The Time Course of Repetition Effects for Words and Unfamiliar Faces

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SUMMARY

The repetition effect on reaction time to words and unfamiliar faces was examined at lags of 0, 4, and 15 items between first and second presentations. For words, subjects made either a lexical decision or a decision based on the stimulus's structural attributes. In the lexical decision task, a significant repetition effect was found at all three lags for words, whereas for nonwords the effect was significant only at Lag 0. In the structural decision task, the repeated decision was facilitated for both words and nonwords only at Lag 0, despite a word superiority effect at all lags. Target faces were presented either zero, one, or five times before testing. Subjects made either structural discriminations (face/nonface) or recognition judgments. In the structural discrimination task, the effect of repetition was significant only at Lag 0 (regardless of the number of pretest presentations). In the recognition task, the repetition effect was longer lasting, and its magnitude increased with the number of presentations which, presumably, determined the strength of the episodic memory trace. These results are taken as showing that repetition effects, like other measures of memory, are influenced by the type of stimulus, its preexperimental history, the level to which it is processed, and the lag between the initial presentation and the test. The manner in which these variables affect performance, however, may differ across memory tests. The dissociations between performance among repetition tests, and between repetition tests and other types of memory tests, is interpreted according to a task-specific, component-process approach to memory.

The improved identification of a stimulus with repetition is known as the repetition effect (Forbach, Stanners, & Hochhaus, 1974; Murrell & Morton, 1974; Winnick & Daniels, 1970). A common interpretation of the repetition effect is that the initial presentation of an item temporarily activates its abstract representation in memory, making it easier to reactivate that representation or its logogen when the item is repeated (Clarke & Morton, 1983; Morton, 1979). As evidence about repetition effects accumulated, this logogen-based ac-
Without discounting the possibility that abstract representations in memory might be involved in producing repetition effects, we wish to stress, as others have, that they may stem also from repeated access to a more highly specific representation that embodies stimulus attributes and situational factors (Jacoby, 1983; Jacoby & Hayman, 1987); in short, that it is mediated by memory for a particular event. Thus, repetition effects could be explained either by explicit retrieval of the initial episode (the subject actually remembers having seen the item and uses that information to facilitate performance) or by the reinstatement on the second presentation of encoding operations and procedures performed on the stimulus initially, or both (Carroll & Kirsner, 1982; Dannenbring & Briand, 1982; Feustel et al., 1983; Forster, 1985; Forster & Davis, 1984; Jacoby & Dallas, 1981; Kolers, 1976; Proctor, 1981; Ratcliff, Hockley, & McKoon, 1985; Scarborough et al., 1977).

From a mnemonic perspective, it is not surprising to discover that not all stimuli produce equally large and consistent repetition effects. The nature of the trace left by the stimulus at its first presentation probably depends (among other factors) on the type of stimulus, its preexperimental history, and the manner in which it is processed (i.e., on the attributes on which attention was focused during presentation). Our study was designed to examine some of the factors that determine the magnitude and the duration of the repetition effect. To this end, we compared repetition effects over a range of lags, for verbal and facial stimuli, in tasks that focus attention on physical attributes or on mnemonic representations.

Experiment 1

In contrast to the reliable repetition effects for words, the mere existence of repetition effects for nonwords is controversial. Several authors have reported significant effects for nonwords (Feustel et al., 1983; Logan, 1985; Scarborough et al., 1977), whereas others could not obtain them (Cermak, Talbot, Chandler, & Wolbarst, 1985; Forbach et al., 1974; Forster & Davis, 1984; Moscovitch, 1985) or obtained them for only some of the subjects (Ratcliff et al., 1985). One source of the discrepancy may be that the techniques used to assess repetition effects varied from study to study, in some cases greatly and in other cases more subtly. Another source of the difficulty in obtaining reliable repetition effects with nonwords may be due to the difference between the preexperimental history of words and nonwords; at the first presentation during an experiment, nonwords, by definition, do not have a preexistent representation in memory. Referring to such a representation may have a facilitatory effect on performance as suggested by the proponents of the logogen-based account. Alternatively, the more robust repetition effects for words than for nonwords may occur because the encoding and retrieval of the initial episode may be much easier for meaningful material than for nonmeaningful material.

Both of the foregoing explanations should apply equally to verbal and nonverbal material. Indeed, it has already been shown that repetition effects occur for line drawings of real objects and for well-known faces (Bruce & Valentine, 1985; Scarborough et al., 1979; Warren & Morton, 1982). Studies of repetition effects for unfamiliar nonverbal stimuli are rare. The meager evidence that exists suggests that repetition effects for unfamiliar faces is weak or nonexistent (Young, McWeeny, Hay, & Ellis, 1986), but those effects have not been systematically studied. We decided, therefore, to examine repetition effects for unfamiliar faces and compare them with the effects for words.

Unfamiliar faces are particularly appropriate stimuli to use for this comparison because people are probably as experienced in processing faces as they are in processing words (Baddeley, 1982; Bruce, 1983; Winograd, 1981). On the other hand, unfamiliar faces, like nonwords, are not represented in memory prior to the study.

We have designed a face perception task in which subjects are shown unfamiliar faces and nonfaces and are required to discriminate between the two. The nonfaces were constructed by interchanging the inner features of the face (eyes, nose, and mouth) with each other. To examine repetition effects, some of the faces and nonfaces were repeated at lags of 0, 4, and 15 items. In addition, repetition effects with similar lags were examined in a regular lexical decision task for words. By comparing the pattern of repetition effects for the different types of stimuli, we hoped to shed light on the processes underlying repetition effect at long and at short lags.

Method

Subjects. The subjects were 24 undergraduates from the Hebrew University in Jerusalem who participated for course credit or for pay. They were all native speakers of Hebrew with normal or corrected-to-normal vision.

Stimuli and apparatus. Because there is no reliable frequency count for Hebrew words, the 56 different words used in the lexical decision task were selected from a pool of 200 nouns rated for frequency by 50 independent judges, on a scale from 1 (very infrequent) to 5 (very frequent). The mean rated frequency of all words ranged between 2.0 and 3.0, with a mean of 2.60. The number of consonants in each letter string ranged from 3 to 5 letters with a mean of 3.95 for each lag group. The nonwords were legal but meaningless permutations of the consonants of the real words. All the verbal stimuli (words and nonwords) were presented in the regular unvoweled Hebrew orthography (Navon & Shimron, 1984). Because target items were not counterbalanced, special care was taken to match the items across lag groups. The frequency of the target words and the number of letters per stimulus in each lag group were identical.

