THE EFFECTS OF ADJECTIVAL MODIFICATION ON PROACTIVE INTERFERENCE AND LEARNING TO LEARN

by

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INTRODUCTION

Proactive Interference

Individuals, in the normal course of events, are often faced with the task of remembering information which has been learned at an earlier point in time to meet the demands of the present. Psychologists have attempted to study in the laboratory the processes underlying such memory retrieval by means of a technique called free recall. The free recall task consists of two parts: (a) The study of a large group of items (usually meaningful words) for some specified amount of time and (b), the subsequent remembering (retrieval) of these items at a later point in time. While the free recall task differs in some respects from situations outside the laboratory in terms of the nature of the to-be-remembered material (i.e., lists of words instead of events, dates, or names, etc.), it is similar in that the subjects (*S*s) are required to retrieve appropriate information upon instruction.

Tulving (1968) has underscored the point that with *meaningful* material the *S* does not have to "learn" the items since the term "meaningful" implies that the semantic content of the items is already known (i.e., stored in memory). Further, Tulving argues, that *S*'s real task in a free recall situation is to somehow distinguish the recently presented words from the myriad of other words already stored in memory.

If Tulving's analysis is correct, then what cues does the *S* use to distinguish the newly presented to-be-recalled words from other words in memory? Underwood (1969) and others (Shiffrin, 1970;

Norman & Rumelhart, 1970) have proposed that attributes or characteristics of words (e.g., taxonomic class, phonetic makeup, temporal tags, frequency of occurrance, affective tone) are the crucial information used for the storage and retrieval of words in memory. Indeed, attributes of a word may be available to the S even when the word itself is not. For example, people can often indicate the affective tone, the number of syllables, etc. of a to-be-remembered word without actually being able to recall the word itself (e.g., Brown & McNeil, 1966; Wickens, Shearer, & Eggemier, 1971).

The notion that storage and retrieval of meaningful material from memory is largely dependent upon the storage and retrieval of the attributes associated with that material has been incorporated in the theoretical models of Atkinson & Shiffrin (1968) and Shiffrin (1970). Wickens (1970) has provided support for this notion within the confines of a short-term memory procedure. The short-term memory procedure consists of a single trial in which Ss are first presented with a single stimulus to study (e.g., a word), are then asked to perform an unrelated task (e.g., counting backwards) for a specified time (usually up to 30 seconds), and then are asked to recall the original stimulus. With this procedure a decrement in recall performance can be produced over successive trials when different exemplars of the same class are used on each trial (e.g., lion, horse, dog). This increasing decrement has been attributed to an increase of proactive interference (PI) across trials (Keppel & Underwood, 1962). That is, the act of encoding early items interfers with or makes more difficult the encoding and remembering of later items. Wickens has argued that the observed PI may be due to confusion among attributes. That is, all the items which make up a given class of material share many attributes in common. As S tries to encode more and more members of the same class over successive trials, the attributes common to all become the most salient, and individual attributes become less and less distinctive. If the assumption is made that encoding and retrieval of distinctive attributes is necessary for recall, then it should follow that recall performance will decrease over successive trials when Ss are asked to remember different exemplars of the same class.

A marked improvement in recall can be produced by a change in class of material (e.g., from nouns to verbs). This effect is known as the release from proactive interference effect. The effect derives its name from the theoretical build up, and subsequent release from PI over successive trials. In this instance Wickens argues that a change in class of material results in an improvement in performance because items of the new class share relatively few attributes with those of the old class (i.e., the change in attribute distinctiveness is responsible for the release from PI). Hence, S is able to encode the attributes which are distinctive to the new words with which he is now confronted.

The same mechanisms which serve to produce and release PI in the short-term memory situation involving single words may also be operative in the more complex free recall learning situation where Ss learn two or more successive lists, each containing many words. More specifically, previous research (Sheull, 1968; Thompson &

Poling, 1969; Thompson, 1972) has shown that PI occurs when there is categorical overlap between the words of successive lists (i.e., lists which contain several subgroups of words based on taxonomic class such as animals, occupations, etc.). An example of such categorical (taxonomic) overlap would be as follows: List 1 contains the animal names lion, horse, and cow, and List 2 the animal names pig, elephant, and giraffe.

It seems reasonable to propose as Wickens has done in the case of single-word (short-term) memory, that interference in the free recall learning situation results from the fact that items belonging to the same category share many attributes or characteristics in common. In successive lists involving the same categories, but different exemplars, the Ss become unable to distinguish among the items of the two lists. The overlapping characteristics common to the words in each of the two lists makes the items difficult to distinguish from one another and leads to slower learning of the second list relative to a second list with no categorical overlap. If this analysis is correct, then it can be tested by altering the saliency of the attributes common to words of a category. A procedure for manipulating attribute saliency is described below.

If the assumption is made that attribute commonality is, at least in part, the basis for clustering (i.e., the tendency for Ss to emit categorically related items together in recall), then clustering performance provides an indicant of the amount of attribute commonality among a list of words. Data reported by Gonzales & Cofer (1959) and more recently by Cofer, Segal, Stein, & Walker (1969) on the effects of adjectival modification on clustering performance within the learning of a single categorized list provides an interesting way to manipulate attribute commonality. These researchers showed a substantial decrease in clustering performance, relative to a no modification condition, when adjectives appropriately modified only the noun with which they were paired and no other noun in the list. Examples of such <u>specific modification</u> might be "school bus" or "covered wagon." Presumably the reduction in clustering performance occurred by an alteration of the saliency of the common attributes the word shared with other members of that category. That is, by appropriately modifying a noun with a specific adjective the saliency of distinctive attributes may be increased, and conversely the saliency of common attributes reduced, therby reducing clustering. This reduction in clustering performance was also accompanied by a corresponding decrement in free recall performance. The presumed alteration of common attribute saliency may have made the list more difficult to organize and hence, retarded recall performance.

Cofer and his associates were further able to show a substantial increase in clustering performance, relative to a no modification condition, when a class of adjectives (e.g., color) was used to modify a category of nouns such as articles of clothing. Examples of <u>class modification</u> might be "green sweater" or "black tie." Presumably the increase in clustering performance was due to a heightening of the saliency of the common attributes the word shares with other members of the category. In other words, by modifying a category of nouns by a class of adjectives the saliency of attributes common to all items of the category was increased, thereby increasing clustering performance. The failure of Cofer and his associates to find a corresponding statistically reliable increase in recall performance for the Class Modification condition, relative to a no modification condition, suggests that the relationship between clustering and recall is not a simple one.

Based on the above formulation, it seems reasonable to hypothesize that the relative amount of PI produced through the repetition of categories across lists (using different category exemplars in each list) can be manipulated directly. Categories which are repeated in the second list but whose nouns are modified by adjectives specific to those nouns should show little or no second list PI (relative to a no modification condition), because such modification whould serve to effectively restrict, both _within_ and _between lists_, the amount of commonality of attributes shared among items from the same category. On the other hand, categories whose nouns are modified by class adjectives should show substantial PI when both categories and classes are repeated across successive lists because such modification should serve to heighten, both _within_ and _between lists_, the commonality of attributes among the items of those categories. One purpose of the present research was to test this hypothesis.

Clustering and Learning to Learn

The discussion thus far has focused upon adjectival modification as a method for manipulating and studying attribute saliency and PI within a multi-list, repeated category paradigm. A related, and perhaps more general, question concerns the role of attribute saliency in the retention of a simple multi-list, non-repeated category free recall paradigm. Previous research has shown that when Ss are required to learn several lists of words in succession, recall performance increases across lists (Postman, 1969). This effect has been called the learning-to-learn effect, and has been termed a non-specific transfer effect since the changes in performance across lists do not depend upon the interrelationships among the specific items of the two lists. This is in distinction to specific transfer effects which may be attributed directly to inter-item relationships among the items of successive lists. The PI experiment described above is an example of a specific transfer study.

One of the salient features of both specific and non-specific transfer paradigms is the tendency for Ss to organize or exhibit grouping tendencies in their recall. While recent evidence (Thompson & Roenker, 1971) has suggested that this organization of to-be-remembered material may be an important factor in the learning-to-learn effect, the nature of this relationship is, as yet, unclear. Before attempting to examine this relationship a more general discussion of the phenomenon of organization and clustering is in order.

