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The Role of Mental Contiguity in Memory: Registration and Retrieval Effects

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Implicit contiguity of related items whose list presentations are physically disparate results from the subject looking back through memory so as to bring the items together in mental experience. Effects of implicit contiguity were examined in three experiments by controlling looking-back behavior during list presentation and varying the separation of target items and related items that were later provided as recall cues. The effectiveness of semantic cues was enhanced by their implicit contiguity with target items during study. However, Experiment III showed that the effectiveness of acoustically related cues was uninfluenced by either physical or implicit contiguity. Experiment III also revealed that finding faster "decay" of acoustic than semantic information is dependent upon retention test arrangements.

It is well established that many cases of unsuccessful recall are due to failures of the retrieval mechanism rather than to failures of registration or storage. While this emphasis on retrieval problems has focused attention on the concept of retrieval cues, many questions concerning cue construction and cue effectiveness remain unanswered. One factor that was early recognized as being an important determinant of cue effectiveness was prior contiguity of the cue and the material to be remembered. It was soon realized, however, that physical contiguity occurs too infrequently to account for all differences in cue effectiveness, so the notion of implicit contiguity (contiguity of mental experience of the cue and target) was introduced as a construct. The present experiments were designed to control implicit contiguity and assess its importance as a determinant of cue effectiveness.

The introduction of implicit contiguity brings with it the problem of describing how items whose presentations were physically disparate are brought together in mental experience. The most common solution to this problem has involved the implicit associative response (Underwood, 1972; Voss, 1972; Wallace, 1970); it is supposed that strong natural language associates of a word are elicited as implicit responses during study. When two study items are highly associated in the natural language, presentation of one is said to elicit the other so that implicit contiguity is produced, even though the related items were not physically contiguous during study. A recognition process would also seem to be implicated since both study items and items not from the list would be brought to mind; the subject must discriminate between the two types of associative responses so that only items from the list are rehearsed and recalled.

The implicit associative response appears to be a relatively passive mechanism that automatically gives rise to implicit contiguity when related items are included in the same list. However, rather than being automatic, the production of implicit contiguity may perhaps be better characterized as an active process, under the subject's control. When a study item is presented, the subject may choose to look back through his memory of previously presented study words in search of related items so that implicit contiguity is a result of a suc-

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cessful memory search. If implicit contiguity is produced by means of an active process that is potentially under experimental control, its importance as a determinant of cue effectiveness can be assessed.

In the present experiments, active mental contiguity was manipulated by presenting pairs of related words in a list with the number of items intervening between pair members being varied. The subject's task was to judge the presence or absence of a specified relationship between each presented item and one(s) presented earlier. In one condition, subjects were to decide if a presented item was related to the immediately preceding item in the list; this is referred to as the one-back condition. Subjects in a second group, the *n*-back condition, were to judge if a presented item was related to any preceding item in the list. For both conditions, list presentation was followed by a final free recall and a final cued recall test. In the cued test, the first member of a related pair was given as a cue for recall of the second member of the same pair.

The primary interest was in the influence of looking-back instructions on later recall of related items that were not physically contiguous during study. Implicit contiguity was expected to result from the subject's looking back through memory and locating a related item. Thus, when related items were not physically contiguous, their implicit contiguity should be produced only in the *n*-back condition. For later free recall, implicit contiguity of related items during study should enhance total recall by increasing the probability of recalling both members of a related pair given that one member is recalled. The final cued recall test allows an even more direct means of assessing the influence of implicit contiguity. The later cue effectiveness of one member of a related pair for recall of the other should be enhanced by implicit contiguity during study.

Experiment I

Method

Lists. Eighty-word lists were constructed from two instances each of 33 categories, and one instance each of 14 further categories occuring in the Battig and Montague (1969) norms; list items were randomly chosen from among the five most frequently reported instances of their respective category. Five category pairs were employed in primacy and recency buffers with one member of each pair occurring in the primacy buffer while the remaining member occurred in the recency buffer. Within the list, members of each of the 28 remaining category pairs were separated by either 0, 1, 3, or 7 intervening items; seven pairs were randomly assigned to each of the four levels of spacing. The 14 single items were distributed throughout the list positions intervening between the primacy and recency buffers. With the further restriction that all item types (levels of spacing and single items) must be represented n times before any item type could be represented $n+1$ times, the assignment of items to serial positions was random. Four lists of the form described were constructed by rotating category pairs through the four levels of spacing so that, across lists, each level of spacing was represented by the same items. A different random assignment of item types to list position was also employed for each of the four lists. Each of the lists was employed equally often during training.

Procedure. Words were prepared as slides and presented individually at a 5-sec. rate. All subjects were informed that a portion of the items in the list would share category membership with another list item. Subjects in judgment conditions were to judge the presence of a category relationship between items. In the one-back condition, subjects were to judge if each item was from the same category as the item *immediately* preceding it in the list, while subjects in a second condition (*n*-back) were to judge if each item was from the same category as *any* preceding list item. A response box containing two buttons was provided for the judgment task; subjects were instructed to press the right button to indicate the presence of the specified relationship, and the left button to indicate its absence. Lights visible to the experimenter indicated the subject's judgment allowing it to be recorded.

