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EFFECTS OF MODALITY OF PRESENTATION ON DELAYED RECOGNITION[1]

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Summary.—Auditorily and visually presented lists were either tested or not tested immediately after input and were later tested on a delayed recognition test. For those lists given the immediate free-recall test, auditory presentation was superior on this immediate test. On the delayed recognition test the tested lists led to higher performance than non-tested lists. For tested lists auditory presentation led to superior recognition for the terminal serial positions, while for non-tested lists visual presentation led to higher performance on the last few positions. The fact that modality of presentation had opposite effects on delayed recognition of the lists was discussed in terms of current models of modality effects.

A recurring problem in the literature on short-term memory in recent years has been a phenomenon known as the modality effect. The general finding is that auditorily presented verbal items are recalled at a much higher level in short-term memory tasks than are visually presented items (Corballis, 1966; Murdock, 1967; Penney, 1975). This finding occurs in nearly all the short-term memory tasks in which modality has been varied and is probably more generalizable than any other short-term memory phenomenon. However, most of the research directed at explaining the phenomenon has been done using the free recall procedure. With this technique the modality effect is manifested as auditory superiority over the terminal or recency positions and no difference between modality conditions over the primacy and middle positions.

Although several attempts have been made to explain the modality effect in short-term memory (Craik, 1969; Murdock & Walker, 1969; Watkins, Watkins, & Crowder, 1974), probably the most popular explanation put forth has been that proposed by Crowder and Morton (1969). The theory argues that there is a prelinguistic auditory store (PAS) similar in nature to the visual icon but of longer duration. This store is thought to retain information sufficiently long to affect immediate memory tasks since the subject can quickly transfer the information from a prelinguistic auditory store to the short-term memory before beginning to respond. Since the visual sensory store is known to last only a fraction of a second, visual presentation would not allow the subject this additional source of available information and, thus, auditory presentation would lead to enhanced recall.

In a test of the Crowder and Morton explanation of modality effects, Engle

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(1974a) presented a redundant, non-recalled "zero" at the end of 12-word lists which were presented either visually or auditorily. This procedure, known as the suffix technique, eliminated the contribution of prelinguistic auditory store in the recall of auditorily presented lists of digits (Crowder & Morton, 1969). However, Engle (1974a) found that the suffix eliminated only part of the auditory superiority, indicating that the modality effect is the result of a more complicated combination of processes than just the subject's supplementing recall from the short-term store with information from the short-lived prelinguistic auditory store.

Something that has complicated the construction of an adequate theory of modality differences even more is the failure of some researchers to find that the modality effect has any carry over to long-term memory (viz., Tulving & Madigan, 1970; Brelsford & Atkinson, 1968). This raises the possibility that the auditory superiority in tasks is an epiphenomenon, especially if we assume that anything which increases the capacity of short-term memory increases the probability of storage in long-term memory.

However, Engle and Mobley (1976) have recently argued that delayed recall following presentation and immediate free recall of auditorily or visually presented lists of terms is not the best index to the effects of modality on long-term memory. Since more items are recalled in immediate free recall following auditory presentation, more auditory than visual items will be strengthened by the simple act of recall (Darley & Murdock, 1971). Thus, any measure of the effects of modality on long-term memory must be done independently of immediate recall following list presentation. Engle and Mobley cued their subjects at the end of each auditorily or visually presented list whether to recall that list or to not recall the list but do a number subtraction task instead. A surprise final free recall was requested for all lists including those not tested in immediate free recall. For those lists given the immediate free recall, the final recall performance demonstrated marked auditory superiority over the recency positions while the performance on lists not given immediate free recall demonstrated sizable visual superiority over the recency positions.

Engle and Mobley (1976) interpreted their data to mean that the recency items in auditory presentation are encoded and processed much more superficially than are the visual recency items. According to this view, adopted from Craik and Lockhart (1972) and Penney (1975), the auditory superiority of recency items in immediate free recall results because the superficial codes of these items are recirculated via maintenance rehearsal more easily than the richer semantic codes of visual recency items.

