

The Modality Effect: Is It a Result of Different Strategies?

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The theory that modality effects in immediate and delayed free recall are a result of differential encoding of recency items by subjects receiving auditory and visual presentation was tested in a series of experiments. Four of the experiments manipulated knowledge of list length and mode of presentation and found no decrement in auditory superiority when the subject was ignorant as to which items were recency items. This appears to disconfirm any theory that modality effects found for recency items in immediate free recall are a consequence of different subject strategies. Requirements for a general theory of modality effects and echoic memory are discussed.

Auditory presentation leads to enhanced retention on tasks designed to measure short-term memory. This is true regardless of whether the comparison is between auditory and visual presentation or between vocalized visual and silent visual presentation (Penney 1975). This phenomenon, known as the modality effect, is not only an intriguing and interesting problem in its own right but has potential implications for theories of the nature of short-term memory (Murdock, 1967), and plays a crucial role in current theories of echoic memory (Crowder & Morton, 1969).

One of the early attempts to explain the modality effect was by Crowder and Morton (1969), who argued for the existence of an auditory sensory, or echoic memory, which they labeled Precategorical Acoustic Store (PAS). The PAS was assumed to be analogous to the visual iconic memory but, as compared to the 0.25- to 0.50-second duration of the icon, to persist for approximately 1.5 to 2 seconds. Crowder (1971) suggested that a subject receiving auditory input uses the lingering information in PAS

against which to check his prepared response prior to beginning recall. If the subject detects any discrepancies between the prepared response and the information in PAS, then a correction is made prior to recall. Since the subject given visual input would not have a source of information lasting as long as the PAS, performance would not be as good as that of the subject given auditory input.

The standard technique used to study the PAS is the suffix technique, in which a redundant speech sound is appended as a suffix to a list of words or digits to be recalled. The typical finding is a marked reduction in performance over the terminal positions, and, in fact, the recency effect observed in the no-suffix control condition is virtually eliminated by the redundant suffix. In a test of Crowder's (1971) theory, Engle (1974) varied modality of presentation and presence or absence of a redundant suffix. If the suffix eliminated the supplemental information remaining in PAS as Crowder (1971) suggested, the suffix should have eliminated the auditory superiority. In two different experiments, however, Engle found that the suffix reduced the modality effect only slightly. Contrary to Crowder's (1971) theory that the suffix should eliminate the PAS component, performance was still better on recency items in the auditory suffix condition than in the visual condition. Engle (1974) argued that since the suf-

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fix caused a partial reduction in the auditory recency effect, the PAS was one factor responsible for the modality effect, but that an additional factor was the differential quality of rehearsal given to the auditory and visual recency items.

In other words, it was assumed that the information that was stored and rehearsed in short-term memory was somewhat different for auditory and visual presentation. This argument was carried further by Penney (1975), who argued that auditory recency items are encoded more superficially, in terms of Craik and Lockhart's (1972) levels of processing framework, than are visual items which are assumed to be given a deeper or more semantic encoding.

This approach to modality effects would seem to suggest that long-term effects of modality should also be observed. If the items presented auditorially are encoded more superficially than visual items, they should be recalled less well on a delayed test. Engle and Mobley (1976) argued that delayed recall of lists that have also been tested for immediate recall is not the best way to measure the effects of modality on long-term memory. Since more items are recalled in immediate free recall following auditory presentation, more auditory items will be strengthened simply by the act of recall. Thus, they argued, any measurement of the effects of modality on long-term memory must be done in the absence of recall immediately following list presentation. To accomplish this, Engle and Mobley cued their subjects at the end of each list whether to recall the list or to do a number subtraction task instead. Then, an unexpected final free recall test was given for all lists. For those lists not tested for immediate free recall, there was a sizable superiority of visual presentation, restricted to the last few positions in the list. In other words, this test of long-term memory showed visual superiority over the same list positions which show auditory superiority in immediate free recall. This finding has been replicated with a delayed recognition test by Engle and Durban (1977).

The finding was also replicated in an experiment by Engle and Goldson (Note 1). The differential encoding account of both short-term and long-term modality effects suggested that inducing a deeper level of processing should benefit auditory recency items more than visual recency items on a delayed test. Engle and Goldson varied modality and whether or not the list was tested on immediate recall. Additionally, during input, half the subjects categorized each word as either living or nonliving, while the other half of the subjects had no categorization task. In replication of Engle and Mobley (1976), the latter subjects showed visual superiority in delayed recall for the recency items from the nontested lists. The subjects that received the categorization task, however, and presumably had to analyze the items semantically, showed no difference in recall of recency items between auditory and visual presentation. Thus, auditory recency items benefited more than visual recency items by the deeper level of encoding.

One finding common to all these studies is that both short-term auditory superiority and the long-term visual superiority occur only over the recency positions of the free recall curve. This suggests that, for some reason, subjects use their knowledge of relative list position to differentially rehearse auditory and visual recency items. This hypothesis predicts that if the subject is not given information about relative list position, then both the short-term and long-term modality effects should be reduced or eliminated. That is the prediction the experiments reported here were designed to test.

