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Orthography and Phonology in Lexical Decision: Evidence From Repetition Effects at Different Lags

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Full- and partial- (orthographic or phonemic) repetition effects for Hebrew voweled and unvoweled words and nonwords were examined at Lags 0 and 15 between the first and the second presentations. For voweled words, phonemic and orthographic partial-repetition effects were equivalent at Lag 0, each about half the size of the full-repetition effect. At Lag 15, the full-repetition effect was reduced to the size of phonemic repetition, which was as big as it was at Lag 0. In contrast, the orthographic repetition effect disappeared. For unvoweled words, the phonemic repetition effect was significant only at Lag 0, whereas the full-repetition effect was significant at both lags. Lexical decisions for both voweled and unvoweled nonwords were facilitated only by full repetition at Lag 0. It was concluded that addition of vowel marks attracted the subjects' attention and, therefore, lexical decisions for voweled stimuli were mediated by phonemic analysis.

Recognition of words is improved by repetition. This effect was demonstrated for lexical decision (Forbach, Stanners, & Hochhaus, 1974; Ratcliff, Hockley, & McKoon, 1985; Scarborough, Cortese, & Scarborough, 1977), identification of perceptually degraded stimuli (Carroll & Kirsner, 1982; Jacoby, 1983; Jacoby & Dallas, 1981; Murrell & Morton, 1974), and many other tasks. Because the facilitation observed with repetition probably depends on residual influences of the first presentation of the stimulus, the repetition paradigm has been exploited primarily for studying memory mechanisms and memory organization (Jacoby & Dallas, 1981; Kolers, 1976; Scarborough et al., 1977; Tulving, 1985). The nature of the trace left by the stimulus at its first presentation probably depends (among other factors) on the manner in which it has been encoded for storage and on the stimulus attributes on which attention was focused during its perception. Therefore, the word-repetition effect may be useful also for the investigation of lexical access and word-recognition processes.

Many studies have shown that recognition of printed words (as reflected by lexical decisions) involves parallel processing of two types of cues: orthographic and phonemic. Most of the time, lexical decisions involve some combination of two perceptual processes: one based on the recognition of the orthographic structure of the stimulus and the second based on the phonemic structure that is deciphered from the orthography (see McCusker, Hillinger, & Bias, 1981, for a review). Repeated presentation of a word obviously implies that, in addition to its meaning being repeated, the orthographic and phonemic informational aspects are also repeated. Therefore, each of these three word attributes might contribute to the repetition effect. Because in most languages it is difficult to manipulate independently the orthographic, phonemic, and semantic information conveyed by a word, there have been only a few attempts to disentangle their individual contributions to the repetition effect.

If the phonemic structure of the stimulus is extracted and used during the lexical decision, it should be possible to observe repetition effects between homophones, even if the different words are related to different lexical entries and represented in print by different orthographic patterns (e.g., *sail* and *sale*). Moreover, if this facilitation is due to processes active outside of the lexicon, it should appear for both words and nonwords. The effect of phonemic repetition on visual word recognition has been investigated in several studies, but the results have not been conclusive. Hillinger (1980) used a priming technique and reported that, relative to a neutral condition, lexical decisions for target words were facilitated by phonologically similar, but graphemically different, primes (e.g., *eight* and *mate*). Other studies, however, set some constraints on the phonemic repetition effect. Humphreys, Evett, and Taylor (1982), for example, found facilitation of lexical decision by phonemic repetition only by using real-word homophones. Davelaar, Coltheart, Besner, and Jonasson (1978) constrained this effect even further by showing that it was found only if the high-frequency homophone had been presented before the low-frequency homophone in a pair, and if phonemic processing of words was not discouraged by pseudohomophonic nonwords (e.g., *bloo* for *blue*). In a more

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recent study, however, the same group of authors reported phonemic facilitation effects when words were primed by pseudohomophones (Besner, Dennis, & Davelaar, 1985). Attempts to examine orthographic repetition effects on lexical decisions for homographs that were not homophones were similarly few, and they usually used pairs of words that were not entirely homographs (e.g., *couch* and *touch*; see Meyer, Schvaneveldt, & Ruddy, 1974).

Hebrew orthography presents an excellent opportunity to generalize some of the previous results across languages and to disentangle better the effects of phonemic and orthographic repetition in the absence of morphological or semantic relationship between the targets and the primes. Hebrew has a special way of conveying phonemic information in print. Consonants are represented by letters, but vowels are represented by small diacritical marks located under, above, or within the consonants. The vowel marks, however, are omitted in most reading material (except poetry and prayer books). Moreover, different words may share an identical consonantal structure but have different pronunciations (because their [absent] vowels are different). Therefore, the exact phonemic structure of unvoweled words cannot be unequivocally deciphered from print. For example the words סֵפֶר (means *book* and is read [sɛphɛr]), סַפָּר (means *barber* and is read [sɑpɑr]), and סְפָר (means *frontier* and is read [sphɑr]) are represented in print identically, without the diacritical marks. Consequently, it has been suggested that lexical decisions for isolated unvoweled Hebrew letter strings are based mostly on the orthographic structure of the stimulus (Bentin, Bargai, & Katz, 1984; Bentin & Frost, 1987; Koriat, 1984), and naming is mediated by the lexicon (Frost, Katz, & Bentin, 1987).

In a recent study, Bentin and Frost (1987) reported that lexical decisions for unvoweled strings of consonants are faster than for any of the voweled alternative words that could have been represented by those strings. On the other hand, if one specific phonological alternative had to be chosen, as in naming, the response to the unvoweled consonant strings was as fast as to the voweled high-frequency alternatives. Furthermore, lexical decisions for the unvoweled consonant strings were faster than naming the same strings. This pattern of results suggested that lexical decisions for unvoweled strings of Hebrew consonants may be reached before a specific phonological alternative represented by that string of consonants is accessed. If this hypothesis is true, repetition of the orthographic consonantal structure might facilitate lexical decision performance even if the repetition involved two morphologically, semantically, and phonemically different words as determined by the (present) vowel marks (like [sɛphɛr] and [s p r] in the previous example).

The effect of phonemic repetition without orthographic identity on lexical decision was examined in Hebrew by Bentin et al. (1984). In that study the authors used several pairs of allophonic letters (different letters that represent in print exactly the same phoneme) and vowel marks to construct pseudohomophones (nonwords that sounded like words but looked different). They found that these stimuli had a small facilitatory effect on positive lexical decisions for subsequently presented phonemically identical words. The effect of phonemic repetition for pairs of real-word homophones with different orthographic structures and different lexical entries has not yet been examined in Hebrew.