The purpose of the present study was to try to extend the findings of the Engle and Mobley (1976) study to delayed recognition tests of long-term memory and to seek confirmation of the phenomenon. It was thought to be of some importance to demonstrate that the phenomena reported by Engle and Mobley were, indeed, results of factors operating at encoding and not retrieval. And, Tulving not withstanding (Tulving & Thomson, 1973), the delayed recognition procedure is probably the best technique for answering this question.

METHOD

Subjects

Seventy-two students from the introductory psychology courses served as part of a course option and were tested in groups of one to four.

Materials

A word pool of 480 relatively high frequency words was compiled and from this pool 240 words were randomly chosen to be presented as memory lists. The 20 lists of 12 words each were constructed so as to avoid any obvious within list associations. The delayed recognition test consisted of all 480 words from the pool printed in a random order with a box beside each one for the confidence rating.

Visual presentation was by Kodak projector timed by a Lafayette repeating interval timer and auditory presentation was over headphones from a Sony stereo tape recorder. The presentation rate was kept constant by reading the words for taping at the same rate as the projector was being progressed which was 1.1 sec. per word.

Design and Procedures

The variables in this experiment were modality of presentation, test or no test of each of the free-recall lists that a subject received and the random order in which the lists were assigned to the tested and non-tested conditions. Modality was a between-subjects variable as was order of tested and not tested lists in a session. Each subject received 20 lists and, by one of six different random orders, each list was either tested or not tested immediately after presentation. Regardless of modality, if the list was to be tested, the subject was shown a question mark by slide projector in cadence with the last word in the list. If the list was not to be tested the subject saw a three-digit number which served to cue the subject to *not* recall the list and from which he or she subtracted by three's in writing, on the recall sheet for the list. A 60-sec. period followed each list for recall or for number subtraction.

Each of the 20 lists subject received was assigned to either the tested or non-tested condition and the lists were presented in a random order. Three random orders of presentation of the 10 lists to be tested and the 10 to be non-tested were generated from a table of random numbers. Three additional orders were mirror images of the original three such that each tested list in the original order would be non-tested in the corresponding mirror-imaged order. All recall and number subtraction was written on a separate page for each list.

Subjects were assigned to conditions alternately in the order of arrival at the laboratory and were given standard free recall instructions except that, for the non-tested lists, they were told we were interested in the effects of the list presentation on the number subtraction. They were given no indication that a final recognition test of all lists would be given, and about 1 min. after the end of the last 60-sec. period the subject was given the booklet containing the final recognition test and instructed to attend to each word on the test and mark a confidence rating for each word. The confidence rating was a 6-point scale, with 1 being very sure the word was a list word and 6 being very sure the word was not a list word. The subjects were given ample time to finish the test—about 25 min. on the average. Data from two subjects, one in each modality, could not be used because of a failure to follow directions either on immediate free recall or on the recognition test.

RESULTS AND DISCUSSION

Immediate Free Recall

Because of the data lost from the two subjects, each of the analyses described below was an analysis of variance for unequal *N*s using proportional weighting (Lindquist, 1953). The immediate recall data were analyzed by collapsing across all 10 of the lists that were tested immediately after presentation. These data are shown in Fig. 1 as a function of serial position.

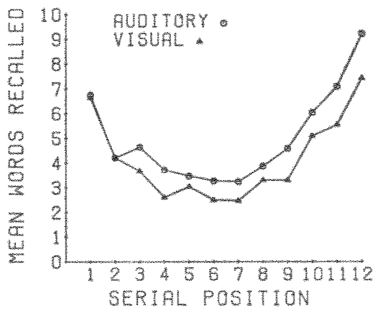

FIG. 1. Mean immediate recall of the recalled lists for auditory and visual presentation

Obvious from Fig. 1 is that auditory presentation was superior to visual presentation ($F_{1,58} = 31.1$, $p < .001$, $MSe = 5.7$). These are rather unusual free recall data, however, by the absence of an interaction between serial position and modality ($F_{11,638} = 1.12$, $p > .10$). Auditory presentation led to superior performance at every serial position except the first.

