READING 4

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The fate of primary memory items in free recall

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The question of whether items retrieved from primary memory (PM) are as well registered in memory as those retrieved from secondary memory (SM) was examined in a free-recall study. It was found that words in terminal serial positions were retrieved best in immediate recall but least well in a second recall session. The conclusion was drawn that PM items are less well learned than SM items, and the implications for models of memory were examined. Subsidiary findings were that auditory presentation was superior to visual presentation and written recall was superior to spoken recall in PM. Also, words retrieved late in immediate recall had the highest probability of retrieval on the second recall session.

When a subject (*S*) is presented with a list of unrelated words for free recall, he usually retrieves the last few words in the list right away and then augments this terminal cluster with the recall of words from the beginning and middle of the list. The better recall of terminal items (the recency effect) can be handled by one-process models of memory (Melton, 1963) by postulating that an item's strength or accessibility is very high immediately after presentation but falls off rapidly as further items are presented. In the last few years, however, several theorists have advocated two-process models of memory to describe the results of free-recall studies. For example, Waugh and Norman (1965) proposed that the last few words are retrieved from primary memory (PM) whereas earlier words are retrieved from secondary memory (SM) with greater difficulty. While generally accepting the PM/SM distinction, two-process theorists have themselves split into two camps: those postulating two stores (Atkinson & Shiffrin, 1968; Glanzer & Cunitz, 1966) and those who argue for one memory store but two retrieval processes (Tulving, 1968).

The one-process model and the two-store model make different predictions regarding the registration in permanent memory of items presented in the middle and at the end of a list. It is known that recall of a word in free-recall learning facilitates its recall on subsequent trials (Lachman & Laughery, 1968; Tulving, 1967). Thus, since terminal items are recalled best in immediate free recall, they should receive most facilitation as a group and also be best recalled on a subsequent trial—this is presumably the prediction that one-process models must make. On the other hand, the two-store model described by Atkinson and Shiffrin (1968) predicts that terminal items should be recalled least well on a subsequent trial. This follows from the notion that the short-term store contains a rehearsal buffer which can hold 4–5 words. Once the buffer is full, further incoming items will knock out words already present—usually on the principle of "first in, first out." Words in the

middle of the list will thus remain in the buffer until approximately four further words have been presented, but words at the end of the list will remain in the buffer for a shorter time on average since they are retrieved soon after presentation. The model further postulates that the strength of registration in LTM depends on the length of an item's stay in the buffer so it follows that the last words in a list, although better recalled than earlier words in immediate recall, should have the least strength in permanent memory.

The preceding argument reduces to the question of whether PM items are as well learned as SM items. Bjork (1968) explored this problem in a free-recall learning study and found better learning of words retrieved from the middle of the list than words retrieved from terminal positions. In the present experiment, *S*s were given ten lists for immediate free recall and were subsequently asked to recall as many words as they could from all lists. The serial position curve of this "final recall" session was then examined to determine whether items originally in the terminal positions were recalled better or worse than items from the middle of the lists. It may be pointed out that this technique differs from that employed by Glanzer and Cunitz (1966). In their study, irrelevant material was interpolated between list presentation and free recall while the present experiment deals with words which have already been recalled once.

Other variables of interest were the modes of input and response. Previous researchers have used either auditory or visual input and either spoken or written responses with the implicit assumption that provided the words were correctly perceived, such variations should make little difference. Recent studies, however, have called this assumption into question. Murdock and Walker (1969) have shown that auditory presentation is superior to visual presentation in single-trial free recall and that this superiority is confined to the last few input positions. With regard to response mode, studies by Murray (1965) and Craik (1969) have shown a superiority of written over spoken response in free recall. It was therefore decided to conduct the present experiment under the four combinations of auditory or visual presentation with spoken or written recall to establish either that the findings were general over input and response modes or interacted with these modes. More generally, further normative data would also be obtained on the effects of manipulating input and response modes in free recall.

