, use the attribute conception as a fundamental assumption in the theories, although a general acceptance of multiple types of memory information seems prevalent in one form or another. Whatever the nature of the theory, a number of systematic issues present themselves for resolution. Some of these may be mentioned.

If a memory consists of several attributes, how is it possible to determine the role of each? As might be anticipated, the answer with respect to a specific attribute will evolve from articulate theories and careful experimental controls. As another issue, how are we to view the subjects in the experiments? Are we to view them as passive recipients of attributes with little or no control over either the attributes which become a part of memory or over the utilization of those attributes in determining performance? Again, answers for specific attributes will gradually evolve. For example, we have shown that a subject can treat the frequency attribute and an associative attribute as two uncorrelated attributes. When the subject is asked to display his knowledge of frequency he can do so without interference or spillover from the associative attribute, and he can handle the reverse with equal facility.

Another most difficult issue which is being debated concerns the appropriate unit for the experimental analysis of memory functioning. Put in extreme form, the question is whether the appropriate unit is an idea or is it at the level of a simple association. The latter

type of unit has dominated most of the research over the years but there is a question as to how generalizable the laws are which result from this approach. On the other hand, it has been argued that many of our memories must necessarily consist of relatively simple units, such as associative units, perhaps organized by various hierarchical associative units. This position might argue that at least there will be many memories formed in schools or other training situations in which the elementary-unit approach will be directly applicable. However this may be, the approach used in the research prosecuted under the contract has been of the elementary-unit type.

The enormous scope of the problem in understanding memory functioning makes it necessary that within a single laboratory the range of research must be quite limited. The work performed during the past five years has dealt with only a few attributes and the summary of the research will be organized around the attributes involved.

Frequency Attribute: Verbal-Discrimination

The theoretical developments which attempted to specify the role played by the frequency attribute in memory functioning largely occurred in our laboratory. It is perhaps understandable why a considerable proportion of our research effort has been devoted to testing and refining the theory. Somewhat independently, it has been applied to the recognition task known as the verbal-discrimination task, and to classical recognition tasks, although the "gist" of the application is much the same in both cases. The two areas will be kept separate here.

In the verbal-discrimination task the subject is presented a

series of pairs of words (or other verbal units) and the experimenter has arbitrarily designated one as correct in each pair, the other as incorrect. Frequency theory is aimed at an explanation of how the learning of this task occurs. Essentially, the theory assumes that the discrimination between the incorrect and correct words in each pair is mediated by a frequency discrimination and rule-application behavior. It can be shown that the human memory is very sensitive to differences in event frequency. The theory views this as a skill and proceeds to show how the skill can mediate verbal-discrimination learning. By the way in which the verbal-discrimination task is presented, the correct item is given higher frequency than the incorrect item. If the subject can discriminate between these two frequencies, and if he applies the appropriate rule to all items (choose the word with the higher frequency), correct performance will result.

Three general comments will be made by way of summary comments of the research and theory dealing with verbal-discrimination tasks. First, the theory assumes that the independent variables which govern frequency assimilation and discrimination among frequencies also govern recognition performance in verbal-discrimination tasks. Thus, the laws of frequency assimilation and discrimination serve as a model for predicting the outcome of the effect of independent variables in verbal-discrimination performance. In this case, however, the theory developed initially without having available the requisite laws and relationships for frequency assimilation and discrimination. It has been necessary, therefore, to study simultaneously the facts of frequency discrimination and the facts of verbal-discrimination learning. In the publications

listed below, some include data only on frequency discriminations, some only data on verbal-discrimination learning, and some include evidence on both topics.

