JOURNAL OF VERBAL LEARNING AND VERBAL BEHAVIOR, 15, 519–527 (1976)

The Modality Effect: What Happens in Long-Term Memory?

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Auditorily and visually presented lists were either recalled (R) or not recalled (NR) immediately after input and were later tested on a delayed recall test. For lists given the immediate free recall test, auditorily presented items were better recalled than visually presented items, but only for the last few serial positions, thus replicating the standard modality effect. In delayed recall, recall of items in the R lists was superior to the recall of items in the NR lists. More importantly, for R lists, auditory presentation led to superior recall for the last few serial positions whereas for NR lists visual presentation led to superior recall for the last few serial positions. The fact that modality of presentation had opposite effects on the delayed recall of R and NR recency items was discussed in terms of a prelinguistic auditory store and that store's effect on the depth to which material is processed.

For a long time psychologists have been concerned with whether the modality in which material is presented has any effect on recall of the material. McGeoch (1942), in an early review of the human learning literature, concluded that modality of presentation has little or no effect on rate of learning. But beginning with several studies by Murdock (1967, 1968) the modality of presentation has taken on new and increased importance in general theories of human episodic memory. The general finding that has given rise to this new importance is that auditorily presented verbal materials are recalled at a much higher level in short-term memory tasks than are visually presented items. This finding occurs in probably more tasks and is more generalizable than almost any other phenomenon in studies of short-term memory. It holds for paradigms using paired-associates, free recall, serial recall, and tasks relying on both recognition and recall (cf. Penney, 1975).

In single-trial free recall situations the auditory superiority is most prominent over the last four or five serial input positions, that is, the recency positions. The middle list positions seem to be little affected by modality with the exception that some studies show superior recall for visual presentation on the first two positions (Engle, 1974a). However, this visual superiority on the primacy positions seems to occur consistently only with between-subjects designs (Craik, 1969) and is not the central focus of the current study.

Several attempts have been made to delineate the theoretical implications for modality effects in short-term memory (Penney, 1975; Craik, 1969; Murdock & Walker, 1969). One explanation for the effect is that the short-term store is primarily auditory or acoustic in nature. Auditorily presented materials would enter this store directly while visually presented materials must first be translated into an acoustic code before entry. This notion would seem to predict auditory supremacy for all serial input positions since the additional transformation would have to be made for each visual item throughout the list. Since the modality effect is typically confined to the terminal items this theory does not attract much support.

Another explanation relies on preperceptual or prelinguistic stores. Crowder and Morton

Discussions with James Neely have measurably improved this paper.

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(1969) have proposed that there is a prelinguistic auditory store (PAS)[1] similar in nature to the visual icon but of a longer duration. They argue that the PAS is capable of holding information sufficiently long to affect immediate memory tasks but loses information either by displacement by subsequent auditory events or by decay with the passage of time. It is assumed that the subject transfers the last item or two from the PAS to the short-term store before beginning to respond. Thus, even if recalling the list takes more than 1–2 sec, the last item or two is more likely to be recalled.

Similar to Crowder and Morton's explanation, Craik (1969) argues that the superiority of auditory presentation over the recency portion of the list reflects the output from a postlinguistic short-term store which is itself indifferent to input mode but which can be augmented by relatively unprocessed information still present in the sensory stores. The modality effect would occur as a result of the output from the short-term store being supplemented by the information in PAS for auditory presentation. Since the visual sensory store decays too quickly to be of any benefit in the recall of visually presented items, the recency effect obtained in free recall with visual presentation is considered to be pure output from the short-term store.

Engle (1974a) tested Craik's (1969) explanation of the modality effect by presenting a redundant, nonrecalled "zero" at the end of 12-word lists which were presented either visually or auditorily. This procedure, known as the suffix procedure, had been found to eliminate the contribution of PAS 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 probably the result of a more complicated combination of processes than just the subject supplementing recall from the short-term store with information from the short-lived PAS.

Another, more general, attempt to explain the modality effect suggests that the two modalities lead to different kinds of rehearsal strategies. This view stems from the belief of Craik and Lockhart (1972) that after a stimulus is recognized it may undergo further processing such as the elaboration of associations or generation of images. The result of this processing is the memory trace, with the strength of that trace depending on the depth of processing or degree to which the stimulus is elaborated, enriched, and tied to already existing memory traces. A further postulate is that information derived from very shallow levels of processing can be recirculated in the memory system without the processing going to any deeper level. Presumably when the subject then recalls the recirculated information, immediate performance will be high but the long-term memory trace will be much weaker than for an item that was processed to a deeper level of analysis.

