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Rehearsal as a control process

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A probe experiment using lists of four CVC-word pairs was carried out, manipulating the opportunity to rehearse between the end of the list and the onset of the probe. Following the test on the last list, subjects were asked to write down as many of the responses (words) from the entire experiment as they could remember. Rehearsal resulted in significantly better performance on the probe responses, but there was no difference between the rehearsal and no-rehearsal conditions on the final free recall of response items. The results support the notion that rehearsal does not automatically increase the response strength of items in the long-term store.

Most current models of memory (e.g., Atkinson & Shiffrin, 1968; Waugh & Norman, 1965) assume that rehearsal contributes to the transfer of information to long-term storage (LTS). More specifically, it is usually postulated that the probability of an item being in LTS is an increasing monotonic function of the amount of rehearsal. Several studies have provided support for this postulate in a free recall task (Rundus & Atkinson, 1970) and in delayed recognition following a free recall experiment (Rundus, Loftus, & Atkinson, 1970). However, more recently, a number of investigators have reported results that are incompatible with the above. Thus, Craik and Watkins (1973) manipulated the amount of time the item resides in short-term store (STS) and the amount of rehearsals it receives and found that these do not predict its probability of recall from LTS (measured by an unexpected final recall test). Craik and Watkins conclude that rehearsal performs two different functions: maintenance function, which merely "keeps the items alive" and elaborating function, which processes the items more deeply, for more permanent storage. Similar findings were reported by Jacoby (1973), Jacoby and Bartz (1972), Watkins and Watkins (1974), and Woodward and Bjork (1973). Woodward and Bjork (1973) found also that whereas final recall did not improve as a function of rehearsal, final recognition did.

The above studies used free recall procedures. Some evidence for similar conclusions in a paired associates task was reported by Spector, Laughery, and Finkelman (1972) in a directed forgetting study. In this experiment, the subjects were given a probe recall task after presentation of a list of paired-associate items (CVC-words). Probe recall was better after rehearsal than after no-rehearsal. On the other hand, intrusion analyses showed that to-be-remembered (TBR) set intrusions were as frequent in the no-rehearsal condition as in the rehearsal condition. Also, the percent intrusions from the list presented on a particular trial, as opposed to omissions or intrusions from other lists, was the same for rehearsal and no-rehearsal conditions.

If rehearsal increases item strength, intrusions from the TBR set should be more frequent when there is an opportunity to rehearse. Their failure to find this effect led Spector et al. to suggest that rehearsal is not an automatic process, in the sense that rehearsal does not necessarily increase item strength. More specific to the PA task, they argued that the rehearsal may somehow affect the overall retrieval scheme without simply increasing item strength. For example, in more traditional PA terminology, the rehearsal might affect the associative learning or stimulus discrimination without affecting response learning. If the retrieval scheme fails to work on a given trial (which can be inferred by an incorrect response), response strength will not affect the intrusion pattern differentially for the rehearsal and no-rehearsal conditions.

The present experiment was designed to explore the role of rehearsal in a PA task more directly. A probe recall task was employed similar to that used by Spector et al. (1972). After the probe recall task, subjects were given an unexpected free recall task for all of the response items (words) in the PA task. If rehearsal does not increase the response strength in LTS, the rehearsal

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Table 1
Mean Number of Correct Responses from the First and Second Parts of the Lists for R and NR Conditions

	R	NR
First	6.68	6.29
Second	7.16	4.71

conditions should not differ on the delayed FR task, since the retrieval cue (the stimulus part of the pair) is not presented. On the probe recall task, however, rehearsal should enhance performance.

METHOD

Subjects

Thirty-six students (18 males and 18 females) from an introductory psychology course participated as subjects in the experiment. Participation partially fulfilled a course requirement. Assignment to the two conditions was random. There were 17 subjects in the no-rehearsal (NR) condition and 19 in the rehearsal (R) condition.