This unusual finding was not caused by the scoring procedure because a more strict method in which only the exact word presented was counted correct yielded the same pattern of results. We have no clear explanation for this auditory superiority over the middle positions particularly since Engle and

Mobley (1976) found a much more typical modality function using an identical procedure. Nevertheless, looking at just the terminal serial positions, we find the standard auditory superiority present, with the magnitude of this superiority comparable to prior studies.

Delayed Recognition Data

The data of primary importance to the present study were those from the delayed recognition test. The confidence ratings for all the 240 presented words were transformed to give a *d′* score for each subject for each serial position of the tested and non-tested lists. This *d′* score was calculated as a *Z* score, with the standard deviation being that of the distribution of confidence ratings from both old and new words from the recognition test. The mean of the 10 items from a given serial position (across lists) served as one mean and the mean of all lures served as the other mean. Although an analysis of variance was done on these scores, the data shown in Fig. 2 were collapsed across positions 1-2 (B),

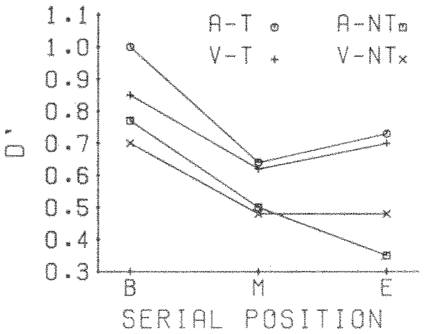

FIG. 2. Mean *d′* scores for recalled and non-recalled lists as a function of modality and serial position (Beginning = 1-2, Middle = 3-8, End = 9-12)

3-8 (M) and 9-12 (E) in order to provide a clearer pictorial representation of the experimental effects. The analysis consisted of a modality (2) × test-non-test (2) × order (6) × serial position (12) design. The main effect of order was not significant nor did it interact with any other variable. Inspection of Fig. 2 demonstrates that tested lists led to better delayed recognition than non-tested lists generally ($F_{1,58} = 116.9$, $p < .001$, $MSe = .147$). While the tested lists yielded a slight positive recency effect in both modalities, the visual non-tested lists showed no detectable recency effects and the auditory non-tested lists showed a marked decline or negative recency effect over the terminal positions. These latter findings reflect the interaction of serial position × tested-non-tested × modality ($F_{11,638} = 2.55$, $p < .01$, $MSe = .071$).

With one notable exception these data with delayed recognition replicate and extend the findings of the Engle and Mobley (1976) study with delayed recall, with the exception being that Engle and Mobley found a sizable auditory superiority for the terminal positions of the tested lists while the present data show only a very slight auditory superiority on these positions. This apparently occurred because the visual condition failed to show a negative recency effect in the present study while, in the non-contingent final recall analysis of the Engle and Mobley study, the visual condition showed a very marked negative recency effect. We feel that this is not a critical discrepancy in the data from the two studies since they come from all the items presented on the tested lists and, as will be demonstrated below, the data are considerably different when only obtained for items given successful recall on the tested lists. The critical comparison between the two studies is the modality difference for the recency position of the non-tested lists, and the present data agree with those of Engle and Mobley in showing visual superiority on these items. This seems to indicate that auditory recency items are encoded less well at the time of input than visual recency items despite the fact that more auditory recency items are recalled immediately after list presentation.

But what about the long-term memory strength of those items that were recalled from the lists given the immediate test? This can be measured by looking at the final recognition performance of those items the subjects were successful at recalling on the immediate free recall. Mean confidence rating was used instead of d' because the number of items contributing data varied as a function of serial position and modality condition. This seemed to make the analysis very sensitive to any violations of the assumptions required for calculation of d'. These data are shown in Fig. 3 with mean confidence rating plotted as a