Penney (1975) suggests that the modality effect can be thought of in just these terms. She suggests that auditory items are processed to a very shallow level with the resulting nonsemantic features being recirculated until recall of those items. The visual items would be processed more deeply, that is, semantically, but the information would not be recirculated as easily as that for the auditory items. For this kind of analysis to work it must be assumed that this differential rehearsal only occurs for the terminal items since the modality effect is confined to that part of the list.

A finding that complicates the construction of a general theory of the modality effect is the lack of any consistent modality differences in measures of long-term memory (cf. Tulving & Madigan, 1970; Brelsford & Atkinson, 1968). The notion that modality effects arise because auditory presentation allows recall

[1] Crowder, in a personal communication, has suggested that the name "prelinguistic auditory store" is more appropriate and fits the nature of the store more than does "precategorical acoustic store," thus the newer term is used here.

from the short-term store to be supplemented with information from the echoic store can explain the absence of modality effects in long-term memory if it is assumed that the supplemental echoic information is completely transitory and totally ancillary to the information in the short-term store. If, as the work of Engle (1974a) suggests, however, the modality effect results from a combination of memory processes and structures more complicated than simply the readout from one structure (echoic store) supplementing the readout from another structure (short-term store), then some differences in either strength or retrievability of auditory and visual items in long-term memory should be found.

Similarly, the levels-of-processing view predicts long-term memory differences for auditory and visual presentation but only for the terminal items. Since, with this explanation, the auditory items are processed less elaborately and to a shallower semantic level than are the visual items, a delayed recall test should show a modality effect just the opposite of that found with immediate recall. That is, the visual items should be recalled at a higher level than the auditory items on a test of long-term memory.

One thing that might complicate this predicted long-term-memory modality effect is the simple fact that more auditory items are recalled on the immediate test than are visual items. Darley and Murdock (1971) have shown that the act of immediate recall increases the probability that an item will be recalled on a delayed test. Thus, more auditory items will be strengthened by the simple act of immediate free recall than will visual items.

Thus, the current study was undertaken to test the idea that, without the strengthening act of recall, visual presentation would lead to higher recall performance on a delayed recall test than would auditory presentation. It was further hypothesized that the normal immediate free recall procedure would yield a different pattern of results on a delayed test than a condition that did not have immediate recall of each list. It was predicted that with immediate free recall after each list the two modalities would either be roughly equal on the delayed test or that the auditory condition would yield higher performance at least for the terminal items.

Method

The experiment consisted of presenting subjects with lists of words in either the visual or auditory mode. After each list was presented, the subject was cued either to recall the list or to not recall the list. It was assumed that, if the above hypotheses were correct, a delayed recall of all lists would show a reversal of the typical immediate recall modality effect for the nonrecalled lists while the delayed recall of those lists given immediate recall should show either no difference or auditory superiority.

Subjects

Seventy-two students from the introductory psychology courses at the University of South Carolina served as part of a course option and were tested in groups of one to four. All current ethical standards were met.

Materials

Twenty lists of 12 words each were constructed from relatively high frequency words (Kučera & Francis, 1967). The lists were formed so as to avoid any obvious within-list associations.

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, recall or nonrecall of

each of the free-recall lists, and the random order in which the lists were assigned to recalled and nonrecalled conditions. Modality was a between-subjects variable with 36 subjects receiving auditory presentation and 36 subjects receiving visual presentation. Each subject received 20 lists and, by one of six different random orders, each list was either recalled or not recalled immediately after presentation. Regardless of modality, if the list was to be recalled the subject was shown a question mark on a 3 × 5 card by the experimenter after the list had been presented. After nonrecalled lists the subject saw a three-digit number which served as the cue to not recall and from which he or she subtracted by threes, in writing, on the recall sheet for that list. A 60-sec period followed each list either for recall or for number subtraction.