The notion that output from memory (recall) is organized is well documented in the psychological literature. As early as 1953 Bousfield was able to show that recall of categorized word lists tended to be clustered on the basis of the taxonomic classes present in the list. Tulving (1962) showed a similar phenomenon for "unrelated" words. That is, he found that sequential dependencies among items in recall developed over successive recall trials. Finally, Mandler (1967) demonstrated that, when dealing with "unrelated" words, Ss could consistently sort the words into self-created categories and then use these categories as a basis for grouping in a subsequent recall task. Mandler's work represents a unique combination of the techniques of both Bousfield and Tulving.

These three lines of research leave no doubt that output from memory is organized with respect to the nature of the items in the list. Recent research concerning organized output has yielded several important findings. First, organization seems to aid recall (Mandler, 1967; Thompson, Hamlin, & Roenker, 1972), although the relationship is not a simple one since degree of organization and amount of recall do not vary in a simple one to one relationship (Thompson & Roenker, 1971). Secondly, organization increases across successive trials within a single list, as well as across successive lists (Thompson & Roenker, 1971). Thirdly, recall performance with categorized lists increases over successive lists (Thompson & Roenker, 1971). This increase in recall performance over successive categorized lists is known as the learning-to-learn phenomenon. While learning-to-learn effects are not soley limited to situations involving categorized lists, the immediately important fact is that such non-specific transfer effects do occur in categorized lists.

If organization does aid recall, and intra-list organization increases with practice, then it seems reasonable to suppose that the learning-to-learn recall effect may, in part, be due to a learning-to-organize (i.e., clustering) effect. Recent data (Thompson & Roenker, 1971) have suggested that this indeed may be true. In a multi-list, free recall paradigm, Thompson and Roenker demonstrated a marked improvement in clustering performance over the three trials of List 1 with somewhat smaller but reliable increases in clustering performance on successive lists (i.e., a learning to cluster effect). While no direct test of the organizational (i.e., clustering) component of the learning-to-learn effect was provided by Thompson et al., the data provided suggestive evidence that Ss did indeed learn how to cluster. The relationship between this learning-to-cluster effect and the learning-to-learn effect remains to be explored more fully by manipulating the level of clustering performance. The results reported by Cofer et al.(1969), which were discussed above, provide a vehicle with which to manipulate attribute saliency and thereby the level of clustering performance. If learning to cluster is in part responsible for learning-to-learn effects in the recall of categorized word lists, then the disruption of clustering produced by Specific Modification of nouns should disrupt the learning-to-learn recall effect. On the other hand, the enhancement of clustering produced by Class Modification should result in an enhanced learning-to-learn recall effect over successive categorized word lists.

In order to test these hypotheses a simple design containing two successive categorized lists for each type of adjectival modification was employed. To avoid contamination of specific transfer effects, the design required that different categories be employed in Lists 1 and 2. Further, since all conditions contained no repeated categories in the second list, they also served as baseline control groups for the proactive interference experiment described earlier.

METHOD

Subjects

The Ss were 168 summer school students at Kansas State University who were paid for their participation in the experiment. All Ss were tested in groups of seven.

Experimental Design

The Ss were randomly divided into six groups of 21 Ss each[1]. The six groups represent the experimental (repeated) and control (nonrepeated category) conditions used with each of three types of adjectival modification: Nouns Alone (no adjective modification), Specific Modification (an adjective appropriately modified only the noun with which it was paired and no other noun in any list), and Class Modification (a class of adjectives modified a category of nouns). The experimental design as well as examples of categories and types of adjectival modification are presented in Table 1. As can be seen in Table 1, in the Specific Modification (SM) repeated category condition there was no clear associative relationship between the adjectives. On the other hand, in the Class Modification (CM) repeated category condition the class of adjectives was repeated across lists, thereby resulting in a high degree of associative relationship among the adjectives. This repetition of classes of adjectives coupled with the simultaneous repetition of categories of nouns represents an intentional confounding in the CM condition. As was pointed out in the introduction, it was hypothesized that class modification should produce a high degree of attribute commonality among the words of a category. This high degree of attribute commonality

Table 1

Experimental Design with Example Categories and Example items

Type of Modification		List 1	List 2
Nouns Alone (NA)	Repeated Categories (Exp.)	<u>Clothing</u> socks coat	<u>Clothing</u> sweater shorts
		<u>Occupations</u> doctor accountant	<u>Occupations</u> lawyer salesman
	Nonrepeated Categories (Control)	<u>Crimes</u> rape beating	<u>Clothing</u> sweater shorts
		<u>Fish</u> trout catfish	<u>Occupations</u> lawyer salesman
Specific Modification (SM)	Repeated Categories (Exp.)	<u>Clothing</u> bobby socks mink coat	<u>Clothing</u> cashmere sweater jockey shorts
		<u>Occupations</u> medical doctor public accountant	<u>Occupations</u> patent lawyer magazine salesman
	Nonrepeated Categories (Control)	<u>Crimes</u> statutory rape child beating	<u>Clothing</u> cashmere sweater jockey shorts
		<u>Fish</u> rainbow trout channel catfish	<u>Occupations</u> patent lawyer magazine salesman
Class Modification (CM)	Repeated Categories (Exp.)	<u>Clothing</u> beige socks gold coat	<u>Clothing</u> red sweater green shorts
		<u>Occupations</u> capable doctor accurate accountant	<u>Occupations</u> effecient lawyer effective salesman
	Nonrepeated Categories (Control)	<u>Crimes</u> terrible beating sickening rape	<u>Clothing</u> red sweater green shorts
		<u>Fish</u> odorous trout stinking catfish	<u>Occupations</u> efficient lawyer effective salesman

was hypothesized to retard second list retention when both lists were modified by class adjectives. To test this hypothesis it was necessary to repeat the classes of adjectives across lists.

The three experimental (E) groups received three trials on each of two lists. The six categories of List 1 were repeated in List 2. Only the categories, not the nouns or adjectives were repeated. Lists 1 and 2 were identical in the type of modification employed. That is, if List 1 contained only nouns, then List 2 also contained only nouns. The same was true for the SM and CM conditions. All three conditions contained exactly the same set of nouns and differed only in the nature of the modification of those nouns. For a more detailed description of the Lists, see Appendix I.

The three control (C) groups also received three trials on each of two lists, but the second list contained six new categories. To insure that performance on the second list was only a function of the inter-list relationships among the words and not of the specific list employed, all the E groups and their appropriate control groups saw identical second lists, and differed only in the nature of the first lists. Once again, all three C groups saw exactly the same sets of nouns but differed in the nature of the modification of those nouns (i.e., Nouns Alone, Specific and Class Modification).

To insure that the results were not list or category specific, each of the six groups was further divided into three subgroups of seven _S_s each. The three subgroups within each major condition received a different combination of six categories in each list as well as a different order of lists. The use of categories was counterbalanced across Ss.

Materials

Experimental Groups -- Nine categories were selected from the Battig-Montague norms (1969). Fourteen nouns were chosen from each category. Although individual items ranged in normative frequency from 10 to 405, the mean word frequency per category, as well as the distribution of normative frequencies, was matched across all categories. Each category was divided into two subcategories of seven exemplars each whose mean frequency was equated. This yielded a total of 18 subcategories with each major category represented twice.

A total of six lists, each 42 items in length and representing six subcategories of seven items each, was generated from these 18 subcategories. No subcategory appeared more than once within any given list, and was used no more than twice across all six lists. These lists were used for the NA condition. For the SM condition, the nouns were modified by adjectives so as to meet the following dual criterion: 1) Adjectives were selected such that they meaningfully modified, to the satisfaction of E and two independent judges, the noun with which they were paired, and at the same time 2) did not meaningfully modify any other noun in any list. Finally, for the CM condition a class of adjectives (e.g., color) was used to modify a category of nouns (e.g., articles of clothing).

Control Groups -- Nine additional categories, comprised of seven exemplars each, were drawn from the Battig-Montague Norms

(1969). Although individual items ranged in frequency from 10 to 295, the mean per category frequency was approximately matched with the mean per category frequency of the 18 experimental group subcategories.[2] Three lists, comprised of six categories each were generated from these nine categories, with each category appearing no more than once per list. The categories were counterbalanced across lists. These three lists were used as List 1 for the C groups, with each subgroup within a major condition receiving a different list.

