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THE QUARTERLY JOURNAL OF EXPERIMENTAL PSYCHOLOGY, 1994, 47A (2) 407–435

Morphological Analysis of Disrupted Morphemes: Evidence from Hebrew

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In concatenative languages such as English, the morphemes of a word are linked linearly so that words formed from the same base morpheme also resemble each other along orthographic dimensions. In Hebrew, by contrast, the morphemes of a word can be but are not generally concatenated. Instead, a pattern of vowels is infixed between the consonants of the root morpheme. Consequently, the shared portion of morphologically-related words in Hebrew is not always an orthographic unit. In a series of three experiments using the repetition priming task with visually presented Hebrew materials, primes that were formed from the same base morpheme and were morphologically-related to a target facilitated target recognition. Moreover, morphologically-related prime and target pairs that contained a disruption to the shared orthographic pattern showed the same pattern of facilitation as did nondisrupted pairs. That is, there was no effect over successive prime and target presentations, of disrupting the sequence of letters that constitutes the base morpheme or root. In addition, facilitation was similar across derivational, inflectional and identical primes. The conclusion of the present study is that morphological effects in word recognition are distinct from the effects of shared structure.

The internal structure of a word plays a key role in its recognition. Whereas much work on visual word recognition has focused on phonology, more recent efforts have focused on aspects of morphology. One experimental

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The research reported here was conducted at the Hebrew University in Jerusalem and was supported by funds from National Institute of Child Health and Development Grant HD-01994 to Haskins Laboratories and from the Israel Foundation Trustees to Shlomo Bentin.

task that is sensitive to the morphological components of words is repetition priming. Significant facilitation among visually presented morphologically related words in the repetition priming variant of the lexical decision task is well documented (Stanners, Neiser, Hernon, & Hall, 1979). Generally, responses to targets that are formed around the same base morpheme as their (morphologically-related) primes are faster and more accurate than those to targets following unrelated primes. Sometimes the facilitation with morphological relatives as primes is equivalent to the effect of an identical repetition of the target; at other times it is numerically reduced relative to identical repetitions but is still statistically reliable (Fowler, Napps, & Feldman, 1985). Effects of morphological relatedness with visually presented materials in the lexical decision task have been found across a variety of languages including Serbo-Croatian (Feldman & Fowler, 1987), English (Fowler et al., 1985; Feldman, 1992), and Hebrew (Bentin & Feldman, 1990), as well as American Sign Language (Hanson & Feldman, 1989; see also Emmorey, 1989). When more than a few seconds and/or other items separate the second presentation from the first, the pattern of facilitation due to morphological relatedness is distinct from the pattern due to semantic association (Bentin & Feldman, 1990; Dannenbring & Briand, 1982; Henderson, Wallis, & Knight, 1984; Napps, 1989). At average lags of 10 items, orthographic similarity of morphologically unrelated prime and target (e.g. pairs such as *diet* and *die*) produces neither facilitation nor inhibition (Bentin, 1989; Feldman & Moskovljević, 1987; Hanson & Wilkenfeld, 1985; Napps & Fowler, 1987). In short, the repetition priming procedure is a viable tool for studying how the morphological relation among words is represented in the lexicon and how that relation distinguishes itself from other types of similarity.

An examination of morphologically complex words across languages reveals two basic linguistic principles by which such words are constructed. In one, discrete morphemic constituents are linked linearly. There is a base morpheme to which other elements are appended so as to form a sequence. This principle defines a concatenative morphology, of the kind characteristic of English and Serbo-Croatian, for example. In languages with a concatenative morphology, suffixes and prefixes are regularly appended to the base morpheme in a manner that preserves its phonological and orthographic structure. According to the other principle, morphemic units are not just appended to a base form, but also modify its internal structure. This principle defines a non-concatenative morphology of the kind found in Hebrew, for example (McCarthy, 1981).

In the repetition priming studies of morphological processing conducted with visually presented English and Serbo-Croatian materials mentioned above, primes and targets were typically constructed around the same base morpheme and only differed with respect to affix. As a result, among

morphological relatives, the base morpheme remained intact and unchanged. Exceptions consist of studies that explored effects of changed spelling and/or pronunciation among morphologically related pairs (e.g. *heal* and *health* or *sleep* and *slept*) at long lags (Stanners, Neiser, Hernon, & Hall, 1979; Fowler et al., 1985; see also Kempley & Morton, 1982), studies that examined spelling and sound changes among morphological relatives at varying short lags and SOAs (Napps & Fowler, 1987), and a study with German materials that examined *umlaut* changes (Schriefers, Friederici, & Graetz, 1992). Even in those studies, however, the changes introduced to the base morpheme were relatively minor (e.g. consisting of a vowel or a vowel plus consonant change) as compared to the portion that was preserved. The structure of materials in those studies reflects a general principle of construction for languages with a concatenative morphology. That is, when morphemes are concatenated, it is almost always the case that the phonological and orthographic structure of the base morpheme will be preserved among regular morphological relatives (but see Kelliher & Henderson, 1990). A morpheme is typically a sequence of consonants and vowels that forms a syllable (or several), and concatenative word formation processes tend not to disrupt the coherence of the morpheme. The implication of this is that in concatenative languages such as English, morphological relatives will tend to have sequences of letters in common. As applied to the construction of materials in the typical repetition priming task where morphologically related pairs are formed by adding a suffix, the initial portion of primes and targets will tend to be identical.

Nonconcatenative formation processes are less likely to preserve the integrity of the base morpheme. The base morpheme in Hebrew is an abstract form called the "root" and is comprised of a string of three (or four) consonants. The root is not a complete phonological unit as it includes no vowels. Superimposed on the root is the "word pattern", which consists primarily of vowels. The root, together with a word pattern, constitutes the word. Some word patterns consist exclusively of vowels, and, typically, the vowels are infixed between the consonants of the root. Other word patterns include a consonant prefix (e.g. M plus vowel) or a suffix (e.g. vowel plus T) as well. Both the word pattern and the root are productive and convey morphological and semantic information (Ornan, 1971). For example, the root **SH-M-N** can take many word patterns, including -e-e- to form the noun /ʃemen/ [which means "oil"], and -a-e- to form the adjective /ʃamen/ [which means "fat"]. Similarly, the root **Z-M-R** can take many word patterns, including -a-a-, -e-e-, and -i-e-. Note that roots such as **Z-M-R** and **SH-M-N** are productive in that they generate several words in the semantic fields related to singing and oil, respectively. Similarly, the word patterns are productive and tend to modify the root in systematic

ways (Berman, 1978). For example, the -a-a- word pattern tends to denote an agent, the -e-e- pattern an object, and the -i-e- the past tense of an active verb in the third person singular. Thus, in Hebrew, /zamar/ meaning "a singer", /zemer/ meaning "a song", and /zimer/ meaning "he sang" are all morphologically related, because they share the **Z-M-R** root, and they are all bi-morphemic, because they include a word pattern as well as a root.