Three random orders of lists to be recalled and lists not to be recalled were generated using a table of random numbers. Each order had 10 recalled and 10 nonrecalled lists. Three additional orders were intended to be mirror images of the original three such that each recalled list in the original order would be nonrecalled in the corresponding order. Through a transposing error one of the orders was not exactly a mirror image of its corresponding 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 nonrecalled 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 recall of all lists would be requested, and about 1 min after the end of the last 60-sec period the subject was given a sheet and instructed to recall all words from both recalled and nonrecalled lists. They were given at least 5 min for delayed recall but more time if needed. Each experimental session lasted approximately 40 min.

Results

The immediate recall data were analyzed by collapsing across all 10 of the lists that were recalled immediately after presentation. These data are shown in Figure 1 as a function of serial position. Analysis of variance on the data showed the main effect of Modality to be significant, $F(1, 60) = 6.56, p < .02$, indicating that performance was better in the auditory condition than in the visual condition. The Serial Position main effect was significant, $F\ (11,\ 660) = 65.57,\ p < .001$, as was the Serial Position × Modality interaction, $F\ (11,\ 660) = 10.0,\ p < .001$. The cause of the interaction is clearly shown in Figure 1. The visual condition was superior to the auditory condition on the first two serial positions while the auditory condition attained superiority over the last five serial positions. None of the other main effects or interactions was significant, including all the terms involving order of recall and nonrecall.

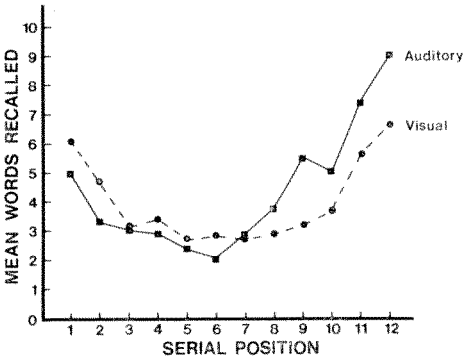

FIG. 1. Mean immediate recall of the Recalled lists for auditory and visual condition.

Since modality differences had been predicted over the last four positions, another analysis was performed for just those data. This again led to nonsignificant effects of order of recall and nonrecall and the interactions of order with the other variables. The main effect of Modality was significant, $F\ (1,\ 60) = 37.67,\ p < .001$, as was Serial

Position, F (3, 180) = 102.52, $p < .001$, but the SP × Modality interaction was not, F (3, 180) = 2.00, $p > .05$. The gist of all these analyses is that the recalled lists yielded results very much like the typical modality effects study: visual superiority on the first two positions but, more importantly for the present study, marked auditory superiority on the recency serial positions.

The delayed recall data are the most crucial for the hypotheses being tested in this study and are shown in Figure 2. Because of

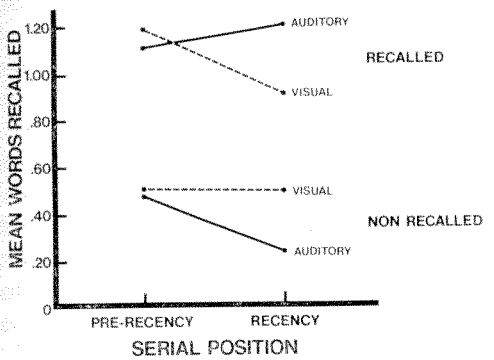

FIG. 2. Delayed recall data for the Prerecency and Recency positions from the Recalled and Nonrecalled lists in the auditory and visual conditions.

general noise in the data and the predicted distinction between terminal or recency input positions and earlier list positions, the serial position data for positions 1–8 were averaged and are labeled Prerecency and the data for positions 9–12 were averaged and are labeled Recency. Analysis was done on both the raw serial position 1–12 data and the averaged Prerecency and Recency data. Since both analyses reached the same conclusions, results of the Prerecency and Recency analysis are presented here. It should also be mentioned that the data for the Recalled lists in Figure 2 are mean number of words recalled on delayed recall noncontingent on recall on the IFR test. This was done simply to make the curves more comparable to those for the Nonrecalled lists.