For the NA control groups, List 1 was composed of only the nouns from these C group categories. For the adjective noun pairs C conditions (SM and CM control groups), List 1 was composed of adjective noun pairs which met the restrictions described above for the SM and CM conditions respectively. In all cases List 1 and List 2 were identical in the type of modification employed.

Procedure

During the study portion of each trial, the words or pairs of words were presented through a Kodak Carousel slide projector. In order to equate levels of acquisition on List 1, different rates of presentation were used as established from a pilot study. Nouns were presented at the rate of one word per second, and the adjective noun pairs at the rate of one pair of words every four seconds. The Ss were instructed to attend to each word or pair of words so as to be able to remember it. The order of presentation of the words or pairs of words was varied randomly from trial to trial.

The final word or pair of words in each list was followed by a three-digit number. The Ss filled a 30-sec. interval between presentation and recall by counting backwards from that number at a 1-sec. rate. The Ss were required to write each three-digit number down as they counted backwards. An examination of these backward counting data showed no reliable difference in counting scores between the six conditions, $F(5,162) < 1$. This task was used to eliminate the short-term memory or recency component in free recall (Glanzer & Cunitz, 1966), since it was unclear whether or not adjective noun pairs would be registered in the short-term memory store as single or double units of information. If the adjective noun pairs were stored as double units, then the no modification conditions hold an advantage over the modification conditions since more to-be-recalled units can be stored in short-term memory and spewed out in an immediate free recall test. Thus, to preclude any differential short-term memory storage for conditions the counting backwards task was employed.

During recall the Ss were instructed to write down on a sheet of paper the words in whatever order the words or pairs of words occurred to them. In the SM and CM conditions the Ss were instructed to recall pairs if possible, or either portion of the pair if the entire pair could not be recalled. Two minutes were allowed for the recall portion of each trial.[3] Each recall trial was recorded on a separate sheet in the answer booklet. There was a 30-sec. interval between trials and a 1-min. interval between lists. The specific instructions read to S are presented in Appendix II.

RESULTS

As indicated in the introduction, the data were analyzed in two ways. The first series of analyses attempted to show the effects of repeated categories on PI under different conditions of adjectival modification. That is, attention was focused upon differences in performance between Experimental (E) and appropriate Control (C) groups under the various adjectival modification conditions. The second series of analyses dealt with only the C groups, that is the condition in which no categories were repeated across lists. These comparisons were designed to show the effects of adjectival modification on learning to learn. Each of these issues will be considered in turn. Before turning to the PI data it is first necessary to examine List 1 performance to assure that both E and appropriate C groups under each type of adjectival modification were comparable in terms of performance prior to transfer.

List 1 Recall

The total number of nouns recalled correctly on each trial of first list learning was tabulated separately for each S. A preliminary examination of the recall data showed an unexpected difference in noun recall performance between the E and C group under the Nouns Alone (NA) condition. A similar difference between E and C groups did not obtain for either the Specific Modification (SM) or Class Modification (CM) condition. Furthermore, this difference was inconsistent with pilot data which showed no difference between E and C groups in the NA condition.

Thus, the difference would appear to represent a sampling error. The nonequivalence of these two groups would render interpretation of List 2 differences difficult, at best. The discrepancy was resolved by doubling the *N* for the E and C groups under the NA condition. The data are shown in the left hand portion of Figure 1c, separately for each of the three trials of learning. As can be seen, performance on List 1 was virtually identical for the E and C groups when N was increased, thereby supporting the contention of an original sampling error. The left hand portion of Figures 1a, and 1b show List 1 performance for the E and C groups under SM (1a)and CM (1b) conditions. Analysis of List 1 data showed no reliable differences between E and C groups for any type of adjectival modification, all F's < 1, thereby indicating approximate equivalence of E and C groups within each modification condition prior to transfer.

Proactive Interference (List 2 Recall)

The mean number of correct nouns recalled was computed separately for each trial of List 2 learning for the E and C groups under the SM, CM, and NA conditions. The data are shown in the right hand portion of Figures 1a, 1b, and 1c, respectively. As was pointed out earlier, PI is indicated by poorer recall performance by E groups relative to appropriate C groups. As can be readily seen, little or no PI was produced in the SM condition. On the other hand, substantial PI was present in both the CM and NA conditions. To assess the relative amounts of PI present under the different types of adjectival modification conditions a percent transfer score was computed. This involved subtracting the mean

Figure Caption

Fig. 1. Mean correct recall for each of three trials on two lists for the control and experimental groups of the (a) Specific Modification, (b) Class Modification, and (c) Nouns Alone conditions.

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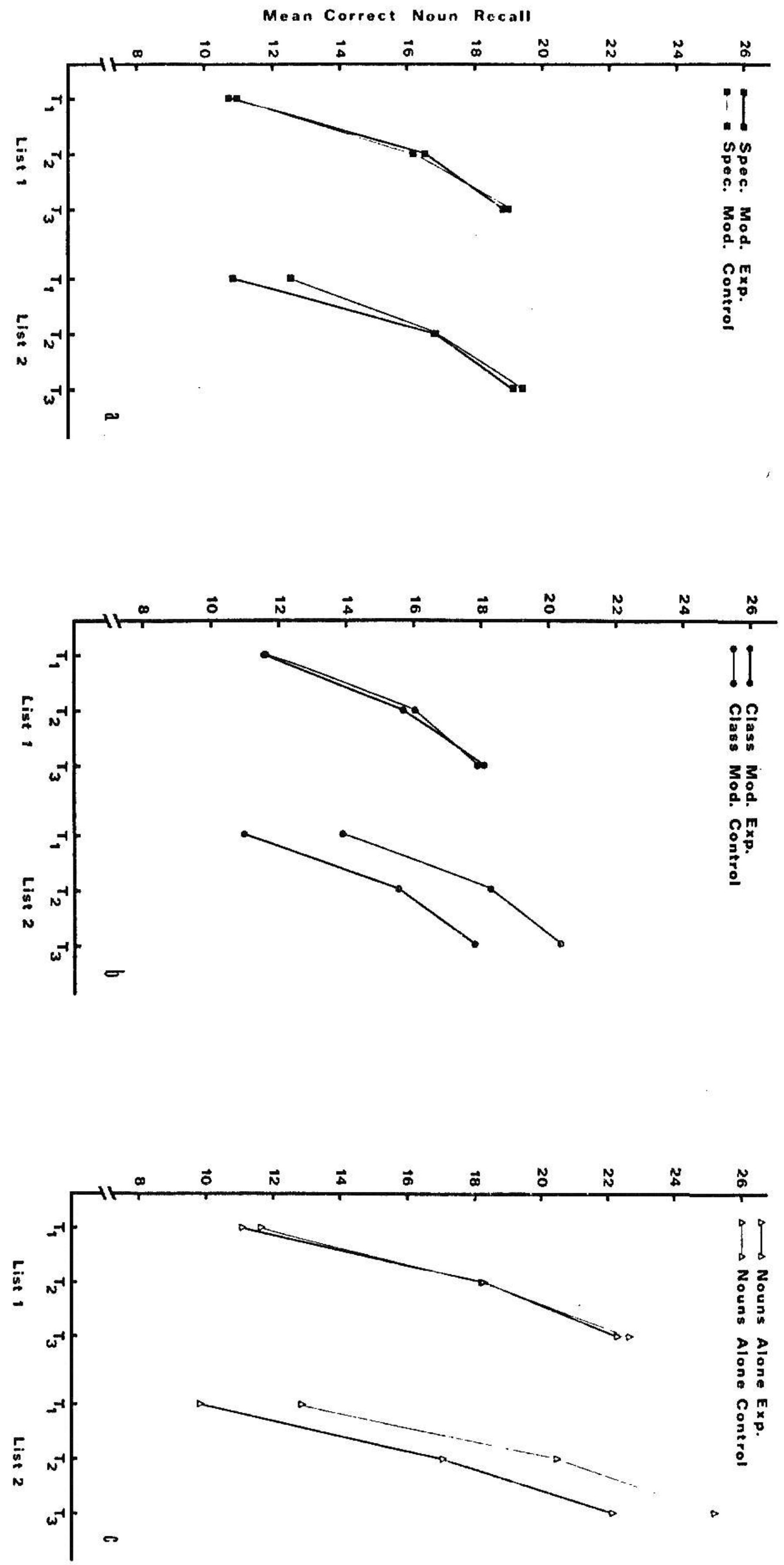