Second, the theory as originally formulated indicated that frequency produced by implicit associate responses (IARs) to the words in the verbal-discrimination list would need to be seriously considered in estimating the frequency relationships among the words in the pairs. Results from our laboratory as well as from the laboratories of other investigators have given little support to this aspect of the theory. Two reasons for this have been tendered. One, it may be that IARs occur with greatly diminished frequency when pairs of words are presented for study (as compared with the frequency when single words are used, as in the free-recall task). Two, frequency resulting from the direct presentation of words is such as to dominate or "swamp" any minor and inconsistent additional inputs which might be produced by IARs. The first alternative has now been shown to be wrong, i.e., IARs to words in pairs are as frequent as are IARs to single words. We therefore lean toward the second reason to account for the lack of an effect of presumed IARs in verbal-discrimination learning.

Third, we have consistently pointed out that the theory holds that the frequency attribute dominates recognition decisions in the usual or typical verbal-discrimination task. But, if under special circumstances the frequency attribute becomes invalid, other attributes will "take over" the decision processes. In fact, we have shown some of the conditions under which the frequency attribute becomes invalid.

For example, the double-function, verbal-discrimination list is one in which the right and wrong items have equal frequency, hence the frequency attribute is invalid as a discriminatory attribute. This task is extremely difficult for the college student, although some learning does occur. Our research has shown that the basis for this learning is not likely to be a contingency rule, but just how any learning occurs for this task is not known at the present time. There are other procedures, particularly transfer procedures, where frequency of right and wrong words within the task can be equalized; still, the subject's performance does not fall to a chance level, indicating that other attributes can be used in these "emergencies", although performance increments are much slower than when frequency discriminations are possible.

These remarks emphasize that a memory for an event does consist of a collection of attributes. Frequency theory merely states that in the usual recognition task the frequency attribute largely mediates performance, the other attributes serving, in a manner of speaking, as back-up attributes. In a recent review of the literature on verbal-discrimination learning (Eckert, E., & Kanak, N. J., Psychological Bulletin, 1974, 81, 582-607), the following was stated:

> "The literature pertaining to verbal discrimination acquisition, transfer, and retention is reviewed. Integrated into the review of these data are discussions of frequency theory, extensions to the frequency theory, and hypotheses independent of frequency theory. It is generally concluded that the frequency theory is suitable for the explanation and

prediction of data in experiments which require only recognition memory and that other theoretical accounts or extensions are needed to predict and explain verbal discrimination problems which require processes other than simple recognition memory."

We agree entirely with this conclusion, and the following papers prepared during the contract period may be used as documentation.

Retention of a verbal discrimination. Journal of Experimental Psychology, 1970, 84, 1-14. (Footnoted as being under the previous contract, 1228 (15), but not included in the final report for that contract.)

Retention of frequency information with observations on recognition and recall. Journal of Experimental Psychology, 1971, 87, 149-162.

Learning-to-learn verbal-discrimination lists. Journal of Verbal Learning and Verbal Behavior. 1972, 11, 96-104.

List length and method of presentation in verbal discrimination learning with further evidence on retroaction. Journal of Experimental Psychology, 1972, 93, 181-187.

The retention of frequency information for categorized lists. Journal of Verbal Learning and Verbal Behavior, 1973, 12, 99-107.

The role of associations in verbal-discrimination learning. American Journal of Psychology, 1972, 85, 499-518.

Retention of verbal discrimination lists as a function of number of prior lists, word frequency, and type of list. Journal of Experimental Psychology, 1973, 100, 101-105.

Conceptual associations and verbal-discrimination learning. American

Journal of Psychology, 1973, 86, 613-615.

On the independence of attributes of memory. Technical Report, November, 1973.

Implicit associational responses produced by words in pairs of unrelated words. Technical Report, August, 1974.

Contingent associations and the double-function, verbal-discrimination task. Technical Report, August, 1974.

Frequency Attribute: Classical Recognition

The extension of frequency theory to the classical recognition situation was a natural one since operationally the procedures for verbal discrimination and classical recognition have much in common [Underwood, B. J. Recognition memory. In H. H. Kendler and J. T. Spence (Eds.), Essays in neobehaviorism. New York: Appleton-Century-Crofts, 1971]. In what is called here, classical recognition, the subject is presented a series of units and is subsequently tested for his memory of those units by either of two methods. In the forced-choice test, an old item (presented for study) is paired with a new item (not presented for study), and is asked to decide which of the two had been presented for study. The similarity to the verbal-discrimination task, and to multiple-choice tests widely used in educational testing is obvious. In the second method of testing the subject is given a series of old and new words, randomly mixed, and is asked to identify each as belonging either to the old or to the new category.

