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Primary versus Secondary Rehearsal in Imagined Voices: Differential Effects on Recognition

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Subjects were asked to rehearse word trigrams in a particular prefamiliarized male or female voice for 5, 10, or 15 sec. In Experiment 1, recognition performance improved with the amount of primary (maintenance) rehearsal only if the speaker's voice at test matched the rehearsal voice, but recognition performance improved with the amount of secondary (elaborative) rehearsal regardless of the sex of the speaker at test. With a visual testing procedure in Experiments 2 and 3, the amount of primary rehearsal given to a trigram had no effect on recognition performance unless the original voice context was reinstated mentally at test. These results suggest that: (a) Secondary rehearsal builds up semantic associations, whereas primary rehearsal serves to associate items with their physical characteristics at presentation. (b) There is an important memory search component in recognition as well as in recall. (c) Imaginal operations can yield a product in memory that is similar to that left by perceptual operations.

Based on research conducted within the framework of the dual-storage conception of human memory (Atkinson & Shiffrin, 1965; Waugh & Norman, 1965), rehearsal was presumed to have the two simultaneous functions of maintaining information in short-term store and transferring information in short-term store to long-term store. More recently, however, these two functions of rehearsal have been shown to be largely independent of one another. On the one hand, Jacoby and Bartz (1972), Woodward, Bjork, and Jongeward (1973), and others have demonstrated that large amounts of rehearsal can take place with only a small amount of later recall. On the other hand, Einstein, Pellegrino, Mondani, and Battig (1974) have shown that an item that is isolated in a list by some distinguishing physical feature is recalled more often than the other items in the list without being rehearsed more often.

One result that would appear to be inconsistent with the independent functions of rehearsal was obtained by Woodward et al. (1973). They found that increases in the amount of primary or maintenance rehearsal did yield increases in recognition performance, even though there were no such effects on recall. Woodward et al. reasoned that even though primary rehearsal, in contrast to secondary or elaborative rehearsal, does not interassociate the items or attach them to a retrieval plan or scheme of some kind, primary rehearsal does serve to associate an item with its

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"general situational context." Since the recognition test as typically carried out is a test of recognition-in-context, not recognition in some absolute sense, recognition performance, but not recall performance, is facilitated by primary rehearsal. The initial motivation for the present experiments, though they turn out to have other important implications as well, was to demonstrate that primary rehearsal does in fact improve recognition by associating an item with certain aspects of its situational context at presentation. An alternative explanation of the Woodward et al. result would be that with a greater amount of primary rehearsal, a greater amount of unavoidable semantic elaboration of the item occurs. It would have to be argued, however, that such elaboration somehow facilitates recognition judgments without serving to support free recall.

The probability of recognizing an item as having been presented earlier in an experiment depends upon the amount of information provided at test that overlaps directly (or indirectly through mediation) with information in the episodic memory trace (Tulving & Watkins, 1975). It is assumed here that the general situational context in which an item is presented, along with any information activated from semantic memory (Tulving, 1972), determines the composition of the episodic memory trace for the item. For purposes of the present research, it is not important whether these two types of information are actually retained as two distinct memory codes (one conceptual and one a "presentation" code) as suggested by Rabinowitz, Mandler, and Barsalou (1977). The general situational context, as we define it, refers to any physical aspects of the experimental situation that might distinguish the current presentation of an item from the subject's past encounters with the item. Nominal situational context corresponds to any physical attributes of an item as presented (intraitem context) and to any physical aspects of the environment in which it occurs (extraitem context). Functional situational context refers to those aspects of the nominal context as encoded in the episodic memory trace.

Available evidence suggests that, typically, primary rehearsal does not serve to strengthen associations between an item and its extraitem situational context. Several researchers have observed a facilitation in recall performance, but not in recognition performance, when extraitem forms of situational context are preserved at test, such as the experimental room (Smith, Glenberg, & Bjork, 1978), drug-induced state (Eich, 1979), and the natural environment—on land versus underwater (Godden & Baddeley, 1975). Thus, it would appear that extraitem context can serve as a retrieval cue; but if other retrieval cues are available, such as a "copy cue" in recognition, situation-dependent memory is less likely to be observed (for an elegant statement of this argument and a systematic review of past results, see Eich, 1979). This is, of course, opposite the results and argument of Woodward et al. (1973).

Taken at face value, the failure to find an effect of situational context on recognition is clearly inconsistent with the argument of Woodward et al. (1973) that primary rehearsal associates an item with its situational context. It could be, however, that primary rehearsal does serve to associate an item with its intraitem situational context. Thus, whereas changes in drug state and environmental factors seem not to affect recognition, changes in intraitem context such as speaker's voice (Craik & Krisner, 1974; Geiselman & Glenny, 1977) and type font (Kirsner, 1972, 1973) have been shown to affect recognition. Also, Woodward et al. (1973) displayed words visually in the same type font for both rehearsal and test, whereas in an unpublished experiment by the second author, in which presentation and test modalities differed, the duration of primary rehearsal had no effect on recognition. Similarly, in an experiment where presentation and test modalities also differed, Jacoby (1973) found that whether the interval between an initial presentation and a test of recall was filled with rehearsal or a subtraction task had no effect on later recognition.