Subjects within each judgment condition were divided with regard to the learning instructions given, incidental or intentional. Intentional learning instructions informed subjects that their retention of the list would be tested; subjects were not informed of an impending test by the incidental learning instructions. The manipulation of learning instructions was intended to assess the importance of possible additional rehearsal resulting from intentional learning instructions. It was also of interest to determine if intentional learning instructions would take precedence over and eliminate any effects of looking-back instructions. Subjects in a fifth condition, the "Learn" condition, received intentional learning instructions but did not engage in a judgment task.

After list presentation, all subjects were read five sets of nine digits, formed by randomly arranging the digits 0–9, and asked to recall each set immediately after its presentation. The purpose of the digit recall task was to eliminate any short-term memory of list words. Next, subjects were asked to recall as many list words as they could in any order that they wished. Recall was written with no maximum time limit on the recall period; a minimum of 5 min. attempting recall was required. Following the free recall test period, a cued recall test was administered. The first item from each category pair presented during study, excluding primacy and recency buffers, was provided as a cue for recall of the second-presented pair member. The cues were arranged in a random order and typed in a single column with a blank adjacent to each cue. Subjects were instructed to fill the blanks with a presented item from the same category as the adjoining cue. There was no time limit on the final cued recall test.

Design and Subjects. Two levels of learning instructions (incidental and intentional) were factorially combined with two looking-back tasks (one-back and *n*-back) to form four between-subjects conditions. A fifth condition received intentional learning instructions but did not engage in a judgment task. Study spacing of category members (0, 1, 3, or 7 intervening items) was represented as a within-subject factor.

The subjects were 80 students in an introductory psychology class who participated for course credit; 16 subjects were randomly assigned to each of the five between-subject conditions. All subjects were tested individually.

Results and Discussion

Judgment accuracy. The probability of a "yes" judgment during list presentation was computed for the second-presented member of each category pair and for seven of the single items; probabilities for each level of spacing and single items were, thus, based on seven observations per subject. Since analyses revealed no significant effects of incidental versus intentional learning instructions, mean probabilities of a "yes" judgment were collapsed across learning instructions for display in Table 1. In the one-back condition, a "yes" judgment was correct when spacing was 0, and incorrect for all other spacings and single items. In the *n*-back condition, "yes" was the correct judgment at all spacings, and incorrect only for single items.

TABLE 1
PROBABILITIES OF A "YES" JUDGMENT IN EXPERIMENT I

Judgment condition	Spacing 0	1	3	7	Single items
One-back	.92	.04	.04	.04	.04
n-back	.89	.82	.81	.83	.12

The probability of a correct judgment was quite high in all cases. In the *n*-back condition, the probability of a correct "yes" judgment showed a slight but nonsignificant decline between spacings of 0 and 1, and then remained stable across greater spacings. The probability of an incorrect "yes" response in the one-back condition was low and remained stable across spacings 1–7 and single items. For single items, the probability of incorrectly responding "yes" was higher in the *n*-back than in the one-back judgment condition, $F(1,62) = 11.57$, $p < .01$.

Final recall. Cued recall results from the learn condition and the two looking-back conditions are shown in Figure 1; results from the looking-back conditions are collapsed across incidental versus intentional learning instructions since this factor did not approach significance in any of the analyses.

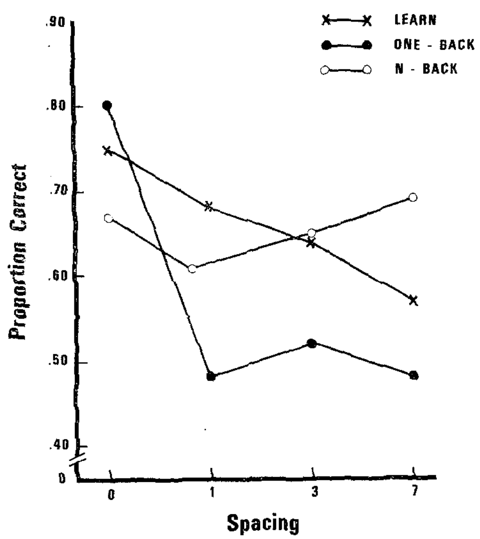

FIG. 1. Cued recall in Experiment I.

Cued recall in the learn condition declined steadily with increases in spacing. Of greater interest are differences in the performance of the two looking-back conditions. Cued recall in the one-back condition was quite high at 0-spacing, and uniformly low at greater spacings. Performance remained stable across spacings in the *n*-back condition and was higher than that in the one-back condition at all spacings except 0. Thus, when members of a related pair were not physically contiguous during study, cue effectiveness was enhanced if subjects were required to look back through memory and find the first presented member of a pair during the presentation of the second member.