It is useful to point out that when different roots accept the same word pattern, the semantic information carried by that word pattern is not fully consistent. Specifically, although the word pattern -a-a- often denotes an agent, it is also sometimes used to denote the past-tense singular form of active verbs, as well as some adjective forms. Compare, for example, the contribution of the -a-a- pattern to the root **Z-M-R** [/zamar/ meaning "singer"] with its effect on the root **L-V-N** [/lavan/ meaning "white"]. Similarly, the semantic contribution of the root is not consistent in any simple sense over all morphologically-related items. Therefore, it is implausible that analysis of a word's morphological components proceeds independent of the lexicon.

The principle of building words in Hebrew, in contrast to that of languages such as English and Serbo-Croatian, dictates that the phonological and orthographic similarity of morphologically-related words in Hebrew will be spread over several syllables. Root morphemes consist of a sequence of consonants, and the requisite vowels for a particular word pattern are infixed between the consonants. Rather than forming continuous units, morphemes tend to be disrupted and distributed over several syllables. Consequently, the root morpheme constitutes neither an orthographically nor a phonologically coherent whole.

Alternative Accounts of Morphological Effects

Accounts of morphological effects in word recognition with materials from concatenative language often minimize the role of purely linguistic variables such as the morpheme and rely on orthographic and phonological patterning of letter units or on semantic similarity in conjunction with shared orthographic and phonological structure. For example, Seidenberg (1987) suggested that patterns of high and low probability of transition among sequences of letters could account for (syllabic or) morphological patterning, because transitional probabilities of letter sequences that straddle a (syllabic or) morphological boundary tend to be low (bigram troughs) relative to probabilities of sequences internal to a unit. In an illusory conjunction paradigm, subjects who tended to misidentify the colour of the target letter were more likely to assign the colour of another letter from within the same morphological unit than from an adjacent but different unit. Although this result provides support for orthographic

(specifically, bigram) structure in a particular task, it does not negate the influence of morphology in word recognition. Recently, in fact, morphological effects have been demonstrated in a lexical decision task when colour boundaries within a word were either consistent or inconsistent with morphological boundaries (Rapp, 1992). Moreover, morphological boundary effects were evident both in words with bigram troughs at the boundary and in words without troughs. Similar effects have also been reported for compound words (Prinzmetal, Hoffman, & Vest, 1991). Whether or not orthographic factors in morphological processing prove to be relevant for languages with concatenative morphologies such as English, it is difficult to see how they could be adapted eaily to non-concatenative languages such as Hebrew because morphemes are not always coherent units. In sum, the tendency to interpret morphological effects as orthographic patterning makes it essential to examine orthographic influences on morphological processing in a language in which the morpheme is not always an orthographic entity.

The emphasis on orthographic patterning is also evident in morphological parsing models in which the affixes of a morphologically complex word are first eliminated and then the remaining portion of the letter string is matched to candidate entries in a lexicon (e.g. Taft & Forster, 1975). Although affix parsing models may be plausible in languages such as English in which the repertoire of morphological affixes is relatively limited, their practicality is severely compromised in languages with differing morphological structures (cf. Henderson, 1989). In Turkish, for example, sequences of morphological affixes may be appended to one root and the form of those affixes may vary due to phonological factors. Moreover, some affixes may be applied more than once. Consequently, a process of suffix stripping with subsequent analysis of the remainder may have to undergo many iterations before the root can be successfully identified. It has been proposed that for Turkish, priority in morphological analysis of a word goes to the root, and only then is its sequence of affixes identified in a left-to-right manner (Hankamer, 1989). In contrast, morphological parsing in Hebrew poses special problems because the root morpheme constitutes neither a coherent phonological nor orthographic unit, and morphological formation is less systematic.

In a study of morphological analysis using repetition priming with Hebrew materials (Bentin & Feldman, 1990), patterns of facilitation for prime–target pairs that were related by semantic association and by a shared (morphological) root were compared. The study exploited the fact that although words constructed around the same root are, by definition, morphologically related, the semantic relation among morphologically related forms in Hebrew may vary dramatically. All of the morphological relations of prime and target pairs were derivational in nature. As a con-

sequence, the meaning of a derived form was not always predictable in any simple way from a semantic analysis of its component morphemes (see Aronoff, 1976). Facilitation due to morphological relatedness was evident at lags that averaged ten intervening items. Moreover, facilitation was equivalent for semantically close (e.g. *kitchen–cook*) and semantically distant (e.g. *slaughter–cook*) prime–target relatives. That is, the magnitude of facilitation to the target meaning "cook" was equivalent following primes meaning "kitchen" and "slaughter". These findings are, in fact, consistent with the claim based on English materials that at long lags semantic overlap between prime and target does not influence the magnitude of repetition priming (Feldman, 1992). In summary, when all related words were derivational in nature and an average of ten items intervened between prime and target, facilitation due to morphological relatedness in the repetition priming task was not sensitive to the semantic similarity of prime and target. This outcome suggests that morphological analysis is not based on the semantic overlap of morphological relatives.

Covariants of Morphological Structure in Hebrew

With respect to orthographic structure of words in Hebrew, it is important to note that most vowels are represented by optional diacritics placed beneath, above or within the preceding consonant although some vowels are represented by letters. Because words are conventionally written without vowel diacritics, morphologically complex words that share a root morpheme but differ with respect to word pattern will tend to be orthographically (but not phonologically) indistinguishable. For example, the words /gever/ and /gavar/ are both written גבר (note that in contrast to English and to phonemic notation, Hebrew is read from right to left). These words are morphologically related and mean "man" and "overcome", respectively. Because the word pattern is composed exclusively of vowels and because the /e/ and /a/ vowels are represented by optional diacritics, these two words have the same orthographic form as conventionally written. Of course, although both words have phonological forms that are created around the **G-V-R** root, their phonological forms differ because of the infixed vowels. By contrast, when vowels are written, and particularly when one of them is represented by a letter, then the orthographic pattern of the root morpheme, like its phonological pattern, is no longer a coherent unit. For example, the sequence מִשְׁמָר is read /miʃmar/, meaning "guard", whereas the sequence שׁוֹמֵר, is read /ʃɔmer/, which means "guardian". These words are morphologically related as they share the root ש-מ-ר (**SH-M-R**). They differ, with respect to phonological form as well as orthographic form, however, because in one case the letter for the /ɔ/ vowel of the word pattern is infixed between the consonants of the

root. In the present study, we use patterns of facilitation for morphologically complex words in the repetition priming task to ask whether the morphological processing of disrupted roots, as typically occurs in Hebrew, is similar to the processing of continuous roots as typically occurs in concatenative languages.