The application of frequency theory is straightforward, namely, that recognition decisions are made primarily on the basis of frequency differentials between old and new words. Nevertheless, for various

reasons, both the theoretical and empirical problems which have arisen from classical recognition studies have had far greater ramifications than has been true for the verbal-discrimination task. These ramifications will be reflected in the present summary.

A careful consideration of the frequency information which the adult carries with him makes it clear that this information has always been abstracted from a broader or larger context. We can estimate with considerable precision the frequency with which various words are used in printed texts. This information has been abstracted from the text, since the words are rarely seen in isolation. So too, our knowledge of the relative frequency with which letters occur in words results from our ability to abstract these frequencies from the word contexts. It seemed necessary, therefore, in applying frequency theory to classical recognition, to include this abstracting skill in the theory, assuming that the abstraction may also occur in certain of the tasks given in the laboratory. Thus, if pairs of words are used in the recognition task, we must presume that the memory for the pair carries frequency information about each word separately, and also about the pair as a pair (joint frequency). We have in fact shown that even a syllable within a word probably has some independent frequency representation in the memory for that word. We see no particular limit on this abstracting process. For example, it seems beyond doubt that if a word occurs in several sentences in a paragraph, and another word occurs in only one, this differential frequency information is a part of the memory for that paragraph. All of this means that the frequency

attribute becomes a very flexible basis for theory, a fact which has both liabilities and assets.

A number of approaches have been taken in testing frequency theory using classical recognition. Perhaps the most convincing approach has been to show that essentially the same findings are produced if a subject is requested to make frequency judgments as if he is requested to make recognition decisions. Further, it has been shown that when errors are made for the two types of judgments, they tend to fall on the same items.

A hotly debated issue among psychologists studying memory functioning concerns the role of the associative attribute in recognition memory. This issue has extended to interpretations of how a subject retrieves a word in free recall. One position has been that the associative attribute is used to retrieve a word and then a recognition check (just how, is rarely specified) is made to see if indeed the word was in the list. Another position holds that both recognition and recall involves the retrieval of associative information. This has led to tests in which various verbal cues have been presented to the subject to see if recall can be produced, and in some laboratories, to see if the cue will in fact diminish the possibility of recognition even if the word is available. Although we used the cue-retrieval technique in an early study during this contract period, we subsequently reached the conclusion that such procedures were neither going to tell us much about retrieval processes nor about recognition processes [Underwood, B. J. Are we overloading memory? In A. W. Melton and E. Martin (Eds.), Coding processes in human memory. Washington, D. C.: V. H. Winston,

1972].

In two other contexts, however, we have judged that the assessment of the role of association in recognition memory is of systematic importance. One of these involves the association between pairs of words. What role does this association play in classical recognition memory for the pair? One must presume that for certain situations, perhaps situations in which the recognition task is a somewhat complex one, e.g., recognition of sentences, predictions from frequency theory will simply break down. It is of importance to establish the boundary lines for a theory, which, in our language, means to establish the conditions under which the frequency attribute becomes subservient or is dominated by other attributes in memory. One approach to the establishment of these boundary conditions involved a series of studies on the effect of an association between words in a pair on recognition of the pair. Somewhat to our surprise, the data denied that strength of an association between words in a pair had any influence on the recognition decisions. In fact, frequency information did almost as well in predicting the results as did such information for predicting the results of single-word recognition. We have proposed an extension of frequency theory along the lines noted earlier, namely, that frequency may accrue to each word in a pair or to the pair as a unit, and that it is this information which is primarily responsible for the recognition decisions. A strong association is important only because it increases pair-unit frequency, although at the expense of individual word frequency. This extension of the theory is being tested at the present time.