Watkins and Watkins (1974) reported an experiment relevant to this prediction. They presented, for free recall, seven lists varying in length from 8 to 20 items. Their subjects checked off boxes on a sheet of paper as the items were read to them by the experimenter. Some of the subjects had the same number of boxes to be checked as there were items in the list. In this condition, called the Informed condition, sub-

jects were thus made aware of which items were to be terminal or recency items. The subjects in the other condition, the Uninformed condition, had 30 boxes for each list and thus had no prior knowledge of list length. Following the recall of the last list the subjects were given an unexpected test on recall of all words from all the lists.

Watkins and Watkins found that immediate free recall of recency items was greater if list length was known than if the subject was uninformed about length. Final recall of recency items, on the other hand, was better in the Uninformed than in the Informed condition. These data were taken as theoretical support for the levels-of-processing notion proposed by Craik and Lochart (1972). Watkins and Watkins argued that, if the subject was informed about list length, as in the standard free recall situation, he or she encoded the terminal items to a very superficial level and maintained them at that level via rehearsal. They further argued that uninformed subjects encoded the terminal items just as they did the earlier items.

The method developed by Watkins and Watkins seemed to be a reasonable way of testing the prediction that the modality effect should be diminished in a situation where subjects could not use knowledge about list length to rehearse the terminal items differently than the preterminal items, or to rehearse auditory terminal items differently than visual terminal items. The first experiment reported here was an attempt to replicate the Watkins and Watkins study in our laboratory. Modality of presentation was manipulated in the second experiment. As will be seen, neither of these experiments turned out as expected; and to clarify matters, three other experiments were done.

EXPERIMENT 1

Method

Subjects. A total of 148 students of introductory psychology participated as subjects. The subjects were tested in groups of 4–10.

Materials. A word pool of 98 two-syllable words was used to make seven lists ranging in length from 8 to 20 in increments of two. There were seven arrangements of the 98-word pool such that each arrangement had a unique ordering of words within lists and ordering of list lengths. The lists were recorded on tape at a rate of 2 seconds per word and were presented by tape recorder.

Procedure and design. The subjects were told that they would be presented with seven lists of words and that at the end of each list they were to write down as many of the words as they could remember. Subjects were told that no word would be presented twice and that no two lists would have the same number of words. All subjects were given response booklets with one page allocated for each list. Each page of the booklets had 0.25-in. squares drawn in a column down the right side of the page. As in the Watkins and Watkins study, the subjects were instructed to mark consecutive boxes as the words were presented. The subjects in the Informed condition were informed that the number of squares varied from page to page and that the number of squares would always equal the number of words presented. The subjects in this condition were thus aware of the length of the current list. The subjects in the Uninformed condition had 30 boxes on each page and were thus ignorant of the length of the list currently being presented. Informed and Uninformed subjects were never tested in the same session. Subjects in both conditions were instructed to recall the last words in the list first.

The end of the list was signaled by a tone presented 2 sec after the last item, and all subjects were instructed not to begin recall until they had heard the tone. They were allowed 60–90 sec for free recall of each list. After the last such recall period, they performed arithmetic problems for 60 sec and then received instructions for the unexpected final free recall test (FFR).

Results and Discussion

The data analyzed were the number of

words recalled from the first two and last six serial positions of all lists. Immediate free recall data are shown in Figure 1 where it can be readily observed that the Informed-Uninformed variable had no significant effect, $F < 1.0$, nor did the variable have the predicted interaction with Serial Position, $F < 1.0$. The only significant effect for these data was the typical main effect of Serial Position, $F(7, 938) = 153.8$, $p < .001$, $MS_e = 1.56$.

Interestingly, the data from the final recall of all list items, shown in Figure 2, do conform to the results of Watkins and Watkins (1974). There is an obvious superiority for the Uninformed subjects over the recency positions, as is indicated by the main effect of the Informed-Uninformed variable, $F(1, 134) = 5.7$, $p < .025$, $MS_e = .16$, and the marginal interaction of this variable with Serial Position, $F(7, 938) = 1.72$, $p < .10$, $MS_e = .08$.

It is not clear why the delayed recall data replicated that of Watkins and Watkins while the immediate recall data did not. While this experiment was an attempt at an exact replication of Watkins and Watkins, the potential differences between our experiments that might affect the results range from the intellectual level of the subject population to the use of unmixed as opposed to mixed groups. The delayed recall findings did suggest, however, that the

method might be useful to test predictions of the differential rehearsal account of modality effects. That this was not the case will be seen from the following experiment.

EXPERIMENT 2

The theory that generated the Watkins and Watkins procedure would suggest that an important factor is the extent to which the subjects in the Informed condition use the information available to them to "isolate" the recency items for differential rehearsal. We decided that by using procedures designed to more directly create this isolation we could probably adapt this procedure to test for the prediction that ignorance of list length would reduce or eliminate the modality effect.

Method

Subjects. A total of 128 students from an introductory psychology class participated for course credit. The subjects were tested in groups of 1-2.