Apparatus and Materials

The stimulus materials, CVC-word pairs were the same as those used in Spector et al. (1972). The CVCs were taken from Archer's (1960) norms, ranging between 37 and 62. No CVC involving a Y was used. The words were high-frequency three- or four-letter words. CVC word pairing was done randomly. Thirty-four lists were composed, each containing four pairs. Two lists were used for practice, and 32 were experimental lists. The item pair tested on each list was determined randomly, with the restriction that each of the four serial positions will be tested equally often (eight times). Exactly the same lists were used for the two rehearsal conditions.

In addition to the PA lists, two lists were composed of a random selection of 16 words in each. All words were high frequency and were five or six letters long. These two lists were recorded on a tape recorder at the rate of one word per second.

Procedure

In the PA task, the lists were presented visually with a slide projector. In each list, subjects saw two pairs for 2 sec each, followed by a 3-sec blank slide, followed by two more pairs for 2 sec each, followed by another 3-sec blank slide, followed by an 8-sec test slide that contained one of the four CVCs in that list. A brief ready slide (blank red) signaled the beginning of the next trial.

The second blank interval defined the rehearsal condition. For both groups, the time was filled with white noise, but in the NR condition a low-level beep was inserted in the noise for 100 msec, in 16 of the 32 lists. Subjects in the R condition were instructed to ignore the white noise, while subjects in the NR condition were instructed on the signal detection task. The signal detection procedure was similar to a technique used by Reitman (1971) and was chosen in order to prevent verbal interference. Subjects were told that there would be a beep 50% of the time and that they should respond to the beep before responding to the probe. The timing of the beep within the 3-sec noise varied. In the 16 lists, it appeared five times 1 sec after the initiation of the white noise, five times after 2 sec, and six times after 1.5 sec. Subjects were instructed that the timing was not constant, but they were not told its exact nature.

The first blank slide was always blank, so that both R and NR groups could rehearse in it. This was done in order to provide the possibility of within subject analyses of the effect of rehearsal. In both rehearsal conditions, subjects were instructed to guess.

At the end of the lists, subjects in both rehearsal conditions were told to turn their answer sheets over and write down as many words as they could remember from the entire experiment. They were given 5 min. Following this free recall test, subjects were presented with the two 16-word lists with a tape recorder. They were given standard free recall instructions. They were told that none of the words in these lists had appeared in the experiment and that all were five or six letters long. A 1-min recall period was given for each of the lists. The purpose of these lists will be explained in the results section.

RESULTS

For the results to be meaningful, it is essential to demonstrate that the rehearsal manipulation had an effect on the PA probe task. These results will, therefore, be presented first.

Each subject was scored on his response to the probe task on each of the 32 trials. The range of possible scores is 0-32. The mean performance of the R and NR groups was 13.8 and 11.0 items correct, respectively. This difference is statistically significant [$t(34) = 1.94$, $p < .035$, one-tailed].

A within subject statistical test was performed to test for a rehearsal effect. Both R and NR groups have a 3-sec rehearsal period after the first two pairs. The NR group's rehearsal is prevented by the signal detection task in the second interval. Therefore, if rehearsal increases performance, and if we assume that subjects rehearse the first two pairs during the first blank interval (an assumption that agrees with subject's postsession verbal reports), we should obtain a Rehearsal by Serial Position interaction. More specifically, if we divide the 32 lists into two parts, the 16 where first or second pair was tested and the 16 where third or fourth was tested, there should be a stronger rehearsal effect on the last two pairs. This comparison yielded a significant rehearsal effect, $t(34) = 2.14$, $p < .05$. The mean numbers of correct responses for this analysis are presented in Table 1.

Having established the effect of rehearsal on the probe task, the results of the free recall data were then analyzed. Homonyms were not scored as correct and neither were changes in tense or in number. For example, no credit was given for "foot" if "feet" was correct. Responses that came from the two practice lists were not counted.

The mean number of words correctly recalled for the R and NR conditions were 12.47 and 12.59, respectively. This difference is not significant [$t(34) = .08$].