The faces, taken from an old alumni yearbook from Cornell University, were unfamiliar to any of the subjects. None of the faces had facial hair or glasses. Nonfaces were constructed by switching locations of the internal features of the face (eyes, nose, and mouth). The relevant features were cut out from prints with a scalpel. The pictures were reassembled either in the correct way or with the internal feature switched. Target faces and nonfaces assigned to each lag group were chosen at random, and there was no obvious specificity of the facial stimuli used in each group. The order of verbal and facial tasks was counterbalanced across subjects.

Tasks and design. Each subject was tested in a lexical decision task, and in a face/nonface discrimination task. In the lexical decision task, 80 words and 80 nonwords were presented in two blocks of 80 trials each. In the face/nonface discrimination task, 80 unfamiliar faces and 80 nonfaces were presented in two blocks of 80 trials each. In each stimulus group (words, nonwords, faces, and nonfaces) there were 32 fillers that appeared only once, and 24 targets that were...
repeated at three different lags: Lag 0 (the second presentation immediately followed the first), Lag 4 (4 stimuli separated the two presentations), and Lag 15 (15 stimuli separated the two presentations). Eight different targets were randomly assigned to each of the three lag groups. Reaction times (RTs) and percentages of errors were averaged separately for each stimulus group.

All stimuli were prepared on regular 35-mm slides and projected on a white wall located about 2.5 m from a Kodak Carousel slide projector. Exposure time was controlled by a Vincent Uniblitz Shutter Drive Unit. Subjects responded by pressing either a yes or a no microswitch. The experiment was controlled by a PDP 11/23 computer.

Procedure. The experiment took place in a dimly lit room. Subjects sat approximately 2.5 m from the wall on which the stimuli were exposed. They were instructed to press one of the two alternative microswitch buttons, according to whether the current stimulus was or was not a legal Hebrew word (in the lexical decision task), or according to whether the current stimulus was or was not a normal human face (in the face/nonface task). The dominant hand was always used for “yes” (i.e., word or face) responses and the other hand for the “no” responses.

Following the instructions, 24 practice trials (12 words [or faces]) and 12 nonwords (or nonfaces) were presented. Each stimulus in the practice session was presented only once. The 160 test stimuli were presented next in two equal blocks, with a 3.5-s stimulus onset asynchrony and a 1000-ms exposure time. Reaction times were measured to the nearest millisecond, and those longer than 2.5 s were discarded.

Results

The RTs and the errors were averaged for each subject across stimuli in each lag group separately for the first and the second presentation. Only responses to targets that received correct responses on both presentations were included in the average. These data were analyzed by a within-subjects, three-way analysis of variance (ANOVA). The independent variables were stimulus type (word, nonword, face, or nonface), lag (0, 4, or 15), and order of presentation (first or second). Tukey-A post hoc analysis and planned t tests were used to assess differences within independent variables and between individual cells.

Across stimulus type, RTs were shorter when targets were repeated than when they were presented for the first time. However, the magnitude of the repetition effect differed with stimulus type and lag (see Figure 1).

The statistical analysis revealed that all three main effects and two-way interactions were significant (see Table 1). The main effect of stimulus type, \( F(3, 69) = 47.54, \text{MS}_e = 27,956, p < .0001 \), was attributable to the significant difference \( p < .01 \) between the positive and the negative responses: Words and faces were faster than nonwords and nonfaces, but there was no difference within each pair. The main effects of lag, \( F(2, 192) = 19.07, \text{MS}_e = 3,514, p < .0001 \), and of repetition, \( F(1, 23) = 70.34, \text{MS}_e = 3,276, p < .0001 \), can be better interpreted in view of the interaction between lag and repetition effects, \( F(2, 46) = 15.55, \text{MS}_e = 2,721, p < .0001 \). The effect of repetition was larger at Lag 0 (72 ms) than at Lag 4 (34 ms) and than at Lag 15 (14 ms; \( p < .01 \) at each step). The difference between the repetition effects at Lag 4 and Lag 15 was marginally significant \( p < .05 \). The significant interaction between the stimulus type and the repetition effects, \( F(3, 69) = 7.86, \text{MS}_e = 2,215, p < .0004 \), revealed that the repetition effect was larger for words (67 ms) than for any other stimulus type \( p < .01 \) and larger for nonwords (48 ms) than for faces and nonfaces \( p < .01 \) and \( p < .05 \).

Figure 1. The difference between reaction times to the first and second presentations, at Lags 0, 4, and 15. A: words (solid line) and nonwords (dashed line) in the lexical decision task. B: faces (solid line) and nonfaces (dashed line) in the face/nonface discrimination task.
Table 1

Repetition Effects (in Milliseconds) for Each Stimulus Type in the Lexical Decision and Face/Nonface Discrimination Tasks

<table>
<thead>
<tr>
<th>Condition</th>
<th>Lag 0</th>
<th>Lag 4</th>
<th>Lag 15</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>First</td>
<td>Second</td>
<td>First</td>
</tr>
<tr>
<td>Words</td>
<td>M</td>
<td>SEM</td>
<td>M</td>
</tr>
<tr>
<td></td>
<td>587</td>
<td>487</td>
<td>606</td>
</tr>
<tr>
<td>Nonwords</td>
<td>M</td>
<td>SEM</td>
<td>M</td>
</tr>
<tr>
<td></td>
<td>745</td>
<td>652</td>
<td>732</td>
</tr>
<tr>
<td>Faces</td>
<td>M</td>
<td>SEM</td>
<td>M</td>
</tr>
<tr>
<td></td>
<td>544</td>
<td>492</td>
<td>536</td>
</tr>
<tr>
<td>Nonfaces</td>
<td>M</td>
<td>SEM</td>
<td>M</td>
</tr>
<tr>
<td></td>
<td>682</td>
<td>636</td>
<td>702</td>
</tr>
</tbody>
</table>

Discussion

The results of Experiment 1 revealed a clear distinction between the pattern of repetition effects for words and that of all other stimuli, nonwords, faces, and nonfaces. For words, significant repetition effects were found at all three lags, whereas for nonwords, faces, and nonfaces, repetition effects were significant only at Lag 0.