Materials. All subjects were presented with seven lists drawn from the same pool of 98 concrete nouns as in the former experiment. These lists were 8, 10, 12, 14, 16, 18, and 20 words long, with four different lists of each length.

As in Experiment 1, the subjects were given booklets for immediate free recall

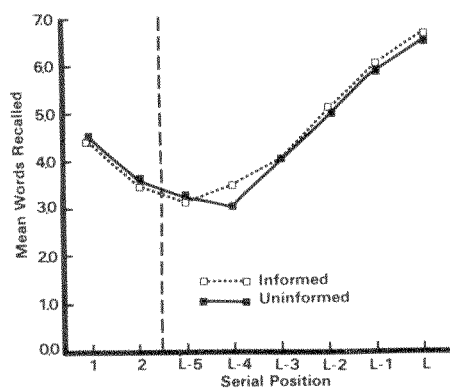


FIG. 1. Mean words recalled as a function of serial position for the first two and last five serial positions.

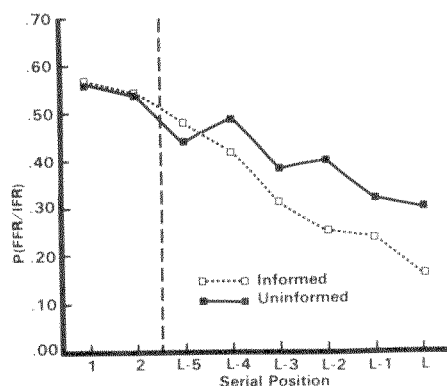


FIG. 2. Probability of final free recall given immediate free recall as a function of serial position for the first two and last five serial positions.

with each page containing squares drawn down the right-hand margin. For the subjects in the Informed condition, the number of squares always equaled the number of words in the current list, and for the other half of the subjects, the number of squares was always 30. The stimuli that were to be presented visually were typed and photographed for 35-mm slides. Those to be presented auditorily were taped and presented over headphones.

Procedure and design. The two presentation modalities were crossed with two levels of knowledge of list length (Informed or Uninformed), four different random orders of list length, and the four different assignments of words to lists to give 64 cells, with two subjects per cell. Presentation rate was 2 seconds per word.

The subjects in the Uninformed condition were told that they would be presented with a series of word lists for immediate free recall and that the number of words per list would vary considerably. They were further told that they should write their recall on each page of the booklet but that performance could be maximized by recalling the last few items first.

Subjects in the Informed condition were given the same instructions with the following additions. They were told that before each list the experimenter would tell them exactly how many words would be in that list, and the number of boxes in the margin of the response sheet corresponded to the number of list items, and that a small light (fixed to the wall on which visual presentation occurred) would be turned on immediately before the final five words in the list. This change was made from the Watkins and Watkins procedure because preliminary tests showed the box-checking method to be unworkable with visual presentation.

The end of the list was marked in the Auditory condition by a short tone presented 2 seconds after the last word, and in the Visual condition by a slide containing two question marks. The subjects in both In-

formed and Uninformed conditions were told not to start recalling the items until occurrence of the cue noting the end of the list.

About 2 minutes after the recall of the last list, the subjects were tested for final free recall of all items. They were encouraged to take at least 5 minutes to complete the recall.

Results and Discussion

As with the previous study, the data from the first two and last six serial positions of each list were used, and these were summed across the lists to yield a score of 0–7 for each of eight serial positions for each subject. The immediate free recall data (IFR), shown in Figure 3, clearly demonstrate the expected effect of Knowledge of List Length, $F(1, 124) = 10.8, p < .01, MS_e = .59$, and the interaction of Knowledge with Serial Position, $F(7, 868) = 5.9, p < .001, MS_e = .26$, manifested by superiority of the Informed subjects over those positions near the end of the list. While the effect of Modality, $F(1, 124) = 6.7, p < .01$, and the Serial Position \times Modality interac-

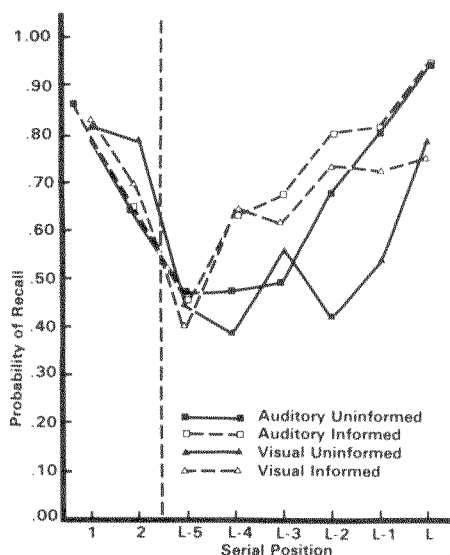


FIG. 3. Probability of immediate free recall as a function of serial position for the first two and last five serial positions.

tion, $F(7, 868) = 4.6, p < .01$, were significant, the prediction of a $SP \times \text{Modality} \times \text{Knowledge}$ interaction that motivated this series of experiments failed to materialize, $F < 1$. As Figure 3 shows, the modality effect is sizable for both knowledge conditions. If anything, the modality effect tended to be greater for the Uninformed subjects than for the Informed subjects, which is contrary to the differential levels of rehearsal account of the modality effect.

