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Immediate Free Recall and Three-Week Delayed Recognition[1]

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Twenty-five *S*s were shown 10 lists of words, each list followed by a free-recall test. Overt rehearsal of the word lists was required during study and was tape-recorded. Three weeks later *S*s returned for a recognition test on these words. Initial recall and three-week delayed recognition were increasing functions of amount of rehearsal accorded the item. The probability of delayed recognition decreased as a function of the initial serial study position, and appeared to increase as a function of its output position on initial recall. Further analysis of this latter result suggested that delayed recognition first rises and then falls as a function of output position in initial recall.

In a recent study by Craik (1970) *S*s were presented with 10 lists of words with a single immediate free-recall test following each list. At the end of this series of trials a final test was given in which *S*s were asked to recall as many words as possible from all of the preceding lists. Two interesting results emerged from the study. First there was a marked difference between the shapes of the serial position curves for immediate and final recall. The recency effect, which had been quite strong in immediate recall, was absent from final recall; in fact, final recall was found to decrease over serial input positions. The second result concerned the relationship between the probability of recall on the final test and the position of that item in *S*'s initial output protocol: the later an item appeared in *S*'s initial recall, the higher was its probability of recall on the final test.

In the present study *S*s were given a series of word lists with each list followed by a free-recall test on that list. During the study of these lists *S*s were required to rehearse list items aloud; this overt rehearsal was recorded and analyzed following the procedure described by Rundus and Atkinson (1970). Three weeks later *S*s were given a recognition test on all words presented in the initial session. The experiment is, then, a partial replication of the Craik (1970) study. In addition, this paradigm affords an opportunity to determine how delayed recognition is related to rehearsal at the time of initial study.

METHOD

Twenty-five Stanford undergraduate females served as *S*s in an initial one-hour experimental session. Each *S* was shown 11 lists of 20 "unrelated" nouns with frequencies of occurrence from 10 to 40 per million (Thorndike & Lorge, 1944). The first list shown to each *S* was the same, and was a practice list not included in the data analysis. Otherwise, the order of lists and the order of items within a list were random for each *S*. Words were presented singly on cards, each word being shown for 5 sec. Following presentation of each list *S* was given a 2-min. written free-recall test on that list. As each list was presented *S*'s rehearsal process was recorded using the procedure described by Rundus and Atkinson (1970). The *S* was instructed to study the list by filling the 5-sec. presentation interval for each word with overt repetitions of any words, including the current one, from the list being presented. This overt rehearsal was tape-recorded.

Approximately three weeks later each *S* was contacted and asked to participate in another experiment. Twenty *S*s returned and were paid $2.00 each for the second session. At no time prior to arrival at the second session were *S*s told that they were to be retested on the previously learned material; in fact, at the time of the first session *E* did not know that *S*s would be asked to

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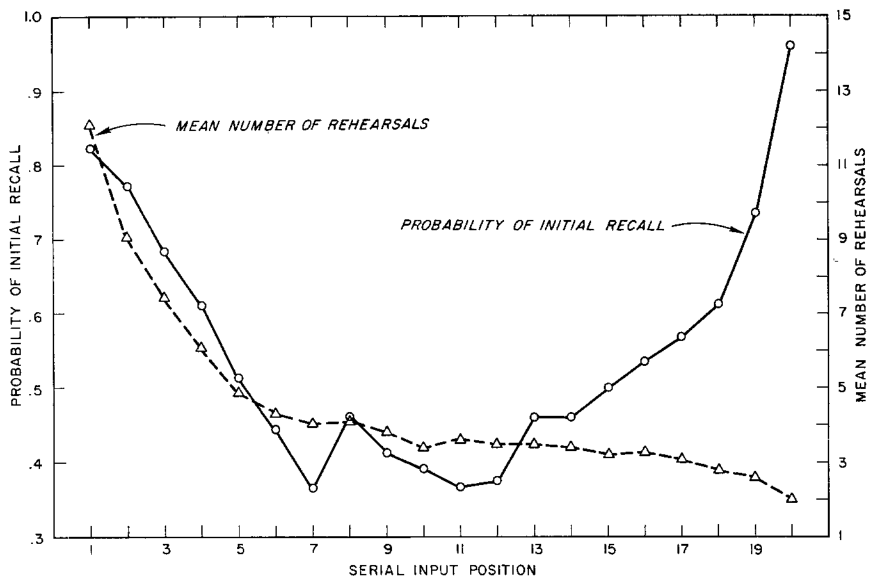

FIG. 1. The probability of initial recall, P(Re), and mean number of rehearsals as functions of the item's list position during study.