Although Order inexplicably interacted with Serial Position and Recall and Nonrecalled (RN), F (5, 60) = 3.28, $p < .05$, and F (5, 60) = 2.53, $p < .05$, respectively, the most important and interesting findings involved the other variables. The main effects of Serial Position, F (1, 60) = 5.59, $p < .025$, and RN, F (1, 60) = 206.56, $p < .001$, showed that Prerecency items were recalled better than Recency items and that words from Recalled lists were recalled better than words from Nonrecalled lists. While the main effect of Modality was not significant, $F < 1$, the critical RN × Modality interaction was, F (1, 60) = 7.31, $p < .001$, as was the Serial Position × RN × Modality interaction, F (1, 60) = 10.99, $p < .001$. Figure 2 shows all of these effects very clearly. Tukey HSD tests at the .01 level showed that, for the Recalled lists, auditory was superior to visual on the Recency Positions but no difference was obtained at the Prerecency positions.

For the Nonrecalled lists, visual presentation was superior to auditory presentation at the Recency positions while there was no difference at the Prerecency positions. Thus, without the beneficial act of immediate recall visual presentation yields higher performance for the terminal items on a test of long-term memory.

Two related questions that are raised by the data in Figure 2 are: (1) Why is there auditory superiority on the Recency positions for the Recalled lists? and (2) Why, with the Recalled lists, is there a negative recency effect with the visual condition but not for the auditory condition? To answer these question we need to look at a conditional analysis of the delayed recall data. Table 1 shows that the percentage of those recency items recalled on the immediate test that were also recalled on the delayed test is about the same for the visual and auditory conditions. What this probably means is that while the act of recall benefits auditory and visual items equally, it does this for more auditory items than visual items, thus yielding higher mean recall for the

TABLE 1

RECALL DATA FOR THE RECALLED LISTS

	Modality	Serial position												Pre-recency	Recency
		1	2	3	4	5	6	7	8	9	10	11	12		
Total recalled on IFR	A	179	118	113	103	85	74	103	134	198	180	268	323	909	969
	V	221	169	112	121	98	102	98	102	116	133	202	239	1023	690
Total recalled on DR and on IFR	A	49	35	51	43	29	20	23	30	38	40	50	42	280	170
	V	54	45	30	33	39	37	21	32	22	27	37	24	291	110
Percentage of those items recalled on IFR also recalled on DR	A	27.4	30.0	45.1	41.7	34.1	27.0	22.3	22.4	19.2	22.2	18.7	13.0	30.8	17.5
	V	24.4	26.6	26.8	27.3	39.8	36.4	21.4	31.4	19.0	20.3	18.3	10.0	28.4	15.9
Total recalled on DR and not on IFR	A	4	6	1	8	5	7	3	3	1	2	1	0	37	4
	V	5	7	3	7	5	7	6	11	7	4	5	5	51	21
Percentage of those items not recalled on IFR that were recalled on DR	A	2.2	2.5	.4	3.1	1.8	2.4	1.2	1.3	.6	1.1	1.1	0	1.8	.8
	V	3.6	3.7	1.2	2.9	1.9	2.7	2.3	4.3	2.9	1.8	3.2	4.1	2.8	2.8

auditory terminal items than visual terminal items.

The second question is answered by these same data. Looking at the proportion of immediate free recall items recalled on delayed recall there is a clear negative recency effect for both auditory and visual conditions. As Engle (1974b) found, the occurrence of the negative recency effect depends on whether the delayed recall is analyzed contingent or noncontingent on recall on the immediate test. The noncontingent analysis (Figure 2) shows rather clear negative recency for the visual recalled items but positive recency for the auditory recalled items. The contingent analysis (Table 1) shows very clear negative recency for both presentation conditions.

Of course, the Nonrecalled data can only be analyzed by number of items recalled on the delayed test since no immediate test was given. With these data the auditory condition shows a very clear negative recency while the visual condition shows neither positive nor negative recency.

Some readers may be interested in the data for items recalled on the delayed test that were not recalled on the IFR test, that is, the reminiscence items. The bottom four rows of Table 1 give these data, but since the numbers were so small no statistical analysis was done. The visual condition had a higher percentage of reminiscence than the auditory condition on 11 of the 12 serial positions, particularly on the recency positions. Even if these differences are real they could be due to item selection effects but they also fit the predictions of one of the models discussed below.

Discussion

The differences obtained in the present study with delayed recall are small in absolute terms compared to the absolute differences between the two modalities on the immediate test. But for the recency items on the immediate test, performance of the auditory group exceeded the visual group by a factor of 1.4. For the recency positions of the Nonrecalled lists on the delayed test, visual performance exceeded auditory performance by a factor of 2.0. So, the fact that the differences we are talking about are small on an absolute scale does not seem to denigrate their importance.