The final free recall data are shown in Figure 4 as the probability of final free recall given that the item was recalled on IFR. Figure 4 shows the significant Knowledge \times Serial Position interaction, $F(7, 868) = 3.2, p < .01, MS_e = .06$, and the main effect of Knowledge, $F(1, 124) = 13.3, p < .01, MS_e = .14$. These findings reflect the fact that the Uninformed subjects had superior delayed recall, but only on the last six items. This of course replicates the findings of Watkins and Watkins that Informed subjects do better on recency items on the immediate test while Uninformed subjects do better on the same items on delayed recall.

While the Modality \times Serial Position interaction was significant, $F(7, 868) = 3.0, p < .01$, this was due almost entirely to visual superiority at positions L-4 and L-3. The two modes were virtually coincident on the

last three positions. Modality did not interact with Knowledge of List Length either in the two-way interaction or in the three-way interaction including Serial Position. So, with neither immediate nor delayed recall did the modality effect decline when subjects were kept uninformed of when the recency items were being presented. This certainly fails to confirm the prediction of the differential rehearsal theory of modality effects, particularly considering the knowledge of list length did have the predicted effect on the recency items for both immediate and delayed recall tests.

While the first experiment replicated only the delayed recall of the Watkins and Watkins (1974) experiment, our Experiment 2 replicated both their immediate and delayed recall data. However, Experiment 2 failed to obtain the interaction of modality with knowledge of list length which was predicted by the differential encoding account of modality effects. This failure to obtain the expected interaction may have been the result of the particular procedures used in this experiment. The procedures used in our two experiments and in the Watkins and Watkins experiment are rather unlike the standard free recall situation. The subject was never exposed to the same list length twice and only received seven lists. The standard free recall procedure of multiple lists of the same length probably allows subjects to develop strategies for rehearsal and retrieval that were precluded by the method we used in Experiment 2 (Goodwin, 1976). We felt that a procedure making use of more lists of a narrow range of lengths might be a better test of the predicted interaction of modality with knowledge of list length, as well as serving as a test of the generality of the findings of the Watkins and Watkins (1974) experiment.

EXPERIMENT 3

Method

Subjects. Seventy-two students from an introductory psychology class were used as subjects.

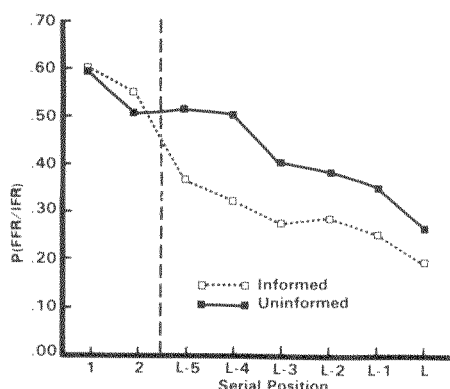


FIG. 4. Probability of final free recall given immediate free recall as a function of serial position for the first two and last five serial positions.

Materials and apparatus. The item pool consisted of 320 high-frequency words chosen from Kučera and Francis (1967). The words were used to construct 13 20-item lists and five 12-item lists with the constraint that no words with obvious associations could occur contiguously. The words were typed and photographed for presentation by slide projector at 1.1 seconds per word.

Procedure. All subjects were given a series of 18 lists for immediate free recall. The first three 20-item lists were given for practice, and their data were not analyzed. Following the practice lists, the subject received 10 20-item lists and five 12-item lists. A partial random selection of the particular words within lists and serial positions was achieved by starting the first nonpractice list at one of 18 randomly chosen positions in a fixed loop of the 320 words.

Half of the subjects received the lists in a blocked fashion (Blocked group) with the 12-item lists all occurring either (a) immediately after the three practice lists, (b) after 8 of the 20-item lists had been presented or, (c) after all 13 of the 20-item lists had been presented. The Blocked subjects were told before each list how long it would be and that the next n lists would be either 12- or 20-item lists. This procedure was used to insure that the subject would be able to adopt the input and output strategies commonly used in standard free recall experiments.

The other half of the subjects, the Randomized group, received the lists in a semirandom fashion. This group had the five 12-item lists placed randomly among the 15 test lists with the constraint that no more than two 12-item lists could occur consecutively. There were six different orders of list length for this group such that, over the six orders, a 12-item list occurred at each of the 15 positions twice.

The reason for having the three practice trials 20 items in length and having twice as many 20-item as 12-item lists, was to establish a set to encode all lists as if they were

20-item lists. In addition, instructions to the Randomized group suggested that all lists be studied as if they were going to be long lists. If the subjects in this condition adopt the strategy of treating all lists as if they were 20-items long, then knowledge of list length should have a large effect on recall of the last few positions of the 12-item lists but not of the 20-item lists.

All subjects were shown the words via a slide projector, but half of them vocalized the items at input, while the other half remained silent. There has been considerable research showing vocalized visual input to yield performance similar to that following auditory input. Thus, to keep confusion at a minimum across the different experiments, we will call the vocalized condition Auditory presentation, and the nonvocalized condition Visual presentation.