Analyses provided support for the above description of results. Variability was quite high in the learn condition so that the effect of spacing was not significant, $F(3,45) = 2.33$, $P > .05$. An analysis that included only the two looking-back conditions revealed that the main effects of looking-back condition, $F(1,60) = 4.58, p < .05$, and spacing, $F(3,180) = 10.87$, $p < .001$, were significant as was their interaction, $F(3,180) = 8.71$ $p < .001$. A further analysis excluded 0-spacing and revealed a highly significant advantage for the *n*-back judgment condition, $F(1,60) = 25.52$, $p < .001$; effects involving spacing did not approach significance in either looking-back condition when 0-spacing was excluded.

If a "yes" response during presentation indexes implicit contiguity and implicit contiguity enhances recall, then items given a correct "yes" response during presentation should show higher cued recall than items given an incorrect "no" response. This expectation was confirmed by the results of a conditional probability analysis. The probability of cued recall was substantially higher for items given a correct "yes" during presentation (.68) than for items given an incorrect "no" (.38), $F(1,31) = 30.61$, $p < .001$. Thus, conditionalizing on the judgment made in the *n*-back condition during presentation leads to the same conclusion as do comparisons between the *n*-back and one-back conditions: Cued recall is enhanced by implicit contiguity of the cue and target item during study.

Free recall performance was substantially lower than cued recall but the pattern of results obtained was quite similar. The free recall effect of spacing was not significant in the learn condition. Among the looking-back conditions, the main effect of spacing, $F(3,180 = 4.00$, and the interaction between looking-back and spacing, $F(3,180) = 4.77$, were significant, both ps $< .01$; the form of the significant interaction was identical to that described for cued recall.

One source of information can be gained from the free recall results that was not available from cued recall: The probability of free recalling single items was substantially higher in the *n*-back (.21) than in the one-back (.13) judgment condition, $F(1,60) = 7.89$, $p < .01$. There are several possible explanations of this higher free recall of single items in the *n*-back condition. One possiblity is that subjects in the *n*-back condition were more likely to detect relationships between single items and items that were supposedly instances of other categories; this possibility is supported by the higher probability in the *n*-back condition of responding "yes" to single items during study. By this view, the advantage of the *n*-back condition in free recall of single items would be due to the establishment of additional relationships that could be used to aid retrieval. A second possibility relates to prior research (Jacoby, 1973; Jacoby & Bartz, 1972) that has shown that final free recall can be enhanced by increasing the retention requirements of the initial task. The *n*-back task employed in the present experiment required subjects to retain an item in a form that allowed it to be accessed after the presentation of several intervening items, whereas the one-back task only required that an item be accessible immediately after its presentation. Due to the greater demands of the *n*-back task, more complete processing and better long-term retention of individual items may have been produced.

Results that remain to be discussed were common to cued and free recall. The most important among these results is the effect of looking-back instructions. Recall was higher when the judgment task required subjects to look back through memory so that implicit contiguity of related items was produced, allowing the conclusion that implicit contiguity is an important determinant of cue effectiveness and can be brought under experimental control. In agreement with prior research (Hyde & Jenkins, 1969; Jacoby & Goolkasian, 1973), the manipulation of incidental versus intentional learning instructions did not alter recall performance. The looking-back tasks were successful in controlling the production of implicit contiguity, regardless of learning instructions, and any additional rehearsal in intentional learning conditions did not aid later recall.

Two additional results in the first experiment are worthy of comment. The first is the higher recall at 0-spacing in the one-back than in the *n*-back condition. A possible interpretation of this result is that implicit contiguity of category instances is necessary for a functional pair to be established, so that the number of functional pairs was larger in the *n*-back condition where implicit contiguity of pair members occurred regardless of their spacing. The general notion is that cue effectiveness depends on the total number of functional associations or units formed in a situation so the difference in recall at 0-spacing is comparable to an effect of list length.

The second result that should be commented upon is the effect of spacing in the learn condition. The decline in recall as spacing was increased replicates the results of prior experiments (Cofer, Bruce, & Reicher, 1966; Glanzer, 1969). However, this decline can now be interpreted in the light of the importance of looking back during list presentation. The high variability in the recall of the learn condition suggests that there were individual differences in looking-back, and that the decline in recall across spacings may simply index the number of subjects who looked back far enough to find the first-presented member of a related pair during presentation of the second member. The use of specific looking-back instructions offers the advantage of reducing individual differences so that any remaining effects of spacing can be more accurately assessed.

Experiment II

The second experiment was basically a replication of the first with a few minor modifications. Only the one-back judgment conditions with incidental learning instructions were included since other conditions employed in Experiment I yielded very little additional information. More important modifications had to do with the final retention test. Only the final cued recall test was given, and that test was modified so that cued recall of single items could be assessed. Single items in the study list were each drawn from a separate category; later recall of these items was cued by providing a previously nonpresented instance of the same category.