In contrast to semantic priming, with its fast rate of decay (Meyer, Schvaneveldt, & Ruddy, 1975), the repetition effect for words is long lasting. Significant effects of repetition were found after hours, days, or even years (Jacoby, 1983; Kolers, 1976; Scarborough et al., 1977) and for lists in which 40 and even 120 unrelated items separated the initial and the repeated presentation of the stimulus (Feustel, Shiffrin, & Salasoo, 1983; Moscovitch, 1985). In a recent study, Bentin and Moscovitch (1988) examined the time course of repetition effects for words and for unfamiliar faces. They found that deeper and more elaborate processing of the stimulus during its initial presentation increased the duration of the repetition effect (Craik & Tulving, 1975; Smith, Theodore, & Franklin, 1983). The present study was based on the assumption that similar factors should determine the time course of partial repetition effects. It was assumed that the partial repetition effect would be long lasting if the repeated attributes had been used when the stimulus was initially encountered. Therefore, the duration of the repetition effect could indicate the manner in which the repeated information has been processed at its initial presentation.

In the present study I examined the time course of partial (phonemic or orthographic) repetition effects in order to assess the relative role of phonemic and of orthographic information in lexical decision. In Experiments 1 and 2 the repeated stimuli were words, and in Experiments 3 and 4 the repeated stimuli were nonwords.

Experiment 1

In this experiment partial repetition effects on lexical decision for words were examined by using voweled stimuli. Three types of repetition were used; the same target was presented twice (full repetition), preceded by a phonemically different prime that shared the same letters but different vowel marks (orthographic repetition), or preceded by an orthographically different but identically pronounced prime (phonemic repetition; see representative examples in Figure 1). Because this technique required a very careful selection of stimuli, there were not enough examples of targets with two kinds of primes to permit a within-subjects design. Therefore only the full repetition effect could be examined within subjects, whereas the partial repetition effects were examined across subjects as described in the following section.

Method

Subjects. The subjects were 144 undergraduate students from The Hebrew University, who participated in the experiment as part of the requirements of courses in psychology or were paid for participation. They were all native speakers of Hebrew.

Design. Response times (RTs) to the same target words were measured in the three repetition conditions (full, phonemic, and orthographic) with either 0 or 15 intervening items between the prime and the target. A different group of 24 subjects was tested in each condition and with each lag; thus each subject was exposed to only one type of priming manipulation. The response time to the

	REPETITION TYPE			TARGET
	FULL	PHONEMIC	ORTHOGRAPHIC	
Hebrew Print	דָּבָר	דַּוָּר	דֶּבֶר	דָּבָר
Phonetic Transcription	davar	davar	dɛvɛr	davar
English Translation	something	mailman	pestilence	something

Figure 1. Examples of each repetition type condition used in this study.

first presentation of each target in the full repetition condition was used as the baseline.

Stimuli and apparatus. The target stimuli were 16 words, each of which had two meaningful primes, a homograph and a homophone. No prime was both homograph and homophone to the target (see representative examples in Figure 1). In the phonemic and orthographic repetition conditions, there was no morphologic or semantic relationship between the primes and the targets.

In addition to the 16 primes and 16 targets, each list contained 58 filler words and 90 nonwords, summing up to 180 stimuli per list. The same targets, fillers, and nonwords were presented in the three lists in an identical pseudorandom sequence. Thus, the only different items among the lists were the primes that determined the type of repetition examined in that list. In the phonemic repetition list, primes and targets were homophones but not homographs.[1] For example, the Hebrew word *davar* (a postman) primed the target *davar* (something; see Figure 1). In the orthographic repetition list, the primes and the targets shared an identical letter structure but had different vowel marks, which determined different pronunciations. For example, the word *dɛvɛr* (pestilence) primed the target *davar* (something; see Figure 1). Finally, the two types of repetition were combined in the full repetition list. In this list, the primes and the targets were identical, that is, the same word was presented twice.[2] The serial position of the prime–target pairs was randomly determined and they were evenly distributed throughout the list.

The fillers were related neither to targets nor to primes in any way. The nonwords were pronounceable, meaningless permutations of letters that could not be interpreted as words with or without vowel marks. The letters were 1 cm × 1 cm, generated by a PDP 11/34 computer and exposed at the center of a Tectronix 611 cathode-ray tube. All the words and nonwords were presented with vowel marks. Their consonant strings ranged from two to four letters, and there were no significant stimulus length differences between primes, targets, fillers, and nonwords. On average, a stimulus subtended a visual angle of approximately 3.5°.

Procedure. Subjects were tested individually in a dimly lit, quiet room. They sat about 70 cm from the screen, which was elevated to eye level. The instructions were to press a *yes* button-microswitch if the stimulus presented was a word and a *no* button if it was a nonword. The dominant hand was always used for positive responses and the other hand for negative responses. The instructions were followed by 40 practice trials (20 words and 20 nonwords). During practice there were no repetitions. The 180 test stimuli were presented in one session. The exposure time was 2.5 s per stimulus and the interstimulus interval was 0.5 s. Thus, the stimulus onset asynchrony was 3,000 ms. This relatively long exposure time was used to permit free scanning of both letters and diacritical marks and enable the subject to use his or her preferred encoding and response strategy. Their RTs were measured in milliseconds from stimulus onset. A limit of 2,500 ms was set, after which responses were not accepted.

Results

The RTs to correct responses and the percentages of errors were averaged for each stimulus across all subjects who were exposed to it and for each subject across each stimulus group (primes, targets, fillers, and nonwords). The skewness of the RT distributions was reduced by eliminating values that were more than 2 *SD*s above or below the mean of the stimulus or subject. Less than 1.5% of the RTs were such outliers.

The performance data for targets and the repetition effects on RT in each repetition condition relative to baseline are presented in Table 1.

The effects of repetition type and of lag were assessed first by a repeated measures analysis of variance (ANOVA) that compared the RTs to the identical targets in the full, phonemic, and orthographic repetition conditions, at Lag 0 and at Lag 15. The pattern of the partial repetition effects was also assessed separately by comparing the RTs to the targets in the orthographic and phonemic partial repetition conditions with the RTs to the same words in the baseline condition. Statistical significance of differences between any two single cells was tested by the planned t tests. The level of alpha error was set to $p < .05$.

An ANOVA showed that targets were faster at Lag 0 (585 ms) than at Lag 15 (624 ms), $F(1, 15) = 12.77$, $p < .003$, $MS_e = 2{,}936$. There was also a significant main effect of repetition type, $F(2, 30) = 22.14$, $p < .0001$, $MS_e = 1{,}075$; and, most important, a significant interaction between the effects of repetition type and lag, $F(2, 30) = 4.25$, $p < .025$, $MS_e = 685$.