Results and Discussion

The 12- and 20-item data were analyzed by separate analyses of variance. While the standard effects of Serial Position and Modality were significant for both the 12- and 20-item lists, as shown in Figure 5, the predicted interaction of Random versus Blocked presentation with Modality and Serial position was not significant for the 12-item lists, $F < 1.0$. The Auditory curves for the Random and Block conditions were virtually coincident over the recency positions for both 12- and 20-item lists.

Experiment 3 not only failed to support the differential rehearsal notion, it also failed to demonstrate the sizable effect of knowledge of list length observed using the Watkins' procedure. In this experiment we had hoped to establish a set on the part of subjects in the Random condition to encode all lists as if they were long lists. We attempted to establish this set through instructions, practice trials, and the blocking of list lengths. The next experiment also used these procedures; and to further insure that the subject would have ample opportunity to develop a stable strategy, twice as many lists were used.

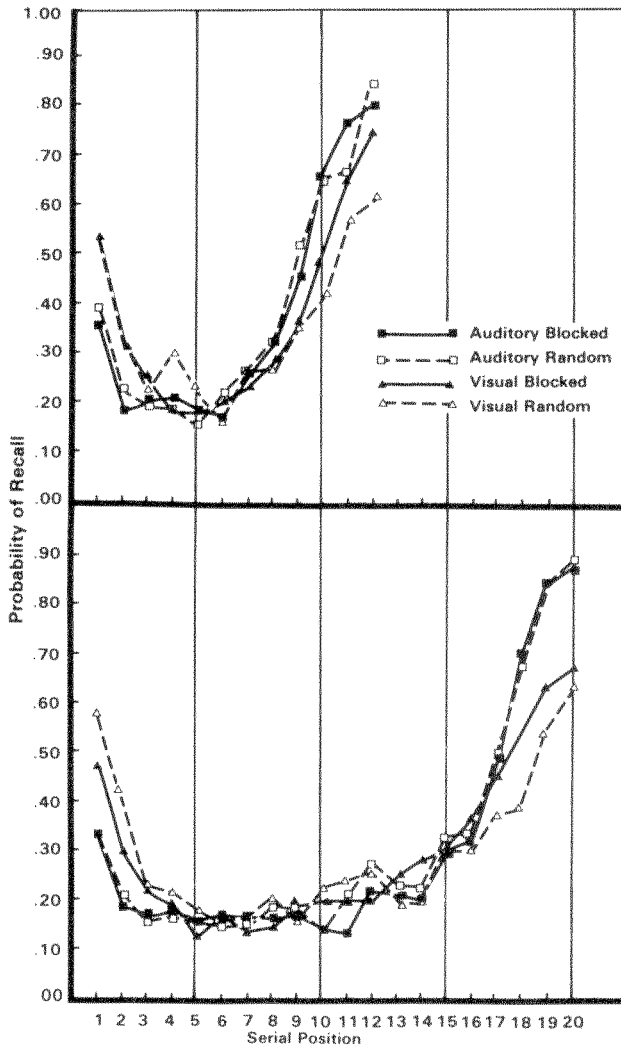


FIG. 5. Probability of recall as a function of serial position for 12- and 20-item lists.

EXPERIMENT 4

Method

Subjects. The subjects were 96 students from an introductory psychology course.

Materials and apparatus. The 10 12-item and 20 18-item lists all consisted of high-frequency nouns and were presented visually by slide projector or auditorily via tape recorder and speakers.

Procedure. The procedure was very similar to that of the previous experiment in that lists were presented either blocked or randomly by list length. No practice lists

were given, but in the Random condition the first two lists were always 18-item lists. Modality of presentation was auditory for half the subjects and visual for the other half, and the presentation rate was 1.1 seconds per item. Two minutes after recall of the last list, the subject was given an unexpected test for recall of all items.

Results

The immediate recall data shown in Figure 6 exhibit the standard effects of modality and serial position for both 12-item and 18-item lists. The short lists in this experi-

ment did give rise to a Blocked vs Randomized effect $F(1,84) = 5.5, p < .05$, but this factor did not interact with mode or serial position. This indicated slightly poorer performance for the Random groups across serial positions, for both modalities. Visual inspection of Figure 6, however, shows a result similar to Experiment 3, in that an effect of knowledge of list length on the recency items seem to occur in the visual, but not in the auditory condition. Again, this is counter to the prediction of a differential rehearsal theory of the modality effect, which predicts that knowledge

should have its greatest effect on the recall of auditory recency items.