The importance of single-items is that effects in their cued recall cannot be due to implicit contiguity produced by looking-back instructions; the cue does not occur during list presentation so it cannot be brought into implicit contiguity with the target item by means of a backward search. This being the case, cued recall of single items provides a baseline against which implicit contiguity effects of looking-back instructions can be assessed. Comparisons with cued recall of single-items will be used to answer two questions. First, do looking-back instructions influence the processing of individual items rather than the implicit contiguity of related items? There is some possibility that the higher free recall of single-items and other advantages of the n-back condition in Experiment I were due to more extensive processing of individual items. Differential processing of individual items should be revealed by cued recall of single-items as well as by cued recall of category pair members. If cued recall of single-items is not influenced by looking-back instructions, any effects with category pairs included in the list must be due to implicit contiguity. Second, are any benefits gained from list presentation of the cue aside from those due to implicit contiguity? If not, cued recall of single-items should be as high as that of items presented with spacings greater than 0 in the one-back condition.

Method

The materials and construction of lists were the same as described in Experiment I with the exception that an additional item was selected from seven of the categories that had previously contributed only a single item; additional items were selected from the remaining four most frequent instances of their respective categories. Excluding the primacy and recency buffers, each list contained 28 category member pairs with seven pairs presented at each of four spacings (0, 1, 3, and 7 intervening items). Single items from seven remaining category pairs were distributed throughout the list as were seven filler items that were not later tested in final cued recall. Five lists of the form described were constructed by rotating category pairs through the four spacing and the single item presentation conditions; single items were items that also served as the second-presented member of a category pair.

Procedure. Only the n-back and one-back judgment conditions of Experiment I with incidental learning instructions were included. Instructions for the one-back condition were altered to emphasize that the subject should respond "yes" only if a presented item was from the same category as the item immediately preceding it in the list, and should respond "no" even if the item was from the same category as another item that was further back in the list than the immediately preceding item. These instructions had the effect of informing subjects that the list contained pairs that were not presented with 0-spacing; subjects were not so informed in Experiment I.

After list presentation and the digit recall task employed in Experiment I, subjects were given a cued recall test. The first-presented item from each category pair was provided as a cue for recall of the second-presented pair member; recall of single-item categories was cued by providing the category pair members that were not included in list presentation. The cues were arranged in a random order and typed in a single column with a blank adjacent to each cue. Subjects were instructed to fill the blanks with a presented item from the same category as the cue adjoining the blank.

An identical test was used following all study lists so that across study lists items representing the four spacing and the single-item presentation conditions were cued with the same words.

Additional procedural details were identical to those described in the Method of Experiment I.

Design and subjects. Two between-subjects conditions differed in the looking-back task required (one-back and *n*-back); four spacing (0, 1, 3, and 7 intervening items) and the single item presentation conditions were represented as five levels of a single within-subject factor.

The subjects were 30 students in an introductory psychology class who participated for course credit; 15 subjects were randomly assigned to each of the looking-back conditions. All subjects were tested individually.

Results and Discussion

Judgment accuracy. Probabilities of a "yes" judgment response during list presentation are presented in Table 2; each probability is based on 105 observations.

TABLE 2
PROBABILITIES OF A "YES" JUDGMENT IN EXPERIMENT II

Judgment condition	Spacing 0	1	3	7	Single items
One-back	.89	.10	.04	.09	.02
n-back	.89	.83	.76	.85	.14

The probability of an incorrect "yes" response in the one-back condition varied across Spacings 1–7 and single-items, $F(3,42) = 5.26$, $p < .01$, in Experiment II whereas it remained constant across spacings in Experiment I. Judgment accuracies obtained in the *n*-back condition were quite similar to those found in Experiment I; there was a nonsignificant decrease in the probability of a correct "yes" response across levels of spacing, $F(3,42) = 2.34$, $p > .05$. As in Experiment I, the probability of an incorrect "yes" response to single-items was lower in the one-back than in the *n*-back condition, $F(1,28) = 16.29$, $p < .01$.

Final cued recall. The final cued recall results are plotted in Figure 2. The interaction of judgment condition and spacing was essentially identical to that observed in Experiment I. Cued recall in the one-back condition was quite high for pair members presented with 0-spacing and drastically lower when members of a category pair were more widely spaced. In the *n*-back condition, recall was lower than in the one-back condition at 0-spacing but higher at all other levels of spacing. The only discrepancy between the results of Experiments I and II was in recall of items presented with spacings greater than 0 in the one-back condition; cued recall was somewhat higher with a spacing of 1 than with greater spacings in the present experiment while performance remained stable across all spacings greater than 0 in Experiment I. This discrepancy coincides with the discrepant judgment results in the one-back condition and may have been due to differences in instructions between the two experiments. Of greater interest, cued recall of single-items revealed no effect of looking-back instructions, and generally was as high as that for pair members presented with spacings greater than 0 in the one-back condition.