The planned t test revealed the following pattern of differences: The RTs to targets in the full repetition and in the orthographic repetition conditions were faster at Lag 0 than at Lag 15, $t(15) = 5.94$, $p < .0001$, and $t(15) = 3.41$, $p < .004$, respectively, whereas in the phonemic repetition condition, targets were responded to about equally quickly at both lags, $t(15) = 1.10$, $p > .28$. At Lag 0 the responses to targets in the phonemic repetition and in the orthographic repetition conditions were similarly fast, $t(15) = 1.42$, $p > .17$; at Lag 15, the responses to targets in the phonemic repetition condition were significantly faster than in the orthographic repetition condition, $t(15) = 5.90$, $p < .0001$. The separate analysis of the partial repetition effects (relative to the baseline) showed that the repetition main effect was significant, $F(2, 30) = 31.81$, $p < .0001$, $MS_e = 1{,}081$, and the lag effect was not, $F(1, 15) = 2.36$, $p > .14$, $MS_e = 3{,}345$. The interaction between the repetition and the lag effects was significant, $F(2, 30) = 5.02$, $p < .014$, $MS_e = 1{,}172$. This interaction was

[1] Note, however, that the orthographic difference between primes and targets in the phonemic repetition condition was based on only one different letter and occasionally allophonic vowel marks.

[2] Note that different vowel marks were connected to the target and prime in the orthographic repetition condition and hence, strictly speaking, the two stimuli were not entirely homographic. For the same reason, the full repetition contained more than a sum of the orthographic and phonemic repetition effects.

Table 1
Response Times (in Milliseconds) and Percentage of Errors to Voweled Targets

Targets	Lag 0				Lag 15			
	RT	SE_M	% error	RE	RT	SE_M	% error	RE
Baseline	672	12	4.6		663	14	5.2	
Full repetition	551	10	2.3	121	606	13	2.6	57
Phonemic repetition	593	10	5.9	79	611	14	4.4	52
Orthographic repetition	610	12	1.6	62	655	14	2.1	8

Note. RT = response time; % error = percentage of errors; RE = repetition effect.

explained by Tukey-*a* post hoc comparisons that revealed that at Lag 0 both the phonemic and the orthographic repetition conditions were faster than the baseline, whereas at Lag 15 the orthographic repetition condition was no longer significantly faster than the baseline.

The full repetition effects at Lag 0 and at Lag 15 were analyzed separately in a mixed model ANOVA, in which the repetition effect was compared within subjects and the lag effect was compared between subjects. This analysis showed that the targets were faster at the second than at the first presentation, $F(1, 46) = 16.33$, $p < .0003$, $MS_e = 11{,}259$, and that the main effect of lag was not significant, $F(1, 46) = 1.98$, $p > .16$, $MS_e = 8{,}688$. The interaction between the effect of lag and the effect of full repetition was not significant, $F(1, 46) = 1.63$, $p > .20$, $MS_e = 11{,}259$.

The percentage of errors was similarly small at both lags (Table 1). Fewer target words were erroneously classified as nonwords in the full repetition and orthographic repetition conditions than in the unprimed and the phonemic priming conditions. However, the small absolute number of errors and their distribution did not allow any meaningful statistical evaluation. Note that, given the relatively small number of targets per group (16), one or two errors in either direction can change the pattern completely. Therefore, the accuracy data should be treated with caution.

The RTs and percentage of errors to fillers and nonwords are presented in Table 2.

Because the effect of repetition type was assessed by using a different group of subjects in each repetition condition, it was necessary to partial out overall group differences. This was achieved by comparing the RTs to fillers, nonwords, and targets in a mixed model, three-factor ANOVA. The between-subjects factors were repetition group (full, orthographic, and phonemic) and lag (0 and 15); the within-subjects factor was stimulus type (target, filler, and nonword). This analysis showed that the stimulus type effect was significant, $F(2, 276) = 115.78$, $p < .0001$, $MS_e = 6{,}947$; and the lag and the repetition group effects were not, $F(1, 138) = 0.12$, and $F(2, 138) = 1.52$, respectively. The interaction between the stimulus type and the lag effect was significant, $F(2, 276) = 3.43$, $p < .04$, $MS_e = 6{,}946$; most important, the interaction between stimulus type and repetition group was also significant, $F(4, 276) = 5.43$, $p < .0004$, $MS_e = 6{,}946$. The three-factor interaction was not significant, $F(4, 276) = 2.27$, $p > .06$, $MS_e = 6{,}946$. The nature of the interactions was elucidated by an additional similar analysis from which the target words were eliminated. This analysis showed only a significant stimulus type effect, in which the nonwords were slower than the fillers, $F(1, 138) = 123.14$, $p < .0001$, $MS_e = 4{,}357$, but no main effect of repetition group and no interactions. The latter analyses showed that the performance of the three groups of subjects with fillers and nonwords was similar. Therefore the significant effect of the repetition type could not be accounted for by an occasional bias or overall differences among the groups.

Table 2
Response Times (in Milliseconds) and Percentage of Errors to Voweled Fillers and Nonwords

Targets	Lag 0			Lag 15		
	RT	SE_M	% error	RT	SE_M	% error
Full repetition						
Fillers	622	26	3.4	667	26	4.2
Nonwords	715	35	7.1	757	37	9.5
Phonemic repetition						
Fillers	641	18	4.3	647	18	3.8
Nonwords	711	28	7.6	720	28	7.8
Orthographic repetition						
Fillers	663	18	4.6	668	22	4.3
Nonwords	741	27	10.0	780	31	7.3

Note. RT = response time; % error = percentage of errors.

Discussion

The results of Experiment 1 showed that immediate repetition of either orthographic or phonemic information equally speeded lexical decision for words and that the magnitudes of each of those partial repetition effects were about half the full repetition effect. At Lag 15, however, the orthographic repetition effect disappeared, whereas the phonemic repetition effect was as large as at Lag 0. The full repetition effect at Lag 15 was reduced by an amount that was very similar to the orthographic repetition effect at Lag 0. The different durability of the phonemic and orthographic repetition effects may reflect a difference in the way these two attributes of printed words were attended and utilized during word recognition in the lexical decision task. I will elaborate on this proposition in the next few paragraphs.

Without discounting the possibility that access to a preactivated abstract representation in memory might be involved in producing repetition effects, several studies have suggested that repetition effects may also be mediated by memory for a particular event. Thus, they could be explained either by explicit retrieval of the initial episode (the subject actually remembers having seen the same or a similar item and uses this information to facilitate response-related processing) or by the reinstatement on the second presentation of encoding operations and procedures performed on the first presentation, 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 et al., 1985; Scarborough et al., 1977).