The other matter having to do with the role of the associative attribute in recognition memory evolves from the use of classical interference paradigms for determining proactive and retroactive interference. Our research, coming at the problem from several different angles, has shown that interference does not occur in the recognition memory for pairs of words. It is very difficult to understand this conclusion without assuming that the association per se is not involved in these decisions, because under exactly the same conditions when recall (retrieval via the associative attribute) is required, very heavy proactive and retroactive interference is observed. Perhaps one of the more important implications is that such results must necessarily feedback upon and thereby influence interpretations of proactive and retroactive interference, and of the phenomenon of unlearning which forms a part of the total amount of retroactive inhibition observed by recall procedures. Our work on this problem is continuing at the present time.

In short, we have not yet found the situation in which frequency theory breaks down in recognition. Our current thinking is that if the frequency information accruing as a part of a memory is judged by the subject to be a valid basis for the decision process, this information will dominate the recognition decisions. As noted earlier in this report, we have presented evidence that the subject, at least the young adult subject, clearly has the skill to match the demands of the task with the information he has in memory, and to choose the information which he must believe will mediate the most successful performance. We believe that approaching the problems of memory functioning with full recognition of this skill possessed by the subject offers an extremely

fruitful future for research efforts.

The following reports were used to produce the above summary of work in this area.

Word frequency and short-term recognition memory. American Journal of Psychology. 1970, 83, 343-351.

Restricted associates as cues in free recall. Journal of Verbal Learning and Verbal Behavior, 1970, 9, 136-141.

Testing effects in the recognition of words. Journal of Verbal Learning and Verbal Behavior. 1970, 9, 117-125.

Recognition and number of incorrect alternatives presented during learning. Journal of Educational Psychology, 1972, 63, 1-7.

Word recognition memory and frequency information. Journal of Experimental Psychology, 1972, 94, 276-283.

Associative matching and cumulative proactive inhibition. Bulletin of the Psychonomic Society, 1973, 1, 48.

The syllable as a source of error in multisyllable word recognition. Journal of Verbal Learning and Verbal Behavior, 1973, 12, 701-706.

The role of the association in recognition memory. Journal of Experimental Psychology Monograph, 1974, 102, 917-939.

A comparison of the effects of formal similarity among trigrams and among word triads. Memory & Cognition, 1974, 2, 283-288.

A recognition test of vocabulary using signal-detection measures and some correlates of word and nonword recognition. Technical Report, February, 1973.

Associative interference and recognition memory. Technical Report, November, 1973.

Associative loss in unlearning: An alternative explanation. Technical Report, August, 1974.

Associative Attribute: Massed versus Distributed Practice

This area of research was initiated a few years ago, and revolves around a relatively simple paradigm. If a subject is presented a free-recall list for a single study trial, and if a given item occurs twice within the list, its recall will be far superior if the occurrences are distributed (other items fall between the two occurrences) than if the two occurrences occupy adjacent positions. This represents a major violation of the total-time law which states that learning is directly related to the length of study time.

One explanation which has been offered to account for the finding is a fairly direct translation of Martin's encoding variability hypothesis. As applied to the massed versus distributed finding, the theory proposes that the distributed item occurs in two different (variable) contexts within the list, where context is specified as the other words surrounding the distributed word. It is further assumed that retrieval is produced by these contextual cues. Therefore, since the subject has essentially established two associations to the word, one for each context, its probability of being recalled is greater than for a massed item where only a single contextual association has been established. There are a number of ambiguities in this theory, and in general our work on the massed-distributed problem has not been conducted within this framework. Our most pointed objection to the theory is that direct tests of the encoding variability hypothesis have been negative. Our working orientation has been of a very simple character, namely,

that the difference in recall between the massed and distributed items results from a decrement in the associative learning for the massed item, not a facilitating effect for the distributed one. In effect, we have been led to believe that for a massed item the subject essentially stops processing the item; the attention of the subject toward establishing a firm associative attribute is diminished because of the redundancy in memory produced by the massing.