To explore these issues further, subjects in the present experiments were asked to engage in primary or secondary rehearsal of verbal items, but to do so in a particular imagined speaker's voice, which was then either maintained or changed on a later recognition test. Craik and Kirsner (1974) and Geiselman and Glenny (1977) have shown that a word is more likely to be recognized if it is spoken by the same person at test as it was when initially presented. Craik and Kirsner used a continuous recognition paradigm in which subjects had 4 sec after the auditory presentation of each item to make a yes–no recognition decision and to give a confidence rating. Though the voice effect in recognition was rather small, with only a 4.2% difference between recognition for same-voice repetitions and different-voice repetitions, the difference was highly reliable and was observed after a lag of 2 min with 31 intervening items.

The paradigm used by Geiselman and Glenny (1977) was somewhat different than that used by Craik and Kirsner and the observed magnitude of the voice effect was much larger. In their experiment, subjects were first introduced to a male and a female speaker via a tape recording with instructions to attend to characteristics of the two voices. The subjects were then presented a series of word pairs on slides, one slide every 10 sec, where some of the slides had blue backgrounds and some had pink backgrounds. If the slide was blue, the subjects were to imagine that the male speaker was repeating the word pair over and over again for the entire 10 sec. If the slide was pink, the subjects were to imagine that the female speaker was repeating the word pair over and over again. After all of the slides had been shown, the subjects were given an unanticipated recognition test for the words using auditory presentation, with some of the words spoken by the male and some spoken by the female. The results

were quite remarkable. Even though the subjects did not actually hear the speakers saying the words originally, the average difference in recognition probability between "same-voice" and "different-voice" items was .11. This finding provides strong support for the idea that imaginal operations can produce memories that are quite similar to those that result from perceptual operations.

EXPERIMENT 1

In Experiment 1, speaker's voice (male or female), amount of rehearsal (5, 10, or 15 sec), and type of rehearsal (primary or secondary) were varied orthogonally. In the primary-rehearsal conditions, as in the Geiselman and Glenny (1977) study, the subjects were instructed to repeat the words over and over again "in terms of the speaker's voice," not in their own inner voice. Then, in an unanticipated yes–no recognition test for the individual words, each word was either spoken by the same speaker as at initial presentation or the sex of the speaker was reversed. If primary rehearsal facilitates recognition performance because of greater association of an item with its intraitem situational context, then greater amounts of primary rehearsal should facilitate recognition performance more if the sex of the speaker of the word is preserved with the test item than if it is not.

In the secondary-rehearsal conditions, subjects were instructed to attempt to interassociate and elaborate the to-be-rehearsed words, again in terms of the speaker's voice. They were told to construct sentences, to note semantic similarities, and so forth. It was not clear whether the voice effect would be observed with items given secondary rehearsal because with larger amounts of semantic-imaginal information in the episodic memory trace, accessing the trace from the test item may be less dependent on the physical context. Even if recognition could not be achieved on the basis of the situational context, the episodic memory trace might still be located during a memory search operation based on the semantic associations formed during the initial processing. This conception is consistent with the "double-access" theory of recognition offered by Atkinson and Juola (1974) and Rabinowitz, Mandler, and Patterson (1977), and predicts that the voice effect should be markedly smaller for the items that receive secondary rehearsal. Further, the greater the amount of secondary rehearsal the lesser the voice effect should be; that is, when the subject does a retrieval search, the probability of successful retrieval should increase steadily with the amount of secondary rehearsal, independent of whether the rehearsal was carried out in the same voice or in the other voice.

Method

Subjects. The subjects were 24 undergraduate volunteers, 12 males and 12 females, obtained from the introductory psychology course at the University of California, Los Angeles. They were tested in groups of six, three males and three females per group.

Materials and procedure. Subjects were first familiarized with the particular male and female voices used in the experiment. They listened to a tape recording of a 14-sentence passage about psychoanalysis in which 7 of the sentences were spoken by a male and the remaining 7 sentences were spoken by a female. The subjects were told, "Rather than paying attention to what these two people are saying, I want you to listen carefully to characteristics of their voices."