Mean Correct Noun Recall
8
10
12
14
16
18
20
22
24
26
Spec. Mod. Exp.
Spec. Mod. Control
T1
T2
T3
List 1
List 2
a
Class Mod. Exp.
Class Mod. Control
b
Nouns Alone Exp.
Nouns Alone Control
c

number of correct recalls on each trial of List 2 learning for the appropriate C group ($\overline{C}$) from the trial score of each Experimental S. The difference was then divided by the mean correct recall score of the control condition: or

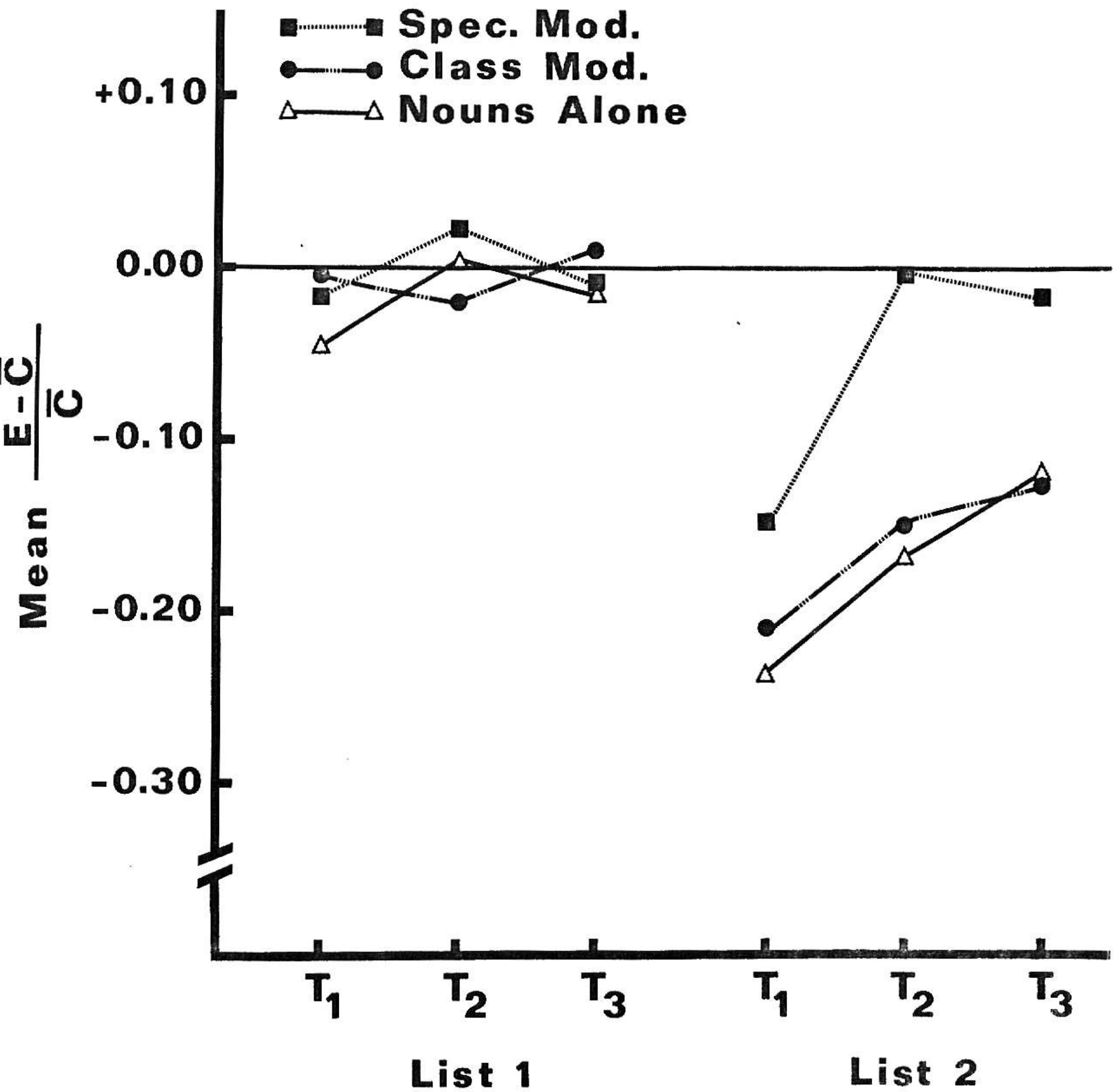
$$\frac{E - \overline{C}}{\overline{C}}$$

It should be noted that with this transformation a score of zero represents no negative transfer (i.e., equals control performance) and a minus score negative transfer or PI.

The percent transfer scores are presented graphically in Figure 2. To reduce the effects of between S variance, an analysis of covariance was performed on the List 2 data, using overall List I performance as the covariate. While this analysis revealed reliable overall differences in amount of negative transfer between types of adjectival modification, SM (-.056), CM (-.162), and NA (-.175), $F(2,80) = 5.67$; $p < .01$, the crucial result was that the SM condition produced reliably less PI than the average of the CM and NA conditions, $t(59) = 2.39$; $p < .025$. This finding is consistent with the hypothesis that SM reduced attribute overlap and thereby PI. In this connection, it should be noted that although the difference between E and C groups on Trial 1 of List 2 for the SM condition was not statistically significant, $F(1,20) < 1$, the data suggest a moderate amount of PI present on this first trial. Pairwise comparisons showed that there were no differences in the relative amounts of PI produced by the CM and NA conditions, $t(59) = .73$; $p > .05$. This result is contrary to the hypothesis that CM should enhance attribute overlap and thereby increase PI. Finally,

Figure Caption

Fig. 2. Mean percentage difference between control and experimental groups for each trial of each list for Specific Modification, Class Modification, and Nouns Alone conditions.


Spec. Mod.
Class Mod.
Nouns Alone
+0.10
0.00
-0.10
-0.20
-0.30
Mean $\frac{E-\bar{C}}{\bar{C}}$
T_1
T_2
T_3
T_1
T_2
T_3
List 1
List 2

under all conditions the difference between E and C performance diminished across trial, $\underline{F}(2,162) = 8.96$; $p < .001$. There were no other statistically significant effects (all p's $> .05$).

It is important to note that Ss in the CM and SM conditions were required to recall pairs of words. Therefore, it is conceivable that the relatively large difference between E and C groups in the CM condition and the contrasting smaller difference in the SM condition could be due to a trade off in the type of item recalled. That is, in the CM condition, for example, the lower level of correct noun recall found in the E group, relative to the C group, may have been compensated by a higher level of correct adjective recall. Similarily, in the SM condition the lack of differences between E and C groups in noun recall may have been accompanied by a difference in number of adjectives recalled. To evaluate these possibilities, adjective recall for List 2 was analyzed.

Adjective Recall--The mean number of adjectives correctly recalled on each List 2 trial by the E and C groups under the SM and CM conditions are shown in Figures 3a and 3b, respectively. Evidence for a trade off effect would be represented by a significant Adjectival Modification X Experimental-Control interaction. This interaction did not obtain, $\underline{F}(1,80) < 1$. The analysis further showed that there were no reliable overall differences between E (14.62) and C (14.84) groups, $\underline{F}(1,80) < 1$. However, the mean number of adjectives recalled was reliably greater under the SM (15.63) than CM (13.81) condition, $\underline{F}(1,80) = 3.98$; $p < .05$. The finding of better adjective recall under the SM as opposed to the CM condition is not suprising due to the fact that the adjective noun pairs in the SM

Figure Caption

Fig. 3. Mean correct adjective recall for the three trials of List 2 for the control and experimental groups of the (a) Specific Modification and (b) Class Modification conditions.