Linguists distinguish between two types of morphologically complex words. Words that share a base morpheme but differ with respect to *inflectional* affixes are generally considered to be forms of the same word (e.g. *calculate, calculated*). Words that share a base morpheme but differ with respect to *derivational* affixes are generally considered to be different words (e.g. *calculate, calculator, calculation*). As a secondary objective in the present study, we use patterns of facilitation to ask whether inflectional and derivational formations are likely to involve distinct types of representations and/or processing.

Experimental evidence for this linguistic difference has been difficult to obtain in English. One possible reason for the failure to find evidence for the linguistic distinction between inflectional and derivational formations is that the similarity of orthographic form cannot be equated in English. Specifically, because inflectional formations and derivational formations tend to differ with respect to length of affix (or because the transitional probability from the final letter of the base morpheme to the initial letter of the affix differs for inflectional and derivational affixes), these comparisons are not appropriate.

In Hebrew, by contrast, it is possible to identify pairs of words that are, respectively, inflectionally and derivationally related to the target and are equated with respect to orthographic and phonological similarity to that target. By definition, all such words are morphologically related to each other because they are constructed around the same root morpheme. Words in a pair differ with respect to the word pattern, but inflectionally-related and derivationally-related word patterns can be matched with respect to presence (and letter length) of prefixes and/or suffixes. In this way, the structural similarity to a target of inflectional and derivational relatives can be matched so that types of morphological formations can be compared.

To summarize, the primary goal of the present study was to examine the role of orthographic patterning in morphological analysis. Accordingly, using morphologically non-concatenated Hebrew materials, the orthographic integrity of the base morpheme across morphological relatives was systematically manipulated in the repetition priming task. Sometimes prime and target presentations preserved the same orthographic form as the root morpheme, and sometimes they did not. A secondary goal of the present study was to compare facilitation by inflectional and derivational relatives. Primes and targets shared a common root, and primes were either

inflectionally or derivationally related or identical to the target. Lexical decision latency to the target was compared following morphologically related and identical primes. A series of three experiments was conducted in an attempt to uncover the contribution (if any) to word recognition of orthographic similarity over and above that of morphological relatedness.

EXPERIMENT 1

Across languages, a variety of mechanisms for forming words exists, the most common being the addition or affixation of an element to a base morpheme (Matthews, 1974). Affixation includes three processes, defined by the position relative to the base morpheme, where addition occurs. These include prefixation, suffixation, and infixation in positions that are initial, final, and internal to the base morpheme. Prefixation and suffixation entail the linear concatenation of elements, whereas infixation is nonconcatenative insofar as the integrity of the base morpheme is disrupted. As described above, the characteristic morphological process of Semitic languages, such as Hebrew, relies on a skeleton of consonants into which a pattern of vowels is infixed (although a prefix or suffix may also be appended). The morphological system of Semitic languages is distinguished for its productivity, the manner in which semantic modification of the root occurs among complex forms that share a root, and for the nonconcatenativity of morphemes (Berman. 1978).

As noted above, the orthographic integrity of the base morpheme is generally maintained in English and in Serbo-Croatian but not always preserved in written Hebrew. For processes of infixation, morphological changes typically entail appending different word patterns to a root, where the word patterns specify the requisite vowels of a word. When represented by a letter, vowels in the word pattern necessarily disrupt the sequence of consonants that comprise the root. Consider, for example, the words נָפַל and נָפָל and compare them with the target word נוֹפֵל. The target is the present tense of the verb "to fall", in the third person singular (pronounced /nɔfɛl/). The first form is inflectionally related to the target and is pronounced /nafal/; it is the past tense of the same verb in the same person. The second form is derivationally related to the target and is pronounced /nɛfɛl/, which means "a dropout". By definition, all three forms are morphologically related, because they share the same root נ-פ-ל (N-F-L). Note, however, that in the target word, the root morpheme is not continuous. It is disrupted by the vowel וֹ /ɔ/, which is part of the word pattern. Contrast this pattern with that for the words עָבַד and עֶבֶד as compared with the target עֲבָדִים. The target is pronounced /avadim/, meaning "slaves". The first word is inflectionally related to the target, is pronounced /ɛvɛd/, and is the singular form "slave". The second word is derivationally

related to the target, is pronounced /avad/, which is the past tense, third person singular of the verb "to work". Note that in this case the orthographic root ע-ב-ד remains intact in all related forms. The orthographic similarity (due to preservation of the orthographic pattern for the root) of the morphological relatives depicted in the latter example is characteristic of all regularly related pairs in English. In the present experiment with Hebrew materials, the pattern of facilitation due to morphological relatedness of prime–target pairs was compared when the orthographic form of the shared root was disrupted over prime and target presentations (e.g. פ-ל-ו) and when it was intact (e.g ע-ב-ד).

It has already been demonstrated that in Hebrew facilitation in the repetition priming task is sensitive to derivational relatedness of prime and target (Bentin & Feldman, 1990). If inflectional and derivational formations in Hebrew are similarly represented in the lexicon, then it is anticipated that the magnitude of facilitation in the lexical decision repetition priming task will not vary with type of morphological relation, and a comparison of inflectional and derivational primes is included in the present investigation. It is anticipated that if orthographic similarity of prime to target is independent of morphological relatedness, then the pattern of facilitation for roots that are disrupted and roots that are not disrupted will not differ.

Methods

Subjects. Forty-eight first-year students from the Department of Psychology at Hebrew University participated in Experiment 1. All were native speakers of Hebrew. All had vision that was normal or corrected-to-normal and had prior experience in reaction-time studies. None had participated in other experiments in the present study.

Stimulus Materials. Forty-eight Hebrew word triplets were constructed. Each included three forms: a target word, a word that was inflectionally related to it, and a word that was derivationally related to it. All members of a triplet were constucted from the same root morpheme, but they differed with respect to word pattern. The orthographic and phonemic overlap of morphologically related words to their targets was systematically manipulated. Targets consisted of 24 verbs in present tense, third person singular and 24 plural nouns. For verb targets, the inflected forms were past-tense formations (third person singular), and the derived forms were nouns in singular case. In the verb set, the roots were orthographically continuous in both inflected and derived forms, but the roots were disrupted in the target by the infixation of a letter vowel. For the noun targets, the inflected forms were the same nouns in the singular, and the derived

forms were verbs in the past tense (third person singular). In this set, the roots were orthographically continuous in targets as well as related forms.

Four types of words preceded each target, and they were counterbalanced across experimental lists. Words inflectionally and derivationally related to the target, an identical repetition of the target, and an (orthographically, phonologically and semantically) unrelated word served as primes. The orthographic similarity of the derived and inflected primes to their target was matched within each triplet. (All word triplets and their English translations are listed in Appendix A.) The unrelated words had the same morphological structure (word pattern) as did the related words (for other targets), although they necessarily had different root morphemes.

Ninety-six pseudowords were constructed by combining meaningless three-consonant root morphemes with real word patterns. Root morphemes in pseudowords were not repeated over successive trials so as to enhance the orthographic salience of the words.