Analyses provided support for the above description of results. The main effect of presentation condition (spacings 0–7, and single items) and the interaction between the presentation and looking-back conditions interaction were both highly significant, $Fs(4,112) = 55.68$ and 27.74 both $ps < .001$. Across spacings 1–7, performance was higher in the *n*-back than in the one-back condition, $F(1,28) = 4.48$, $p < .05$. The effect of looking-back condition in cued recall of single-items did not approach significance, $F < 1$. Varying spacing across levels 0–7 had only a marginally significant effect in the *n*-back condition, $F(3,112) = 2.68$, $p < .05$. In the one-back condition, cued recall was higher at a spacing of

1 than at greater spacings or single-items, $F(3,112) = 6.34$, $p < .01$; differences among spacings 3 and 7, and single items were not significant.

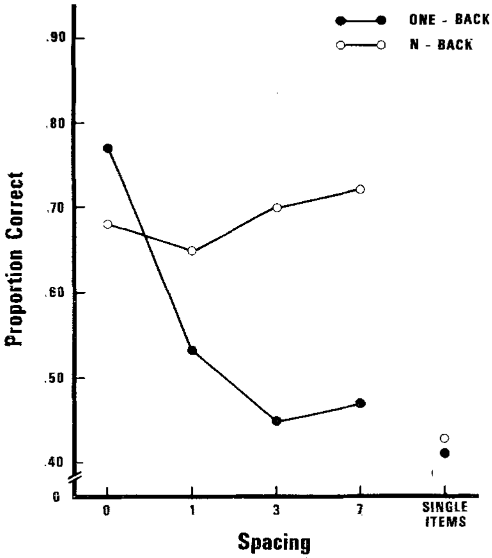

FIG. 2. Cued recall in Experiment II.

As in Experiment I, cued recall in the n-back condition was conditionalized on judgment classification during list presentation. A correct "yes" judgment response was taken as an indication that implicit contiguity had occurred while an incorrect "no" judgment provides evidence that implicit contiguity of the cue and target did not occur during presentation. The conditional probability analysis revealed that cued recall was higher for items given a correct "yes" during presentation (.73) than for items given an incorrect "no" (.45), $F(1,14) = 15.63$, $p < .001$. Again, both the conditional probability analysis and comparisons between the one-back and n-back conditions verify the importance of implicit contiguity during study.

Results of the present experiment revealed that looking-back instructions influenced cued recall only when there was an opportunity during study for implicit contiguity of the cue and the item that was to be recalled. Since there was no effect of looking-back instructions in cued recall of single items, effects when pairs of related items were presented must have been due to implicit contiguity rather than differences in processing of individual items. Other comparisons with cued recall of single items revealed that cue effectiveness does not benefit from including the cue in the same list as the target item unless implicit contiguity of the two is produced during study.

EXPERIMENT III

The third experiment was designed to determine if the importance of implicit contiguity is dependent on the nature of the relationship between items. It has been suggested that the memory trace of a presented item is best characterized as being a collection of attributes (Underwood, 1969; Wickens, 1970). Most theorizing has centred around differences in memorability of attributes with the claim often being made that the acoustic attribute of an item decays more rapidly than the semantic one (for example, Craik & Lockhart, 1972; Kintsch & Buschke, 1969). However, it is quite possible that attributes differ in retrievability rather than decay rate. Semantic relationships may have a greater influence on storage and later retrieval than do acoustic relationships. If so, implicit contiguity would be more important when items were semantically related.

It seems reasonable that implicit contiguity serves only as an opportunity for detection of further relationships among items rather than producing an automatic strengthening of an association. The notion is that implicit contiguity allows subjects to further compare related items, and is only effective if the memory coding of items is influenced by this further comparison. With semantically related items, common features are brought to mind so that the meaning that is encoded is a product of the interaction among items rather than the meaning of the individual items. In this vein, it is quite easy to show that a word's precise meaning is influenced by the context in which it is presented (for example, Light & Carter-Sobell, 1970). Acoustic features, on the other hand, seem less susceptible to the influence of context; most words are pronounced the same regardless of what items precede them. Due to this differential sensitivity to context, implicit contiguity of semantically related items is likely to have more influence on encoding than is implicit contiguity of acoustically related items.

Method

Lists. Lists containing either semantically or acoustically related items were formed from materials employed in Experiment II, and 35 pairs of acoustically related words. Members of acoustically related pairs were common words that differed from one another only in the initial consonant (for examples, rock and dock); at least three nonpresented common words could also be formed by changing the initial consonant so that given one member, the rule "common word that differs only in the initial letter" did not uniquely specify the remaining member of a presented pair. An attempt was made to minimize semantic similarity between members of an acoustically related pair.