At Lag 0 the subject is most likely aware of having seen the same item in the preceding trial. As a result, when the task is identical, the same response is elicited on the second presentation as on the first, without the subject having to recapitulate the operations that led to that decision initially. At longer lags, however, the repetition effect is determined by the strength of the trace left in memory by the repeated stimulus from its first presentation. The nature of this trace probably depends (among other factors) on the manner in which the repeated information was processed, that is, on the attributes on which attention was focused during presentation and on the manner in which those attributes were used for task performance (Bentin & Moscovitch, 1988; Jacoby & Hayman, 1987; Ratcliff et al., 1985).

Seen from this mnemonic perspective, the longer lasting effect of the phonemic than the orthographic repetition may be taken as evidence that more attention resources have been allocated to the phonemic than to the orthographic attributes of words presented for lexical decision and that the memory traces of those words were based on phonological cues.

Because most of the words represented in the lexicon were originally acquired through speech, there is little doubt that lexical representations are phonological. Therefore, several authors have suggested that access to a lexical entry from print necessarily requires that phonemic codes are extracted from the graphemic representation (Besner et al., 1985; Hillinger, 1980; Meyer et al., 1975; Spoehr, 1978). On the other hand, the influence of orthographic aspects on word recognition has led other authors to suggest a "direct" route from print to the lexicon (Frederiksen & Kroll, 1976; Kleiman, 1975; Seidenberg, 1985; Taft, 1982, 1986). The direct route hypothesis implies that, as people become literate, abstract orthographic codes are stored in the lexicon along with the phonemic and phonologic information (Bentin & Frost, 1987). Specifically, it has been reported that in orthographies such as Hebrew, in which the phonology is not easily deciphered from print, lexical access is mediated primarily by orthographic codes (Bentin et al., 1984; Bentin & Frost, 1987; Frost et al., 1987; Koriat, 1984). Therefore, the absence of long-lasting interhomograph facilitation at Lag 15 in the present study is particularly puzzling. One possible explanation of this result is that the addition of vowel marks to the consonants shifted subjects' attention to the phonemic structure, which was explicitly given. This hypothesis was tested in Experiment 2 by using a similar experimental design with words presented in unvoweled form.

Experiment 2

As was mentioned in the discussion of Experiment 1, Hebrew orthography is very shallow in its voweled form (i.e., the phonemic information is presented by the combination of consonants and vowel diacritical marks in a direct and unambiguous manner).[3] Moreover, because in Hebrew printed words are usually unvoweled, lexical representation of the orthography probably does not include the vowel marks. Therefore, it is possible that the addition of the vowel marks encouraged the subjects to extract the phonemic codes from the graphemes and use them for lexical access, while shifting attention away from the orthographic codes.

The above strategy, however, is discouraged by the regular, unvoweled print. Even if a string of consonants is associated with only one word in the lexicon and can be read in only one manner, the phonemic cues presented in print are only partial. Furthermore, the same string of consonants may represent more than one word, each with a different phonemic structure. Therefore, as suggested by Bentin and Frost (1987), it is likely that lexical decisions for unvoweled Hebrew stimuli are based on matching the presented graphemic clusters with some abstract orthographical representations of words in the lexicon.

In the present experiment, I examined short- and long-lasting repetition effects for unvoweled stimuli. Obviously, omission of vowels precluded the orthographic manipulation (see Figure 1). Therefore, in these experiments I compared only full repetition with phonemic repetition effects. If recognition of unvoweled stimuli for lexical decisions is based primarily on the orthographic rather than phonemic structure, the time course of the phonemic repetition effects should differ from that observed in Experiment 1.

Method

Subjects. The subjects were 96 undergraduate students of The Hebrew University, paid for participation. They were all native speakers of Hebrew who had not participated in the previous experiment.

Design. The design of Experiment 2 was similar to that of Experiment 1 with the exception that only two types of repetition (full and phonemic) were used. Forty-eight subjects were tested in the full repetition condition (24 at Lag 0 and the other 24 at Lag 15), and the other 48 subjects were tested in the phonemic repetition condition (24 subjects at each lag).

Stimuli and procedures. The stimulus lists used in the full repetition and phonemic repetition conditions of Experiment 1 were presented in this experiment, except that all stimuli (words and nonwords) were unvoweled. The procedures were identical to those used in Experiment 1.

Results

The RTs to correctly responded targets were averaged and corrected for extreme values by using the same procedures as in Experiment 1. Less than 1.5% of the RTs were outliers.

[3] The term *orthographical depth* refers to the relationship between graphemes and phonemes. In a deep orthography, this relationship is complex (see, e.g., the sound of *ea* in *heal* and *health* or the sound of *a* in *hat* and *father*). In a shallow orthography, this relationship is simple. In the extreme case (as in Serbo-Croatian), the relationship between letters and sounds is simply isomorphic.

At Lag 0, the RTs to target words were longer in the unprimed than in both the full repetition and the phonemic repetition conditions; in contrast, at Lag 15, the RTs to unprimed targets were longer than in the full repetition condition but similar to those in the phonemic repetition condition (Table 3).

The effect of repetition type at each lag was assessed first by comparing the full and the phonemic repetition conditions. An ANOVA showed that responses were faster at Lag 0 (582 ms) than at Lag 15 (604 ms), $F(1, 15) = 6.43$, $p < .025$, $MS_e = 1{,}229$; the RTs in the full repetition condition (567 ms) were faster than in the phonemic repetition condition (620 ms) over lags, $F(1, 15) = 46.74$, $p < .0001$, $MS_e = 983$; and the interaction between the two factors was not significant, $F(1, 15) < 0$. A separate analysis of the full repetition effect showed a significant main effect of repetition, $F(1, 15) = 24.47$, $p < .0003$, $MS_e = 3{,}505$, and a significant interaction between the lag and the repetition effects, $F(1, 15) = 9.26$, $p < .0085$, $MS_e = 2{,}037$. This interaction suggested that the repetition effect was significantly greater at Lag 0 than at Lag 15. However, planned t tests showed that at both lags the effect of full repetition was significant, $t(15) = 2.14$, $p < .05$, and $t(15) = 5.83$, $p < .0001$, for Lag 15 and Lag 0, respectively. The effect of phonemic repetition at each lag was assessed by comparing the RTs to targets in the phonemic repetition condition with the RTs to the first presentation of the targets in the full repetition condition. An ANOVA showed that neither the main effect of repetition nor the main effect of lag was significant, $F(1, 15) = 2.52$, $p > .13$, $MS_e = 2{,}447$, and $F(1, 15) < 0$, respectively, but that the interaction between those two factors was significant, $F(1, 15) = 11.23$, $p < .005$, $MS_e = 967$. Planned t tests revealed that the phonemic repetition effect was significant at Lag 0, $t(15) = 2.74$, $p < .016$, but, in contrast to the full repetition effect, the partial (phonemic) repetition effect was not significant at Lag 15, $t(15) = -0.53$.