The finding that a massed item is more poorly recalled than is a distributed item has extremely broad generality. It occurs for nonsense material, for words, for sentences, for children, for adults, for pairs of words, and so on. This generality, plus the sheer magnitude of the effect, makes it a memory phenomenon of great interest. Unfortunately, the robustness of the phenomenon has served as a drawback in trying to bring a theoretical understanding to it. If one could produce a meaningful case where the effect did not appear, one could get a lead toward a more precisely stated theoretical position.

As it stands, the attenuation-of-attention hypothesis will satisfactorily account for about half of the total effect. We have also been able to experimentally vary the amount of attenuation with the corresponding changes in the massed-distributed difference, but again, the basic phenomenon did not disappear. At the present time, no theoretical approach has proven satisfactory, and we are seeking new approaches. The fact remains that this phenomenon is large in magnitude, with a great deal of applied value (as in learning a foreign language vocabulary), but it seems now that something of a stalemate

exists in attempts to further the analysis. A new approach, or a new paradigm, is clearly needed. At the present time we have no research underway on this problem except for a master's candidate who is trying an individual-differences approach to the attenuation-of-attention hypothesis. The slackening of work on the effect is clearly apparent in the relatively few articles produced during the contract period.

A breakdown in the total-time law in free-recall learning. Journal of Verbal Learning and Verbal Behavior, 1970, 9, 573-580.

Encoding variability: Tests of the Martin hypothesis. Journal of Experimental Psychology, 1970, 86, 317-324.

Further evidence on the MP-DP effect in free-recall learning. Journal of Verbal Learning and Verbal Behavior, 1972, 11, 1-12.

The spacing effect in the learning of word pairs and the components of word pairs. Memory & Cognition, 1974, 2, 742-748.

Associative Class Attribute and Forgetting

One of the facts which has been most resistant to interpretation is that a simple associative task learned by a naive subject will show 20% forgetting over a 24-hour retention interval. The amount is independent of the type of material or task as long as associative learning is clearly involved. A theory was developed in 1960 to account for this loss in terms of interference. Tests of the theory have been rather universally negative. This theory assumed that the loss was produced primarily by interference (proactive) from simple associations which had been learned outside the laboratory prior to the learning of the task of interest in the laboratory. The theory maintained complete integrity in using the model of laboratory-induced interference. It

has been difficult to decide whether the model is completely inappropriate or whether some aspect needs changing.

As noted, the theory was based on a conception of simple associative interference as exemplified by the association which develops between a pair of words in the laboratory when a list of paired associates is presented for learning. It occurred to us that perhaps the interference of interest did not lie in merely these simple and direct associations but also, and perhaps more importantly, in higher-order associations or associative class attributes. Many words can be viewed as being organized in memory in a hierarchical structure where the hierarchical levels represent successively more inclusive categories. For example, a wolf is a wild animal which may be associated at a higher level with a horse as a four-footed animal, which may be associated at a still higher level with birds as warm-blooded animals, which may be associated at a still higher level with plants as living things. Perhaps, in conducting our usual studies where words are more or less randomly put together to form lists, they all violated the structure of the organization of words in memory, hence all were subject to the same amount of interference from the higher-order habits. (There was evidence that would argue against this position; for example, nonsense syllables would be unlikely to have representation in memory in a hierarchical-like organization; still, they showed no less nor more forgetting than did corresponding lists of common words.) If these hierarchical associations were important for long-term memory, it seemed to us that we should at least be able to construct lists which would show different rates of forgetting. More particularly, if the task

involved words which were ordered so as to fit the presumed hierarchy, forgetting might be less than for the same words ordered so as to violate the hierarchy during serial learning. The latter list should suffer interference over time as a result of the hierarchical habits gradually asserting the original structure.

