The effects of rehearsal on frequency coding

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It has been claimed e.g., Hasher & Zacks, 1979, 1984) that encoding of frequency information is a result of an automatic process. This claim has been supported by experimentation that has included tests of several criteria suggested for the identification of automatic processes. The present experiment extends these tests to a case in which frequency judgments were obtained in a non-boolean task with masked presentation. In this test, frequency coding was very sensitive to manipulation. In fact, in one condition there was no reliable evidence of any frequency coding. These results are at odds with the claim that frequency coding is automatic.

In recent years, there has been a growing interest in the study of automatic processes. One frequently cited example of such processes is the encoding of frequency information. Hasher and Zacks (1979, 1984) and Zacks, Hasher, and Smillie (1982) have argued that people automatically code how often an event has occurred. In order to test whether frequency information is encoded automatically, Hasher, Zacks, and colleagues have examined a number of criteria which should be satisfied by a process if it is automatic. Their results have shown that encoding of frequency information is not affected by age (Attag & Hasher, 1980; Hasher & Chomiak, 1977; Hasher & Zacks, 1979); does not benefit from practice (Flasher & Chronokon, 1977; Zacks, Hasher, & Smillie, 1982); is not influenced by competing task demands (Zacks, Hasher, & Smillie, 1982); does not show individual differences (Zacks, Hasher, & Smillie, 1982); and is not enhanced by intention to code frequency (Flavell & Bower, 1975; Zacks, Hasher, & Smillie, 1982).

The major assumption underlying all of these criteria is that automatic processes should function at a constant level under all circumstances. Thus, if frequency coding is a such a process, we would expect that manipulation of coding strategy would not affect the fidelity of frequency judgments.

The purpose of the present experiment was to test whether variation in encoding strategy has an effect on frequency judgments. To render this a powerful test, we intentionally confounded two encoding strategies. The first one was the level of processing used by the subjects while encoding the information. In one condition subjects created a mental image of each pair of words presented, in the second condition subjects simply repeated the words aloud. The second encoding strategy was the intention to learn the information. In the condition in which subjects used mental imagery, they were also instructed to remember the words in order to prepare for a later memory test; in the condition in which they only repeated the words, they were not led to expect a later memory test. If automatic processes function at a constant level under all circumstances, as Hasher and Zacks (1979) have claimed, we should expect no difference between the frequency judgments of the two groups. This variation in encoding strategy was implemented in a task that involved variation in the number of times that subjects rehearsed the words whose frequency was later tested. The basic task was a modification of the classic Brown-Peterson short-term memory task (Glenberg, Smith, & Greens, 1977). On each trial, subjects were given a set of three two-digit numbers to hold in memory. During the retention interval, they were given a pair of words. One group was told to create an image linking the words in the pair in preparation for an upcoming memory test for the words, and to elaborate this image as they rehearsed the words aloud. The other group was told simply to repeat the words aloud, and was told nothing about a later memory test. For both groups, the number of overt rehearsals was varied from 1 to 10. After a series of such trials, we queried subjects from both groups about the number of times each word pair had been repeated—in short, about frequency for the word-pairs. If frequency is automatically coded, there should have been no difference in performance of the groups on the frequency test. But there most definitely was.

METHOD

Subjects
Forty undergraduate students at the University of Michigan served as paid volunteers in a session of approximately 75-min duration.

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Design
The experiment included two major independent variables. The first, varied within subjects, was the number of rehearsals required on each trial (1, 2, 4, 8, 16, or 32); the second, varied between subjects, was the instruction under which rehearsal occurred. In one condition, sub-
jects were told to study the word list at the beginning of each trial, after which they were told to read the same list again three times. The procedure for the other condition was the same, except that the words were presented in a random order. The order of the conditions was counterbalanced across subjects.

Subjects
There were four types of stimuli employed: number and words in the learning phase and frequency test phase.

Number Phase
This phase consisted of the main experimental task: the subjects were given a set of six numbers and were asked to recall them using a method of their choice. The numbers were presented in random order, and the subjects were not allowed to use any kind of mnemonic device. The task was to recall the order of the numbers, and the accuracy of recall was recorded.

Frequency Test Phase
This phase consisted of the recall test. The subjects were given a list of words and were asked to recall as many as possible in a specified time period. The words were presented in random order, and the subjects were not allowed to use any kind of mnemonic device. The task was to recall as many words as possible, and the accuracy of recall was recorded.

RESULTS
The reported results included only 40 of the 42 subjects. Two subjects were excluded from further analysis (one in the incidental condition who performed the frequency test, and the other in the incidental condition who did not perform any memory test).

Table 1 presents the percentage of numbers recalled as a function of rehearsal condition and number of rehearsals. A strict criterion was used in which a response was scored as correct only if all two-digit numbers were recalled in their correct order. The analysis showed that recall performance was significantly higher for the incidental-rehearsal condition than for the three other conditions.
condition, the increase in subjective performance across rehearsal intervals was rather small (F(5,95) = 1.54; n.s.).