As expected, stimuli that had no preexperimental representation in memory did not support a repetition effect at lags longer than 0. Although this result is consistent with predictions based on logogen models, for reasons stated earlier, we would prefer to explore alternative interpretations that emphasize other differences among the stimuli and the manner in which they might be processed.

One such alternative is that the trace left in memory by the first presentation of the stimulus may be too weak for the unfamiliar stimuli to sustain repetition effects at long lags. The very familiarity and meaningfulness of the words ensures that they can be processed more deeply and that their subsequent memory trace may be stronger (Craik & Lockhart, 1972; Craik & Tulving, 1975). Also, unlike the lexical decision task, distinguishing a face from a nonface requires that attention be directed only at superficial features to see if they conform to a generic model of a face. This shallow process may not be conducive to the formation of a strong memory trace and may have further exaggerated the difference in repetition effects between words and unfamiliar faces.

A recently completed study on repetition effects for voweled and unvoweled Hebrew words supported the latter interpretation (Bentin, in press; Bentin & Shoshani, 1986). In the voweled condition, when attention can be directed easily to phonemic aspects of the word, long lasting phonemic but not orthographic repetition effects were found. The long lasting phonemic repetition effects were abolished when the words were presented without vowels.

This account predicts that the repetition effects for words at long lags can be attenuated or even abolished if the subjects are made to attend only to the superficial visual attributes rather than to deeper internal representations. Conversely, repetition effects for faces can be extended and enlarged by creating a stronger memory trace for the target. Experiments 2 and 3, respectively, examine each of the foregoing two predictions.

Experiment 2

The same words and nonwords were presented in the same order as in the previous experiment. However, instead of deciding whether the items were words, subjects had to determine whether the first and the last letter of each word or nonword occurred in alphabetical order. For example, if the word is bahur (young man), the answer would be “yes” because b precedes r in the Hebrew alphabet, whereas if the word is tanur (stove), the answer would be “no” because t follows r in that alphabet. We assumed that in this task, subjects’ attention was directed towards the structural rather than lexical aspects of the stimuli. If our interpretation is
correct, the repetition effect for words should come to resemble that of unfamiliar faces at long lags.

Method

Subjects. The subjects were 24 undergraduates from the Hebrew University in Jerusalem and were paid for participation in this study. They were all native speakers of Hebrew with normal or corrected-to-normal vision. None of the subjects in this study had participated in Experiment 1.

Task and design. Words and nonwords were presented one at a time. The subjects were instructed to compare the first and last characters of each letter string and to press one button if the two characters were in alphabetical order, another button if they were not. The pseudorandom order used in Experiment 1 was repeated in the present experiment. There were 80 words and 80 nonwords. Within each stimulus group there were 32 fillers that appeared only once, and 24 targets that were repeated at three different lags: 0, 4, and 15. The correct response was “yes” for half of the trials in each group. Thus, there were 16 fillers and 4 targets in each lag group that required a “yes” response, whereas the other 16 fillers and 4 targets in each lag group required a “no” response. The same stimuli and apparatus were used as in Experiment 1, except for one pair of targets (Lag 4) and two fillers that were replaced in order to keep the 1:1 proportion between “yes” and “no” responses in each condition.

Procedure. The procedure resembled that of Experiment 1 with one exception: Preliminary tests revealed that the task used in the present experiment required more practice in order to achieve a level of performance comparable with the lexical decision performance. Therefore, instead of 24 practice trials, each subject received 48 practice trials prior to the presentation of the first test block.

Results

The RTs and errors were averaged for each subject across the stimuli in each lag group, separately for the first and the second presentations. As in Experiment 1, only correct responses to targets at both presentations were included in the averages. “No” responses were always slower than “yes” responses. However, because the trend of the repetition effects was identical for both response types, the “yes” and the “no” responses were collapsed, which yielded averages based on up to eight stimuli (see Table 3).

The repetition effect at each lag for words and nonwords was assessed by a within-subjects three-way ANOVA. The independent variables were stimulus (word or nonword), lag (0, 4, or 15), and order of presentation (first or second). Tukey-A post hoc procedure was used to compare individual cells.

In contrast to lexical decisions, the pattern of the repetition effects in the present task was similar for words and nonwords. For both stimulus types there was a large repetition effect at Lag 0, but no effect at Lag 4 or at Lag 15 (see Figure 2).

The ANOVAs revealed a significant word superiority effect (the responses to words were faster than to nonwords), $F(1, 23) = 29.02, MSe = 13, 792, p < .001$. The main effects of lag and order of presentation were both significant, $F(2, 46) = 39.26, MSe = 17, 381, p < .001$, and $F(1, 23) = 87.71, MSe = 10, 650, p < .0001$, respectively, but the more important result was that the order of presentation (repetition effect) interacted significantly with lag, $F(2, 46) = 48.29, MSe = 14, 718, p < .001$, but not with stimulus, $F(1, 23) = 3.83, MSe = 7, 181$. Post hoc analyses revealed that the repetition effect was significant at Lag 0 for both words and nonwords and not significant elsewhere.

The percentage of errors in each condition is presented in Table 4. The distribution of errors revealed that there was no speed-accuracy trade-off. A within-subjects ANOVA revealed that more errors were made with nonwords than with words, $F(1, 23) = 11.09, MSe = 0.552$, and that the repetition effect was marginally significant, $F(1, 23) = 3.49, MSe = 0.67, p < .075$. The interaction between stimulus type and repetition effects was not significant. The significant interaction of repetition and lag effects, $F(2, 46) = 5.71, MSe = 0.82, p < .008$, and Tukey-A post hoc analysis revealed that the repetition effect was significant at Lag 0 ($p < .01$) but not at Lag 4 or at Lag 15.