Each list was homogeneous with regard to the type of relationship (semantic or acoustic) held by pair members. Within a list, members of a related pair were separated by either 0, 3, 6, or 12 intervening items; seven pairs were randomly assigned to each of the levels of spacing. In addition, seven single items from related pairs were distributed throughout the list. Other details of list construction were identical to those of Experiment II; across lists, each level of spacing and single items were represented by the same pairs.

Procedure. One-back and *n*-back judgment conditions with incidental learning instructions were employed. Subjects received only one list so that relationships among items were all of one type (either semantic or acoustic); judgment task instructions were compatible with the type of relationships present in the list. For example, subjects in the one-back condition that received a list containing acoustically related pairs were instructed to respond "yes" if a presented item sounded similar to the item that immediately preceded it. Instructions for the one-back condition did not mention that an item might be related to some earlier presented item other than the one immediately preceding it.

A final cued recall test followed list presentation. Separate tests were prepared for lists containing acoustically related pairs and those containing semantically related ones; subjects were informed of the relationships (semantic or acoustic) between cues and items that were to be remembered. The remaining procedural details were identical to those of Experiment II.

Design and subjects. Two types of relationships (semantic and acoustic) were factorially combined with two looking-back conditions (one-back and *n*-back) to form four between-subjects conditions. Presentation condition (spacings of 0, 3, 6, and 12 and single items) was included as a within-subjects factor.

The subjects were 60 students in an introductory class who participated for course credit; 15 subjects were randomly assigned to each of the four combinations of acoustic verses semantic relationship and looking-back condition. All subjects were tested individually.

Results and Discussion

Judgment accuracy. Probabilities of a "yes" judgment response are shown in Figure 3.

Across all spacings and single items in the one-back condition, the probability of a correct acoustic judgment was slightly higher than that of a correct semantic judgment, $F(1, 28) = 4.60$ $p < .05$. In both the acoustic and the semantic conditions, the likelihood of an incorrect "yes" response during one-back judgments remained stable across spacings greater than 0 and single items.

Judgment accuracies from the *n*-back condition can be employed to assess differences

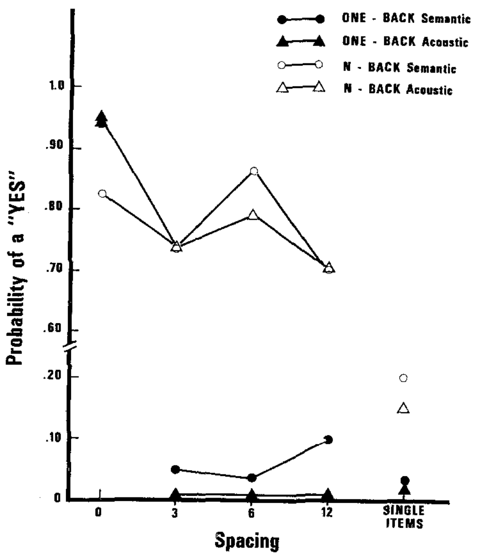

FIG. 3. Probabilities of a "yes" judgment in Experiment III.

in decay rate of acoustic and semantic information. If acoustic information decays faster, the decline in the probability of a correct "yes" response across increases in spacing should be more rapid in the acoustic than in the semantic condition. The probability of a correct "yes" response did decline across Spacings 0–12, $F(3,84) = 5.12, p < .01$. However, there was no difference between the acoustic and semantic condition in the rate of decline; the interaction of relationship judged and spacing did not approach significance, $F(3,84) = 1.26, p > .10$. The probability of a false alarm, an incorrect "yes" to single items, was also quite similar for the semantic and the acoustic judgment conditions, $F < 1$. Thus, in agreement with earlier investigations (Bregman, 1968; Shulman, 1970), the present results did not provide evidence that acoustic information decays faster than semantic information.

Final test. Final cued recall results are shown in Figure 4. The most striking aspect of those results is the higher cued recall when subjects were judging semantic rather than acoustic relationships. The effects of spacing and looking-back instructions also differed for the semantic and acoustic conditions. Results in the semantic condition were quite similar to those of Experiments I and II: Cued recall was higher in the one-back than in the n-back condition at 0-spacing while the opposite was true at higher levels of spacing. There was little difference between the one-back and n-back conditions in the usefulness of semantic cues for recall of single-instances; cued recall remained stable across spacings greater than 0 and single items in the one-back condition. In contrast, neither looking-back instructions nor spacing had any effect in the acoustic condition. The effectiveness of an acoustically related cue was not enhanced by including it in the same list as the item that was to be remembered, regardless of either the physical or implicit contiguity of the cue and target item.