Since this comparison is quite important, and since it is a between subjects comparison, an attempt was made to control for individual differences by covarying out subjects' scores on the final two free recall lists. This analysis was done in the following manner: The two free recall lists were scored (homonyms were considered correct since the lists were presented auditorily). Each subject received a score on each of the lists that was the number of words correctly recalled, disregarding the last four words on the list. The last four words were ignored

in order to get a better long-term memory measure. Since they correlated, the scores from the two lists were then combined for each subject. This score was used as a covariate in an analysis of covariance, using the FR data from the experiment as the dependent measure. The results of the ANCOVA were the same: the difference between R and NR conditions was not significant, [$F(1,33) = .02$].

In the following analyses, ANOVA and ANCOVA yielded the same results; therefore, only the simple ANOVA outcome will be reported.

The next analysis was carried out to explore for the following argument. In the probe task, the R group performs better than the NR group, in terms of correctness. However, since subjects are encouraged to guess, even the NR subjects tend to respond on most trials, and their responses are usually from the correct list. It might be argued that both R and NR groups free recall mostly words that they responded with in the probe task, and these words are usually correct according to the FR criterion since they come from the PA experiment. An analysis was carried out comparing the R and NR groups on number of words free recalled that had not been given as responses in the probe task. The means for the R and NR groups were 4.16 and 5.00, respectively. This difference is not significant [$t(34) = .95$].

Since the probe data show that most (if not all) of the rehearsal effect in this experiment is located in the second part of the lists (see Table 1), another attempt was made to detect the effect on FR performance, given this finding. For each subject, the number of words correctly recalled from the second part of the lists was counted. The means for the R and NR groups were 5.0 and 4.4, respectively, a nonsignificant difference [$t(34) = .98$].

During this analysis, one important fact was observed: a large majority of the FR responses appeared in the first halves of the lists in the PA trials. The mean numbers of words correctly recalled from the first and second halves are 7.78 and 4.67, respectively. This difference is statistically significant [$t(34) = 2.72, p < .02$]. It should be noted again that this effect does not interact with rehearsal condition.

A final result concerns the signal detection task in the NR condition. The subjects performed the task above chance, but not perfectly, which shows that they were busy listening to the beep during the interval. Their performance on the probe task did not correlate with their performance on the signal detection task, which indicates no trade-off between the two tasks.

DISCUSSION

The hypothesis that rehearsal in a PA task does not necessarily increase item strength was supported by the results of this study. The data showed that performance on the probe task was affected by rehearsal. Subjects in the NR group reported that they were busy listening and unable to rehearse; whereas, most subjects in the R group reported that they could easily ignore the white noise. Performance in the probe task did not correlate with performance on the signal detection task.

In spite of a clearly effective rehearsal manipulation, no rehearsal effect on the final free recall was found. A number of independent tests were tried, controlling for individual differences, but none yielded a result that even approaches significance. If rehearsal increases item strength, such a difference should have been found.

The fact that most of the free-recalled words come from the first half of the lists suggests an interpretation similar to the one derived from the free recall studies referred to in the introduction. It can be argued that in the probe test, responses from the first part of the list come from LTS, and responses from the second part are retrieved from STS. Given the time parameters of the present experiment, this argument is not unreasonable. If rehearsal of the second part of the list is performing only a maintenance function (Craik & Watkins, 1973), then there should be a difference between rehearsal and no-rehearsal condition in the immediate test, and no difference on the final recall test. Furthermore, a negative recency effect should be observed on final recall, since items in the first serial positions of the list are processed for more permanent storage. All of this was found.

Evidence for negative recency effects in final recall in a PA task were reported by Madigan and McCabe (1971) and McCabe and Madigan (1971). However, these authors did not manipulate rehearsal opportunity and thus could not show that the negative recency does not interact with rehearsal.

It can be concluded that the effect of rehearsal on permanent storage is not automatic. It can automatically maintain items in STS but not transfer information about them into LTS. It is probably under the subject's control whether rehearsal time is used for mere recycling of items or for more elaborated processing of them.

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