As in the previous experiment, only a few errors were made in response to target words (Table 3). More errors were made by the phonemic repetition group than by the full repetition group. The subjects in the full repetition group made more errors in response to the first than to the second repetition of the target. Note, however, that these trends were very unreliable; for example, the relatively higher percentage of errors in the full repetition group was contributed by only 3 subjects who made three errors each, while 18 subjects in this group had no errors at all.

The RTs and percentage of errors to fillers and nonwords in the full and phonemic repetition groups are presented in Table 4.

Table 4
Response Times (in Milliseconds) and Percentage of Errors to Unvoweled Fillers and Nonwords

Targets	Lag 0 RT	Lag 0 SE_M	Lag 0 % error	Lag 15 RT	Lag 15 SE_M	Lag 15 % error
Full repetition						
Fillers	723	26	5.4	657	26	7.0
Nonwords	949	28	16.0	857	37	13.0
Phonemic repetition						
Fillers	707	18	5.6	663	18	5.2
Nonwords	887	35	19.0	782	28	11.9

Note. RT = response time; % error = percentage of errors.

As in Experiment 1, overall group differences were partialed out by comparing the RTs to fillers, nonwords, and targets in a mixed model, three-factor ANOVA. The between-subjects factors were repetition group (full and phonemic) and lag (0 and 15), and the within-subjects factor was stimulus type (target, filler, and nonword). This analysis showed that there were no systematic differences among groups aside from those induced by the experimental manipulations. Between subjects, the main effects of lag and of repetition group and the interaction between those two factors were not significant, $F(1, 92) = 2.52$, $F(1, 92) = 0.15$, and $F(1, 92) = 0.04$, respectively. Within subjects, the stimulus main effect was significant, $F(2, 184) = 133.16$, $p < .0001$, $MS_e = 12{,}854$; and the two-way interactions between stimulus and lag and between stimulus and repetition group were also significant, $F(2, 184) = 4.96$, $p < .01$, $MS_e = 12{,}854$, and $F(2, 184) = 5.08$, $p < .009$, $MS_e = 12{,}854$, respectively. The three-way interaction was not significant, $F(2, 184) = 0.10$. A similar analysis excluding the targets (the only stimulus type that should have been affected by repetition type) showed that the only significant effect was the main effect of stimulus: Nonwords were slower than fillers, $F(1, 92) = 115.43$, $p < .0001$, $MS_e = 13{,}482$.

Discussion

The results of Experiment 2 revealed that at Lag 0 both full and phonemic repetition effectively facilitated lexical decisions for unvoweled words. As with voweled words, the full repetition effect was twice as big as the phonemic repetition effect. Thus, at Lag 0 the repetition effects obtained with voweled words were apparently replicated with unvoweled words. At Lag 15 the effect of full repetition was considerably

Table 3
Reaction Times (in Milliseconds) and Percentage of Errors to Unvoweled Targets

Targets	Lag 0 RT	Lag 0 SE_M	Lag 0 % error	Lag 0 RE	Lag 15 RT	Lag 15 SE_M	Lag 15 % error	Lag 15 RE
Baseline	659	17	2.1		621	15	2.8	
Full repetition	552	9	1.3	107	582	9	2.3	39
Phonemic repetition	613	13	3.5	46	627	12	2.0	−6

Note. RT = response time; % error = percentage of errors; RE = repetition effect.

reduced and the effect of phonemic repetition disappeared completely. Thus, in sharp contrast to voweled words, repetition of phonemic attributes had no long-lasting effects on lexical decisions for unvoweled words.

As was elaborated in the discussion of Experiment 1, it was assumed that the partial repetition effects at Lag 15 are based primarily on subjects' ability to remember the occurrence of identical information at first presentation. Along with this hypothesis, the pattern of repetition effects found in the present experiment suggested that when processing unvoweled words, subjects' attention was not focused on phonemic attributes of the stimuli. In other words, the results of Experiment 2 supported the hypothesis proposed in previous studies of word recognition in Hebrew, which is that lexical decisions for unvoweled words may be based primarily on recognition of the orthographic structure of the stimulus. Accordingly, when unvoweled Hebrew words were presented for lexical decision, attention was directed toward the orthographic aspects of the stimulus. Lexical access was mediated by orthographic codes, and long-lasting orthographic memory traces were formed. Therefore, it is possible that the significant long-lasting full repetition effect observed in the present study reflected, at least in part, the effect of orthographic repetition, which was absent when voweled words were presented.

The similarity of the repetition effects for voweled and unvoweled words at Lag 0 suggests that immediate repetition for both stimulus conditions might have been mediated by similar cognitive mechanisms. One possible account of the immediate repetition effect is that encoding operations are facilitated by repetition. An implication of this account is that the mechanism of immediate repetition is probably prelexical; in addition, the phonemic repetition effect at Lag 0 suggests that, contrary to my basic assumptions, even for unvoweled words phonemic attributes were attended and encoded during word recognition.[4]

A different account of the immediate repetition effects is based on the assumption that the response given to the stimulus at its first presentation is still available in memory. According to this account, the mechanism that mediates the immediate repetition effect is unrelated to lexical access processes. Such an interpretation may account for the phonemic repetition effect with unvoweled words at Lag 0 without assuming that those attributes were used for lexical access. In other words, immediately repeated phonemic attributes were recognized but they were not used for lexical access. In Experiment 3 an attempt was made to address this possibility by examining full phonemic and orthographic repetition effects for nonwords. Lexical, or postlexical, mechanisms should influence only words whereas prelexical mechanism should influence both words and nonwords.