Following the introductory voice familiarization, the subjects were presented another tape recording that contained 28 word triads. The items were constructed such that all words were common four-letter nonhomophonic nouns and no triad contained words that began with the same letter, that rhymed, or that were interassociated in some obvious way. Just before a given word triad was spoken, the speaker (male or female) said "repetition" or "association." The subjects were instructed that if the speaker said repetition, they were to imagine that the speaker was saying the three words over and over again until the next set of three words was presented. If the speaker said association, then they were to imagine that the speaker was forming meaningful associations among the three words. Following each word triad, there was a blank interval of either 5, 10, or 15 sec, during which time the subjects performed the repetition or association task. The subjects were not told about the ensuing recognition test; but rather, "When we are finished, I will ask you some questions about the experiment to see how well you were able to repeat and associate the words in the speakers' voices."

Half of the word triads were spoken by the male and half were spoken by the female. In addition, half of the triads were preceded by the "repetition" instruction and half were preceded by the "association" instruction. Which triads were spoken in the male or female voice, and which triads were followed by the repetition or association instruction was counterbalanced across subjects. The postitem interval was partially counterbalanced with each word triad being followed by two of the three possible intervals equally often.

After being presented the word triads, the subjects were given a questionnaire that asked the following questions: (a) How well do you think you were able to form associations among the three words in terms of the male's voice? (b) How well do you think you were able to form associations among the three words in terms of the female's voice? (c) How well do you think you were able to repeat the three words in terms of the male's voice? (d) How well do you think that you were able to repeat the three words in terms of the female's voice? The possible responses for each question were: very poorly, poorly, fairly well, and very well. This questionnaire took approximately 45 sec to complete.

After the questionnaire, the subjects were presented a tape recording of 144 individual four-letter words with a 5-sec blank between words. Seventy-two of the one hundred forty-four words had been presented on the original tape recording and the sex of the speaker on the test tape was crossed with the sex of the speaker on the original tape. Half of the 72 distractors were also spoken by each speaker. The subject's task during each 5-sec interword interval was to respond on an answer sheet with "yes" or "no" depending on whether the word had been presented on the original recording. The answer sheet consisted of the numbers 1 to 144 with a blank next to each number; the words did not appear on the answer sheet. The sex of the speaker on the test tape was irrelevant to the subjects' response decision because the subjects were told,"your task is simply to indicate whether or not each word was presented to you on the original tape."

Design and analysis. The data matrix for the recognition of the words constituted a 2 × 2 × 3 × 2 array, with the specific factors being sex of subject, rehearsal type (repetitive rehearsal or associative rehearsal), rehearsal interval (5, 10, or 15 sec), and voice combination (the same voice at test as at initial presentation or a different voice at test than at initial presentation). In addition, the questionnaire data were analyzed using a 2 × 2 × 2 analysis of variance with the factors being sex of subject, rehearsal type, and sex of the speaker. This analysis was conducted to determine (a) whether the subjects found it easier to do primary rehearsal or secondary rehearsal in another person's voice, and (b) whether this relationship interacted with the sex of the speaker and/or the sex of the subject. The dependent variable was each subject's ratings on the four 4-point scales.

Results

Recognition data. In Fig. 1, the recognition hit rate is plotted as a function of rehearsal time for the four combinations of rehearsal type (primary or secondary) and whether the voice at test matched or mismatched the original voice at input. The main effects in Fig. 1 are all significant. Words given secondary rehearsal were better recognized than words given primary rehearsal ($F(1,22) = 38.2$, $MS_e = 2.35$, $p < .001$), recognition increased with amount of rehearsal ($F(2,44) = 9.6$, $MS_e = .58$, $p < .001$), and recognition of words spoken in the same voice at test as at input was better than the recognition of words spoken in a voice that mismatched the input voice ($F(1,22) = 25.6$, $MS_e = .72$, $p < .001$). The false-alarm rate for the recognition test was rather high, .31.

The most striking aspects of the data in Fig. 1, however, lie in the interactions. Whether the test and input voices matched made a larger

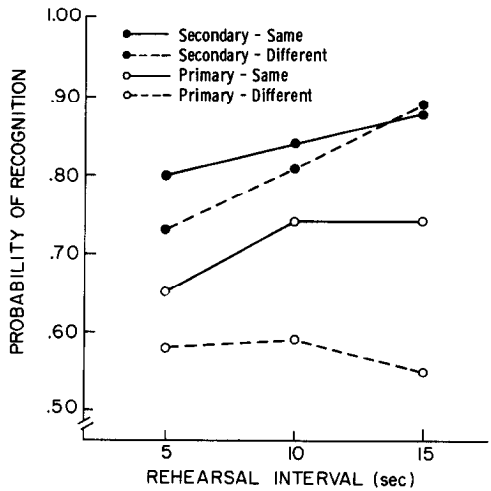

FIG. 1. The probability of word recognition displayed as a function of type of rehearsal, whether the speaker's voice at test was the same as the voice at initial presentation or was different, and rehearsal interval. The false-alarm rate for new items was .31.

