Interference and encoding processes

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The interference effects of a card-sorting task on immediate and final free recall were investigated in two experiments. The Ss listened to 20 lists of 12 words. During list presentation, Ss sorted playing cards into 0, 1, 2, or 4 categories. In Experiment I, sorting condition was a between-Ss factor and all words were presented at a 2-sec rate. In Experiment II, sorting condition was a within-Ss factor and presentation rate was varied between groups. It was hypothesized that as the amount of interference present during learning increased, Ss would resort to the use of a more stable storage mechanism. The results did not support this hypothesis. In Experiment II, rate differences were found in the recency portion of the serial position curve in final free recall which were not apparent in initial free recall. This finding was discussed in terms of a short- and long-term store model of memory and a depth of processing interpretation.

Recently, Jacoby & Bartz (1972) have shown flexibility in short-term information processing as a function of task requirements. In their experiment, Ss free-recalled lists of words immediately or after a 15-sec silent or 15-sec filled delay. A final free recall (FFR) test of memory was administered at the end of the experimental session. The Ss who were required to recall following a filled delay recalled more items from late serial positions on the FFR task. The Ss recalling immediately or after a 15-sec silent delay did not differ on the FFR task. Jacoby & Bartz (1972) argued that these results were due to differences in the *kind* of information processing conducted by the S, rather than differences in the number of times items were rehearsed.

The present study investigates information processing under different levels of concurrent interference. The present experiments are similar to past experiments by Baddeley, Scott, Drynan, & Smith (1969) and Bartz & Salehi (1970), in which card-sorting tasks were used to produce different levels of interference for Ss attempting to learn lists of words. These studies showed that recall from the first serial positions declined as the complexity of the card sorting task increased. Because the card sorting task decreases the amount of time available for processing each item, it is possible that the S spends the available time on fewer words. It is also possible that those items might be processed in a different manner under different levels of interference.

In the present study, as the amount of (card-sorting) interference increases, immediate free recall (IFR) should decrease. However, long-term retention (FFR) might be expected to increase with increasing interference if the S encodes information in a more stable manner, as suggested by Jacoby & Bartz (1972).

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EXPERIMENT I

Method

Subjects

The Ss were 48 undergraduate volunteers enrolled in psychology courses at Iowa State University. The Ss received extra course credit for participation.

Lists

Nouns rated A and AA in Thorndike and Lorge were assigned randomly to 20 lists of 12 words each. The lists were tape-recorded for presentation at a 2-sec rate. Thirty seconds were allowed for the S's immediate free recall of each list.

Interference Task

The sorting materials included a deck of playing cards and a sorting template. The template contained 1, 2, or 4 card-sized outlines drawn appropriately in red or black. The Ss were instructed to sort the cards as the words were being presented, sorting one card with the presentation of each word. Three groups of Ss were instructed to sort the cards into 1, 2, or 4 categories. That is, cards were simply turned over (1 category), sorted by color (2 categories), or sorted by suit (4 categories). A fourth group of Ss were instructed to hold the cards without sorting (control).

Procedure

The Ss were assigned to the four interference conditions in the order of their appearance at the laboratory. The Ss were tested in small groups of up to four Ss. The Ss were given the instructions for their interference task and were told to remember as many words as possible. All recall was written. After the recall of the last list, the Ss were required a FFR, recalling as many words as possible from all 20 lists presented. There was a 5-min time limit on FFR.

Analysis

The number of words recalled in each of two six-word segments of the lists (SPs 1-6, 7-12) were analyzed in a 4 by 2 analysis of variance. The factors were sorting condition (0, 1, 2, or 4 categories) and list segment. Recall from FFR was analyzed in the same manner.

Results

The sorting requirements produced significantly different recall $F(3,44) = 8.86$, $p < .01$. Unlike earlier findings (e.g., Bartz & Salehi, 1970), highest recall was found in the one-category condition. Aside from this finding, recall decreased as the number of categories required by the interference task increased. Although most of the effect of the sorting task appeared to be in the early serial positions, the interaction of sorting conditions and list segments only approached significance, $F(33,484) = 1.40$, $p < .10$.

There were no significant differences among the conditions on the FFR task ($Fs < 1$).

Discussion

The results of the present experiment replicate the findings of Baddeley et al (1969) and Bartz & Salehi (1970). These authors found that the serial position curves for IFR showed differences at early serial positions, but not at the final serial positions. Baddeley et al (1969) suggest that the primacy differences indicate that variables which reduce the limited processing capacity of memory only influence LTM.