Experiment 3

Words and nonwords are probably processed similarly until lexical entries are identified for words (McClelland & Rumelhart, 1981). Those processes include extraction of relevant orthographic and phonemic information from the string of letters and encoding this information in a form that can be matched with word-distinctive information prestored in the lexicon. Several other processes that originate in the lexicon and act in a top-down manner take place in parallel and influence word recognition. Word-level phonological information is probably used also for processing pseudohomophones. However, because by definition the lexicon contains information only about words, top-down processes that originate in the lexicon should have a more limited effect on lexical decision for regular nonwords. This is not meant to assert that there are no top-to-bottom influences on recognition of nonwords. These influences, however, are more limited and affect primarily the letter-level rather than word-level processing.[5]

Examination of repetition effects for nonwords and comparison of those effects with the effects observed for words might help to distinguish between lexical and nonlexical origins of those effects. The purpose of Experiment 3 was to examine phonemic and orthographic partial repetition effects for voweled and unvoweled nonwords at Lag 0 and Lag 15.

Method

Subjects. The subjects were 80 undergraduate students of The Hebrew University, paid for participation. They were all native speakers of Hebrew who had not participated in the previous experiments. Forty-eight subjects were presented with voweled stimuli (words and nonwords), and the other 32 subjects were presented with unvoweled stimuli.

Task and design. A lexical decision task, identical to the task used in Experiments 1 and 2, was used in the present experiment. The experimental manipulations and designs were similar to those used in the previous experiments, with the following exceptions: (a) Full and partial (phonemic or orthographic) repetition effects were tested for nonwords and (b) manipulation of lags was done within subjects; each subject was presented with two sets of equivalent (but different) prime–target pairs. One set was used for repetition at Lag 0 and a second set at Lag 15. The sets used for each lag were counterbalanced across subjects. The same targets were used with different subjects in each repetition type condition.

Stimuli and procedures. There were three stimulus lists. In each list, there were 32 target nonwords, 32 prime nonwords, 26 filler nonwords, and 90 words. The words were the 58 fillers and 16 targets used in Experiments 1 and 2 and 16 new words. The three lists were identical except for the different primes that determined the repetition type. Obviously, only full and phonemic repetition lists were used for unvoweled stimuli. The procedures in the present experiment were similar to those in Experiments 1 and 2.

Results

The RTs were averaged for each target across subjects and for each subject across the stimuli in each group. Extreme

[4] Apparently one way out of this contradiction is to assume that the immediate phonemic repetition effect reflected, in fact, repetition of the common letters. This explanation is, however, unlikely (at least in its simple form), because it cannot account for the complete disappearance of the repetition effect at Lag 15.

[5] To avoid misunderstandings, note that according to this interpretation any phonological structure that is stored and may be retrieved from a long-term storage becomes a word even if it is not related to a meaning. Such a meaningless word has an entry in the lexicon and is processed identically to meaningful words except that it is not sensitive to semantic manipulations.

RTs (more than 2 *SD* above or below the subject's or target's mean) were excluded. Less than 2.8% of the responses were outliers.

Voweled stimuli. The RTs and percentage of errors to voweled nonword targets in each repetition type category are presented in Table 5.

As in Experiments 1 and 2, the main effect of repetition type was assessed by a stimulus analysis. The RTs to each target in the three repetition conditions was compared by a mixed-model ANOVA. The within-stimulus factor was repetition type (full, phonemic, and orthographic) and the between-stimulus factor was lag (0 and 15). This analysis showed no main effect of lag, $F(1, 30) < 1.0$, a significant effect of repetition type, $F(2, 60) = 30.80$, $p < .0001$, $MS_e = 4{,}555$; and a significant interaction between the lag and the repetition type factors, $F(2, 60) = 12.32$, $p < .0001$, $MS_e = 4{,}555$. Planned comparisons showed that at Lag 0 the RTs to targets in the phonemic repetition condition were significantly longer than in the full repetition condition, $t(15) = 6.59$, $p < .0001$, but shorter than in the orthographic repetition condition, $t(15) = 4.05$, $p < .002$. At Lag 15, however, the RTs to targets in the phonemic repetition condition were not significantly different either from those in the full repetition condition, $t(15) = 0.8$, $p > .43$, or from those in the orthographic repetition condition, $t(15) = 1.12$, $p > .28$. The RTs in the orthographic repetition condition, at Lag 15, were significantly longer than those in the full repetition condition, $t(15) = 2.41$, $p < .03$.

To elucidate better the pattern of repetition effects, the phonemic and orthographic conditions were also compared with the baseline condition. An ANOVA showed no effect of lag, $F(1, 30) < 1.0$; a significant repetition effect, $F(2, 60) = 6.35$, $p < .004$, $MS_e = 4{,}637$; and no interaction, $F(2, 60) = 1.41$, $p > .25$, $MS_e = 4{,}637$. Planned *t* tests revealed that the RTs at first presentation were not different from the phonemic or orthographic repetition effect either at Lag 0 or at Lag 15, $t(15) = 1.21$, $p > .24$, and $t(15) = 1.96$, $p > .06$, for the phonemic and orthographic repetition at Lag 0; and $t(15) = .07$, $p > .94$, and $t(15) = 1.23$, $p > .23$, for the phonemic and orthographic repetition at Lag 15, respectively.

The full repetition effect for voweled nonwords was assessed by a mixed-model ANOVA. The within-subjects factor was the repetition condition (first and second presentations), and the between-subjects factor was lag (0 and 15). This analysis showed no effect of lag, $F(1, 30) = 3.50$, $p > .07$, $MS_e = 7{,}751$; a significant repetition effect, $F(1, 30) = 51.78$, $p < .0001$, $MS_e = 2{,}355$; and a significant interaction, $F(1, 30) = 31.58$, $p < .0001$, $MS_e = 2{,}355$. Planned *t* tests revealed that the full repetition effect was significant at Lag 0, $t(15) = 7.98$, $p < .0001$, but not at Lag 15, $t(15) = 1.32$, $p > .20$.

Table 6
Response Times (in Milliseconds) and Percentage of Errors to Voweled Fillers in the Nonword Repetition Experiment

Targets	Filler nonwords RT	SE_M	% error	Filler words RT	SE_M	% error
Full repetition	703	28	4.0	636	29	2.5
Phonemic repetition	694	29	2.4	647	29	2.0
Orthographic repetition	717	22	2.1	635	15	0.5

Note. RT = response time; % error = percentage of errors.

Fewer errors were made in the full repetition condition than in any of the other conditions at Lag 0, and at Lag 15 there was no difference in the percentage of errors made by each group.

The RTs and errors to filler words and filler nonwords are presented in Table 6. An ANOVA on fillers revealed that within subjects, words were faster than nonwords, $F(1, 45) = 67.41$, $p < .0001$, $MS_e = 1{,}503$, but no overall group differences and no interaction were found.

Unvoweled stimuli. The RTs and percentage of errors to unvoweled nonword targets at the first and second presentations in the full repetition condition and in the phonemic repetition conditions at each lag are presented in Table 7.