Four test orders were assembled. Each list was comprised of 96 words and 96 pseudowords. All items were presented with their vowels. The 96 words consisted of the 48 targets and their 48 primes. Twelve targets were preceded by identical repetitions, 12 targets were preceded by derivationally related primes, 12 were preceded by inflectionally related primes, and 12 targets were preceded by morphologically, orthographically, and semantically unrelated word primes. The lag between prime and target varied between 7 to 13 items, with an average of 10. The serial position of all target words and pseudowords was identical across test orders. The primes were rotated among the four lists, so that within a list each type of prime was equally represented, and, across lists, each target was preceded once by each of the four types of primes.

Procedure. Twelve subjects were randomly assigned to each of the stimuli lists. Thus, the four prime types were compared within subjects across all 48 targets and within stimuli across all 48 subjects. Speed and accuracy were equally emphasized in the instructions.

The stimuli were presented approximately 80 cm from the subject, at the centre of a Macintosh monochromatic screen. Each item was exposed until the subject responded or for 2000 msec, whichever came first. The interval between onset of successive stimuli was 2500 msec.

The dominant hand was used for word responses, and the non-dominant hand was used for pseudoword responses. Latencies were measured from stimulus onset to the nearest millisecond, using a special software algorithm,[1] and errors were automatically registered. Following the instructions, a practice list comprised of 24 items (two identity, two inflectional,

[1]We thank Len Katz for developing the software.

and two derivational prime–target pairs, as well as 12 pseudowords) was presented. After a short pause, the experimental list followed in one block. The complete experimental session lasted about 20 min.

Results and Discussion

Fewer than 2% of lexical decision reaction times were more extreme than two *SD*s from the mean for subjects and for items in each condition, and these outliers were excluded from all analyses. Mean lexical decision latencies and errors in Experiment 1 are summarized in Table 1.

The statistical reliability of the repetition priming effect was tested by ANOVA with repeated measures across subjects (F_1) and across stimuli (F_2). The factors of target continuity (disrupted, continuous), and prime type (unrelated, identity, inflectional, derivational) were examined. The effect of target continuity was not reliable $F_2(1, 46) = 0.43$, $MS_e = 17429$, $p > 0.50$.[2] The effect of prime type was significant, $F_1(3, 141) = 20.72$, $MS_e = 2279$, $p < 0.0001$, and $F_2(3, 141) = 18.67$, $MS_e = 2704$, $p < 0.0001$. Tukey-A post-hoc comparisons revealed that whereas all prime types significantly facilitated lexical decisions relative to the unrelated condition ($p < 0.01$), the magnitude of the effect did not differ from one type of prime to another. In particular, it was interesting that facilitation with identity primes was not significantly larger than with inflectional or derivational primes.

The absence of a reliable prime Type × Continuity interaction, $F_2(3, 138) = 0.44$, $MS_e = 2737$, $p > 0.50$, indicated that facilitation from morphologically related primes to orthographically disrupted target did not differ from facilitation to orthographically continuous targets.

TABLE 1
Mean Lexical Decision Times[a] and Percentage of Errors for Targets Following Morphologically Related and Unrelated Prime Words in Experiment 1

	Prime Type							
	Unrelated		*Identity*		*Inflection*		*Derivation*	
RT	769	(14)	701	(14)	709	(14)	710	(13)
Errors	0.5	(0.3)	0.5	(0.2)	0.4	(0.1)	0.5	(0.2)

[a]Lexical decision times in msec.
Note: SE_m in parentheses.

[2]Because the effect of continuity was not significant over items, *F* values over subjects were not included.

TABLE 2
Mean Lexical Decision Latency[a] for Target Words with Disrupted and Continuous Roots Following Primes in the Four Priming Conditions of Experiment 1

	Prime Type			
	Unrelated	*Identity*	*Inflection*	*Derivation*
Disrupted	759 (19)	699 (14)	704 (14)	709 (16)
Continuous	785 (21)	704 (13)	715 (17)	717 (15)

[a]Latencies in msec.
Note: SE_m in parentheses.

The error rate on words was very low and did not differ as a function of prime type, $F_1(3, 141) = 0.24$, $MS_e = 0.4$, $p < 0.80$. Due to the design of the experiment, facilitation due to repetition of pseudowords could not be analysed.

Experiment 1 had three important outcomes: (1) The magnitude of facilitation in lexical decision was similar for prime–target pairs whose structure preserved the orthographic continuity of the root and for those where continuity of the root was disrupted by infixing an additional letter. It was the case that all the disrupted roots were embedded in verb targets, whereas all the continuous roots were in nouns, and that the derivationally related primes (but not the inflectionally related primes) always introduced a change in word class between prime and target. Nevertheless, statistically non-significant and numerically small differences between facilitation by inflectional and by derivational relatives were obtained. This outcome suggests that the morphological repetition effect is sensitive neither to similarity of orthographic form between the prime and the target nor to the preservation of word class. (2) Significant facilitation for inflectionally and derivationally related as well as for identity primes was observed and provided further evidence for morphological analysis in Hebrew. However, the magnitude of the facilitation in lexical decision was not significantly greater for prime–target pairs related by inflection than for pairs related by derivation. Thus, facilitation by repetition priming was not sensitive to the type of morphological relation. (3) Finally, facilitation due to morphological relatedness in Hebrew cannot be attributed to repetition of an initial syllable. Although the initial consonant was always unchanged in prime and target, the following vowel did vary. Initial consonant and vowel overlap of prime and target was greater for inflections than for derivations for the non-disrupted targets, whereas the vowel never overlapped for the disrupted targets. Nevertheless, the pattern was similar for both.

In conclusion, the results of Experiment 1 replicate effects of morphological relatedness in the repetition priming task when the orthographic

integrity of the base morpheme is preserved over prime and target and extends the outcome to cases where the continuity of the root morpheme is disrupted. In addition, it shows that the tendency for enhanced semantic overlap of inflectionally related prime–target pairs relative to derivationally related pairs contributes nothing to the pattern of facilitation. Collectively, these results provide no behavioural evidence for a linguistic distinction between morphological types. Moreover, it suggests that effects due to morphological relatedness are not easily interpreted as a composite of orthographic and semantic similarity.

EXPERIMENT 2

The results of the previous experiment revealed morphological analysis in the lexical decision task. Evidently, subjects were sensitive to repetitions of a sequence of consonants that comprises a root morpheme, whether or not they form an orthographic unit. Importantly, inflectional relationships and derivational relationships produced the same pattern of facilitation. We assume that this outcome can be interpreted as a failure to find evidence for a psychological distinction between morphological types in Hebrew. Aspects of stimulus constuction in Experiment 1 permit an alternative account, however.