difference for words given primary rehearsal than for words given secondary rehearsal (for the Rehearsal Type × Voice Combination interaction, $F(1,22) = 11.8$, $MS_e = .65$, $p < .005$). The triple interaction of Rehearsal Type × Voice Combination × Rehearsal Interval was also significant, $F(2,44) = 4.3$, $MS_e = .56$, $p < .025$. A Cicchetti posttest (Cicchetti, 1972) conducted on the latter interaction indicated that (a) increasing the amount of primary rehearsal from 5 sec to 10 or 15 sec produced an increase in the probability of word recognition for those words that were spoken in the same voice at test as at initial presentation ($p < .05$), but not for those words that were spoken in a different voice, and (b) with secondary rehearsal, the "same-voice" items were not recognized significantly more often than the "different-voice" items at any of the three rehearsal intervals, though these two curves appear to be converging with a greater amount of rehearsal (see Fig. 1).

Questionnaire data. The analysis of variance conducted on the questionnarie data revealed only one significant effect: a main effect of rehearsal type, $F(1,22) = 8.9$, $MS_e = .47$, $p < .01$. The subjects indicated that they were able to carry out primary rehearsal in another person's voice more easily (3.31) than they could carry out secondary rehearsal in another person's voice (2.90), where a rating of 4.0 represents "very well" and a rating of 1.0 represents "very poorly." It is instructive to note, however, that both mean ratings are near or above the "fairly well" category. Hence, most of the subjects felt that they were able to perform the intended tasks.

Discussion

The results of Experiment 1 provide support for the notion that primary rehearsal facilitates recognition performance because of greater association of an item with its intraitem situational context. The probability of recognizing a word increased with the amount of primary rehearsal given to the word, but only if the word was spoken by the same person at test as at initial presentation. It was necessary that the speaker's voice be preserved with the test item such that the amount of overlap between information in the memory trace and in the test item was maximized. Since the probability of recognizing the "different-voice" items that received primary rehearsal did not increase at all with the rehearsal interval, it must be concluded that a greater amount of primary rehearsal does not facilitate recognition performance because of a greater amount of automatic semantic-imaginal elaboration of the item. This implication follows because if the typical increase in recognition performance were due to unintentional semantic elaboration, then the increase should be observed to some extent regardless of whether physical attributes, such as the sex of the speaker, are altered at test.

The word triads that were processed under secondary-rehearsal instructions were recognized more often with a greater amount of rehearsal and more often than items rehearsed under primary-rehearsal instructions. Both of these results were probably due to a greater amount of semantic-imaginal information in the episodic memory trace that could be retrieved at test. Further, with a greater amount of secondary rehearsal, the voice effect was diminished in magnitude and was not reliable statistically. If we can assume that the amount of overlap between information in the memory trace and information in the test item diminished when the test item was presented in a different voice at test, then the voice effect should have been observed to some extent at all values of the secondary-rehearsal interval. Since this was not the case, or at least became less true as amount of rehearsal increased, it might be concluded that secondary rehearsal produces an episodic memory trace that can be retrieved by a systematic search, even when the test item does not have the same physical attributes as those stored in memory. As mentioned earlier, this explanation predicts the apparent decrease in the voice effect with greater amounts of secondary rehearsal. Alternatively, since the decrease in the voice effect was not significant, it could have been the case that speaker's voice was simply less likely to be stored with items that received secondary rehearsal. This explanation is consistent with the subjects' reports that they were not able to form associations among the words in terms of the speaker's voice as well as they were able to repeat the words over and over in the speaker's voice. Perhaps the subjects were limited to elaborating the words in terms of his or her own inner voice. One purpose of Experiment 2 was to test this alternative explanation of the secondary-rehearsal results.

EXPERIMENT 2

The primary purpose of Experiment 2 was to determine whether speaker's voice is a functional part of the general situational context for items processed under the secondary-rehearsal instructions. To make this determination, the 24 subjects in this experiment were presented the same material as in Experiment 1 in the same fashion; but at test, the 144 words were presented visually (typed on paper) without any controlled auditory context. These subjects were asked to indicate (a) whether each word was presented on the presentation tape and then (b) the sex of the speaker for each word that they recognized as having been presented. The word-recognition task was completed before the speaker-retention task was begun and each task required approximately 8 min to complete. If speaker's voice was retained with the memory trace for the items processed under secondary-rehearsal instructions, then the retention of speaker's voice given word recognition should be significantly greater than chance for these items and should increase with amount of rehearsal.

The influence of amount of rehearsal on word-recognition performance should differ as a function of the type of rehearsal. With secondary rehearsal, the increase in the storage of semantic-imaginal information with increased rehearsal should yield systematic increases in recognition performance. With primary rehearsal, however, the increased storage of the input-voice context with increased rehearsal should not yield increasing recognition performance since the voice context was not re-presented during the test.