Frequency Estimations

Spectral measures of performance were calculated and compared across conditions (see Naveh-Benjamin & Joelides, in press, for a detailed discussion of these measures). The first measure is the slope of the function relating estimated actual frequency. A higher slope is an indication of greater discriminability among the actual frequencies of presentation. A linear regression analysis was performed on each subject’s judged estimates, regressing estimated on actual frequencies, and the resulting slopes were compared across conditions. The values for these averaged slopes were 0.18 for the intentional-elaborative rehearsal condition and 0.01 for the incidental-mainstream rehearsal condition (standard deviations were 0.12 and 0.09 respectively). Analysis of these slopes revealed a significant effect of condition (F(38) = 4.79; p < .01). This result indicates that judgments in the incidental-elaborative rehearsal condition could better discriminate among the actual frequencies of rehearsals. Furthermore, the analysis revealed that the slope in the incidental-mainstream condition was not different from zero (t(19) = 0.81), a fact which implies that the subjects in this condition could not reliably discriminate among any of the actual frequencies of presentation.

It is also possible to estimate how the different rehearsal conditions affected the absolute level of frequency estimates. The estimated frequencies for each of the two rehearsal groups are shown in Table 2 as a function of actual frequency. The results show that the absolute level of judged frequency was higher in the intentional-elaborative rehearsal group. A two-way analysis of variance revealed a marginally significant effect of rehearsal condition (F(3,38) = 2.89, p < .10). The effect of actual frequency and the interaction of actual frequency and rehearsal conditions were both significant [F(5,190) = 7.22, p < .01, and F(5,190) = 3.72, p < .01 respectively]. Because high estimates for small frequencies imply overestimation and low estimates for large frequencies imply underestimation, the significant interaction reflects the superiority of performance of the intentional-elaborative rehearsal group over the incidental-mainstream rehearsal group.

The final measure of performance was the mean variability of estimates (a measure of the reliability of the judgments). For each subject, a standard deviation was calculated from the estimates given for each actual frequency.

These standard deviations were then averaged across the actual frequencies to yield one mean standard deviation per subject. The resulting means of these values were 1.95 for the intentional-elaborative rehearsal group and 2.23 for the incidental-mainstream rehearsal group (standard deviations of these means were 0.45 and 0.58 respectively). These results indicate that the variability of the judgments was larger in the incidental-mainstream group. This trend was confirmed by the analysis which showed the difference in standard deviations to be marginally significant (t(38) = 1.71, p < .10). (One reason for obtaining a marginally significant effect could be that some subjects in the incidental-mainstream rehearsal condition tended to give only low estimates, a fact which reduced the range of their judgments’ dispersion).

**DISCUSSION**

The results of the above experiments are quite clear. All three measures of performance on the frequency judgments task show the superiority of the intentional-elaborative rehearsal condition over the incidental-mainstream rehearsal condition. Subjective estimates in the intentional-elaborative rehearsal condition showed better discriminiability among the presented frequencies, higher absolute level of judged frequencies, and less dispersion of the frequency judgments may have been in the incidental-mainstream rehearsal condition. Such results solidified one of the other criteria suggested by Hascher and Zacks (1979) for automatic processing, and they extend the conditions under which it has been shown that strategy multiplications such as attention to form or level of processing affect frequency judgments (Fisk & Schneider, 1984; Goren, 1984; Naveh-Benjamin & Joelides, in press). The present experiments reveal the effects of using strategy under conditions in which repetitions are produced by rehearsal and in which presentation is varied rather than acted as in previous studies.

What could lead to performance differences between the two conditions? There are two obvious variables: intensity of brain and level of processing. Many studies have found no effect of intensity (e.g., Fieser & Bowell, 1975; Zacks, Hasher & Spar, 1982), however, these are recent reports suggesting that under some conditions brain can be an effect of intensity (e.g., presentation can). Naveh-Benjamin and Joelides, in press, offer an explanation of true incidental learning. Goren, 1984.

The results of these experiments, showing that the level of frequency variability has an effect on judgments (e.g., Busch & Rovel, 1975; Hasher & Zacks, 1979), have shown that this effect is actually produced by extra-covert rehearsal given to the stimulus under study, rehearsals which were not longer continued with actual presentation. We [and this claim somewhat belies the assumption that it could be attributed to the automaticity of frequency coding]. We suggest that the effect of frequency rehearsal in all other reported experiments of frequency judgments (e.g., we would report a marginally significant effect of extra covert rehearsal produced in this condition 1 increase the variability of the judgments rather than to decrease it, as actually happened.

Note that the results of the present study is quite in line with the studies that have used similar
References


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