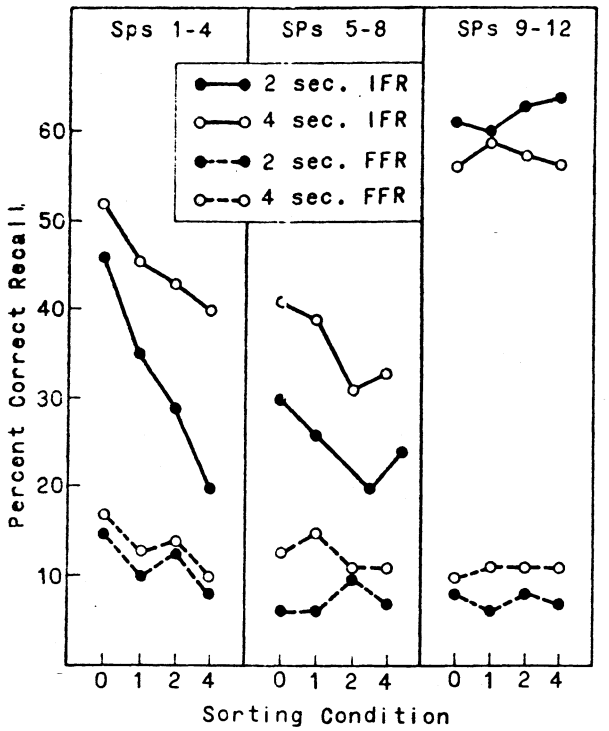

Fig. 1. Recall for list segments as a function of sorting condition.

The superiority of the one-way sort on IFR is not consistent with the notion that the sorting task constitutes a source of processing interference. It is possible that the act of turning over a single card as each word was presented caused the S to somehow attend to the stimulus in a way which was superior to the attention required under the no-sort condition. It can be argued that since very little processing time was required to turn over a card, the processing mechanism was not "distracted" from encoding itmes for IFR. The combination of increased attention and no difference in processing difficulty may have produced the increased IFR.

A second experiment, using a within-Ss design, was conducted in order to investigate further the possibility of processing differences. In order to investigate possible effects of longer presentation rates, two presentation rates were used. It is possible that the Ss will have more time for what Jacoby & Bartz (1972) have termed "deeper processing" at the slower rate.

EXPERIMENT II

Method

The method for this experiment was identical to that of Experiment I, except that each S sorted under all four interference conditions. A symbol in the S's recall booklet informed him of the sorting task to be used for each list. The assignment of sorting tasks was randomized across lists and across Ss.

The lists were recorded for presentation at a 4-sec rate. Twenty Ss, from the source described previously, responded to this recording. Another 20 Ss responded to the 2-sec rate recording used in Experiment I. The number of words recalled in each four-word segment of the list (SPs 1-4, 5-8, 9-12) were analyzed in a 2 by 4 by 3 analysis of variance (Rate by Sorting Condition by List Segment).

Results

Figure 1 presents the IFR and FFR serial position effects at the 2- and 4-sec rates. There was higher IFR at the 4-sec than at the 2-sec rate, $F(1,38) = 5.50$, $p < .05$. The interaction of Rate by List Segment was also significant, $F(2,76) = 8.10$, $p < .01$. As in other investigations of free recall, words in early serial positions benefited more from a slower rate of presentation.

Sorting conditions differed significantly, $F(3,114) = 19.51$, $p < .01$; the number of words recalled declined as the complexity of the sorting task increased. The interaction of Sorting Conditions by List Segment was significant, $F(6,228) = 4.93$, $p < .01$. As Fig. 1 illustrates, the greatest differences among sorting conditions were in early serial positions.

Final Free Recall

As in IFR, the slower presentation rates resulted in greater final free recall, $F(1,38) = 8.84$, $p < .01$. A strong primacy effect produced list segment differences, $F(2,76) = 10.70$, $p < .01$. The sorting conditions differed, $F(3,114) = 4.60$, $p < .01$; recall declined as the complexity of the sorting task increased. None of the interactions were significant.

DISCUSSION

Any advantage the one-way sort provided in Experiment I was eliminated by the within-Ss design of Experiment II. The lower primacy for the one-way sorting task in Experiment II may have resulted from the Ss' using a common processing strategy for all levels of interference rather than the processing difference hypothesized to have resulted from the one-way sorting condition in Experiment I.

The possibility of a common processing strategy is supported by the FFR results. The FFR totals declined as the amount of interference from the card-sorting task increased. In these experiments, the amount of time available for rehearsal was apparently reduced by the sorting tasks.