Table 3

<table>
<thead>
<tr>
<th>Condition</th>
<th>Lag 0</th>
<th>Lag 4</th>
<th>Lag 15</th>
</tr>
</thead>
<tbody>
<tr>
<td>First</td>
<td>Second</td>
<td>First</td>
<td>Second</td>
</tr>
<tr>
<td>Words</td>
<td>M</td>
<td>SEM</td>
<td>M</td>
</tr>
<tr>
<td>Nonwords</td>
<td>M</td>
<td>SEM</td>
<td>M</td>
</tr>
</tbody>
</table>

Figure 2. The difference between reaction times to the first and second presentations, at Lags 0, 4, and 15, for words (solid line) and nonwords (dashed line) in the structural decision task.

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1 We thank Emanuel Donchin for suggesting this task.
The difference between the patterns of repetition effects for words and nonwords in the lexical decision task (Experiment 1) and in the structural task (Experiment 2) was formally analyzed by a mixed-model three-way ANOVA. The independent variables were task (lexical decision or structural), lag (0, 4, or 15), and stimulus (word or nonword). The dependent variable was the repetition effect proper, calculated by subtracting the RT to the second presentation of each target from the RT to its first presentation. The task variable was analyzed within subjects; the lag and stimulus variables were analyzed within subjects. This analysis showed a significant main effect of the task (the repetition effect was larger overall in the structural than in the lexical decision task), \( F(1, 46) = 16.23, MS_e = 14,010, p < .001 \), and a significant main effect of lag, \( F(2, 92) = 55.49, MS_e = 18,302, p < .001 \). Both stimulus and lag interacted significantly with task, \( F(1, 46) = 6.24, MS_e = 9.293, p < .001 \), and \( F(2, 45) = 24.45, MS_e = 18,302, p < .001 \), respectively. Those interactions showed that the relative repetition effect on words and nonwords, and at different lags differ in lexical relatively to structural tasks. The three-way interaction was not significant.

**Discussion**

As predicted, attending to the structural rather than to deeper lexical attributes of words eliminated the long-term repetition effect for them. The short-term effect was, if anything, magnified, but it decayed rapidly. It is highly likely that when one item immediately follows another, memory for the decision that it induces would be nearly perfect regardless of how that item was processed initially. To illustrate this, imagine a subject being asked twice to multiply 12 \( \times \) 32. There is no doubt that if the second presentation immediately follows the first the subject will recognize the items and remember the product, leading to a much faster response. At longer delays, he or she may fail to recognize the items; but even if the subject recognizes them, he or she may need to repeat the calculation, so that the difference between the first and the second response time will be smaller than at short delays.

Our results are consistent with Lockhart, Craik, and Jacoby’s (1976) speculation that performance on memory tests is influenced by the strength and longevity of the memory trace for a particular target, then it should be possible to obtain such effects even for nonverbal stimuli, provided that they are represented in memory prior to the first exposure and that they are remembered well. Experiment 3 tested this hypothesis in a recognition memory paradigm for unfamiliar faces.

**Table 4**

Percentages of Error for Words and Nonwords in the Structural Decision Task

<table>
<thead>
<tr>
<th>Condition</th>
<th>Lag 0</th>
<th>Lag 4</th>
<th>Lag 15</th>
</tr>
</thead>
<tbody>
<tr>
<td>Words</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( M )</td>
<td>9.8</td>
<td>1.5</td>
<td>12.5</td>
</tr>
<tr>
<td>( SEM )</td>
<td>2.0</td>
<td>0.8</td>
<td>2.5</td>
</tr>
<tr>
<td>Nonwords</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( M )</td>
<td>11.9</td>
<td>3.1</td>
<td>7.3</td>
</tr>
<tr>
<td>( SEM )</td>
<td>2.3</td>
<td>1.3</td>
<td>1.8</td>
</tr>
</tbody>
</table>

As predicted, attending to the structural rather than to deeper lexical attributes of words eliminated the long-term repetition effect for them. The short-term effect was, if anything, magnified, but it decayed rapidly. It is highly likely that when one item immediately follows another, memory for the decision that it induces would be nearly perfect regardless of how that item was processed initially. To illustrate this, imagine a subject being asked twice to multiply 12 \( \times \) 32. There is no doubt that if the second presentation immediately follows the first the subject will recognize the items and remember the product, leading to a much faster response. At longer delays, he or she may fail to recognize the items; but even if the subject recognizes them, he or she may need to repeat the calculation, so that the difference between the first and the second response time will be smaller than at short delays.

Another finding of interest concerns the word superiority effect. Although subjects based their judgments on superficial structural features of the word, responses were faster to words than to nonwords at all lags, which suggests that the lexicon was accessed automatically. Automatic access of the lexicon or its associated logogen system was not sufficient to mediate long-term repetition effects. The presence of a word superiority effect at all lags, including those at which a repetition effect was absent, is additional evidence against all models that assume that repetition effects simply depend on the automatic reactivation of a logogen (e.g., Bruce & Valentine, 1985; Clarke & Morton, 1983; Morton, 1979). In addition, this finding supports Bentin and Katz’s (1984) hypothesis that responses to words are influenced primarily by the level of processing at which attention is directed, although additional lexical information may be accessed automatically (Smith, Theodore, & Franklin, 1983).

If repetition effects depend on having a sufficiently strong memory trace for a particular target, then it should be possible to obtain such effects even for nonverbal stimuli, provided that they are represented in memory prior to the first exposure and that they are remembered well. Experiment 3 tested this hypothesis in a recognition memory paradigm for unfamiliar faces.

**Experiment 3**

Subjects made speeded recognition judgments to faces that they had initially inspected one time or five times. Our choice of task and stimuli was determined by the following considerations. Typically, recognition for repeated stimuli is tested by having subjects respond negatively to the initial presentation of the item and positively to the subsequent repetitions. Because it may be critical that both the stimuli and the responses be repeated, we chose a task in which the response to the first and the second presentation of target items during the test session were identical. We selected unfamiliar faces to minimize the possibility of an interaction with stored semantic or lexical information as might have occurred had we used either familiar faces or even nonwords (Glushko, 1979).