In Experiment 1, all pseudowords were constructed from a meaningless string of consonants combined with a real word pattern, and all words (necessarily) consisted of a meaningful root combined with an appropriate word pattern. Therefore, in order to perform the lexical decision task successfully, it was not logically necessary for subjects to attend to the whole word: an analysis of the root would have been sufficient. Consequently, it is possible that the failure to observe a difference between morphologically related primes with inflectional and derivational word patterns reflected the tendency of subjects to ignore perceptually nonsalient vowel information in this experimental setting. It is essential to show that subjects were, in fact, sensitive to the word patterns that create the distinction between inflectional and derivational formations, and this was the intent of the second experiment.

In Experiment 2, the informativeness of word pattern information was enhanced by constructing pseudowords along a different principle. Here, pseudowords consisted of a real root and a real word pattern in an illegal combination. The words consisted of the same items as in the previous experiment. The differentiation between word and pseudowords therefore required the subject to process the word pattern as well as the root. As in the previous experiment, word targets were preceded by identity, unrelated, and inflectionally- and derivationally-related primes.

Method

Subjects. Forty-eight native speakers of Hebrew who were first-year students in the Department of Psychology at Hebrew University participated in Experiment 2. All had normal or corrected-to-normal vision, and all had prior experience in reaction-time studies, although none had participated in other experiments in the present series.

Stimulus Materials. The words used in the present experiment were identical to those used in Experiment 1. The 96 pseudowords were constructed using other productive roots that exist in the language. All roots were combined with legal word patterns, such that the particular combination of root and word pattern was meaningless. For example, the root ע-ב-ד (A-V-D) was combined with the word pattern -ɔ-a-ut in order to form the phonologically legal but meaningless structure עוֹבְדָנוּת, which is pronounced /ɔvdanut/. This manipulation was introduced so as to promote morphological analysis of all letter strings.

The four test orders created for Experiment 1 were modified so that the new set of pseudowords was substituted for the old set. In all other respects the materials were identical to those of the previous experiment.

Procedure. Subjects were instructed to make a lexical decision judgement. The procedure as well as the word stimuli were identical to those of Experiment 1, except that the timing software was measured from a hardware device that eliminated the constant that had been added to each latency in the previous experiment.

Results and Discussion

Mean lexical decision latencies were calculated in each condition, across subjects and across stimuli. Errors and extreme reaction times were eliminated, as in Experiment 1. Mean reaction times and errors for each condition are presented in Table 3.

The comparison of the latencies of lexical decisions to target words in the different conditions was based on ANOVA using subjects (F_1) and stimuli (F_2) as random factors. This analysis showed a significant effect of type of prime, $F_1(3, 141) = 9.98$, $MS_e = 1826$, $p < 0.0001$ and $F_2(3, 141) = 20.71$, $MS_e = 1744$, $p < 0.0001$. Post hoc Tukey-A comparisons of the means indicated that the inflectional, derivational, and identity primes all facilitated lexical decision relative to the unrelated condition, $p < 0.01$. As in Experiment 1, the magnitude of facilitation was similar for the three related prime types. The analysis of error scores showed no significant difference due to type of prime, $F_1(3, 141) = 1.49$, $MS_e = 1.54$, $p > 0.14$.

The responses to targets with orthographically disrupted roots and targets with continuous roots were compared by a mixed model ANOVA

TABLE 3
Mean Lexical Decision Times[a] and Percentage of Errors for Targets Following Morphologically Related and Unrelated Prime Words in Experiment 2

	Prime Type							
	Unrelated		*Identity*		*Inflection*		*Derivation*	
RT	628	(12)	571	(6)	576	(6)	578	(10)
Errors	1.9	(0.4)	1.4	(0.3)	1.9	(0.0)	1.5	(0.4)

[a]Lexical decision times in msec.
Note: SE_m in parentheses.

and are summarized in Table 4. Targets with continuous roots were marginally faster than (different) targets with disrupted roots, $F_2(1, 46) = 3.13$, $MS_e = 8787$, $p < 0.084$. The effect of prime type was reliable and, consistent with the outcome of Experiment 1, there was no Type of Prime × Target Continuity interaction, $F_2(3, 138) = 0.78$, $MS_e = 2459$, $p > 0.501$. Because the pattern of facilitation was similar for targets with orthographically disrupted and orthographically continuous roots and because continuous roots showed numerically smaller facilitation than did disrupted roots, these data support the conclusion of Experiment 1 that preservation of orthographic pattern is not a necessary condition for facilitation due to morphological relatedness. Finally, neither for disrupted roots nor for continuous roots were inflectionally-related primes and derivationally-related primes significantly different from each other.

The outcome of the present experiment replicated that of Experiment 1. The magnitude of facilitation in lexical decision was not significantly greater for prime–target pairs related by inflection than for pairs related by derivation. More important, neither was facilitation influenced by orthographic integrity of the repeated root morpheme. Thus, even when the

TABLE 4
Mean Lexical Decision Latency[a] for Target Words Following Primes with Disrupted and Continuous Roots in the Four Priming Conditions of Experiment 2

	Prime Type							
Target	*Unrelated*		*Identity*		*Inflection*		*Derivation*	
Disrupted	640	(22)	575	(7)	584	(9)	595	(17)
Continuous	602	(11)	563	(9)	568	(7)	561	(10)

[a]Latencies in msec.
Note: SE_m in parentheses.

composition of pseudowords forced subjects to analyse the morphological structure of the items in order to perform the lexical decision task, facilitation in morphological repetition priming was not sensitive to (1) type of morphological relation, nor to (2) preservation (or disruption) of an orthographic pattern for the morpheme across prime and target words.

Plausible accounts of facilitation in the repetition priming task have identified response-related (episodic) as well as lexical influences (e.g. Bentin & Feldman, 1990; Bentin & Moscovitch, 1988; Bentin & Peled, 1990; Forster & Davis, 1984; Monsell, 1985). One account of the present results places the locus of facilitation at the level of the root morpheme that is repeated in both inflectional and derivational pairs. Perhaps repetition serves to facilitate the identification of an orthographically and semantically abstract root within the composite root-plus-word pattern that constitutes a word. Conjointly, facilitation may reflect an aspect of design. In previous repetition priming experiments, it was the case that lexical decision response to a root was also repeated—that is, roots that were parts of words on their first presentation were parts of words on their second presentation. It was never the case that roots that were parts of pseudowords on their first presentation were parts of words on their second presentation. This redundancy between roots and responses might have facilitated the decision process or the selection between the "word" and "not a word" response categories, thereby introducing an additional source of facilitation. In the third and final experiment, the lexical decision associated with a particular root was manipulated over repetitions. The experiment was designed in order to identify an episodic component of facilitation associated with response repetition.

EXPERIMENT 3

Pseudoword structure influences rejection time in the lexical decision task. Caramazza, Laudanna, and Romani (1988) reported that Italian pseudowords composed of illegal combinations of real morphemes were harder to reject than pseudowords composed of one legal morpheme and one illegal (non-morpheme) sequence. Similar results have been reported in English (Katz, Rexer, & Lukatela, 1991). Of course, Italian is a concatenated language like English, and morphemes consist of uninterrupted sequences of letters, whereas in Hebrew the morpheme root is a more abstract unit. Experiment 3 assesses whether Hebrew pseudowords formed around a meaningful root pose special problems relative to pseudowords formed around a meaningless string of consonants. Hebrew pseudowords constructed by combining meaningful root morphemes with real word patterns were compared with pseudowords constructed of a meaningless root with a real word pattern.