Method

The words used in the experiment were drawn from a pool of 600 common two-syllable nouns. For each *S*, these 600 words were randomly sorted into forty 15-word lists. Thus each *S* received a unique set of lists. The *S* was given 10 lists in each of four sessions—each session under a different input-response combination (auditory or visual presentation; spoken or written recall). The words were presented at a 2-sec rate, and immediately following presentation *S* was given 1 min for free recall. For visual presentation the words were shown in a memory drum and for auditory presentation the words were read by *E* in time to a metronome. Responses were either written on separate sheets for each list or were spoken into a dictaphone for later transcription. After recall of the tenth list, *S* was given 5 min to write down as many words as he could from all 10 lists. The instructions were again for free recall.

Twenty student *S*s were tested individually in each of four sessions. The sessions were at least a day apart and the order in which *S*s received the four input-response combinations was counterbalanced across the group.

Results and Discussion

Immediate recall scores were broken down into PM and SM components using a method described by Tulving and Colotla (1970) based on Waugh and Norman (1965). A response is regarded as a PM item if no more than a critical number of other items (either further stimulus items or responses) intervened between the item's presentation and its recall; it is regarded as an SM item if more than the critical number of stimulus items or recalled responses occurred in the item's intratrial retention interval. This method has the advantage that each word can be identified as having been retrieved from PM or SM. In the present study, the critical number of intervening items was taken as six, since that number yielded an

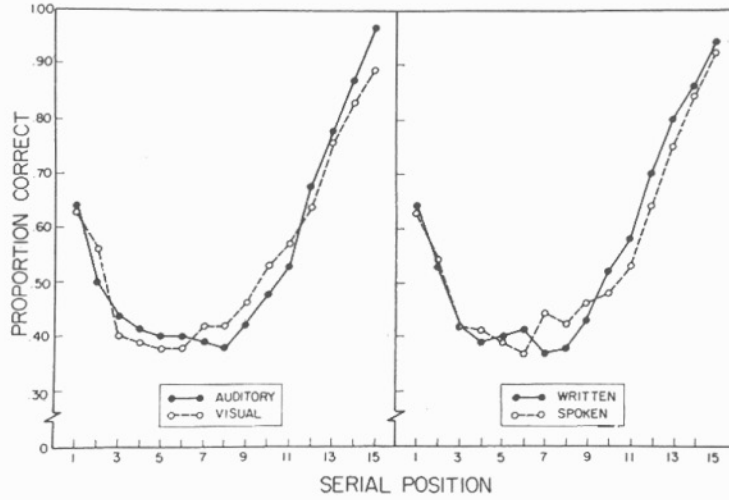

FIG. 1. Serial position curves for different input and response modes.

overall estimate of PM capacity (3.3 words) which was very close to the estimate (3.4 words) calculated by the "guessing correction" technique used by Waugh and Norman (1965).

Input and Response Modes

Figure 1 shows the serial position curves for auditory and visual presentation (combined over response mode) and for spoken and written responses (combined over input mode). The differences are slight but consistent with previous research findings: auditory presentation is superior over the last few input positions and spoken recall is poorer over these positions. An analysis of variance on the PM scores yielded a significant effect of input mode, $F(1, 19) = 6.93$, $p < .05$, and of response mode $F(1, 19) = 9.84$, $p < .01$, but no significant interaction. Thus, although PM differences were slight, they were statistically reliable. A similar analysis on SM scores yielded no significant effects.

It seems likely that the effect of input modality was small since the presentation rate was relatively slow. Murdock and Walker (1969) presented words at the rates of 2 per sec and 1 per sec and found the superiority of auditory presentation to be greater at the faster rate. Presumably input modality would have little or no effect at presentation speeds slower than one word per 2 sec. The superiority of auditory presentation in the recency positions has been variously attributed to a larger prelinguistic store for auditorily presented material (Murdock & Walker, 1969) or to the output from a postlinguistic store augmented by retrieval of material from prelinguistic stores (Craik, 1969). The latter point of view depends on the argument that after 2–3 sec there is still usable information in the auditory prelinguistic store but none in the corresponding visual store.