The recognition test consisted of the same face and nonface stimuli as in Experiment 1, arranged so that the faces the subjects had inspected were repeated at lags of 0, 4, or 15 items. According to our hypothesis, the latencies for correct responses should be shorter on the second presentation than on the first because repeated reference is made to a memory trace of the target. Although memory in this case is tested explicitly by recognition rather than implicitly by lexical decision, repetition effects should nevertheless be found even for previously unfamiliar items. The magnitude and longevity of the effect, however, will be influenced by the strength of
the memory trace for the target. The repetition effect is expected to be stronger and longer lasting when faces are inspected five times than when they are inspected only once during the study session.

Method

Subjects. The subjects were 24 undergraduates from the Hebrew University in Jerusalem and were paid for participation in this study. They were all native speakers of Hebrew with normal or corrected-to-normal vision. None of the subjects in this study had participated in any of the previous experiments.

Task and stimuli. Subjects were presented with a set of unfamiliar faces (targets) and instructed to memorize them. Then, a series of faces and nonfaces were presented one at a time, and the subjects were instructed to press as fast as possible a “yes” button when they recognized a target, and a “no” button otherwise.

The stimuli were the faces and nonfaces used in Experiment 1. There were 56 faces and 56 nonfaces. In each group, 24 stimuli were presented twice, and all others were presented only once. There was a total of 80 face trials and 80 nonface trials. Among the repeated stimuli, eight pairs were presented consecutively (Lag 0), eight were repeated after 4 trials (Lag 4), and eight were repeated after 15 trials (Lag 15). All nonfaces in this experiment were fillers. The target stimuli were 18 out of the 24 repeated faces (6 at each lag). The other 6 repeated faces and the 32 unrepeated faces were also fillers that had not been studied prior to the test. The two repeated fillers at each lag were included to ensure that a repeated face did not automatically elicit a “yes” response. Thus, subjects had to base their decision with reference to their memory of the items that they had studied.

Design and procedure. Each subject was tested in two learning conditions. In the one-trial learning condition, each face was presented only once during the study session. In the five-trial learning condition, subjects were exposed to each target five times in a row. The one-trial learning condition was always tested first. Therefore, before the second testing session, subjects had already seen each target eight times: once during the first study session, twice during the first test session, and five times during the second study session. The RTs to targets were analyzed by a within-subjects, three-way ANOVA. The independent variables were learning condition (one or five), lag (0, 4, or 15) and repetition (first presentation or second presentation). The same design was used to analyze the number of errors in each condition.

The testing conditions of Experiment 1 were repeated in this experiment, with the following exceptions. There were no practice trials after the instructions. Nine targets were exposed for 1000 ms, one at a time, and subjects were instructed to remember them for later recognition. A first block of 80 test stimuli followed, which included all of the nine studied faces. At the end of the first block, another nine target faces were studied, and the second block of 80 test stimuli was run. Next, the first set of nine targets were presented again, and repeated five times, followed by the first block of test stimuli. Finally, the procedure was repeated with the second set of nine targets and the second block of test stimuli. The interblock interval was about 2 min.

Results

The effect of repetition was assessed at each lag by comparing the RTs to targets that were correctly recognized at both the first and the second presentations. Repetition significantly facilitated recognition following both the one-trial and five-trial learning sessions, but the pattern of the repetition effect in both learning conditions was in sharp contrast to the effect of repetition found in Experiment 1 (see Table 5). Following one exposure to the memory set, stimulus repetition facilitated responses at Lag 0 and at Lag 4, but not at Lag 15. Following multiple exposures to targets, the effect of repetition was enhanced considerably at all lags, including Lag 15 (Figure 3).

The ANOVA supported these observations. The main effect of repetition was significant, $F(1, 23) = 39.66, M_{SE} = 41,762, p < .001$, as was the main effect of lag, $F(2, 46) = 10.23, M_{SE} = 24,291, p < .001$. More informative, however, were the significant interactions between the learning condition and repetition, $F(1, 23) = 20.78, M_{SE} = 13,562, p < .001$, and between lag and repetition, $F(2, 46) = 3.88, M_{SE} = 19,275, p < .05$. These interactions and comparison of single cells

<table>
<thead>
<tr>
<th>Learning condition</th>
<th>Lag 0</th>
<th>Lag 4</th>
<th>Lag 15</th>
</tr>
</thead>
<tbody>
<tr>
<td>One trial</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$M$</td>
<td>1,007</td>
<td>1,006</td>
<td>986</td>
</tr>
<tr>
<td>$SEM$</td>
<td>56</td>
<td>46</td>
<td>54</td>
</tr>
<tr>
<td>Five trials</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$M$</td>
<td>985</td>
<td>1,056</td>
<td>1,072</td>
</tr>
<tr>
<td>$SEM$</td>
<td>53</td>
<td>46</td>
<td>74</td>
</tr>
</tbody>
</table>

Table 5 Reaction Times (in Milliseconds) to Faces in the Face Recognition Task

![Figure 3](image-url)
was verified by a within-subjects ANOVA, which revealed a significant effect of learning condition, \(F(1, 23) = 5.96, MS_e = 3.63, p < .05\), and a significant effect of repetition, \(F(1, 23) = 19.03, MS_e = 0.59, p < .001\). However, the interaction between the learning condition and repetition was not significant, \(F(1, 23) = 0.11\), indicating that the repetition effect as measured by accuracy was not as sensitive as that measured by reaction time.

**Discussion**

As predicted, significant repetition effects at lags greater than zero were obtained in a recognition test for previously unfamiliar faces. The effect became larger and decayed more slowly as the number of exposures to the targets increased. After a single pretest inspection of the target, the repetition effect was absent only at Lag 15; however, after five exposures (or more) to the target, the repetition effect for unfamiliar faces in a recognition test was at least as large and long-lived as the repetition effect for familiar words in a lexical decision task. Recognition accuracy also improved with the number of exposures, making the results consistent with our hypothesis that a strong memory trace at first presentation of the target is necessary for obtaining robust repetition effects.