In an article supporting the total-time hypothesis, Cooper & Pantle (1967) state that when the requirements of any task do not exceed simple rehearsal, there is a fixed time requirement for learning a fixed amount of material. The Ss in the present experiments may have been using a simple rehearsal strategy rather than attempting any type of deeper processing or S-controlled use of the STM buffer to concentrate more time on fewer items. A simple rehearsal strategy would account for the failure of the proposed hypothesis of more stable processing under higher levels of interference.

A comparison of primacy differences for 2- and 4-sec presentation rates also indicates a time-dependent relationship. The increase in time available during the 4-sec presentation rate does not raise each sorting task equally. In Fig. 1, it is evident that the difference between the sorting tasks decreased at the 4-sec rate. As more time is required by the sorting tasks, the 2-sec group recalls fewer and fewer words relative to the 4-sec group. This produced the significant Sorting Condition by Rate interaction.

Glanzer & Cunitz (1966) have shown that presentation rate influences only the primacy portion of the serial position curve. The IFR results of the present experiment support this conclusion. In Experiment II, there is a significant interaction between presentation rate and list segment. As shown in Fig. 1, this difference is in the early serial positions. Recall from the recency portion of the curves was similar for both presentation rates. Although not evident in the IFR serial position curves or in Glanzer & Cunitz's (1966) data, recall of the final items in the list may show rate differences. This statement can be supported

by the fact that there was no significant interaction between rate and list segment in FFR. Rather, Fig. 1 shows that there was a relatively constant difference in FFR for all list segments; the recency items recalled in FFR were evidently encoded in a more stable manner at the slower presentation rate. The IFR and FFR results need not be considered inconsistent. The lack of a recency difference in IFR may have resulted from the Ss' recalling the last-presented items from the STM buffer store. This STM buffer may be able to encode information adequately at a 2-sec presentation rate and would thus show no rate differences. On the FFR task, the extra processing time afforded the Ss with a 4-sec presentation rate becomes evident and produces a higher level of recall across all serial positions. This hypothesis is compatible with a parallel process model of memory or a sequential model which assumes that transfer from STM and LTM is accomplished by "copying" the information into LTM without affecting its condition in the STM store (e.g., Shiffrin & Atkinson, 1969).

An alternative to these conceptions of memory has been proposed recently by Craik & Lockhart (1972). Craik hypothesizes a memory system in which a stimulus is encoded in a number of different levels of memory. Although more processing time is required for storage in the deeper levels, information so processed is likely to produce better retention. In the present experiment, it is possible that IFR results from the final serial positions reflect an economical use of a shallower processing level. Equal recall resulted because the shallow trace had not deteriorated by the time IFR was required. The FFR results may demonstrate retrieval from a deeper level of encoding. Since the presentation rates control to some extent the amount of time available for processing, differences in presentation rate would produce differences in the amount of deeper level encoding. The amount of deeper level encoding could have been responsible for the rate differences which were present across all serial positions in FFR.

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Effects of size of ring on backward masking of a disk by a ring*

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Two experiments are reported on the relation between the size of the masking stimulus (a black ring) and amount of backward masking of the target stimulus (a black disk). Both experiments yielded a significant mask-size effect, but the effect was confined to a very narrow range of masking ring diameters. Under the conditions of these experiments, and within that narrow range, amount of masking is a negatively accelerated increasing function of mask size. This result is consistent with some findings in the masking literature, and is predictable from a particular lateral inhibition model of masking, but it is quite inconsistent with other findings. Some suggested bases for the differences are tentatively offered.

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The two experiments reported here were done as part of a larger project investigating configurational variables in visual backward masking (see, for example, Cox, Dember, & Sherrick, 1969; Dember & Stefl, 1972; Sherrick & Dember, 1970). The variable of concern in the present paper is size of the masking figure. We use the paradigm introduced by Werner (1935), with a black disk at target stimulus and a black ring, fitting snugly around the disk, as mask. Mask size is manipulated by varying the "strip width" of the ring, keeping disk diameter and the inner diameter of the ring constant.

Mask size has been investigated in other studies, with conflicting results. In some (e.g., Matteson, 1969; Werner, 1935), increasing mask size increases amount of masking; in others (e.g., Schiller & Greenfield, 1969; Sturr, Frumkes, & Veneruso, 1965), the opposite relation is reported. And in some (e.g., Markoff & Sturr, 1971; Westheimer, 1967), the function is U-shaped. Unfortunately, these studies differ in many ways, which makes it difficult to identify compelling similarities among those experiments yielding similar functions.