The RTs to targets in the full repetition and in the phonemic repetition conditions at Lag 0 and at Lag 15 were compared, as before, in a mixed-model ANOVA with the repetition condition and lag as within- and between-subjects factors, respectively. This analysis showed that the lag effect was not significant, $F(1, 30) = 3.64$, $p < .066$, $MS_e = 16{,}127$, and that both the repetition effect and the interaction were significant, $F(1, 30) = 41.43$, $p < .0001$, $MS_e = 3{,}706$, and $F(1, 30) = 14.79$, $p < .0007$, $MS_e = 14.79$, respectively. Planned *t* tests revealed that the RTs to targets in the full repetition condition were faster than those in the phonemic repetition condition at Lag 0, $t(15) = 9.50$, $p < .0001$, but not at Lag 15, $t(15) = 1.54$, $p > .14$.

Analysis of the full repetition effect (comparison of the RTs at first and second presentations) at Lag 0 and Lag 15 revealed that at Lag 0, RTs were faster than at Lag 15, $F(1, 30) = 4.58$, $p < .041$, $MS_e = 13{,}138$; that the RTs to second presentation were faster than to the first, $F(1, 30) = 49.60$, $p < .0001$, $MS_e = 4{,}455$; and that the full repetition effect was significantly

Table 5
Response Times (in Milliseconds), Standard Error, and Percentage of Errors to Voweled Nonword Targets

Targets	Lag 0 RT	SE_M	% error	RE	Lag 15 RT	SE_M	% error	RE
Baseline	774	19	7.5		747	14	9.1	
Full repetition	619	13	3.75	155	728	19	11.4	19
Phonemic repetition	747	20	5.8	27	749	27	6.2	−2
Orthographic repetition	833	28	8.0	−59	778	30	8.75	−31

Note. RT = response time; % error = percentage of errors; RE = repetition effect.

Table 7
Response Times (in Milliseconds) and Percentage of Errors to Unvoweled Nonword Targets

Targets	Lag 0				Lag 15			
	RT	SE_M	% error	RE	RT	SE_M	% error	RE
Baseline	848	29	5.75		852	24	6.3	
Full repetition	673	16	4.6	175	792	23	5.4	60
Phonemic repetition	829	87	6.1	19	832	35	4.3	20

Note. RT = response time; % error = percentage of errors; RE = repetition effect.

bigger at Lag 0 than at Lag 15, $F(1, 30) = 11.99$, $p < .002$, $MS_e = 4,455$.

The effect of phonemic repetition for unvoweled nonwords was assessed directly by comparing the phonemic repetition to the first presentation in the full repetition condition at Lag 0 and at Lag 15. An ANOVA showed that the two conditions did not differ significantly at Lag 0 or at Lag 15. The main effects and the interaction were not significant, $F(1, 30) < 1.0$; $F(1, 30) = 1.29$; and $F(1, 30) < 1.0$, for the effects of lag, repetition, and interaction, respectively. The percentage of errors was similar in all conditions and at the two lags.

The RTs to unvoweled fillers (words and nonwords) are presented in Table 8.

As for voweled nonwords, ANOVA revealed that there were no overall group differences: Filler words were faster than filler nonwords, $F(1, 30) = 76.79$, $p < .0001$, $MS_e = 1,651$, but no group effects were significant.

Discussion

The results of the present experiment revealed that partial (either phonemic or orthographic) repetition does not facilitate *no* responses to nonwords at either Lag 0 or Lag 15. This result holds both for voweled and for unvoweled stimuli. For voweled nonwords, orthographic repetition tended to inhibit RTs, but compared with baseline, this tendency was not significant. The full repetition effect was significant only at Lag 0 for voweled nonwords and considerably reduced at Lag 15 for unvoweled nonwords. In summary, I conclude that the only reliable repetition effects for nonwords were full repetition effects at Lag 0.

The most important difference between repetition effects for words and nonwords was that for nonwords, partial repetition did not facilitate the response in any of the conditions and lags. Moreover, in contrast to words, at Lag 15 even full repetition was not effective (for voweled nonwords) or was considerably reduced (for unvoweled nonwords). These differences between repetition effects for words and nonwords suggest that the partial repetition effects at both short and long lags, and the long-lasting full repetition effect for words, should be related to their lexical representation. Such an account is elaborated in the General Discussion.

Table 8
Response Times (in Milliseconds) and Percentage of Errors to Unvoweled Fillers in the Nonword Repetition Experiment

Targets	Filler nonwords			Filler words		
	RT	SE_M	% error	RT	SE_M	% error
Full repetition	770	28	3.4	676	26	1.7
Phonemic repetition	750	24	4.3	667	22	1.0

Note. RT = response time; % error = percentage of errors.

General Discussion

The present study examined immediate and delayed partial and full repetition effects on lexical decision using Hebrew word targets and nonword targets, with and without the vowel marks. The partial repetition conditions emphasized either repetition of orthography or repetition of the phonemic structure. Obviously, the effect of orthographic partial repetition could not be examined without the vowel marks. The following pattern of repetition effects emerged: With voweled words, immediate repetition of orthographic attributes or phonemic attributes had similar facilitatory effect on lexical decision. Each of these partial repetition effects was about half the size of the full-word repetition effect. With 15 intervening items, the orthographic repetition effect completely disappeared, whereas the phonemic repetition effect remained intact. The full repetition effect was reduced to the size of the phonemic repetition effect. In contrast to words, partial repetition did not facilitate lexical decision for voweled nonwords, and the full repetition effect was significant only at Lag 0.

Repetition effects for unvoweled words were smaller than for voweled words; the most noticeable difference between repetition effects for voweled and unvoweled words concerned the phonemic repetition. At Lag 0 the phonemic repetition effect for unvoweled words was significant but, in contrast to the effect for voweled words, at Lag 15 it disappeared. The full repetition effect for unvoweled words was smaller than for voweled words at both lags, but its pattern was very similar in the two stimulus conditions. The pattern of the repetition effects for unvoweled nonwords was similar to the pattern observed for voweled nonwords. Repetition of phonemic attributes facilitated lexical decision neither at Lag 0 nor at Lag 15. The full repetition effect was very robust at Lag 0 but drastically reduced at Lag 15.