These results also question the generality of the Watkins' finding regarding knowledge of list length on recall of recency items. While knowledge of list length gave rise to a significant effect, the effect was small and not limited to recency positions. The IFR data from the 18-item lists showed no significant main effect or interaction involving Knowledge but, as can be seen from Figure 6, the standard Modality and Serial Position effects were significant, $F(1,84) = 8.9, p < .01, MS_e = 43.8$ and $F(17,$

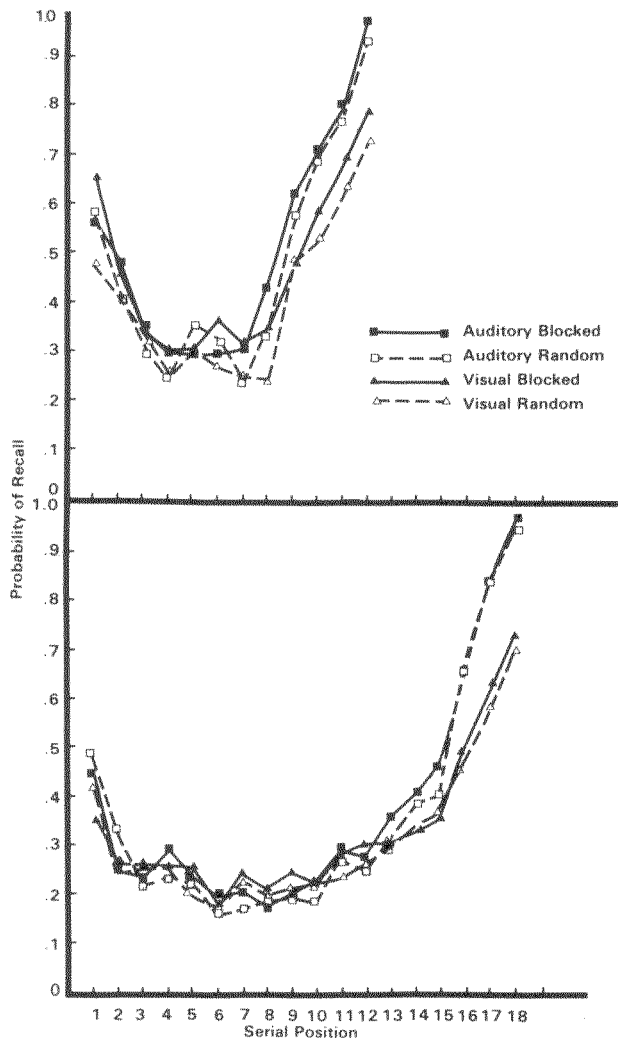


FIG. 6. Probability of immediate free recall as a function of serial position for 12- and 18-item lists.

1428) = 210.7, $p < .01$, $MS_e = 6.25$, respectively. The analysis of the delayed recall data showed the only significant effects to be those of Serial Position for both short and long lists, $F(11, 1012) = 8.6$, $p < .01$ and $F(17, 1564) = 15.3$, $p < .01$, respectively, indicating strong negative recency effects for both groups. The delayed recall data showed no effects of modality, of knowledge of list length, or of their interaction.

EXPERIMENT 5

We felt that before we totally rejected the differential encoding notion, an hypothesis for which we had some affinity, and before we decided that the effects of knowledge of list length observed by the Watkins' might not be generalizable to all free recall situations, we should provide one more opportunity for the effects to obtain. To this end, we decided to expand the range of list lengths, since the published studies observing an effect of knowledge of list length used a broad range of lengths.

Method

Subjects. The subjects were 96 students of introductory psychology and were tested in groups of 2–4 students per session.

Materials. There were 30 lists; 10 at each of the lengths: 10, 14, and 18 items. The lists were formed from high-frequency words and were presented visually via slide projector or auditorily via a tape recorder and headphones.

Procedure. The procedure was similar to the previous two experiments in that free recall lists were presented either randomly or blocked by list length. Three random orders of list length were used in the Random condition while, in the Blocked condition, all six possible orderings of lists length were used. Half the subjects received visual presentation and half received auditory presentation, all timed at 1.1 seconds per word. The subjects were instructed to use whatever study technique they found most effective but not to say anything out loud or even move their lips.

Standard immediate free recall instruc-

tions were given except that subjects were told not to begin writing the items until signaled by a blank slide following the last word in the Visual condition, or a click of a metronome in the Auditory condition. Two minutes after recall of the last list the subjects were given a final free recall test.

Results

The data from each list length were analyzed separately with Modality, Knowledge of List Length (Blocked or Random), and Serial Position as factors. Another analysis was then performed on the terminal four positions, using the same factors. The overall serial position functions for IFR for all three list lengths are shown in Figure 7.

Immediate free recall 10-item data. In the 10-item IFR data, Auditory presentation led to better recall than did Visual presentation, $F(1, 92) = 16.4$, $p < .001$, $MS_e = 4.44$, and Modality interacted with Serial Position, $F(9, 828) = 15.1$, $p < .001$, $MS_e = 3.70$. The main effect of Position was also significant, $F(9, 828) = 62.7$, $p < .001$, $MS_e = 3.70$. These findings were also supported in the ANOVA for the last four positions.

The Knowledge variable approached significance, $F(1, 92) = 2.74$, $p > .10$, but inspection of Figure 4 shows the trend to be *opposite* to the predicted advantage for Blocked lists. All interactions involving Knowledge were nonsignificant with all F values < 1 . These conclusions were also supported by the analysis on just the last four positions.