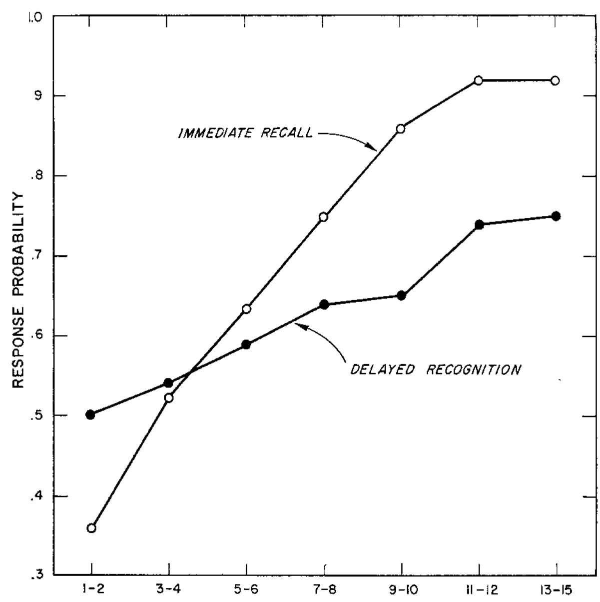

FIG. 2. The probability of initial recall, P(Re), and three-week delayed recognition, P(DRo), as functions of the number of rehearsals accorded an item.

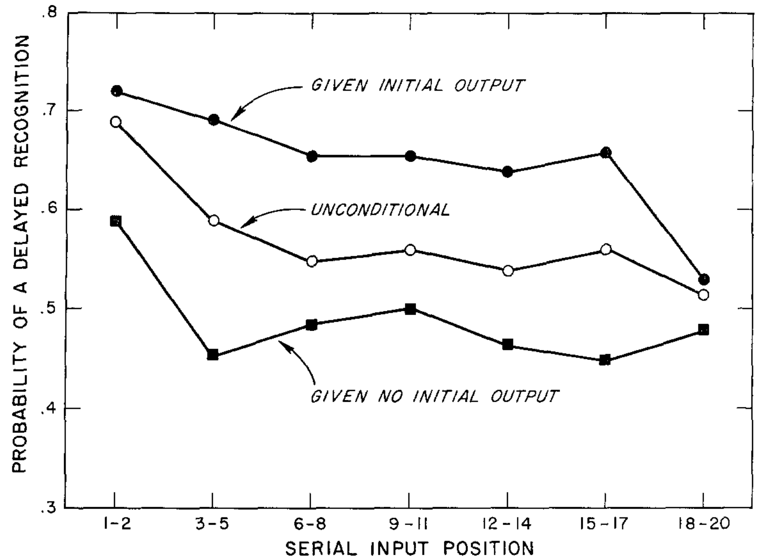

FIG. 3. The probability of a delayed recognition, P(DRo), as a function of the item's list position during study; also shown conditionalized on recall or failure to recall the item on the initial test.

return for further testing. At the beginning of the second session *S*s were reminded of the initial experiment and then given a three-alternative forced-choice test for recognition of the 200 words from the initial session. Ten test sheets were given to *S*, each sheet containing 20 rows of three words per row. One word from each row had been presented in the initial session while the other two words were distractors drawn from the same population as the initial words. The order of the words on the recognition test was random for each *S* and bore no relation to the ordering of the original lists. Subjects were instructed to circle the word in each row which had been presented during the first session and to rate their confidence in the choice using the numbers "1," "2," or "3," where "1" was highly confident and "3" indicated a guess.

RESULTS AND DISCUSSION

Figure 1 presents the probability of recalling an item during the initial session, P(Re), as a function of its input position in the study list. Also shown in Figure 1 is the mean number of rehearsals accorded an item as a function of its input position.[2] These two curves are highly correlated for the first two thirds of the list; however, for the last few list items P(Re) rises while the mean number of rehearsals declines slightly. These results, together with the strong positive correlation between probability of recall and the number of rehearsals accorded an item shown in Figure 2, are like the findings of Rundus and Atkinson (1970). A dual-storage model of memory such as that proposed by Atkinson and Shiffrin (1968) would be compatible with these findings. The model hypothesizes that recently presented items may be retrieved from a highly available but temporary short-term store (STS). If an item is no longer retrievable from STS, its recall probability is a function of the amount of information available in the more permanent long-term store (LTS). The amount of information in LTS for an item is further assumed to be an increasing function of the number of rehearsals it received during study.