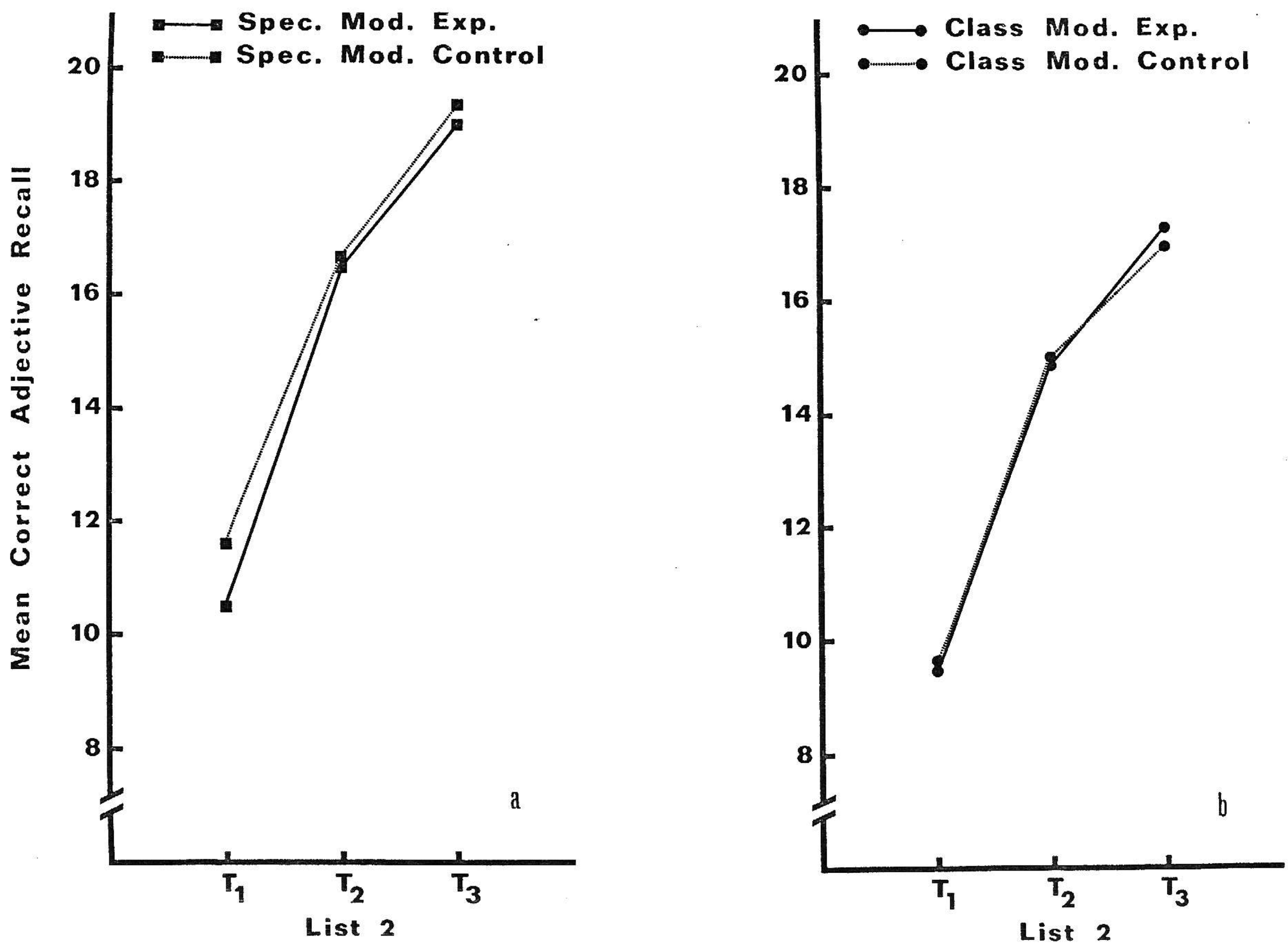

Spec. Mod. Exp.
Spec. Mod. Control
Mean Correct Adjective Recall
20
18
16
14
12
10
8
T_1
T_2
T_3
List 2
a
Class Mod. Exp.
Class Mod. Control
20
18
16
14
12
10
8
T_1
T_2
T_3
List 2
b

Table 2

Mean Number of Intrusions For Each Trial of List 2 For Experimental and Control Groups For The Specific And Class Modification Conditions.

Condition		Trial 1	Trial 2	Trial 3	Mean
Spec. Mod.	Exp.	.43	.52	.33	.43
	Con.	.14	.19	.19	.17
Class Mod.	Exp.	.71	.24	.38	.44
	Con.	.43	.24	.14	.27

condition were more integrated than the adjective noun pairs of the CM condition. That is, recall of the noun portion of the adjective noun pair in the SM conditions may have automatically produced the corresponding adjective portion of the pair. However, in the case of CM, recall of the noun portion of a pair may not have necessarily produced recall of the appropriate adjective (e.g., the name of a color), since that adjective could be paired equally well with many other nouns in the list. The only other reliable effect was an increase in adjective recall across trials, $\underline{F}(2,160) = 286.12$; $p < .001$.

Intrusion Errors--Since intrusions errors are considered as correct responses by Ss, the trade off argument made for adjective recall may also apply to intrusion errors. Specifically, intrusion rates may be higher in the E groups relative to C groups at the expense of correct noun recall.

The mean number of intrusions (noun and adjectives: inter and extra list) for the three trials of List 2 learning under the SM and CM conditions are presented in Table 2. Once again, analysis failed to show an Adjectival Modification X Experimental-Control interaction, $\underline{F}(1,80) < 1$. Thus, the notion that correct noun recall suffered in E groups at the expense of increase intrusion recall was not tenable.

Analysis of intrusion data further showed a reliable over-all difference between E (.44) and C (.22) conditions, in the mean number of these errors, $\underline{F}(1,80) = 4.90$; $p < .05$. The higher intrusion rate for the E groups merely demonstrates, in an ancillary manner, that PI was present in List 2. There were no other statistically significant effects (all p's $>.05$).

<u>Clustering</u>--In the introduction it was assumed that clustering performance was an indicant of the saliency of overlapping attributes among words. From this assumption it was hypothesized that SM would reduce the saliency of common attributes both within and between list, thereby resulting in less PI and a lower level of clustering performance when categories are repeated across lists. If this hypothesis is true, then the clustering data ought to reveal a lower level of clustering performance for the SM experimental group relative to the NA experimental condition on List 1 as well as on List 2.

Further, it was hypothesized that CM would heighten the saliency of overlapping attributes and thereby result in an increase in PI as well as a higher level of clustering performance when categories are repeated across lists. Thus, the CM experimental condition should produce an overall higher degree of clustering than the NA experimental condition on List 1 as well as on List 2.

To examine these hypotheses, a clustering score (ARC) for the E groups of the SM, CM, and NA conditions was computed and analyzed. This score represents the relative amount of clustering between chance and perfect performance, wherein chance is represented by a zero ARC score and perfect clustering by an ARC score of one. A detailed discussion of the ARC measure may be found in Roenker, Thompson & Brown (1971).