It is noteworthy that the repetition effects obtained in our recognition task were as large as and as durable as some of those reported in studies that used a lexical decision task. Typically, the decay rate on recognition tests is much steeper (Moscovitch, 1985; Ratcliff et al., 1985; Scarborough et al., 1977). In most recognition tests, however, the target is presented only twice. The first time it is presented, it is novel and elicits a negative recognition response; the second time the target is “old” and requires a positive response. The uncertainty caused by emitting opposite responses to the same item may oppose the effect of repetition and lead to the decay in performance observed in these studies. Making responses to the target consistent as we did in our study produces a pattern of results in recognition that is similar to that on lexical decision tasks.

One might be tempted to argue that multiple exposures to the unfamiliar targets in our study effectively created a new abstract representation of the target in memory. What ostensibly was a recognition task had, in fact, become a face-against-a-face equivalent of a lexical decision task, as in Bruce and Valentine’s (1985) study on repetition effects for famous faces. Although our particular study may be vulnerable to this argument, identical results are reported by Hockley in a continuous recognition task for words when the target was exposed only once prior to measuring repetition effects (Hockley, 1982; Ratcliff & Hockley, 1980). Our findings and those of Hockley suggest that decision processes following access to a memory trace may be as critical to determining the robustness of the repetition effect as processes involved with the access itself (cf. Forster, 1985; Forster and Davis, 1984). The more general theoretical implications of these findings for theories of implicit and explicit memory will be elaborated in the General Discussion.

The results of the current experiment could be interpreted as indicating that the mere presence of a strong memory trace of the target at the first presentation is sufficient to produce long lasting repetition effects. Experiment 2, however, indicated that the manner in which the target is processed is equally important. Experiment 4 was conducted to show that equivalent considerations apply for newly acquired traces of nonverbal items.

**Experiment 4**

As in Experiment 3, subjects inspected faces one or five times before testing, to ensure the establishment of sufficiently strong memory traces. Instead of testing for recognition, however, subjects were required to make structural face/nonface judgments. The faces they had inspected appeared twice each in the test at lags of 0, 4, or 15 times between the two presentations. If repetition effects depend only on the strength of the memory trace, then we would expect to find similar effects of repetition in this experiment as in the previous one. If, however, repetition effects depend not only on the strength of the internal representation of the target but also on having the subject direct attention to it rather than only to superficial aspects of the stimulus, then long lasting repetition effects should be absent. Indeed, the results should be similar to those of Experiment 1 in which no preexposure to faces occurred, that is, repetition effects at Lag 0, but not at Lag 4 or 15.

**Method**

Subjects. The subjects were 24 undergraduates from the Hebrew University in Jerusalem who were paid for participation in this study. They were all native speakers of Hebrew with normal or corrected-to-normal vision. None participated in the previous experiments.

Task, stimuli, and design. The task was the face/nonface discrimination used in Experiment 1. Subjects were presented with the same faces and nonfaces as in Experiment 3, and in identical order. There were two learning conditions (one- and five-trial learning), three lags (0, 4, and 15), and two levels of order of presentation (first and second). At each lag there were six pairs of identical target faces (the same as in Experiment 3), two pairs of identical filler faces, and eight
pairs of identical nonfaces. In addition there were 32 filler faces and 32 filler nonfaces that were seen only once. The RTs to targets were analyzed by ANOVA that used the same within-subject design as in Experiment 3.

Procedure. Subjects were first instructed to memorize the target faces and were led to believe that they would be tested for recognition at a later time. Following this they had 24 practice trials in the face/nonface discrimination task (50% faces). After the practice, they received the identical stimuli and learning trials as in Experiment 3, except that the decision required of the subjects was face/nonface discrimination rather than recognition.

Results

As in the previous experiments, the mean RT for each subject in each condition was calculated only for target pairs that were correctly categorized as faces or as nonfaces at both the first and the second presentation (see Table 7). Repetition effects for prestudied faces were found in this experiment only at Lag 0. Moreover, the same pattern of repetition was found with one and with five preexposures of the repeated target faces (Figure 4).

These observations were supported by the ANOVA with Tukey-A post hoc procedure. The overall difference between the two learning conditions was not significant, $F(1, 23) = 0.52, MS_e = 34,954$. The main effects of lag and of repetition were both significant, $F(2, 46) = 7.08, MS_e = 6,160, p < .001$, and $F(1, 23) = 11.17, MS_e = 2,305, p < .001$, respectively. The pattern of the repetition effect, however, is revealed by the significant repetition by lag interaction, $F(2, 46) = 10.14, MS_e = 8,210, p < .001$, indicating a large and significant effect at Lag 0 (Tukey-A) but not at Lags 4 and 15. The three-way interaction of lag, repetition, and learning condition was not significant, $F(2, 46) = 1.41, MS_e = 5,809$.

The RTs to first presentation of the preexposed targets were averaged for each subject in each learning condition across the lags yielding a mean based on up to 24 responses. These data were compared with the subject averaged response to the filler faces (those faces that were not preexposed but that nevertheless elicited "yes" responses). Faster RTs were found for targets than for fillers, both in the one-trial learning condition (680 ms and 635 ms for fillers and targets, respectively) and in the five-trial learning condition (681 ms and 651 ms for fillers and targets, respectively). A within-subjects ANOVA revealed that the main effect of stimulus was significant, $F(1, 23) = 21.33, MS_e = 1,582, p < .001$. The main effect of learning condition and the interaction were not significant, $F(1, 23) < 0$ for both comparisons.

The mean RTs to nonfaces in this experiment are presented in Table 8. An ANOVA revealed a significant main effect of lag, $F(2, 46) = 4.73, MS_e = 4,624, p < .01$, but the marginally significant lag by repetition interaction, $F(2, 46) = 3.30, MS_e = 6,734, p < .05$, suggested that the lag effect was influenced by the fluctuation of the repetition effect at the different lags, with the largest effect appearing at Lag 0. The main effect of repetition and learning condition, and the other interactions were not significant.

The percentage of errors was relatively small, and similar in the various conditions (Table 9). The number of errors was too small for a meaningful statistical analysis.