Repetition effects are influenced by many factors such as task variables and lag and, in the case of partial repetition, by the relatedness between the prime and the target (Feldman & Moskovljevic, 1987; Fowler, Napps, & Feldman, 1985; Ratcliff et al., 1985). It is clear, however, that without some kind of memory for the first presentation, no repetition effects are possible. Therefore, one account for most factors shown to influence the repetition effect is that they either determine the strength of the memory trace left by a stimulus at its first presentation, or they determine the probability that the second presentation will arise the memory of the first, or both. In the discussion to Experiment 1, such a mnemonic framework was suggested to account for repetition effects. This framework was based on previous studies in my laboratory (Bentin & Moscovitch, 1988), as well as on the work of others (cf. Jacoby, 1983; Jacoby & Hayman, 1987; Kolers & Roediger, 1984). In essence, it was suggested that, at least for the long lags, in addition to recurrent access to a preactivated abstract representation, lexical decision for a repeated stimulus can also be facilitated by remembering the previous encounter. When only part of the information is repeated, it is reasonable to assume that the probability to relate the stimulus containing the repeated information to the previous encounter is increased if the repeated information is attended and used for task performance. Therefore, partial repetition effects may indicate whether the repeated information was or was not attended and used for task performances. In this discussion, I will refer primarily to the pattern of long-lasting repetition effects because, as previously suggested, those are less likely to reflect nonlexical repetition factors.

In the case of partial repetition as examined in the present study, the targets and the primes were different words. Thus, repetition effects may not be simply explained by direct reactivation of the same lexical entry. On the other hand, straightforward repetition of encoding operations also cannot account for the long-lasting effects because such effects were not obtained with nonwords. One possible explanation is that during processing of the prime, activation spread to other lexical entries that shared common attributes. In other words, the target was indeed preactivated, and therefore its perception was facilitated. Although possible, there are reasons to reject this explanation. One such good reason is that semantic priming is not effective at long lags. If preactivation by spreading activation would be enough to produce long-lasting effects, semantic priming should have been at least as long lasting as the phonemic repetition observed in Experiment 1.

An alternative explanation is based on the assumption that what the subject actually remembers or does not remember when the target is presented is the word that contained the repeated attributes. If, while the target is being processed, the prime is still available in some sort of episodic or working memory, relevant similarities between the target and the prime may facilitate performance. The mechanism for the facilitation of lexical decisions is not clear. One possibility is that the memorized relevant information facilitates lexical access. Lexical access may be facilitated, for example, if as soon as similarities are detected, a subset of lexical entries that share the common attribute is formed, and attention is directed first to this restricted set rather than being evenly distributed throughout the lexicon (cf. Becker, 1976, 1979, 1980; Paap, Newsome, McDonald, & Schvaneveldt, 1982). Alternatively, partial repetition may increase the familiarity of the target and, therefore, speed up the response by changing postaccess decision strategies (Balota & Chumbley, 1984).

Regardless of the exact mechanism used, if the repetition effects depend on the availability of a memory trace for the first presentation, comparison of long-lasting effects of different types of partial repetition may provide some evidence about the nature of the codes used to encode and store the stimulus in memory.

To be more specific, for voweled words long-lasting phonemic, but not long-lasting orthographic, repetition effects have been observed. This result suggests that either the memory trace installed by the voweled primes contained phonemic but not orthographic information or that orthographic information was not important for lexical decision. For unvoweled words, on the other hand, the long-lasting phonemic repetition effect disappeared, whereas the full repetition effect, although reduced, remained significant. A possible interpretation of this result is that when the vowel marks are provided, lexical access is mediated primarily by phonemic codes, but if the stimuli are unvoweled, orthographic codes are used more extensively. Such an interpretation may be compatible with a parallel coding system model in which phonemic and orthographic codes are generated in parallel and the lexicon is accessed by the first process to accumulate sufficient information (cf. Coltheart, Davelaar, Jonasson, & Besner, 1977). Addition of vowels may facilitate phonemic encoding by specifying an unequivocal phonemic structure and, on the other hand, may inhibit orthographic processing by adding unfamiliar visual information that is relevant to the process of word identification. When unvoweled words are presented, phonemic encoding becomes more difficult because the phonemic information presented in print is not complete. On the other hand, unvoweled words are more familiar to fluent readers of Hebrew and, as previously suggested, lexical decisions can be based on the solely orthographic structure of the stimulus.

Alternative accounts of the long-lasting effects in the phonemic repetition condition for voweled words should also be considered. One such account is that, regardless of how the lexicon was accessed, subjects paid more attention to the vowel marks because they are typically not presented in print. Repetition of the vowel marks, according to this account, should have boosted the familiarity of the stimulus and, therefore, have changed the decision strategy of the subjects (cf. Balota & Chumbley, 1984). In the orthographical repetition condition, there was no, or only very little, repetition of the vowel marks, and therefore no facilitation was induced. This account may also explain the absence of any partial repetition effect for nonwords. Any type of repetition might have increased the familiarity of the nonwords and, therefore, interfered with their rejection. The familiarity interpretation is not clearly contradicted by the present data; however, the pattern of partial repetition effects for nonwords indicated that if increasing familiarity inhibited rejection of nonwords, it had a bigger effect for orthographic than for phonemic repetition (Table 5). Moreover, previous results showed that in a lexical decision task involving Hebrew voweled stimuli, pseudohomophones were easier to reject than pseudohomographs (Bentin et al., 1984). Those results suggested that, for Hebrew nonwords, phonemic similarity to words (induced by allophonic letters and vowel marks) is less salient than orthographic similarity. Therefore, the familiarity account cannot easily explain the long-lasting phonemic repetition effects in the absence of orthographic repetition.

The absence of long-lasting repetition effects for nonwords in the present study is consistent with other studies in which repetition did not facilitate lexical decisions, particularly at long lags (Bentin & Moscovitch, 1988; Forbach et al., 1974; Forster & Davis, 1984; Moscovitch, 1985). This difference between words and nonwords may be task specific. Repetition might have increased the familiarity of the nonwords and, therefore, inhibited negative lexical decisions. This interpretation is supported by studies that reported significant repetition effects on identification of nonwords (Feustel et al., 1983; Jacoby & Witherspoon, 1982; Salasoo, Shiffrin, & Feustel, 1985). In contrast to lexical decision, the only effect that increasing familiarity may have on identification performance is facilitation. An alternative account of the missing partial and long-lasting repetition effects for nonwords is that those effects are related to the existence of permanent memory codes (which exist for words but not for nonwords). Existence of such a code may reinforce the episodic traces of the first presentation, and absence of such codes may result in a faster decay of those traces. Although new codes may be installed, it takes more than one repetition to do so (Salasoo et al., 1985). The present data are not sufficient to decide between those two alternative interpretations.

In conclusion, the results of this study may suggest that lexical access for voweled and unvoweled words is mediated by phonemic and orthographic codes, respectively; the full repetition effect probably reflects a combination of the effect of repeating the orthographic and phonologic attributes.

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