Simplifying somewhat, different lists were constructed of the same words, but with the ordering of the words in a serial list producing varying degrees of violation of the presumed structure. The outcome of the first experiment showed essentially no forgetting of the list ordered so as to correspond to the hierarchical structure, and about 25% for the list having zero correspondence. This outcome looked extremely encouraging. However, the error data for the list with zero structure did not at all appear to be of such nature that should occur if interference was being produced at recall by hierarchical habits. In the experiment we had used the anticipation method of learning and it was very clear that the more precisely the order of the words corresponded to the hierarchical structure the more rapid the learning. In the second study we used the study-test method. The recall now did not differ as a function of degree of correspondence to hierarchical structure. It then became apparent that the anticipation method, used in the first experiment, allowed the subject information for the highly structured list which essentially allowed him to reconstruct the list during the recall test. Thus, in essence, we were back to the stubborn fact that the rate of forgetting of the single list is uninfluenced by any characteristics of the materials used in the list. Furthermore, an

additional study showed that the large differences produced in learning as a function of degree of correspondence between the ordering of the words and the hierarchical structure was to a large extent due to the lowest level of the hierarchy. The higher levels of the structure contributed very little to increase the rate of learning over and above that produced by the lowest level. For the time being, at least, it does not appear that this approach is going to give us a further understanding of the causes of forgetting over that provided by the approach using simple, direct associations.

Serial retention as a function of hierarchical structure. Journal of Experimental Psychology, 1973, 99, 236-242.

The locus of the retention differences associated with degree of hierarchical conceptual structure. Journal of Experimental Psychology, 1974, 102, 850-862.

Sources of facilitation in learning conceptually structured paired-associate lists. Technical Report, August, 1974.

General

In the process of developing frequency theory, it occurred to us that the theory had a "built in" theoretical postulate relating individual differences to the theory. The theory assumes that frequency discriminations are fundamentally involved in both verbal discrimination and classical recognition. The finer or more precise the discrimination, the better the performance. It must follow that individuals with precise frequency discriminations must perform better on recognition tasks than should individuals with imprecise frequency discriminations. We were able to support this expectation by various correlational

analyses. This outcome did not, of course, give added support to the theory since the skill at frequency discriminations may merely be correlated with another skill which is in fact responsible for recognition performance. On the other hand, if our analyses had essentially showed zero correlations between the skill of making frequency discriminations and recognition performance, the frequency theory would clearly have to be abandoned.

It seemed upon inspection that many theories either had a built-in individual-differences postulate or that such was implied by the theory or model. It seemed further that such postulates had great value in that they provided an immediate test of the theory, a test which had to be passed or the theory should be discarded. The usual type of postulate, not relating to individual differences, does not have such capabilities, or at least is rarely treated so by the theorist. We therefore proposed that other investigators consider carefully the use of an individual-differences postulate in their theoretical formulations. Individual differences as a crucible in theory construction. Technical Report, August, 1974.

Temporal Attribute: Unfinished Work

Under an earlier contract we discovered that if the learning of two highly interfering lists were separated by several days, the 24-hour retention of the second list was essentially free of interference from the first list. In some way, it appeared, the temporal separation allowed the subject to establish a differentation between the two lists, a differentiation that was so complete that interference was essentially eliminated. Two years ago we undertook a major systematic study on this

phenomenon. The temporal separation was varied at four levels (0, 1, 2, and 3 days), and the retention interval for the second task included a 24-hour interval and a 4-day interval. In addition, two different types of retention tests were used in an effort to identify what particular aspect of the memory was lost as the temporal differentiation increased.

Although our results produced a number of new and theoretically relevant effects (e.g., proactive inhibition was greater than retroactive inhibition after four days), we did not reproduce the earlier finding. We are now in the process of trying to discover the critical variable which was responsible for the differences in the outcomes of the two experiments. At this point in time it appears that the nature of the words in the lists is the critical difference. If this turns out to be the case, it will lead us to an examination of interference as a function of word type, an area which we are approaching in a new line of research just initiated.