<table>
<thead>
<tr>
<th>Order of presentation</th>
<th>Lag 0</th>
<th>Lag 4</th>
<th>Lag 15</th>
</tr>
</thead>
<tbody>
<tr>
<td>Learning condition</td>
<td>First</td>
<td>Second</td>
<td>First</td>
</tr>
<tr>
<td>One trial</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$M$</td>
<td>658</td>
<td>584</td>
<td>634</td>
</tr>
<tr>
<td>$SEM$</td>
<td>35</td>
<td>22</td>
<td>36</td>
</tr>
<tr>
<td>Five trials</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$M$</td>
<td>644</td>
<td>562</td>
<td>665</td>
</tr>
<tr>
<td>$SEM$</td>
<td>46</td>
<td>29</td>
<td>40</td>
</tr>
</tbody>
</table>

Table 7

Reactions Times (in Milliseconds) to Faces in the Face/Nonface Discrimination Task

<table>
<thead>
<tr>
<th>Order of presentation</th>
<th>Lag 0</th>
<th>Lag 4</th>
<th>Lag 15</th>
</tr>
</thead>
<tbody>
<tr>
<td>Learning condition</td>
<td>First</td>
<td>Second</td>
<td>First</td>
</tr>
<tr>
<td>One trial</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$M$</td>
<td>707</td>
<td>686</td>
<td>731</td>
</tr>
<tr>
<td>$SEM$</td>
<td>28</td>
<td>34</td>
<td>40</td>
</tr>
<tr>
<td>Five trials</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$M$</td>
<td>729</td>
<td>688</td>
<td>741</td>
</tr>
<tr>
<td>$SEM$</td>
<td>39</td>
<td>37</td>
<td>48</td>
</tr>
</tbody>
</table>

Table 8

Reactions Times (in Milliseconds) to Nonfaces in the Face/Nonface Discrimination Task

Figure 4. The difference between reaction times to the first and second presentations, at Lags 0, 4, and 15, for discrimination of faces from nonfaces in the one-trial (solid line) and five-trial (dashed line) learning conditions.
Table 9
Percentages of Error in the Face/Nonface Discrimination Task

<table>
<thead>
<tr>
<th>Learning condition</th>
<th>Order of presentation</th>
<th>Face</th>
<th>Nonface</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Lag 0</td>
<td>Lag 4</td>
<td>Lag 15</td>
</tr>
<tr>
<td>One trial</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M</td>
<td>5.5</td>
<td>4.1</td>
<td>6.1</td>
</tr>
<tr>
<td>SEM</td>
<td>1.9</td>
<td>1.7</td>
<td>2.2</td>
</tr>
<tr>
<td>Five trials</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M</td>
<td>5.5</td>
<td>4.1</td>
<td>6.2</td>
</tr>
<tr>
<td>SEM</td>
<td>2.1</td>
<td>1.9</td>
<td>2.2</td>
</tr>
</tbody>
</table>

The different effects of repetition on unfamiliar faces in recognition and structural discrimination tasks was formally examined using the same procedure as was used for words and nonwords. The difference between the RTs to first and second presentations of each target was analyzed by a mixed-model three-way ANOVA. The between-subjects variable was learning condition (one trial or five trials), and the within-subject variables were task (recognition or face/nonface), and lag (0, 4, or 15). The results show that all three main effects were significant. The overall repetition effect in the face/nonface discrimination task (152 ms) was significantly bigger than the overall repetition effect in the face/nonface discrimination task (19 ms), F(1, 46) = 28.8, MSe = 44,068, p < .001, and significantly larger in the five-trial (115 ms) than in the one-trial learning conditions (56 ms), F(1, 46) = 14.38, MSe = 18,384, p < .001. Across tasks and learning conditions, the repetition effect on faces was bigger at Lag 0 than at Lag 4, and at Lag 4 than at Lag 15, F(2, 92) = 11.31, MSe = 27,486, p < .01 (individual differences were analyzed post hoc by a Tukey-A test). The learning condition and task factors interacted significantly, F(1, 46) = 16.31, MSe = 18,384, p < .001, reflecting that the repetition effect was bigger in the five-trial than in the one-trial learning conditions in the recognition task (214 ms vs. 89 ms) but not in the face/nonface discrimination task (17 ms vs. 21 ms). No other interactions were significant.

Discussion

The results of Experiment 4 indicated no evidence for a repetition effect that lasted beyond Lag 0 in a face–nonface discrimination task despite the recently established memory traces for unfamiliar target faces. For faces as for words, superficial, structural decisions could not support a repetition effect in RT. These results confirm that directing attention to an internal representation of the target is necessary for long lasting repetition effects to occur.

General Discussion

At Lag 0, significant repetition effects were found for all verbal and facial stimuli whether or not they were familiar and regardless of the perceptual lexical or mnemonic decision that was required of the subject. In contrast, repetition effects at longer lags varied greatly depending on the type of stimulus, its preexperimental history, and the processing operations carried out by the subjects. Because items were not counterbalanced across lag groups, there is a possibility that an unexpected items effect was confounded with the effects of lag. We proposed to discard this possibility because verbal items were carefully matched across lag groups and facial items were randomly assigned. Moreover, in all experiments, the responses to first presentation of targets varied very little and unsystematically among lags.

The most parsimonious interpretation of repetition effects at both long and short lags is that they result from the "modification [or acquisition] of memory representations by recent experience" (Jacoby & Hayman, 1987, p. 462) and from the processes involved in forming or gaining access to those representations. At Lag 0, perceptual operations leading to recognition of the repeated item may be faster and recognition itself is most likely unfailing and immediate. As a result, when the task and stimuli are identical, the same response is elicited from the subject on the second presentation as on the first, without the subject having to recapitulate the operations that lead to that decision initially. The magnitude of the repetition effect may vary depending on such factors as similarity among the different items, which may make recognition of a particular item easy or difficult. Perhaps for that reason, the smallest repetition effects at Lag 0 across all stimulus types and experiments were found for facial stimuli in Experiments 1 and 4. These particular stimuli were chosen to be nontargets and uniform. Once the subject became familiar with the faces and the task required that attention be paid to each particular face, as occurred in Experiment 3, the repetition effect became as large for faces as for verbal stimuli.