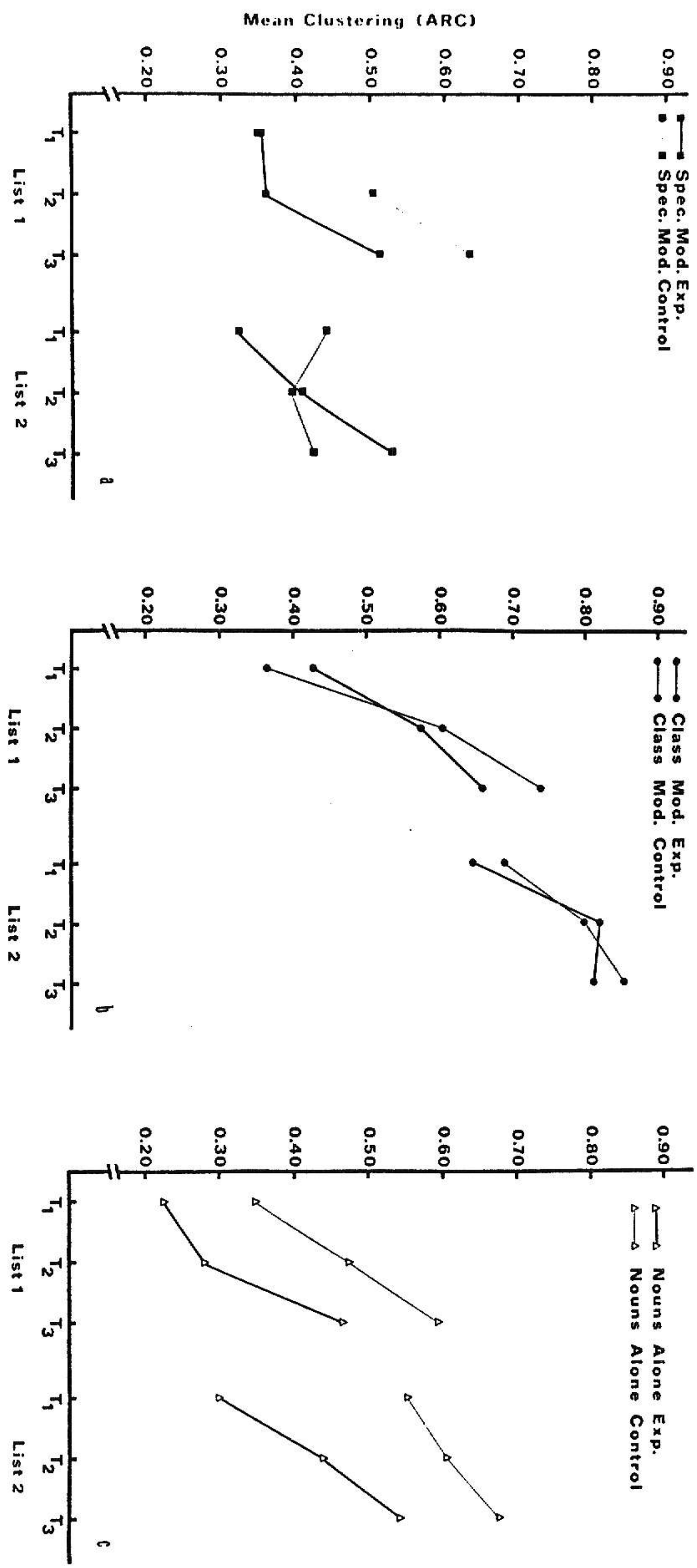
The data for the E groups of the SM, CM, and NA conditions are presented in Figures 4a, 4b, and 4c, respectively.[4] Analysis revealed that clustering performance (averaged across trials) in the CM condition on both List 1 and List 2 ($\bar{X}$'s: L 1 = .55; L 2 = .76) was reliably higher than the NA ($\bar{X}$'s: L 1 = .32; L 2 = .43) condition, F's (1,81) = 12.48, and 26.90, for Lists 1 and 2 respectively, p's $< .001$. These results provide clear support for the hypothesis that Class Modification enhanced attribute overlap and thereby clustering performance. The fact that the SM ($\bar{X}$'s: L 1 = .41, L 2 = .42) and NA conditions did not differ from each other in clustering performance on either List 1, $F(1,81) = 1.73$; $p > .05$, or List 2, $F(1,81) < 1$, suggests that Specific Modification did not decrease attribute overlap relative to the NA condition and thereby reduce clustering performance.

The analysis further revealed a significant Adjectival Modification X Lists interaction, $F(2,81) = 3.71$ $p < .05$. This interaction reflects a relatively large overall increase in amount of clustering across lists for the CM condition (.21), a moderate increase for the NA condition (.11) and virtually no increase for the SM condition (.01). Post test showed that the increase for the CM condition was reliably greater than the increases of either the SM or NA conditions, (1,81) = 5.95; $p < .05$, and that the latter two did not differ from one another, $F(1,81) < 1$. Although not statistically different from the NA condition, the smaller List 1 to List 2 increase found in the SM condition is of the magnitude expected if SM reduces attribute overlap. Nonetheless, the clustering data do not support the hypothesis that SM reduced the saliency of overlapping attributes.

Finally, as expected, overall clustering performance increased across Lists, $F(1,81) = 14.43$; $p < .001$, as well as across trials,

Figure Caption

Fig. 4. Mean clustering scores (ARC) for each trial of two lists for the control and experimental groups of the (a) Specific Modification, (b) Class Modification, and (c) Nouns Alone condtions.



Mean Clustering (ARC)
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
Spec. Mod. Exp.
Spec. Mod. Control
Class Mod. Exp.
Class Mod. Control
Nouns Alone Exp.
Nouns Alone Control
T_1
T_2
T_3
List 1
List 2
a
b
c

$F(2,162) = 17.52$; $p < .001$. There were no other significant effects (all p's $> .05$).

Learning to Learn

The SM, CM, and NA control groups did not contain repeated categories in List 2. Therefore, changes in performance from List 1 to List 2 for these groups provides an uncontaminated test of the effects of adjectival modification, as a means of altering clustering performance, on learning to learn.

Clustering--It was hypothesized that if learning to cluster was, at least in part, responsible for the learning-to-learn recall effect, then SM should reduce the learning to cluster effect and thereby reduce the learning-to-learn recall effect. On the other hand, it was hypothesized that the enhancement of clustering produced by CM should result in an enhanced learning-to-learn recall effect. To test these hypotheses it first must be established that SM and CM affected the learning to cluster effect.

The clustering scores (ARC) for the SM, CM, and NA control groups (see Figures 4a, 4b, and 4c) were analyzed and yielded the following results. Overall clustering performance increased across lists ($\overline{X}$'s: List 1 = .51, List 2 = .61), $F(1,81) = 7.67$; $p < .01$, but, as expected, the magnitude and direction of the change was different for the SM(-.08), CM(+.21) and NA (+.14) conditions, leading to a significant Adjectival Modification X Lists interaction, $F(2,81) = 6.80$; $p < .01$. Subsequent pairwise comparisons showed that the interlist increases in the CM and NA conditions did not differ from one another, $F(1,81) < 1$, but both differed reliably from the SM condition, $(1,81) = 7.44$; $p < .01$. These results clearly show that SM disrupted the learning to cluster effect. Although the difference was not reliable, the greater increase in clustering performance across lists in the CM condition relative to the NA condition suggest that CM enhanced the learning to cluster effect.

Analysis further revealed that overall clustering performance (pooled across lists and trials) differed reliably between conditions, $F(2,81) = 9.15$; $p < .001$, with the CM control condition showing the highest degree of clustering (.68), SM the lowest (.46), and the NA condition an intermediate degree of clustering (.54). Finally, and as expected, clustering performance increase across trials, $F(2,162) = 25.82$; $p < .001$. There were no other statistically significant effects (all p's $> .05$).

Recall--If the hypothesis is true that SM reduces, and CM enhances the learning-to-learn recall effect (relative to the NA condition), then the recall results should parallel those found in the clustering data. That is, the rate of increase in words recalled from List 1 to List 2 should vary with different types of adjectival modification. More specifically, a significant Adjectival Modification X Lists interaction should obtain.

Analysis of the noun recall data of the SM, CM, and NA control groups (see Figures 1a, 1b, and 1c) yielded the following information. Although the Adjectival Modification X Lists interaction did not reach significance, $F(2,81) = 1.26$; $p > .05$, further analysis showed that the difference in interlist increases for the SM condition (.89) versus the pooled CM and NA conditions difference (2.19) approached significance, $F(1,81) = 2.47$; $p < .15$. Thus, the smaller learning-to-learn _recall_ effect in the SM condition parallels closely the small learning to _cluster_ effect noted above for the SM condition. Post test further showed that the learning-to-learn recall effect did not differ reliably between the CM and NA conditions ($\bar{X}$ List 1 to List 2 increase: CM = 2.35, NA = 2.03), $F(1,81) < 1$. However, the numerically larger learning-to-learn _recall_ effect found for the CM condition (relative to the NA condition) mirrors the numerically larger learning to _cluster_ effect found above for the CM condition. The identical ordering of types of adjectival modification in terms of both learning to _cluster_ scores and learning-to-learn _recall_ scores suggest that learning to _cluster_ is indeed involved in the learning-to-learn _recall_ effect.