Immediate free recall 14-item data. Both total and last four positions analyses for the 14-item data suggested the same conclusions as reported above for the 10-item data, that is, significant effects of Modality, $F(1, 92) = 13.2$, $p < .001$, $MS_e = 5.64$, Modality \times Position, $F(13, 1196) = 9.4$, $p < .001$, $MS_e = 3.27$, and Position, $F(13, 1196) = 130.2$, $p < .001$, $MS_e = 3.27$.

However, neither the main effect of Knowledge nor any interactions with Knowledge even approached significance, all F values < 1 .

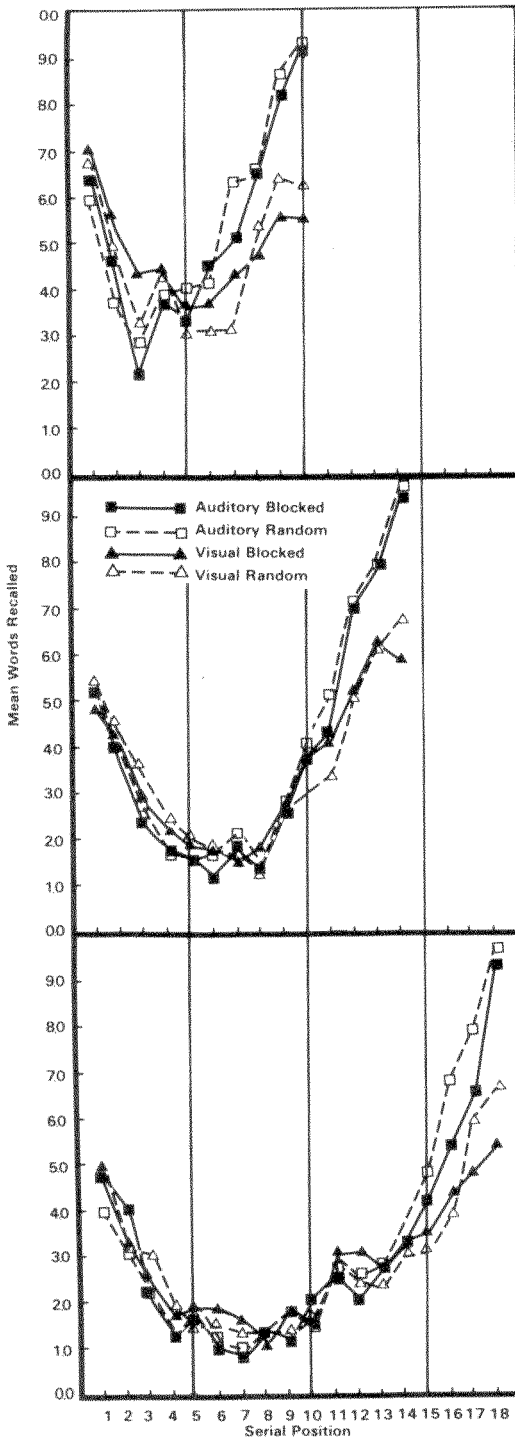


FIG. 7. Mean words recalled as a function of serial position for 10-, 14-, and 18-item lists.

Immediate free recall 18-item data. The analysis of data from all 18 positions yielded similar conclusions to the 10- and 14-item data, that is, significant effects only for Modality, $F(1,92) = 12.0, p < .001, MS_e = 4.61$, Modality \times Position, $F(17,1564) = 11.7, p < .001, MS_e = 2.51$, and Position, $F(17, 1564) = 131.6, p < .001, MS_e = 2.51$. However, the analysis of the last four positions yielded, in addition to these effects a significant main effect of Knowledge with $F(1,92) = 6.0, p < .02, MS_e = 7.42$. Within the last four serial positions, the interaction of Knowledge with Position approached but fell short of significance with $F(3,276) = 2.35, p < .10$. The significant Knowledge effect reflects higher recall for the Random condition over the recency positions, again, opposite the effect predicted, and opposite the findings of Watkins and Watkins.

Final free recall—all lengths. Probabilities of recall on final free recall (FFR) given that an item was recalled on IFR were determined. Separate ANOVAs on these data for each of the three list lengths revealed no significant effects of any factor except Serial Position. The Position effect for all three list lengths was significant, $F(9,828) = 10.01, F(13, 1196) = 8.8$, and $F(17,1564) = 8.0$, for 10-, 14-, and 18-item lists, respectively; all $p < .001$. These findings simply reflected the now standard negative recency effect. There was no effect on the FFR of either Knowledge or Modality.

GENERAL DISCUSSION

This set of experiments was designed to test the theory that modality effects in immediate and delayed recall are at least partly a result of different levels of encoding of auditory and visual recency information. It was assumed that, probably because the echoic trace (PAS) lingers for 1–2 seconds after presentation, subjects given auditory presentation encoded the recency items rather superficially and rehearsed the information at that level. The auditory supremacy on immediate free recall was, thus, believed to be a result of two factors:

(1) echoic information for the last one or two items and (2) rehearsal of the superficially coded trace for all the auditory recency items. The visual supremacy observed on delayed recall by Engle and Mobley (1976) was assumed to be a reflection of the weaker long-term trace for the auditory recency items resulting from the shallower coding given them at presentation.