At longer lags both the preexperimental history of the repeated items and the processes involved in encoding them were shown to influence the repetition effects. Items with a preexperimental representation, such as a lexical entry, are more likely to produce a repetition effect than are items that lack such a representation. Traditionally, this was taken as evidence to support the view that repetition effects depend on the reactivation of abstract representations such as logogens or pictogens (Clarke & Morton, 1983; Bruce & Valentine, 1985). Such a view helped explain why an unfamiliar face or a nonword did not elicit reliable repetition effects at long lags. The preexperimental history of the item, however, may be important for another reason. Within the mnemonic framework that we have adopted, having a preexistent representation in memory is important not because it is available to be reactivated repeatedly, but rather because its existence allows for deeper and more elaborate encoding of the item at its first presentation. A familiar and meaningful item leaves a stronger and more accessible trace in memory than a totally unfamiliar one.
By this account it should make little difference, given the lags used in our study, whether the familiarity with the items was lifelong as for words in Experiment 1 or acquired during the course of the experiment as for faces in Experiment 3. Nor should it matter whether repetition is measured in a lexical decision task as in Experiment 1, or in an appropriate recognition task as in Experiment 3. However, the processes involved in encoding the stimuli and in gaining access to their memory trace, either implicitly or explicitly, are important. Thus, having the subject attend to shallow, structural features of the stimulus rather than to an internal representation of the particular item completely eliminated the repetition effects at lags greater than 0 for both words and newly learned faces. The significant word superiority effect that was found at all lags in Experiment 2 suggests that an internal but generic representation of a word was automatically activated. Contrary to logogen-based accounts, however, such activation was not sufficient to support a long lasting repetition effect.

A number of other observations are consistent with the view that explicit or implicit reference to a particular memory trace is necessary for producing repetition effects. Oliphant (1983) and Forster and Davis (1984) found that presentation of a target in one context (e.g., embedded in the written instructions to the experiment) was not sufficient to facilitate its identification when it was repeated in another context (e.g., presented in isolation when testing for repetition effects). Even if, during the first presentation, the stimulus is actively and deeply processed in the context of a recognition task, long lasting repetition effects are absent if the second presentation is part of a lexical decision test (Ratcliff et al., 1983). Those findings indicate that under some circumstances the relevant memory trace may include the stimulus and its context rather than the stimulus alone (Jacoby, 1983). If so, repetition effects will be attenuated insofar as the target stimulus on the second presentation is perceived to belong to a different class of events or contexts than on the first.

By placing repetition effects in the framework of traditional memory research, we assert that repetition is a technique alongside many others that can be used to investigate memory. As such, it has elements in common with other techniques and aspects that may be peculiar to itself, much as recognition and recall resemble one another in some ways and differ in others. A task-specific, component-process approach to memory is compatible with these observations (Moscovitch, 1984; Moscovitch et al., 1986). This approach, which has much in common with that of transfer-appropriate processing (Morris, Bransford, & Franks, 1977; Roediger & Blaxton, 1987) is based on the assumption that each memory test consists of a variety of component processes. The extent to which performance on different memory tests is dissociable one from the other is determined by the overlap of critical components among the various tests.

The component-process approach is at variance with the view that repetition tests (or repetition priming, as it is often called in recognition of its theoretical roots in the logogen model) are distinctly different from other memory tests (Tulving, 1985). Accordingly, repetition tests are believed to be mediated by a memory system that is fundamentally different from the one that mediates recognition and recall (Cohen, 1984; Mishkin & Appenzeller, 1987; Shimamura, 1986; Squire, 1986; Tulving, 1983, 1985). Thus, the typical finding that the decay rate on recognition tests is steeper than the decay of the repetition effect on lexical decision tasks is taken as one source of evidence that memory as tested explicitly by recognition is dissociable from memory tested implicitly by repetition priming in a lexical decision task (Graf & Schacter, 1985; Moscovitch, 1982; Shimamura, 1986; see also Tulving, 1985; Tulving, Schacter, & Stark, 1982). Our finding and that of Hockley (1982) of equivalent decay rates for repetition effects in lexical decision and recognition tests suggest that a less radical interpretation can account for the differences between implicit and explicit tests of memory.

The task-specific component-process approach recognizes that repetition effects in one test may be influenced by different factors than repetition effects in another test. For example, the level to which an item is processed has a significant effect on long lasting repetition effects as measured in reaction time tests (see also Logan, 1985) but not as measured by perceptual identification. It is conceivable that in the latter case the memory trace of an item encoded in terms of its superficial structural features is sufficient to facilitate performance on a task that by its nature involves the analysis of visual features. Apprehension of the structural properties of the stimulus is easy in reaction time tests, and facilitation may be dependent on a more deeply encoded trace. Similarly, some of the factors that governed repetition effects in our study might not be applicable under different testing conditions. For example, the preexperimental history of the target may have less significance if unfamiliar targets are made extremely salient and memorable.²

One cannot discuss dissociations between performance on repetition tests and that on other tests of memory without mentioning recent findings in research on amnesic patients (for reviews, see Cohen, 1984; Corkin, 1984; Milner, 1966; Moscovitch, 1984; Schacter, 1985; Squire, 1986; Tulving, 1985). Although they are more dramatic than in normal people, the dissociations observed in amnesic patients can nonetheless be explained in the same way according to the component-process approach. As Moscovitch has suggested elsewhere (Moscovitch et al., 1986; Schacter, McAndrews, & Moscovitch, in press), amnesia may be best described as resulting from damage to a component that is necessary for making recently acquired memories available to consciousness (see also Warrington & Weiskrantz, 1982). Performance on tests of memory that do not require explicit conscious recollection of a specific event should be normal. By linking the amnesic patient's deficit to a particular component or to a set of components rather than to an entire system, the possibility is left open that a variety of different amnias or memory disorders can exist. Each of those disorders will be associated with damage to a different component but in only one memory system. Such different memory disorders will become evident as patients are administered a variety of different memory tests designed to tap different component processes in memory. Indeed, the recent evidence of dissociation in performance on different types of repetition tests in

² We thank Larry Jacoby for this suggestion.
normal people (Witherspoon & Moscovitch, 1987), and among patients with memory disorders of different etiology (Butters, 1984; Martone, Butters, Payne, Becker, & Sax, 1984; Shimamura, Salmon, Squire, & Butters, 1987; Weingartner, 1985), suggests that a component-process approach, if not correct, is at least as good as its competitors.

References