Experiment 3 also attempts to evaluate response repetition as a source of facilitation in this task. In the experiments reported above as well as in all previously reported repetition priming studies, the lexical status of the prime and the lexical decision to the target were matched, so that if the answer to the first was "word", then the answer to the second would also be "word", and if the answer to the first was "pseudoword", then the answer to the second would also be "pseudoword". In the present experiment, the effect of morphologically related pseudoword primes on word targets was investigated. That is, primes and targets were always formed around the same root, but, due to illegal combinations of root and word pattern, the lexical status of the prime was not always a real word. Failure to find facilitation when the lexical status of prime and target is not matched would provide evidence for a response-related component to facilitation in the repetition priming task (Logan, 1988).

The addition of a condition in which pseudoword primes are followed by word targets serves to eliminate another potential problem of interpretation. In the previous two experiments, only words were repeated, so that it was possible that subjects used repetition of the root as a criterion for deciding the lexical status of a letter string—that is, if a particular string of consonants had been presented previously, then respond "word". By this account, target facilitation following unrelated primes would be overestimated as these were first presentations of that consonant string. Accordingly, targets following pseudoword primes formed from the same root should show facilitation because the root is repeated. By contrast, if targets following unrelated primes (with different roots) and targets following pseudoword primes (repeated roots) do not differ significantly, then it is unlikely that subjects are exploiting repetition of the root per se as a basis for judging the lexical status of a target.

Experiment 3 was designed to differentiate the effect of repeating a root morpheme from the effect of repeating a lexical decision response. If facilitation following morphological repetition reflects units for accessing the lexicon rather than lexical processes, then target words that contain a root that was previously presented should be faster than targets whose roots were presented for the first time. Importantly, the lexical status of the word in which the root appeared should have no effect. That is, both word and pseudoword primes that contain the root morpheme should facilitate targets. On the other hand, if morphological components must activate a lexical entry in order to produce facilitation, then roots embedded in pseudowords will not facilitate words with those same roots. Such an outcome could also suggest that relatively late processes of decision and response selection contribute to the pattern of facilitation in the repetition priming task.

Method

Subjects. Forty-eight first-year students from the Department of Psychology at Hebrew University participated in Experiment 3. As in the previous experiments, all were native speakers of Hebrew. All had vision that was normal or corrected-to-normal, and all had prior experience in reaction-time studies, although none participated in other experiments in the present study.

Stimulus Materials. The materials from Experiment 1 were modified in the third experiment, so that the response for a particular root was not necessarily constant over the first and second presentations of that root. The materials for the third experiment were identical to those of the previous two experiments, with two exceptions. First, instead of including an identical repetition of each target word, a new prime was constructed. It consisted of an illegal combination of the target root and a word pattern. Accordingly, the correct lexical decision response for these primes was "not a word". As a consequence of introducing a new principle for constructing primes, two types of pseudowords occurred within each test order. One type consisted of pseudowords formed by creating an illegal combination of meaningful root and real word pattern. These were pseudoword primes for real word targets and 12 occurred in each list. The other consisted of a real word pattern on a meaningless root, and these were pseudoword fillers. Both types of pseudowords were presented to each subject, so that they could be compared.

Thus, the design of Experiment 3 was similar to the design of Experiment 1, except that here the identity word primes were replaced by pseudoword primes constructed from the same root morpheme that appeared in the target. With each of the four test orders, the 48 targets were preceded equally often by pseudowords, by inflected primes, by derived primes, and by unrelated word primes. Across test orders, each target was preceded by each type of prime.

Procedure. Subjects were instructed to make a lexical decision judgement, and the procedure and instructions were identical to those of the two previous experiments.

Results and Discussion

Mean decision latencies and error rates for Experiment 3 are summarized in Table 5. Errors and extreme reaction times were eliminated, as in Experiments 1 and 2.

The ANOVA of word latencies revealed a significant effect of type of prime, $F_1(3, 141) = 5.76$, $MS_e = 2016$, $p < 0.001$; $F_2(3, 141) = 11.21$,

TABLE 5
Mean Lexical Decision Times[a] and Percentages of Errors for Targets Following Morphologically Related Word Primes, Unrelated Word Primes, and Pseudoword Primes in Experiment 3

	Prime Type							
	Unrelated		*Pseudo*		*Inflection*		*Derivation*	
RT	653	(13.5)	647	(10.1)	608	(7.30)	609	(7.60)
Errors	2.4	(0.7)	1.9	(0.5)	1.7	(0.5)	1.6	(0.4)

[a]Lexical decision times in msec.
Note: SE_m in parentheses.

$MS_e = 2482$, $p < 0.0001$, although the analysis of error scores did not, $F_1(3, 138) = 1.13$, $MS_e = 1.14$, $p > 0.33$. For latencies, post-hoc Tukey-A comparisons revealed that targets preceded by inflectionally and derivationally related primes were significantly faster than targets preceded by unrelated words. In replication of previous results, the magnitude of facilitation was similar for inflectional and derivational type primes. Reaction times to targets preceded by pseudoword primes were not significantly different from reaction times to targets preceded by unrelated primes, however. This outcome suggests that when the response to a root was not repeated, repetition of the root per se was not sufficient to facilitate (or inhibit) lexical decision. This outcome is important because it suggests that word target responses were not simply facilitated because the same root was repeated during the experimental session.

Comparison of the meaningful root and meaningless root pseudowords revealed that the presence of a meaningful root delayed rejections of pseudowords by about 200 msec (698 msec vs. 902 msec, respectively). This difference was statistically significant, $F_1(1, 47) = 88.5$, $MS_e = 11{,}280$, $p < 0.0001$, and is consistent with the results found in concatenative languages such as Italian and English.

As in the previous experiments, latencies and errors to targets containing disrupted and continuous roots were compared. They are summarized in Table 6. The ANOVA showed that continuous and disrupted target types were not significantly different, $F_2(1, 46) = 1.78$, $MS_e = 9960$, $p > 0.18$. In replication of previous experiments, the effect of type of prime was significant, but there was no Type of Prime × Continuity interaction, $F_2(1, 138) = 0.88$, $MS_e = 2640$, $p > 0.44$.