This theory makes a fairly strong prediction that keeping the subject ignorant of list length, and therefore ignorant of which items are recency items, should reduce auditory superiority on immediate recall. More specifically, we expected a greater decrement in performance for auditory recency items than for visual recency items if the subject was kept ignorant of list length. The weight of the evidence here is strongly opposed to this theory. These data seem to argue quite conclusively that the modality effect, at least in immediate recall, is not a result of differential encoding, and does not depend on the subject knowing which items will be recency items.

Part of the problem in creating a theory to account for the modality effect has been the belief that the echoic trace, what Crowder and Morton (1969) call Precategorical Acoustic Store, persists for less than 2 seconds. Since the auditory superiority on recency items frequently extends 5–6 positions into the list (Engle, 1974) and with rates slower than 2 seconds per item, the echoic trace seemed insufficient to explain the modality effect. Recently, however, Watkins and Watkins (1980) provided support for the notion that the echoic trace may persist for up to 15 seconds; and our laboratory (Engle & Roberts, Note 2) has found evidence for echoic information persisting up to 60 seconds. This might allow a single-factor theory to account for the modality effect in immediate recall, but the finding of a reverse modality effect in delayed recall requires that the theory be elaborated further. It may be that in the standard procedure with a single list length,

the subject given auditory presentation encodes the recency items less richly because he or she can rely on the long-lasting echoic trace. With ignorance of list length, the subject could still use the long-lasting echoic trace but the recency items might not be encoded for short-term memory any differently than visual recency items. If this is true, then knowledge of list length and modality should interact on the delayed recall of nontested lists even though, as we have observed with the current data, they do not interact on tests of immediate recall.

As stated earlier, the modality effect is an important problem because of what it tells us about the nature of echoic and short-term memory. This is particularly true if, as Watkins and Watkins (1980) argue, "The modality effect is a manifestation of echoic memory." The modality effect, however, is really a complex assortment of findings, all of which will have to be woven into the fabric of any comprehensive theory of echoic memory and modality effects. A partial listing of the findings necessarily encompassed by such a theory would include:

- (1) auditory superiority over the 5–7 recency positions in free recall, serial recall, and other STM tasks using lists unmixed as to mode of presentation
- (2) auditory superiority over possibly the entire list if the list includes mixed modes of presentation (Murdock & Walker, 1969; but see Hintzman, Block, & Inskip, 1972) or when certain concurrent tasks are used (Routh, 1976)
- (3) visual superiority on delayed recall and recognition of lists not tested on immediate recall (Engle & Mobley, 1976; Engle & Durban, 1977).
- (4) evidence for modality effects with free recall delayed by up to 60 seconds (Watkins & Watkins, 1979; Engle & Roberts, Note 2)
- (5) evidence for an echoic store lasting long enough to be able to ex-

plain modality effects over the entire recency portion of a free recall curve (Watkins & Watkins, 1980), but also evidence that the suffix procedure does not eliminate auditory superiority in free and serial recall of lists of words (Engle, 1974)

- (6) word length has no effect on auditory superiority in free recall (Watkins & Watkins, 1973)
- (7) there appear to be complex asymmetrical effects of modality in studies of release from proactive interference (Hopkins, Edwards & Cook, 1973; Hopkins, Edwards & Gavelek, 1971; see also Experiment 4 of Watkins & Watkins, 1979) (In fact, the results of studies using mixed lists may ultimately be interpreted within this framework).
- (8) phonetic similarity reduces auditory superiority with serial recall and eliminates the superiority with free recall, at least for very swiftly presented items (Watkins, Watkins, & Crowder, 1974)
- (9) presentation modality has very powerful effects on the patterns of pause time for each item if subjects are permitted self-paced presentation of the list (McFarland & Kellas, 1974)
- (10) studies frequently report visual supremacy over the primacy positions (Engle, 1974; Whitten, Note 3)

Any theory of modality effects will have to be comprehensive enough to explain these findings and others having to do with modality of presentation as well as those findings resulting from direct studies of echoic memory (Crowder, 1978).

A point should also be made here about the generality of the results of the study by Watkins and Watkins (1974). Based on the findings of the last three experiments of the present series, we would have to conclude

that the effects of knowledge of list length observed by Watkins and Watkins may not be generalizable to more standard free recall situations. It certainly takes more work to discount a finding than to establish one and that is the case here. If the results of Watkins and Watkins (1974) do lack generality, however, then an explanation is in order.

There are changes in the way primacy and recency items are processed as the subject receives more and more practice on free recall lists (Goodwin, 1976). It may be that the procedure used by the Watkins' and by us in Experiments 1 and 2 do not cause these changes in processing to occur. It is also likely the case that these changes in processing go beyond just recalling the terminal items first and, thus, instructions to do so would not guarantee that recency items would be processed in the same manner as they would by a subject practiced on a single or small number of list lengths. This suggests that practice on a series of single-length lists prior to the treatment used by Watkins and Watkins (1974) might result in a pattern of data more like what we observed in Experiments 3-5.

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