Results

Recognition data. Recognition hit rate is shown in Fig. 2 as a function of rehearsal type and rehearsal duration. The pattern of results in Fig. 2 seems quite unambiguous. The main effects of Rehearsal Type and Rehearsal Interval were both significant ($F(1,22) = 265.0$, $MS_e = 1.83$, $p < .001$, and $F(2,44) = 3.4$, $MS_e = 2.44$, $p < .05$, respectively), and the Rehearsal Type × Rehearsal Interval interaction effect was also significant, $F(2,44) = 7.1$, $MS_e = 3.06$, $p < .001$. A Cicchetti posttest conducted on the interaction supports what seems apparent in the figure: The recognition of words given secondary rehearsal increased systematically with rehearsal ($p < .05$), but there was no significant effect of rehearsal duration for words given primary rehearsal.

A comparison of Figs. 1 and 2 suggests that the overall probability of word recognition was much smaller in Experiment 2 (.49) than in Experiment 1 (.73). However, the false-alarm rate was .31 in Experiment 1 but only .09 in Experiment 2. It is not clear why the subjects' rate of guessing

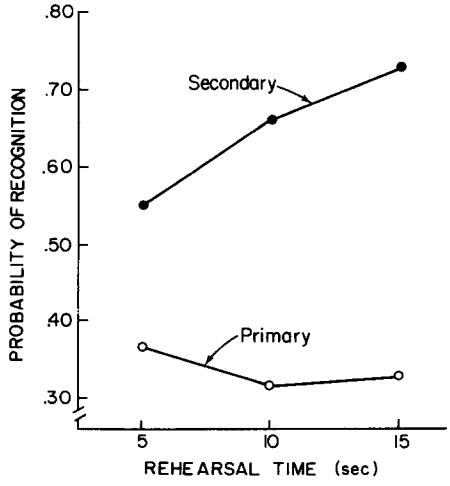

FIG. 2. The probability of word recognition for items presented visually at test as a function of type of rehearsal and rehearsal time. The false-alarm rate for new items was .09.

was markedly greater in Experiment 1, but possibly the presence of the voices in the testing situation served to reinstate the general presentation context and thereby induced the subjects to regard all of the words as more familiar.

Voice-retention data. The analysis of variance conducted on the voice-retention data (conditionalized on word recognition) showed that the only significant effect was the main effect of rehearsal interval, $F(2,44) = 5.4$, $MS_e = .03$, $p < .001$, with voice retention being greater after 10 or 15 sec of rehearsal than after 5 sec of rehearsal. These data are shown in Fig. 3. The main effect of rehearsal type and the Rehearsal Type × Rehearsal Interval interaction effect were not significant (Fs < 1). In Experiment 1, the probability of word recognition for the "same-voice" items that received primary rehearsal did not increase beyond that at the 10-sec rehearsal interval. It is consistent, then, that the probability of voice retention in Experiment 2 did not increase beyond that at the 10-sec rehearsal interval.

Questionnaire data. The analysis of variance conducted on the questionnaire data showed that the only significant effect was the main effect of rehearsal type, $F(1,22) = 12.3$, $MS_e = .45$, $p < .001$. As in Experiment 1, the subjects reported that primary rehearsal was easier to carry out in another person's voice (3.21) than was secondary rehearsal (2.73). Again, both mean ratings were near or above the "fairly well" category.

Discussion

As in Experiment 1, the words that were processed under secondary-rehearsal instructions were more likely to be recognized as amount of rehearsal increased. In addition, the probability of voice retention given word recognition for these items also increased with amount of rehearsal and was not significantly different from the probability of voice retention

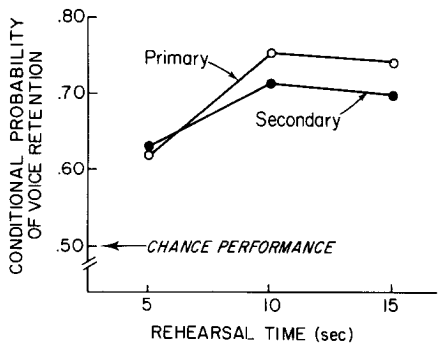

FIG. 3. The probability of voice retention conditionalized on word recognition as a function of rehearsal type and rehearsal time.

given word recognition for the words that were processed under primary-rehearsal instructions. The latter result was obtained at all three values of the rehearsal interval. Therefore, it can be concluded that speaker's voice was a functional contextual attribute for items rehearsed under secondary-rehearsal instructions in Experiment 1. The recognition of these words was simply less dependent on the reinstatement of the voice context at test than was the recognition of words given primary rehearsal.

The words that were processed under primary-rehearsal instructions were not recognized more frequently with a greater amount of rehearsal. This outcome was anticipated since the recognition test was conducted visually; and hence, the presentation and test modalities differed as in the Jacoby (1973) experiment. Since increases in primary rehearsal beyond 5 sec do not, apparently, lead to increases in the storage of semantic-imaginal information in the episodic memory trace that can be elicited by the test item, the amount of overlap between information in the memory trace and information associated with the test item remained constant across all values of the primary-rehearsal interval.