The difference in the lexical decision latency between the two types of pseudowords suggests that during the process of lexical decision roots were examined and that readers cannot ignore the meaningfulness of the roots,

TABLE 6
Mean Lexical Decision Latency[a] for Target Words with Disrupted and Continuous Roots in the Four Priming Conditions of Experiment 3

	Prime Type			
Target	*Unrelated*	*Nonword*	*Inflection*	*Derivation*
Disrupted	634 (17)	638 (14)	609 (11)	597 (9)
Continuous	661 (19)	650 (14)	613 (10)	631 (12)

[a]Latencies in msec.
Note: SE_m in parentheses.

even when they are components of pseudowords. Nevertheless, the presence of a meaningful root in a pseudoword could not facilitate later lexical decision to a word formed from the same root. Because only the pseudoword–word combination was examined, this outcome could suggest that repetition of the episode or particular response is a source of facilitation in the repetition priming task. Alternatively, it is plausible that morphological components must activate a lexical entry in order to produce facilitation at a later point. In any event, it appears that the locus of root facilitation cannot be prelexical and that facilitation is based on morphological relatedness and not orthographic similarity.

GENERAL DISCUSSION

In a series of three lexical decision experiments, significant facilitation due to morphological relatedness of prime and target was observed with Hebrew materials. Subjects performed a lexical decision to both prime and target, and 7 to 13 items intervened between them. When related primes were matched for overall orthographic similarity to targets, facilitation by inflectional primes was equivalent to facilitation by derivational primes, both of which were statistically equivalent to facilitation by identical repetitions. Similar magnitudes of facilitation for the two types of morphological primes are interesting because forms related by derivation generally tend to be less similar in meaning than forms related by inflection (Aronoff, 1976). Moreover, in our particular experiments, pairs related by inflection were always of the same word class, whereas pairs related by derivation changed word class. Evidently, the facilitation that underlies repetition priming among morphologically related forms need not reflect preservation of shared meaning over prime and target. These results are consistent with the claim that at long lags, semantic relatedness per se is not a primary source of facilitation in the repetition priming task (Bentin & Feldman,

1990) and support a distinction between facilitation due to associative and morphological relatedness (Henderson, 1985).

Alternative accounts of facilitation between morphologically related prime–target pairs emphasize the repetition of phonological and orthographic patterns conveyed by a shared morpheme. As described above (see also Berman, 1978), and in contrast to concatenative morphologies such as that of English, morphologically complex words in Hebrew consist of a root morpheme of consonants into which a word pattern is infixed. Consequently, root morphemes are abstract patterns that cannot be realized as unified phonological entities. In the present study, roots were repeated over related primes and targets, but because word patterns changed, related words were not associated with a common phonological structure. Nevertheless, facilitation was observed. In conclusion, appreciation of morphological relatedness does not require phonological identity. As applied to the repetition priming task, repetition of a phonological unit is not necessary in order to produce morphological facilitation.

Accounts of morphological effects that emphasize orthographic structure (e.g. Seidenberg, 1987; Seidenberg & McClelland, 1989) may be more appropriate for concatenative languages, because morphemes tend to be orthographic as well as linguistic units. For example, in English, the base morpheme is typically undisrupted by morphological manipulations.[3] Nevertheless, previous studies in English have demonstrated that for morphologically related words, the repetition of orthographic form plays only a minimal and statistically insignificant role in the morphological repetition effect (e.g. Napps, 1989; Napps & Fowler, 1987). Similarly, in Serbo-Croatian facilitation in repetition priming was equivalent when prime and target were both written in the same alphabet (e.g. *nogom–noga*) and when the prime was in one alphabet (e.g. HOFOM) and target was in the other (e.g. *noga*) (Feldman & Moskovljević, 1987; Feldman, 1993). In Hebrew, the root is always phonologically and sometimes also orthographically disrupted because of its non-concatenated structure.

The major contribution of the present result is to underscore the inappropriateness of an orthographic account of morphological analysis. This claim is based on the following evidence. (1) The magnitude of target facilitation following morphological relatives was similar to that following identical repetitions, although the orthographic similarity of the inflected and derived primes to their matched targets was, by definition, smaller than with identity primes. (2) In all three experiments, the comparison between prime–target pairs with orthographic disruptions to the root and pairs with continuous roots yielded no significant differences. Moreover, in Experiment 3, repetition of the root did not facilitate lexical decision to the target if its first presentation was in the context of a pseudoword,

[3]Exceptions include alternations of strong vowels in pairs, such as *sing–sung* and *meet–met*.

even though the pseudoword was as orthographically similar to the target as were the related words. These results are consistent with the outcome of a similar study conducted with English materials (Fowler et al., 1985) in that changes in spelling (and/or pronunciation) had no effect on the pattern of facilitation between morphologically related prime–target pairs in the repetition priming task. The implication of the above is that facilitation in the repetition priming task in non-concatenative as well as concatenative languages cannot be attributed to repetition of an overall orthographic form, nor to preservation, over successive presentations, of the continuity of an orthographic pattern. In summary, morphological analysis cannot be tied to orthographic units.

Inflections and derivations are contrasted by linguists as representing two different types of morphological formations. In English, inflectional affixes are few and tend to be composed of three or fewer letters, whereas derivational endings can be composed of a more variable number of letters. Moreover, some derivations change the meaning and pronunciation of the base morpheme in a manner that is not characteristic of inflections (Chomsky & Halle, 1968). In Hebrew, it is possible to find inflectional and derivational relatives of a target that modify the structure of the root to a similar degree, although they necessarily differ with respect to their semantic similarity to the target. In the present repetition priming study, no differences between inflectional and derivational types of morphological formations were observed. Consistent with the conclusion of Napps (1989) and Napps and Fowler (1987), it is evident that facilitation due to morphological relatedness in the present study does not represent the convergence of semantic, orthographic, and phonological relationships.

Locus of Morphological Effects

In order to observe morphological facilitation in lexical decision, it is not necessary that orthographic patterning be preserved, and this finding has been interpreted to mean that morphological analysis is not tied to an orthographic pattern. Similarly, facilitation patterns are not sensitive to the semantic overlap of prime and target in either this or an earlier study (Feldman, 1992). Because the morphological character of a word cannot be captured by its orthographic and semantic properties, it seems that the morphological structure in general, and the Hebrew root morpheme in particular, must be represented. A morphological representation in the lexicon has been proposed by several investigators (e.g. Grainger, Colé, & Segui, 1991).

The claim that morphological effects in word recognition reflect lexical processes is based on several sources of evidence. Typically, effects of repeating a morpheme are numerically larger and statistically more robust

for word than for pseudoword prime–target pairs. Significant facilitation for pseudowords in the repetition priming task is unreliable even when the negative lexical decision is repeated over prime and target with the same continuous base morpheme (e.g. Duchek & Neely, 1989; Feldman & Moskovljević, 1987). For example, in the one repetition priming study where Hebrew pseudowords were repeated (Bentin & Feldman, 1990), evidence for facilitation due to repetition with pseudowords depended on the choice of a baseline. Similarly, in at least one study with English materials (Fowler et al., 1985), evidence of facilitation with pseudowords depended on the number of items intervening between prime and target (see also Scarborough, Cortese, & Scarborough, 1986). For morphologically-related word pairs, by contrast, effects tend to be larger in magnitude, and manipulations of lag are not significant (Feldman, 1993). The results of Experiment 3 also cast doubt on a locus for the morphological facilitation that is independent of the lexicon. If it were possible for subjects to extract a root from both words and pseudowords prior to accessing the lexicon, then the effect on word targets of word and pseudoword primes should have been similar. Analogous effects for word and pseudoword primes were not observed, however.