The effect of semantic versus acoustic judgments was highly significant, $F(1,56) = 43.5$, $p < .001$, as were the main effect of presentation condition (spacings 0–12, and single items), the interaction between presentation and looking-back conditions, and the triple interaction, Fs$(4,24) = 3.93$, 9.94, and 3.94, all ps $< .01$. Further analyses revealed that in the acoustic condition neither simple main effects nor interactions approached significance; only the interaction between presentation and looking-back condition generated an F larger than one, $F(4,224) = 1.23, p > .10$. In the semantic conditions, the interaction between presentation and looking-back conditions was highly significant, $F(4,224) = 13.50$, $p < .001$. Across spacings 3–12, recall with semantic cues was higher in the n-back than in the one-back condition, $F(1,56) = 7.88, p < .01$. Cued recall with semantic cues was stable across spacings greater than 0 and single items in the one-back condition, $F < 1$. The effect of spacing in the n-back condition was significant $F(3,224) = 2.78$, $p < .05$, due to the poor recall of semantically related items presented with 0-spacing.

For the n-back condition, recall with semantic cues was conditionalized on judgment

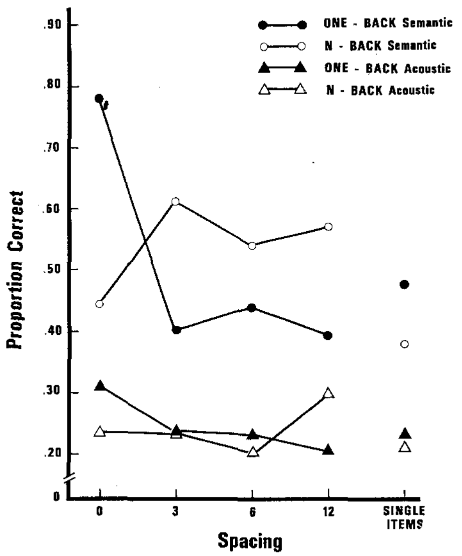

FIG. 4. Cued recall in Experiment III.

classification during list presentation. An analysis of these data revealed that the probability of cued recall was higher for items given a correct "yes" during presentation (.61) than for items given an incorrect "no" (.28), $F(1, 14) = 41.40, p < .001$. As in earlier experiments, the conditional probability analysis and comparisons between the one-back and n-back conditions verify that cued recall is enhanced by implicit contiguity of a target and semantically related cue.

The finding of higher recall after semantic than after acoustic judgments is in agreement with results from earlier experiments (for example, Craik, 1973; Hyde & Jenkins, 1969; Jacoby & Goolkasian, 1973) that have followed presentation of a long list with a final test. These results showing a final test advantage for semantic conditions seem to support the claim that semantic information decays less rapidly than acoustic information (Craik & Lockhart, 1972). However, the accuracy of judgments in the first phase of the present experiment provided a quite different picture by revealing no differences in the rate of decay for semantic and acoustic information. This finding of no difference in rate of forgetting also gains support from other studies in the literature (Bregman, 1968; Shulman, 1970). A retention advantage for semantic information apparently depends on some critical procedural detail.

The procedural detail that is necessary to show an advantage for semantic information may be a rather subtle one. Obvious differences between the judgment and cued recall tasks were: the longer retention interval, the requirement that the target item be produced, and the unpaced nature of the test in final cued recall. However, it is doubtful that any of these factors is critical since other experiments that agree with the judgment results in showing no difference in forgetting of semantic and acoustic information have required production of the target item after long retention intervals (Bregman, 1968) or employed unpaced tests (Shulman, 1970). More important differences might be concerned with another aspect of the testing arrangements. All experiments finding a marked advantage for semantic information have given a retention test following presentation of a long list. In contrast, studies showing no differences in decay rate have either interspersed tests with list presentation, as in the judgment task of the present experiment and in Bregman's study, or tested retention after presentation of a very short list (Shulman, 1970). This difference in testing may influence the choice of strategy, and a semantic advantage may depend on the particular test strategy employed.

Temporal search may be a good description of the strategy employed when tests are interspersed with list presentation or when retention is tested after presentation of a very short list. The notion is that the subject searches back through the list and employs test information to discriminate the memory of the target item from those of other items. When tests are interspersed with study, the majority of the items are usually tested after very few intervening items so a backward search yields a rapid and correct response for most tests; a backward search would also be an efficient strategy after presentation of a short list. If test requirements are satisfied by means of a backward search, it is more reasonable to speak of test information being used to aid in the selection rather than the retrieval of the target item. By this view, the decline in test performance with increases in separation of the presentation and test of a target item is due to a decrease in the efficiency of the backward search as a means of locating the memory of the target item; "decay" rates will be quite similar regardless of whether acoustic or semantic information is provided as a basis for selecting the target item once it has been encountered by the backward search.

After presentation of a long list, the separation of the study and test of a target item is quite large, so a temporal search would be time-consuming and extremely error prone. As a result, the subject may gain access to the memory of the target item by using test information to reconstruct its study encoding, rather than by engaging in a temporal search. Reconstruction of the target item is seen as involving a continuous interplay between memory trace and constructive activities. That is, reconstruction is guided by the memory trace of the target item through continual checks of the test construction for properties that can be identified with the study encoding. The result is much like a servo-mechanism with constructive activities during test homing in on the trace of the target item.