EXPERIMENT 3

The analysis in the foregoing discussion, if essentially correct, has a strong implication. It should be possible, according to that interpretation, for subjects to improve their performance on a visually presented recognition test by simply attempting to imagine each speaker saying any given test word. For words given primary rehearsal, imagining those words spoken in the same voice in which they were originally presented should yield a higher hit rate than would be the case if those words were imagined in the other voice. Further, this voice effect should not occur for words given secondary rehearsal. Experiment 3 was designed to test these predictions.

The design of Experiment 3 also incorporated a condition in which subjects were told to imagine saying a test word in their own inner voice. This within-subjects condition was added as a control measure to determine whether reinstating the speaker's voice at test facilitates recognition or whether instating an incorrect but recently familiar voice at test hinders recognition, or both. The obtained level of recognition for words imagined in the subject's own inner voice seems to be a good control measure since Geiselman and Glenny (1977) concluded that one's own inner voice is neutral with respect to any context effects on memory codes. In their experiments, recognition of words that were originally imagined in the subject's own inner voice did not depend on the sex of the speaker at test, regardless of the sex of the subject.

Method

Subjects. The subjects were 12 male and 12 female undergraduate volunteers from the introductory psychology course at the University of California at Los Angeles.

Procedure. The subjects were tested in six groups of four subjects each, two males and two females per group. The instructions and initial presentation procedure were similar to those used in Experiments 1 and 2. Sixteen word triads were presented auditorily with eight of the triads spoken by a female and the remaining eight triads spoken by a male. Four of the eight triads that were spoken by each speaker were accompanied by the "repetition" instruction and the remaining four triads were accompanied by the "association" instruction. As a counterbalancing measure, each triad was accompanied by each rehearsal instruction for an equal number of subjects. Each triad was followed by 10 sec of silence before the next triad was presented, during which time the subjects were to perform the appropriate type of rehearsal in terms of the speaker's voice. The first two triads and the last two triads were used as buffer items and did not appear later in the experiment.

Immediately after the auditory presentation of the word triads, the subjects were told that they would now be shown 72 individual words, one at a time, on a screen at the front of the room. Each word was shown for 5 sec on a blue, pink, or yellow background and each word was followed in turn by the presentation of a blank slide for 5 sec. If a slide containing a word were blue, the subjects were to imagine how the word would sound if it were spoken by the male speaker that they heard earlier. If the slide were pink, the subjects were to imagine how the word would sound if it were spoken by the female. If the slide were yellow, then they were to simply say the word to themselves in their own inner voice. When the screen was blank, and only then, the subjects were to make a decision as to whether the word had been presented to them earlier in one of the triads on the tape recording. The subjects were told that the purpose of the experiment was to determine whether the imagination procedure could "stimulate" their memories for the words. It was stressed that they were not to make any decision until the screen was blank. Prior to that time the subjects were to concentrate on how the word would sound in the designated voice. This particular portion of the instructions was strengthened after an unsuccessful pilot experiment in which subjects were seen making responses before the screen was blank. The "yes" or "no" responses for each of the 72 words were recorded by the subjects on a sheet of paper.

Thirty-six of the seventy-two words had been presented on the tape recording and one word from each of the 12 nonbuffer triads was presented on each background color. As a counterbalancing measure, each word was presented on each background color for an equal number of subjects.

Design. The data matrix for the recognition responses formed a 2×3 array with the factors being rehearsal type (primary or secondary rehearsal) and voice combination (the imagined voice at test and the presentation voice were the same, different, or the imagined voice at test was the subject's own voice). Both factors were within-subjects factors.

Results

A t test was first conducted between the proportion of false alarms made for distractors that were imagined in the male or female voice at test and the proportion of false alarms made for distractors that were imagined in the subject's own voice at test. This test was carried out to insure that there was no bias in the type of response to those two types of items. The obtained value of t was marginally significant, $t(23) = 1.75, p < .10$, with the subjects being somewhat less likely to make a false alarm for items that were imagined in their own voices at test (.13 versus .17). Since there was a trend toward differential response biases, the recognition data were corrected for this difference. The standard high-threshold correction for guessing was made by subtracting the proportion of false alarms as-

TABLE 1
PROPORTION OF WORDS RECOGNIZED

Rehearsal type	Voice combination		
	Match	Own voice	Mismatch
Primary	.60	.53	.45
Secondary	.80	.73	.82

Note. These proportions have been corrected for guessing.

sociated with each imagined voice (male, female, or own) for each subject from the corresponding hit rates within each cell of the design outlined above, and these values were then divided by 1 minus the corresponding false-alarm rate.