Further analysis showed that overall recall performance (pooled across lists and trials) differed reliably between conditions ($\bar{X}$'s; SM = 15.84, CM = 16.36, NA = 18.33), $F(2,81) = 3.54$; $p < .05$. Recall performance (pooled across trials) improved from List 1 (16.03) to List 2 (17.79), $F(1,81) = 21.71$; $p < .001$. As expected, recall improved across trials (pooled over Lists 1 and 2), $F(2,162) = 430.36$; $p < .001$, but the nature of this improvement was dependent upon conditions. Since inter-trial increases were greater in the NA condition than in the SM and CM conditions a reliable Adjectival Modification X trials interaction was obtained, $F(4,162) = 15.23$; $p < .001$. There were no other statistically significant interactions (all p's $> .05$).

DISCUSSION

Proactive Interference

The recall data clearly demonstrate that substantial and approximately equivalent PI was produced in the Nouns Alone and Class Modification conditions. On the other hand, relatively little PI was produced under the Specific Modification condition (see Figure 2). Furthermore, analysis of the correct adjective recall data and the intrusion data showed that no trade-off occurred between either correct adjective recall and correct noun recall, or between the level of intrusions and correct noun recall. Thus, these findings suggest that the repeated category PI effects observed were largely limited to correct noun recall. In addition, in the CM condition, even though both classes of adjectives and categories of nouns were repeated in List 2, PI was observed only for correct noun recall.

Thus, the recall data support the hypothesis that the saliency of attributes shared by items in a category will be reduced by specific modification, thereby reducing confusability among the items. The complementary hypothesis that class modification will increase the saliency of common attributes and thereby increase confusability among the items is less clearly supported by the recall data.

The effects of adjectival modification on the saliency of attributes shared among items of the same category may be inferred from the clustering data. If the assumption is made that the saliency of common attributes within a given category is, in part, the basis for clustering, then, relative to the NA condition, clustering performance should be highest in the CM condition and lowest in the SM condition. Only half of this prediction is supported by the data. In both List 1 and 2 the CM condition produced reliably more clustering than the NA condition. However, the SM and NA conditions produced essentially equivalent clustering performance on both List 1 and 2. The failure to find a statistically reliable difference in clustering performance between the SM and NA conditions, coupled with the fact that clustering performance in both conditions was substantially greater than chance, suggests that the SM manipulation did not totally eliminate encoding on the basis of common attributes among the items of the categories. Thus, it is not surprising that the recall data suggest that a moderate amount of PI was produced on the first trial of List 2 in the SM condition.

The implications of the results described above may be summarized in three statements. First, an examination of List 1 data showed that the restriction of meaning of nouns through adjectival modification produced a decrement in recall performance relative to the no modification (Nouns Alone) condition, regardless of the type of modification employed. Under conditions of specific modification there was a decrement in recall on all trials of List 1 relative to NA. However, under conditions of class modification a slight facilitation over the nouns alone condition on Trial 1 was found, with a pronounced decrement on subsequent trials. This first trial facilitation effect is in accord with the results reported by Gonzales & Cofer (1959) and Cofer, Segal, Stein, & Walker (1969) using a single trial free recall procedure. The clear and pronounced decrement in recall performance for the CM condition occurred on Trials 2 and 3. Thus, pooled over all three trials recall performance for the CM condition was inferior to the NA condition. These findings suggest that the beneficial effects of the dual basis of organization provided by class modification were largely limited to the first trial. The failure to find a facilitation of class modification over no modification on Trials 2 and 3 suggests that Ss may change recall strategies across trials, although the nature of these strategies is, at present, unknown. In any event, the multi-trial procedure employed in the present experiment would appear to provide a more stable base upon which to assess the effects of adjectival modification.

The second implication of the present results is that adjectival modification may alter the amount of PI produced by the repetition of categories across successive lists. More specifically, increasing the saliency of common attributes (class modification) produced substantial PI. Alternatively, restricting the saliency of common attributes (specific modification) produced relatively little PI.

Third, adjectival modification alters the level of clustering performance. Increasing the saliency of common attributes (class modification) produced a higher level of clustering performance than did no modification. However, restricting the saliency of common attributes (specific modification) did not result in a lower level of clustering performance relative to a no modification condition.

In summary, the data reported here are consistent with the notion that meaningful words may be represented in memory as a constellation of characteristics or attributes, and that the function of adjectival modification is to alter the saliency of these attributes and perhaps restrict their number (i.e., meaning). By a judicious choice of adjectives the saliency of overlapping attributes and perhaps the degree to which constellations of attributes of items overlap may be manipulated.

Learning to Learn

The recall and clustering data provide marginal support for the hypothesis that class modification results in a heightened learning-to-learn effect in recall. The complementary hypothesis that specific modification results in a diminished learning-to-learn effect in recall was also given marginal support.

More specifically, in the clustering data, the largest, numerical, inter-list increase occured in the CM condition and a slight decrease in the SM condition. Although the rates of increase did not differ between the CM and NA conditions, both were statistically different from the decrease found in the SM condition.

The recall data showed an identical ordering of conditions. The CM condition showed, numerically, the largest increase across lists and SM the least increase. The rate of inter-list increase did not differ between the CM and NA conditions. On the other hand, the difference in inter-list rates between CM and NA on the one hand and SM on the other approached, but did not reach statistical significance.

This identical ordering of conditions found in both the clustering and recall data suggest that learning to cluster may indeed be, in part, responsible for learning-to-learn effect in the recall of categorized word lists. However, the relative contribution of the learning-to-cluster (i.e., organize) effect to the learning-to-learn recall effect would appear to be small.

Appendix I

SAMPLE LISTS

Specific Modification Experimental condition

List 1	List 2
jet airplane	school bus
steam boat	mack truck
farm tractor	covered wagon
electric streetcar	golf cart
underground subway	roller skates
dog sled	horseless carriage
moving van	moon rocket
efficiency apartment	canvas tent
prehistoric cave	resort hotel
railroad shack	stately mansion
campus dorm	log cabin
indian tepee	bavarian castle
office building	royal palace
arctic igloo	playboy penthouse
poster bed	secretaries desk
pole lamp	portable television
foot stool	braided rug
file cabinent	grand piano
ham radio	framed picture
stuffed hassock	hand mirror
boston rocker	gas stove
medical doctor	patent lawyer
english teacher	civil engineer
apprentice carpenter	shipping clerk
public accountant	theoretical mathematician
volunteer fireman	fruedian psychiatrist
protestant minister	corner grocer
incumbent senator	magazine salesman
mink coat	bobby socks
bow tie	cashmere sweater
padded bra	jockey shorts
lapeled suit	head scarf
elastic girdle	flared trousers
leaky raincoat	nylon hose
topless bathingsuit	pouched sweatshirt
revolving door	peaked roof
plaster ceiling	living room
dance hall	poured foundation
spiral stairway	raftered attic
linen closet	plate glass
wine celler	screened porch
narrow corridor	columned front

Specific Modification Control condition

List 1	List 2
ice hockey	school bus
water skiing	mack truck
miniture golf	covered wagon
shadow boxing	golf cart
tag wrestling	roller skates
indoor track	horeless carriage
fly fishing	moon rocket
rainbow trout	canvas tent
killer whale	resort hotel
spiny lobster	stately mansion
channel catfish	log cabin
northern pike	bavarian castle
trained porpoise	royal palace
electric eel	playboy penthouse
child beating	secretaries desk
aggravated assualt	portable television
traffic speeding	braided rug
involuntary manslaughter	grand piano
corporate embezzeling	framed picture
statutory rape	hand mirror
petty larceny	gas stove
bumble bee	patent lawyer
Japanese bettle	civel engineer
flitting butterfly	shipping clerk
chirping cricket	theoretical mathematician
earth worm	freudian psychiatrist
lightning bug	corner grocer
furry caterpillar	magazine salesman
soft coal	bobby socks
regular gasoline	cashmere sweater
typing paper	jockey shorts
rubbing alcohol	head scarf
polluted air	flared trouseres
radioactive uranium	nylon hose
activated charcoal	pouched sweatshirt
brazillian coffee	peaked roof
pink lemonade	living room
draft root beer	poured foundation
hawain punch	raftered attic
soda pop	plate glass
chocolate shake	screened porch
pale gingerale	columned front