With the looking-back strategy, knowledge of list membership is direct in that the subject is searching through the list so any item found there is obviously a member of the list. In contrast, employment of the reconstruction strategy requires that list membership be inferred from the properties of the reconstructed trace; performance is limited by the discriminability of the study encoding from prior encodings of the target item. For reconstruction, the relationship between cue information and study encoding is also important in that successful reconstruction is most likely when information provided by the cue corresponds to a significant part of the appropriate memory trace. Thus, when reconstruction is attempted, the form of study encoding is important for both cue effectiveness and the discriminability of the target item.

It is suggested that the effects of implicit contiguity and the effects of semantic and acoustic processing on the final test are due to an influence of study encoding on reconstruction. First, the semantic condition held a final test advantage even in the absence of implicit contiguity during study. This advantage can be attributed to the differential influence of context on semantic and acoustic encoding. Semantic encoding is context dependent so that the trace established in one situation is relatively unique to that situation and discriminable from prior encodings of the same word. In contrast, acoustic encoding is essentially consistent across a large number of contexts so there is little to identify the acoustic trace with the study situation even if the trace can be reconstructed. This difference in sensitivity to context can also be used to explain the differential effects of implicit contiguity for semantic and acoustic conditions. Implicit contiguity will be effective only if study encoding is modified as a result. When a semantically related cue and target are compared during study, the meaning encoded is a product of the interaction of the two so, at the time of cued recall, reconstruction of the study encoding of the cue necessarily reveals some contribution of the target item and aids in its reconstruction. In contrast, acoustic encoding is relatively context free so implicit contiguity of an acoustically related cue and target item does not modify encoding or influence later cue effectiveness. This is not to say that acoustic cues cannot aid retrieval under conditions other than those of the present experiment. For example, acoustic relationships do enhance free recall when intentional learning instructions are given (Jacoby & Goolkasian, 1973). However, it does appear that processing in addition to that required for the detection of acoustic relationships is necessary for dependent storage of acoustically related items.

General Discussion

Slamecka (1972) has suggested that instances of a category are independently stored during study, and that the cue effectiveness of an item from the same category as the target items is totally due to the elicitation of the category name. The present experiments provided evidence of independent storage when category instances were presented with spacings greater than 0 in the one-back condition, preventing the occurrence of implicit contiguity of the cue and target item during study. In the absence of implicit contiguity, the effectiveness of the cue was not enhanced by including it in the study list so it seems reasonable to conclude that the cue and target item were independently stored during study. However, when instances of a category were mentally contiguous during study, dependent storage must have resulted since a presented category instance was much more effective as a cue for recall than was a nonpresented one. It appears that either independent or dependent storage of category instances is possible, and that the form of storage is at least partially determined by implicit contiguity of related items during study.

Cue effectiveness can be enhanced by bringing related items together during study. However, implicit contiguity alone does not appear to be sufficient; an association between the cue and item that is to be recalled is not automatically strengthened as a result of implicit contiguity. Rather, implicit contiguity allows comparisons or interactions among related items, and cue effectiveness is enhanced only if the coding of related items is altered as a result of these interactions. The encoding of semantic attributes is quite sensitive to context so that implicit contiguity during study of a semantically related cue and target item enhances cue effectiveness. In contrast, acoustic encoding is relatively context free, and implicit contiguity of acoustically related items has no effect on later cued recall.

Distinctiveness of the study encoding of the target item is a second factor determining retention. All list learning tasks involve a discrimination problem in that the subject must be able to discriminate between the memory of the target and memories of other list items, or between memories of the list occurrence and other occurrences of the target item. An advantage of semantic encoding that was noted earlier is that semantic encoding is context dependent so that the encoding accomplished during study is relatively unique and, thus, discriminable from prior semantic encodings of the same item. The importance of a second type of uniqueness, uniqueness within the study list, is brought out by comparisons of cue effectiveness in the one-back and *n*-back conditions at 0-spacing. In all three experiments, recall at 0-spacing was higher in the one-back condition, presumably because of the smaller number of relationships established in that condition during study. The present effects of uniqueness are not different in kind from several other effects reported in the literature, including isolation effects, effects of category size, and recognition effects of frequency of occurrence in the natural language. All of these effects point up the basic nature of the discrimination problem for most memory tasks.

As a technique for future research, the looking-back procedure introduced in the present investigations is potentially a very powerful one. A large number of questions asked in memory research are concerned with some result of trace interaction during study. For example, a strength theory assumes that traces of a given type are integrated to produce a probability of occurrence for a particular event or outcome. Forgetting as revealed in investigations of retroactive and proactive interference may also be a result of interaction among memory traces. In general, the integration of past experiences, or any other interaction of memory traces, is likely to be an active process that can be brought under control and investigated by means of looking-back instructions.

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