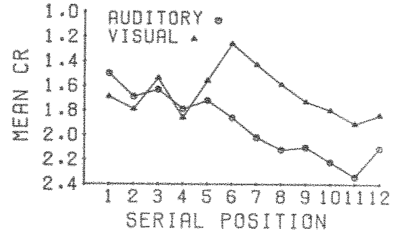

FIG. 3. Mean confidence rating (CR) of those items recalled on the immediate free recall

function of serial position and modality of presentation. Note, first of all, that both functions have very strong negative recency effects despite the fact that the data for all items regardless of recall contingency (Fig. 2) exhibited a positive recency effect. This demonstrates again that whether a positive or negative recency effect is observed on a final recognition test is determined by whether performance is measured contingent or non-contingent on successful recall on the immediate test (cf. Engle, 1974b).

Secondly, notice the much higher performance of the visual condition over the last 7 serial positions. An analysis of variance confirmed the obvious: (1) that confidence rating decreased over serial position ($F_{11,638} = 3.22$, $p < .01$, $MSe = .734$), (2) that visually presented items were better recognized than auditorily presented items ($F_{1,58} = 4.20$, $p < .05$, $MSe = 3.60$), and (3) that serial position interacted with modality ($F_{11,638} = 1.72$, $p < .06$, $MSe = .734$). So, even though there were more auditory than visual recency items recalled on the immediate free-recall test, those same auditory items were recognized less well on the delayed recognition test. This is particularly important since the non-contingent analysis of the final recognition data failed to show the marked auditory superiority on the terminal positions of the tested lists. We would argue that the analysis of final recognition contingent on successful recall on the immediate free recall is much more reflective of long-term memory strength of a given item in a particular condition while the non-contingent analysis is more reflective of the *number* of items from a condition that the subject can recognize. The data in Fig. 3 seem to buttress the arguments of Engle and Mobley (1976) and the arguments presented here that auditory recency items are encoded less well than visual items.

The data could result from several factors. It could be that, since more auditory than visual recency items are recalled on immediate free recall, more auditory items are strengthened by the act of recall than visual items, but the act of recall strengthens the long-term trace of the visual items more than it does the trace of the auditory items. An alternative explanation is that, even though more auditory items are available for immediate free recall, these items are encoded less extensively than are the visual items and the less extensive encoding would lead to a weaker long-term memory trace. This latter hypothesis certainly dovetails nicely with the Craik and Lockhart (1972) proposal but, in all likelihood, both factors are operating to some extent since the d' scores for the non-tested lists showed clear visual superiority only for the last four positions while the contingency analysis in Fig. 3 showed visual superiority over the last seven positions indicating that the act of recall may have differential effects on auditorily and visually presented items.

Engle and Mobley (1976) suggested that the modality effects in short-term memory, and now in long-term memory, are best viewed with respect to the concepts of a prelinguistic auditory store proposed by Crowder and Morton (1969) and within the theoretical framework of depth of processing proposed by Craik and Lockhart (1972). Under this view the prelinguistic auditory store would retain speech sounds for 1 or 2 sec. which would affect the manner in which the terminal items are processed and rehearsed. This would probably have the effect of causing the subject to give a rather superficial encoding to the auditory recency items which could be recirculated easier than a more extensive encoding (Craik & Lockhart, 1972). The auditory recency items would, thus, be more available for recall than the visual items on the immediate free but would be recognized or recalled less well on the delayed test. The act of recall might interact with this differential encoding if recall enhances the trace of a richly encoded item more than it does for a superficially encoded item.

One problem that must be resolved with the current conceptualization is the length of time that the prelinguistic auditory store can retain the terminal items. Crowder and Morton (1969) have proposed a duration of 1 or 2 sec. which would certainly not be sufficient to store the last 3 or 4 items in a free recall list at the current rate of 1.1 sec. per item. We would like to suggest that the length of retention and the number of items stored in the prelinguistic auditory store are determined somewhat by the nature of the items, with words being stored longer and in larger groups. This idea of a flexible and strategically controlled prelinguistic auditory store was proposed by Aaronson (1974) in a general model of auditory-sensory memory and certainly seems desirable in explaining the modality effects in short-term and long-term memory obtained in this as well as other recent papers.

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