Class Modification Experimental condition

List 1

supersonic airplane
speeding boat
sluggish tractor
hustling streetcar
fleeting subway
streaking sled
lumbering van

ramshackle apartment
musty cave
shabby shack
seedy dorm
ragged tepee
battered building
weatherworn igloo

sanitary bed
bright lamp
lacquered stool
polished radio
spotless hassock
varnished rocker
scrubbed cabinet

capable doctor
diligent teacher
able carpenter
accurate accountant
experience fireman
dynamic minister
forceful senator

gold coat
black tie
pink bra
grey suit
white girdle
blue raincoat
orange bathingsuit

oak door
plaster ceiling
tiled hall
iron stairway
cedar closet
stone cellar
painted corridor

List 2

express bus
darting truck
faltering wagon
creeping cart
swift skates
dawdling carriage
accelerating rocket

frayed tent
shoddy hotel
dilapidated mansion
damaged cabin
decandent palace
crumbling castle
deteriorated penthouse

tidy desk
refinished television
vacuumed rug
waxed piano
dusted picture
shiny mirror
immaculate stove

efficient lawyer
tireless engineer
effective salesman
cooperative clerk
competent mathematician
qualified psychiatrist
reliable grocer

beige socks
red sweater
green shorts
purple scarf
brown trousers
tan hose
yellow sweatshirt

thatched roof
carpeted room
cement foundation
beamed attic
stained glass
brick porch
stucco front

Class Modification control condition

List 1	List 2
invigorating hockey	express bus
bracing skiing	darting truck
exciting golf	faltering wagon
refreshing fishing	creeping cart
exhilerating boxing	swift skates
energetic wrestling	dawdling carriage
stimulating track	accelerating rocket
odorous trout	frayed tent
smelly whale	shoddy hotel
pungent lobster	dilapidated mansion
stinking catfish	damaged cabin
reeking pike	decadent palace
putrid porpoise	crumbling castle
foul eel	deteriorated penthouse
terrible beating	tidy desk
appaling assault	refinished television
deplorable speeding	vacuumed rug
hideous manslaughter	waxed piano
troublesome embezzeling	dusted picture
sickening rape	shiny mirror
contemptible larceny	immaculate stove
flying bee	efficient lawyer
scurrying beetle	tireless engineer
flitting butterfly	effective salesman
hopping cricket	cooperative clerk
slithering worm	competent mathematician
gliding bug	qualified psychiatrist
crawling caterpillar	reliable grocer
combustible coal	biege socks
flaming gasoline	red sweater
burning paper	green shorts
blazing alcohol	purple scarf
scorching air	brown trousers
irradiating uranium	tan hose
ignited charcoal	yellow sweatshirt
boiling coffee	thatched roof
foamy lemonade	carpeted room
frothing rootbeer	cement foundation
sparkling punch	beamed attic
fizzing pop	stained glass
creamy shake	brick porch
effervescent gingerale	stucco front

Nouns Alone Experimental condition

Only the noun portion of the adjective-noun pairs listed above under the Specific and Class Modification Experimental conditions were presented to the *S*s. The nouns of List 1 for the Specific and Class Modification Experimental conditions were used as List 1 for the Nouns Alone Experimental condition. The same was true for List 2.

Nouns Alone Control condition

Only the noun portion of the adjective-noun pairs listed above under the Specific and Class Modification Control conditions were presented to the *S*s. The nouns of List 1 for the Specific and Class Modification Control conditions were used as List 1 for the Nouns Alone Control condition. The same was true for List 2.

Appendix II

INSTRUCTIONS

Nouns Alone conditions

This is an experiment in memory. You will be shown two lists of about 40 words each, and you will be asked to recall as many words as you can. Each list will be shown three times. You will be asked to recall by writing down the words you can remember after each showing of the list.

The words will appear one at a time on this screen and you are to study each word so as to be able to remember it.

When a list has been completed, the last word will be a three digit number. Do not turn the page, but as soon as you see the number, write it down, and begin counting backwards by threes from that number by writing the numbers down on the page. Start in the top of the left hand column and do not use the second column until you have filled the first. I will turn on a metronome and I want you to write one number for each beat of the metronome. After you have counted backwards for 30 seconds, I will tell you to turn the page and begin recall.

When you write your recall of the words write the words down in whatever order you remember them, going straight down the page. Do not use the second column until you have filled the first column. That is, write the words down as they occur to you but write them down in a single column. It is not neccessary for you to remember the words in the order you saw them.

You will have 2 minutes to recall each list. When I say stop following your recall, stop writing, turn your page and watch the screen for the next showing of a list. Are there any questions?

Remember, first you will study a list of words, then you will see a 3 digit number and I will tell you to count backwards by three's, then I will tell you to begin recall.

Do not look back at any previous page at any time during the experiment. Are there any questions?

<u>Specific and Class Modification conditions</u>

This is an experiment in memory. You will be shown two lists of about 40 pairs of words each, and you will be asked to recall as many words as you can. Each list will be shown three times. You will be asked to recall by writing down the words you can remember after each showing of the list.

The words will appear one pair at a time on this screen and you are to study each member of the pair so as to be able to remember it.

When a list has been completed, the last word will be a three digit number. Do not turn the page, but as soon as you see the number, write it down, and begin counting backwards by threes from that number by writing the numbers down on the page. Start in the top of the left hand column and do not use the second column until you have filled the first. I will turn on a metronome and I want you to write one number for each beat of the metronome. After you have counted backwards for 30 seconds, I will tell you to turn the page and begin recall.

When you write your recall of the words, write the pairs of words down in whatever order you remember them, going straight down the page. Write one pair of words in each space. If you cannot remember both members of a pair, then be sure to write down that portion of the pair which you can remember. Do not use the second column until you have filled the first column. That is, write the pairs of words or single words down as they occur to you, but write them down in a single column. It is not necessary for you to remember the words in the order that you saw them.

You will have 2 minutes to recall each list. When I say stop following you recall, stop writing, turn your page and watch the screen for the next showing of a list.

Remember, first you will study a list of pairs of words, then you will see a 3 digit number and I will tell you to count backwards by three's, then I will tell you to begin recall.

Do not look back at any previous page at any time during the experiment. Are there any questions?

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Footnotes

[1]In an attempt to eliminate apparent sampling problems, the N for the Nouns Alone Control and Experimental groups was doubled. For a detailed discussion see the results section.

[2]This somewhat smaller range of normative frequencies was due to the nature of the category norms from which the nouns were drawn. In attempting to equate means and distributions for the 18 experimental condition subcategories it was necessary to exhaust the larger categories present in the Battig-Montague (1969) norms. As a result, only smaller categories were left to be employed in the control conditions. While this difference in category size may represent a contaminating factor, it should be recalled that all experimental conditions are compared to appropriate control groups. Consequently, any difference in performance attributable to category size difference should be constant for all conditions.

[3]Pilot data indicated that two minutes was sufficient time for all Ss to emit as many words as they were able to recall.

[4]Clustering scores (ARC) for the three trials of both Lists 1 and 2 were also computed for the SM, CM, and NA control groups. These data are also presented in Figures 4a, 4b, and 4c. An analysis and discussion of these data may be found in the Learning to Learn section.

THE EFFECTS OF ADJECTIVAL MODIFICATION ON PROACTIVE INTERFERENCE AND LEARNING TO LEARN

by

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ABSTRACT

The effects of adjectival modification on the repetition of categories, but not exemplars, across successive lists, and on learning to learn were examined in a free recall paradigm. Three types of adjectival modification were employed: Nouns Alone (no adjectives), Class Modification (a class of adjectives (e.g., color) modified a category of nouns such as articles of clothing), and Specific Modification (an adjective modified appropriately only the noun with which it was paired and no other noun in any list). The results of the repeated category analyses showed: 1) substantial repeated category proactive interference (PI) for the Nouns Alone and Class Modification conditions, and 2) relatively little repeated category PI for the Specific Modification condition. The concepts of attribute commonality and saliency were discussed as possible mechanisms for the results obtained.

Further, analyses of the control groups for learning to learn effects showed: 1) the largest, numerical, learning-to-learn effect in recall for Class Modification and the smallest learning-to-learn effect for Specific Modification, although these differences were not reliable, and 2) an identical ordering of conditions in terms of learning-to-organize (i.e., cluster) effects. The magnitude of the effect was largest in the Class Modification condition. These results were discussed in terms of the relationship between learning to learn and learning to cluster.