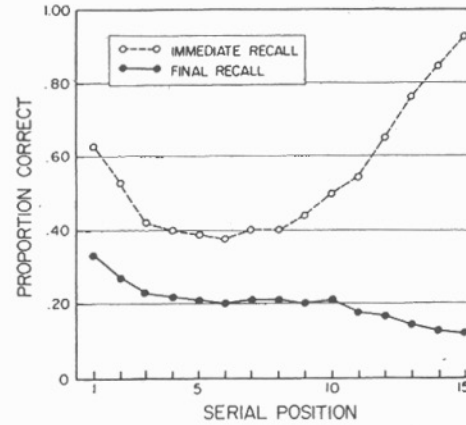

FIG. 2. Serial position curves for immediate and final recall.

The possible reasons for the superiority of written over spoken recall are even more speculative. Perhaps speaking the first few responses interferes with information remaining in PM. Another possibility is that if *S* is writing his responses, it is easier for him to rehearse the last few items in the list which are thus better recalled.

Immediate and Final Recall

Since the input and response manipulations had little effect on recall, scores from the different conditions were pooled to examine the serial position curves for immediate and final recall. Figure 2 shows that immediate recall yielded the classical serial position curve with a primacy effect for the first two items, a flat middle portion, and a recency effect extending over the last six or seven items. Final recall responses included some words which had not been given in immediate recall, but because of their rarity (less than 2% of the words presented) and since they were distributed over all serial positions, they were excluded from the calculation of the final recall serial position curve shown in Figure 2. Thus the final recall curve is composed entirely of words which were also recalled in immediate recall. The serial position curve in final recall consists of a primacy effect, a flat middle portion, and a slight but consistent *negative* recency effect. The reliability of this latter effect was assessed by considering the scores on the last seven serial positions since PM items typically arise from these positions (Waugh & Norman, 1965). An analysis of variance on the scores yielded a significant difference between serial positions, $F(6, 114) = 7.44$, $p < .001$; and a trend analysis of variance was also significant, $F(1, 138) = 18.82$, $p < .001$.

It thus appears that the last few words presented in a list are recalled best in immediate free recall but show the least probability of recall on a subsequent trial. This conclusion is supported by a conditional probability analysis. The probability of a word occurring in final recall given that it was also retrieved in immediate recall was $p = .37$. This value was substantially larger than the probability of final recall given that the word was not retrieved in immediate recall ($p = .04$), and this advantage to words which had already been recalled was shown by all 20 *Ss*. For words which were recalled in both immediate and final tests the probability of final recall given immediate recall from PM was $p = .16$ while the probability of final recall given immediate recall from SM was $p = .51$. The advantage to words recalled initially from SM was shown by all 20 *Ss*. Thus the retrieval of a word in the second recall session depends on whether the word was retrieved in immediate recall, and, further, whether it was retrieved initially from PM or SM.

From these results it is concluded that PM items are not as well registered as SM items in a permanent memory system. The "negative recency effect" in the final recall serial position curve is consistent with the two-store notion that terminal items are held in short-term store very briefly and thus transferred to a long-term store less effectively. Another possibility, although a less attractive one to the present writer, is that PM and SM items are equally well registered in permanent memory but that PM items are less accessible due, possibly, to the less efficient generation of semantic retrieval cues for terminal items.

From the conditional probability analysis, it may be concluded either that words which are easy to retrieve once are easy to retrieve again or that the first recall of a word has a facilitatory effect on its later retrieval. If the second explanation is true, it must be qualified by the finding that recall from PM has less of a facilitating effect than recall from SM.