The analysis of variance conducted on the corrected word-recognition data shown in Table 1 indicated a significant main effect of rehearsal type, $F(1,23) = 31.92, MS_e = .07, p < .001$, with secondary rehearsal leading to a greater probability of recognition than did primary rehearsal. The interaction effect between rehearsal type and voice combination was also significant, $F(2,46) = 4.20, MS_e = .03, p < .025$. A simple main effects analysis showed that the probability of recognition was not significantly different for the three voice combinations in the secondary-rehearsal condition, $F(2,46) = 2.90, p > .05$. However, the simple main effect of voice combination for the primary rehearsal condition was significant, $F(2,46) = 3.96, p < .05$. A Tukey's HSD posttest indicated that the probability of word recognition after primary rehearsal was greater if the imagined voice for a word matched the voice of the original speaker than if the imagined voice did not match the original voice ($p < .05$). As shown in Table 1, when subjects were asked to imagine these words at test in their own inner voice, the probability of recognition was slightly less than when the imagined voice matched the original voice, but was somewhat greater than when the imagined voice did not match the original voice. Neither of these differences was significant.

As concluded by Geiselman and Glenny, the subject's own inner voice does appear to be neutral with respect to any differential context effects on recognition. This conclusion is indicated because recognition performance on words imagined in the subject's own voice at test was independent of whether the original presentation voice was of the same sex or of the opposite sex as the subject's voice (3.6 versus 3.5).

Discussion

The results of Experiment 3 replicate the results of Experiment 1 in that manipulating the voice context for each word at test did not differentially affect the probability of recognizing words that had previously received

secondary rehearsal, but did differentially affect the probability of recognizing words that had previously received primary rehearsal. As was observed in Experiment 1, and was also reported by Geiselman and Glenny (1977), words that were given primary rehearsal in terms of another person's voice were more likely to be recognized later if the original voice context for the word was reinstated. Hence, primary rehearsal in terms of a particular speaker's voice serves to associate the item with the situational context of that voice. The results of Experiment 3 and of Geiselman and Glenny indicate that neither the original voice context nor the test voice context need to be perceptual for the voice effect to be observed, but rather the context can be imaginary in either case. These results imply that to account for the voice effect, it is not necessary to assume (as do Craik and Kirsner, 1974) that subjects have literal auditory copies of spoken words in memory, but that representations of imaginary events can be much like the representations of percepts (Johnson, Taylor, & Raye, 1977; Kosslyn, 1975). Similarly, Smith (1979) has concluded that environmental context (such as the experimental room) can be reinstated from memory, as well as perceptually, to facilitate word recall.

In addition, for words receiving primary rehearsal, the probability of recognizing a word when the subject's own voice was imagined at test was lower than when the original voice was imagined, but was greater than when the other speaker's voice was imagined. Geiselman and Glenny observed the same pattern of results for words imagined in the subject's own voice during the initial presentation. Therefore, it is probably the case that reinstating the original speaker's voice for a word facilitates recognition and that instating an incorrect but recently familiar voice for a previously presented word hinders recognition. This argument suggests that the rehearsal-voice context forms an important aspect of memory traces laid down by primary rehearsal.

GENERAL DISCUSSION

The present results demonstrate four important points, each of which will be discussed in turn. First, the results support the Woodward et al. (1973) conception of primary and secondary rehearsal. Secondary rehearsal builds up elaborate semantic associations, primary rehearsal does not. With a greater amount of primary rehearsal, the physical context in which word triads were presented and rehearsed, namely the speaker's voice, was more likely to be retained in memory, and subsequent word recognition showed a concomitant increase when the voice context was reinstated at test. If the subject was given erroneous voice-context information, however, as in Experiment 1, or no voice-context information, as in Experiment 2, then recognition performance was unaffected by the amount of primary rehearsal given to the item. These results taken to-

gether argue against the possibility that primary rehearsal improves recognition memory because of unavoidable semantic-imaginal processing; rather, it appears that primary rehearsal serves to associate items with their intraitem physical context.

Although it was not a major purpose of this research to examine false-alarm rates under different recognition conditions, it is instructive to note that the pattern of false-alarm rates across the three experiments is consistent with the idea that a speaker's voice characteristics provide contextual information for recognition judgments. Consider the dramatic decrease in the false-alarm rate when a visual testing procedure was used in Experiment 2 (.31 versus .09). This change in false-alarm rates suggests that particular voice characteristics (e.g., average fundamental frequency, intensity, intonation) used to present items constitute contextual attributes such that words not presented previously in an experiment seem more familiar when they exhibit those general voice properties. Along the same lines, subjects in Experiment 3 were somewhat more likely to falsely recognize a distractor imagined in one of the speakers' voices than a distractor imagined in their own voice.