Figure 2 displays a positive relation between the probability of a correct recognition response on the three-week delayed test, P(DRo), and the number of rehearsals accorded an item during the first session. Thus the number of rehearsals per item is a good predictor not only of initial recall perform-

[2] The distribution of rehearsals and other statistics of the rehearsal process were like those reported by Rundus and Atkinson (1970) and will not be reviewed here.

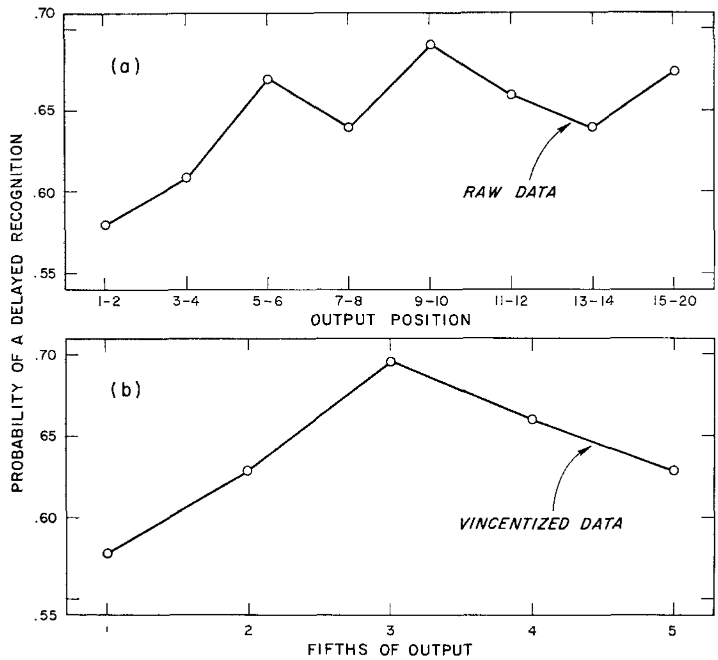

FIG. 4. The probability of a delayed recognition, P(DRo), as a function of (a) the item's position in the initial recall output protocol and (b) the item's position in the Vincentized initial recall output protocol.

ance but also of three-week delayed recognition.

Figure 3 presents P(DRo) as a function of the item's list position during initial study. Also shown is the curve conditionalized upon recall or failure to recall the item on the first test. These curves are similar to the relation found by Craik (1970) between final recall and the item's list position during initial study. For the Craik results and for this study one can hypothesize that relevant information is no longer available in STS at the time of the delayed test, and that performance is strictly a function of information in LTS. Hence, using a model like that proposed by Atkinson and Shiffrin (1968), the delayed memory curve should indeed be a decreasing function of list position.

Craik (1970) also observed a strong relationship between the likelihood of recalling an item on the delayed test and its position in the initial recall protocol. Items output early in the initial recall had a low probability of recall on the delayed test, whereas items recalled late in initial recall had the highest probability of final test recall. A similar but less pronounced relationship between P(DRo) and output position in initial recall was found in the present study; this result is shown in Figure 4a. As suggested by Craik (1970), pp. 147–148 this finding is consistent with the notion that items output early in the initial recall are probably retrieved from STS and have little strength in LTS, whereas those recalled later depend primarily on their strength in LTS. If a delayed test involves only LTS, then those items output early in the initial recall should be more difficult to recall after a delay than those output later.

One problem in interpreting the results displayed in Figure 4a is that *S*s differ in the number of items output in initial recall. In particular, *S*s whose recall scores are high contribute a disproportionately large amount of data to the later output positions. One way to correct for this problem is to Vincentize the data (Hilgard, 1938). Using this procedure the output protocol for each *S* and list is divided into approximately equal parts; in our case, the first fifth, second fifth, etc. The probability of a correct delayed recognition response is computed for words in each fifth of the initial output protocol and then averages are taken over all *S*s and lists.

Figure 4b presents the Vincent function for P(DRo) as a function of the initial recall order in successive quintiles. As in Figure 4a, P(DRo) is low for those items output early in the first recall; however, the function is now seen to rise to a peak and then decrease over later output positions. This result is consistent with the notion that (a) items recalled early in initial output were probably retrieved from STS, and (*b*) the remaining items were from LTS and output in an order determined in part by their strength in LTS. We suspect that if Craik's data were reanalyzed using the Vincent procedure, his function would also peak and then decline for later output positions.

In comparing Craik's general findings and those reported here the following point should be kept in mind: this study employed a three-week delayed recognition test, whereas his study used a second recall test immediately after the lists had been presented for study and recalled. Thus both the length of delay and the type of delay test differed in the two studies. Nevertheless, our results accord well with those reported by Craik, but further investigation needs to be done to clarify the precise relationship between delayed recall and delayed recognition performance.

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