Output Position in Immediate Recall

A final analysis was carried out on the relationship between *output* position in immediate recall and probability of retrieval in final recall. Words which are retrieved first in immediate recall are most likely to be PM items and so should be retrieved rather poorly in final recall. As output proceeds, so a greater proportion of the words will be retrieved from

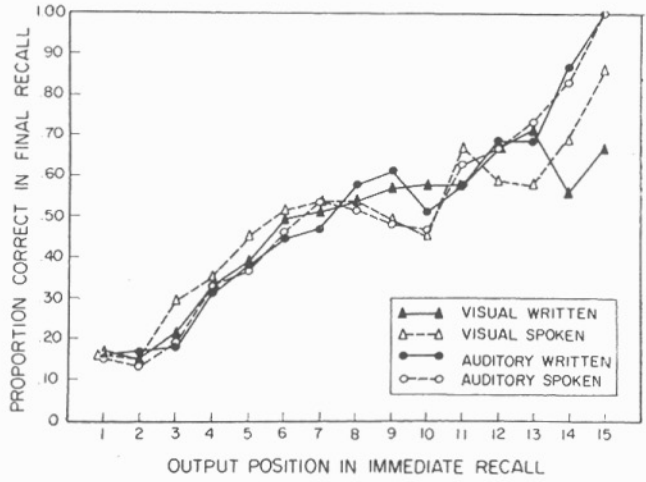

FIG. 3. Probability of retrieval in final recall as a function of output position in immediate recall.

SM, until after the sixth or seventh output position, all words are defined as being from SM. On this argument it was expected that the probability of retrieval in final recall would first rise with output position and then flatten out. However, Figure 3 shows that while there appears to be some tendency for the curves to flatten out between output positions 7–10, they rise again and even reach $p = 1.00$ in two cases. The input-response conditions are shown separately in Figure 3 to make the point that this continued increase is not an artefact of one particular condition. As might be expected, very few *S*s recalled as many as 15 words in immediate recall (the total numbers of words retrieved in output positions 13, 14, and 15 were 68, 36, and 16, respectively) so the absolute values of the last few points are not to be taken too seriously. The continuing upward trend is shown in all four conditions, however, so it seems reasonable to conclude that for SM items there is an additional factor leading to the more efficient retrieval in final recall of words given late in output.

This finding goes against the notion, mentioned previously, that items which are easiest to retrieve in immediate recall are also easiest to retrieve in final recall. Presumably words in output positions 10–15 are retrieved with some difficulty, yet they have the highest probability of retrieval in final recall. Two possible explanations for the finding may be suggested. One is that the first recall of a word acts as a second presentation and that the beneficial effects of this repetition are greatest with long lags (Melton, 1967). Alternatively, the facilitative effects of immediate recall may depend more on the process of retrieval, with difficult initial retrieval somehow being more beneficial for later retrieval.

CONCLUSIONS

The results of the present experiment and their significance may be briefly summarized. First, in a typical free-recall study, there were no large effects due to either input or response mode. Auditory presentation was superior to visual presentation and written recall was superior to spoken recall; both of these small effects were limited to PM—neither input nor response mode affected SM. It seems likely, however, that the differences would be greater at faster presentation rates.

Second, although the last words in the presentation list were retrieved best in immediate free recall, they had the lowest probability of retrieval in the final recall session. Since PM items were recalled best immediately and since it is known that recall facilitates retrieval on a subsequent trial (Lachman & Laughery, 1968;

Tulving, 1967), it seems necessary for one-process models to predict that PM items should also be recalled best in final recall. The finding that terminal items are retrieved *least* well in final recall would thus seem to pose a serious problem for one-process models. While the negative recency effect in final recall was specifically predicted from the two-store model (Atkinson & Shiffrin, 1968), the result does not constitute evidence against a theory which postulates two retrieval processes (Tulving, 1968).

Finally, it was found that the probability of retrieval in final recall was a monotonically increasing function of output position in immediate recall. At least two phenomena appear to be involved in this effect: words given early in output are more likely to be PM items, but within the set of SM items there is still a tendency for words recalled last to be retrieved best in final recall. This latter effect may be due to difficult retrieval somehow being more facilitating or it may be a special case of the repetition effect noted by Melton (1967).

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