Second, the results provide support for the notion that there is an important search or retrieval component in recognition memory. In general, the situational context was found to play a lesser role in the recognition of items processed under secondary-rehearsal instructions than in the recognition of items processed under primary-rehearsal instructions. With a greater amount of secondary rehearsal of a word triad in Experiment 1, the voice effect diminished in magnitude and was not reliable statistically. This pattern was obtained even though the probability of voice retention tended to increase with a greater amount of secondary rehearsal (see Fig. 3). Therefore, it appears that with larger amounts of semantic-imaginal information in the episodic memory trace, recognition performance is less dependent on the preservation of physical aspects of the item at test. According to the "double-access" conception of recognition, the subject is assumed to conduct a perceptual analysis of the test item which results in a familiarity measure on the analyzed perceptual dimensions; in addition, especially if the familiarity judgment falls in an intermediate range, the subject may initiate a retrieval search based on the semantic associations established during the initial processing. Given that the episodic memory trace corresponding to the tested item can be retrieved on that basis, the subject will respond "yes" (the item is old). Thus, physical aspects of an item that are retained as part of the memory trace should have a greater effect on recognition performance following primary rehearsal than after secondary rehearsal, as was observed.

Third, the results say something important about differential effects of different forms of situational context on memory performance. Smith,

Glenberg, and Bjork (1978) found that maintaining the *extraitem* situational context, namely the experimental room, from presentation to test improved word-recall performance, but did not affect word-recognition performance. In the present experiments, *intraitem* situational context was seen to influence recognition, but only if the items had received primary rehearsal. Such functional differences between intraitem and extraitem aspects of an item's situational context make sense, in our view, if one assumes that memory performance reflects the overlap in the information stored at presentation and the information available in a subject's cognitive environment at test. As Eich (1979) has demonstrated in convincing fashion in the drug-state domain, extraitem aspects of context will exert their greatest effect on performance when (as, for example, in free recall) physical cues, such as the stimulus member of a paired associate, or the actual item itself on a recognition test, are not present. When the actual physical item is present, as on the typical recognition test, extraitem aspects of the situational context such as drug state or room have a minimal effect on performance.

Given, however, that certain intraitem aspects of an item are not reinstated at test, such as voice, presentation modality, typefont, and so forth, then recognition performance *should* suffer because the item at test does not completely overlap the item at presentation (in that sense, it is no longer a "copy" cue). When the initial processing is geared to the encoding of the physical aspects of the item, as in the case of primary rehearsal, such changes should have their maximal effects, as was found in the present experiments. Similarly, Kirsner (1972) found that maintaining the same type font at test as at study was more important when nonsense strings of letters were used than when meaningful words were used.

This interpretation, coupled with the "dual-access" characterization of recognition, seems to predict that to the degree intraitem aspects of context are not reinstated at test, then the presence or absence of extraitem aspects of context should influence recognition performance as well as recall performance. That is, to the degree that recognition-via-familiarity-judgment is foiled via changes in the physical copy cue, then search-type processes should play a larger role in recognition, and they should be sensitive to extraitem contextual factors.

Fourth, the results illustrate that imaginal operations can yield a product in memory that is similar to that left by perceptual operations. In Experiment 1, the silent repetition of items in terms of the voice in which they were spoken was sufficient to increase the size of the voice effect. Further, Geiselman and Glenny (1977) have observed that the voice effect can be obtained when the words are presented visually for study, as long as the subjects have been prefamiliarized with the to-be-imagined voices. The counterpart of this finding was seen in Experiment 3 where it was

demonstrated that if the original voice context is reinstated at test in an imaginary way, then the voice effect can be observed even for words that are presented visually for testing. Thus, neither the presentation voice nor the test voice need be perceptual for the voice effect to be obtained.

Finally, we should point out that there is an alternative interpretation of our results, which, in contrast to our view, does not appeal to contextual determinants of memory performance. Glenberg and Adams (1978) advance the view that primary rehearsal builds up the strength of the acoustic–phonemic components of the item being rehearsed. Voicing, in their view, is not a contextual aspect of the item; but, rather, it *is* the memory trace as stored. A subject's familiarity judgment is based on the degree to which his perceptual analysis of an item at test yields a product that matches the trace stored earlier. That idea, coupled with the notion that recognition can also take place via a retrieval–search process, is also consistent with the results we report herein; in fact, the argument is much the same as the one we have advanced, with the strength of the acoustic–phonemic trace itself taking the place of our assumed strength of association between an item and the voicing aspect of its context.

On the basis of parsimony, then, one might favor the Glenberg and Adams (1978) interpretation of primary rehearsal over the Woodward et al. (1973) interpretation as elaborated in the present paper. Fortunately, one need not appeal to parsimony, since the two interpretations have testably different implications with respect to the outcome of other potential experiments. On the basis of that kind of criteria, we feel confident that the virtually automatic association of an item to intraitem and extraitem aspects of its general situational context will prove to be a necessary, primitive assumption of any adequate theory of recall and recognition phenomena.

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