The delayed recall data for the Nonrecalled lists seem to invalidate any theory that says modality effects in short-term memory occur simply through the supplementation of recall from the short-term store by recall of additional items from the prelinguistic auditory store. If that theory were correct, and there were no other additional processes or modifications in existing processes, no differences in recall between auditory and visual conditions should be found for the Nonrecalled lists on the delayed test. Differences in recall on this test might be predicted for the Recalled lists due to the fact that more auditory items are recalled on the immediate test and are thus strengthened by the act of recall. However, the Nonrecalled lists, being free of this contamination, should show no differences on the delayed test since the additional source of available information would have long since decayed and the only basis for recall should be the long-term memory trace that existed at the end of the presentation of each Nonrecalled list. The fact that auditory items are less likely to be recalled from long-term memory than visual items, if the act of immediate recall is eliminated, indicates that this theory, at least in its simplest form, is probably incorrect; it probably is incorrect to assume that modality effects in short-term memory are due to an additional source of recall for auditory items and that this additional source only is important at the end of the list when recall is required and that no differences in processing strategy exist between the two modalities.

One possibility is that visual and auditory recency items are stored in completely separate and different short-term stores and that the auditory store suffers more in the

transmission to long-term memory than does the visual store. This might fit with some of the ideas put forth by Murdock (1967). However, it seems rather unparsimonious to postulate a different type of short-term store for each modality on the basis of the research that now exists.

It seems more probable that processes that are fairly well documented already are contributing to modality differences in short- and long-term memory. One of these processes is probably the prelinguistic auditory store (PAS) proposed by Crowder and Morton (1969). Engle (1974a) showed that the suffix technique did eliminate part of the auditory superiority and this seems to suggest that the PAS is at least partially responsible for auditory superiority over the recency positions on the immediate test.

It seems quite likely that if, indeed, humans have a prelinguistic auditory store that stores speech sounds for 1–2 sec, then this PAS would affect the manner in which terminal list items are rehearsed. Craik and Lockhart (1972) suggest that subjects can choose to encode any of the various features of items to be remembered. The strength of the memory trace depends on the nature of the encoding or the degree of perceptual and semantic elaboration of the stimulus item. Craik and Lockhart say that the subject may choose to process the item to a very low degree of elaboration and to recirculate that information in a maintenance type of rehearsal. This is very efficient if recall is soon after input but it leads to a weaker long-term memory trace. So if auditory items are processed to a more shallow level than visual items they would be recalled less well than the visual items on delayed recall.

The presence of the PAS probably causes the subject to analyze the auditory items less deeply since the more recently presented item would always appear to be highly recallable and thus seemingly in need of less sophisticated rehearsal. Since only the auditory recency items are in PAS at the time of recall, that is where the modality effects are obtained in both short-term and long-term memory. Of course, this assumes that PAS is of long enough duration to hold the last four to five auditory items which would be considerably longer than the 1–2 sec proposed by Crowder and Morton (1969).

Some support for the notion that it is necessary to postulate something equivalent to the PAS in addition to differential depth of processing to explain modality effects was obtained in a study by Engle (Note 1). In this study subjects were presented lists of various lengths auditorily or visually and the various list lengths were either blocked by length so that the subject knew when the terminal items would appear or were presented randomly so that the subject could not predict with any certainty when the end of the list would occur. Ignorance of list length caused a decrement on an immediate free recall over the last four to five positions in the visual condition but only for the two to three positions prior to the last two positions in the auditory condition. The last one to two serial positions were not affected by ignorance of list length in the auditory condition indicating that depth of processing is not the only factor mediating the recency effect for auditory presentation. It seems safe to assume that the PAS is this factor.

Our data suggest that the terminal items are processed less deeply at the time of input primarily because they are highly available in the PAS and in the form of poorly processed but easily recirculated information in the short-term memory. This fits well with the data from the Nonrecalled lists but it also suggests that any items from the Recalled lists not recalled on the immediate test should be recalled very poorly on the delayed test. As mentioned above the reminiscence items are few in number and even those could conceivably be affected by item selection effects. But the existence of higher reminiscence for the visual condition would fit the depth of processing explanation.

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(Received April 26, 1976)