A second source of evidence that—at least some—morphological effects are lexical in origin is the interaction of morphological and frequency effects. Although it is not the case in repetition priming that (relative) frequency of morphologically related prime and target has a significant effect (Feldman, 1992), morphological and frequency effects often interact in other recognition tasks. Accordingly, more frequent words are less sensitive to manipulations of morphological structure than are less frequent words. For example, in an experimental production task (Stemberger & MacWhinney, 1986, 1988), the error rate on lower-frequency morphologically-complex forms was significantly higher than on higher-frequency verb forms. Similarly, it has been suggested (Caramazza et al., 1988) that both whole words and morphological units may constitute viable units for accessing the lexicon, but that the availability of the former are constrained by the frequency of the particular surface form.

It is important to point out that the measure of variance included in Table 3 provides no evidence that performance was more variable in the pseudoword prime condition than in the unrelated prime condition. Therefore, an account based on compensatory processes such as facilitation due to repetition of the root being offset by a change of response to that root seems implausible.

Evidence that facilitation due to morphological relatedness is lexical in locus is compelling and fits well with the results of studies that used different experimental paradigms. What is less obvious is how to account for the effect of morphemic composition on pseudoword rejection laten-

cies. Rejection latencies were more prolonged for pseudowords that included a meaningful root than for pseudowords that did not. This outcome for real roots in illegal combinations with word patterns could reflect a relatively late and strategic re-evaluation of the decision process analogous to the spelling check necessary for pseudohomophone rejection.

Recently, Grainger et al. (1991) have identified two plausible lexical loci for morphological effects in word recognition. As usually conceived, morphological effects are interpreted as sublexical in origin, so that morphological relatedness is represented as a system of facilitatory connections between lexical entries for morphologically-related words or as a pattern of activation among morphological units at a level intermediate between word and letter level units. Whether interpreted as a system of connections between whole word forms or as patterns of activation among shared morphological units, the traditional locus of morphological relatedness is sublexical (but not prelexical) in that it is intermediate between word and letter levels. As noted by Grainger and his colleagues (1991), according to a sublexical account, one might expect to observe inhibition among morphologically-related words because of their shared orthographic structure, but this outcome has not been reported. Alternatively, morphological units may be represented at a level above the word, so that all words formed from the same base morpheme are linked by facilitatory connections to the morpheme, and, conversely, from the morpheme back to related words. By the supralexical account, activation spreads from a specific word to its base morpheme and then on to other words that are morphologically related to it. An extension of the supralexical account is consistent with the claim that facilitation in the repetition priming task with Hebrew materials may reflect the process of extracting the root from the root-plus-word pattern combination that constitutes a word (Bentin & Feldman, 1990). It also alleviates the problem of identifying a morpheme that, in Hebrew, is neither a phonological nor an orthographic entity. Segmenting a root from a word pattern in Hebrew necessarily requires extensive lexical knowledge, therefore the process of root extraction in Hebrew must be distinguished from prelexical processes such as affix stripping (Taft & Forster, 1975).

Almost all Hebrew pseudowords have legal orthographic (and phonological) patterns, so that their differentiation from words must entail examination of the root and may even include an evaluation of its semantic content. This identification may require extracting the root from the word. It is plausible that when roots are repeated over prime and target words in repetition priming, it is the identification of the root that is facilitated. Of course, even the extraction of a semantically meaningful root from its word context is not sufficient to categorize a string reliably as a word. The combination of root morpheme and word pattern must also be evaluated.

It was observed in Experiment 3 that pseudowords composed of a meaningful root in illegal combination with a word pattern were more difficult to reject than pseudowords formed around a meaningless root. Activation from the root could spread down to letter level even in the absence of word level activation, and this pattern of activation throughout the system could have the effect of biasing the decision process towards a word response.

In summary, both lexical and postlexical influences may contribute to the pattern of facilitation in the repetition priming task. For lexical decision, response repetition about the lexical status of a particular morpheme in a particular (word or pseudoword) context introduces a postlexical contribution. Support for the lexical aspect of morphological analysis is tied to the pattern of facilitation in the repetition priming task for word targets. It could arise either sublexically or supralexically. The nonconcatenative morphological structure of Hebrew lends itself to a supralexical representation of morphology. If common morphological units are captured at a level above the word, then discontinuities of phonological or orthographic components of a morpheme are no longer problematic. Prolonged latencies for pseudowords composed of illegal combinations of root and word pattern relative to pseudowords composed from non-root are also anticipated. In sum, morphological analysis in word recognition is not tied to orthographic form and entails lexical knowledge at either a sublexical or a supralexical level.

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Revised manuscript received 1 March 1993

APPENDIX A

Inflectional and Derivational Primes for Targets with Orthographically Disrupted and Continuous Roots

Orthographically Disrupted Roots[a]

Primes				*Targets*	
Inflectional		*Derivational*			
נָפַל	fell	נֶפֶל	dropout	נוֹפֵל	falls
צָלַב	crucified	צְלָב	cross	צוֹלֵב	crucifies
צָבַע	painted	צֶבַע	paint	צוֹבֵעַ	paints
פָּסַח	passed over	פֶּסַח	Passover	פּוֹסֵחַ	passes over
קָטַע	cut	קֶטַע	section	קוֹטֵעַ	cut
סָכַך	sheltered	סְכַך	roofing	סוֹכֵך	shelters
דָּרַך	stepped	דֶּרֶך	way	דּוֹרֵך	steps
קָבַר	burried	קֶבֶר	grave	קוֹבֵר	buries
מָרְפָּא	heals	מַרְפֵּא	cure	מַרְפֵּאת	heals (f)
צָדַק	was right	צֶדֶק	justice	צוֹדֵק	is right
כָּתְבָה	wrote (f)	כְּתָבָה	article	כּוֹתֵב	writes
עָקַב	followed	עָקֵב	heel	עוֹקֵב	follows
שְׂנוּאָה	hated (f)	שִׂנְאָה	hate	שׂוֹנֵא	hates
גָּזַם	pruned	גֶּזֶם	cutting	גּוֹזֵם	prunes
זָרַם	flowed	זֶרֶם	stream	זוֹרֵם	flows
חָנַק	strangled	חֶנֶק	strangulation	חוֹנֵק	strangles
לָקַח	took	לֶקַח	lesson	לוֹקֵחַ	takes
פָּצַע	wounded	פֶּצַע	wound	פּוֹצֵעַ	wounds
קָרַע	tore	קֶרַע	tear	קוֹרֵעַ	tears
קָטַל	exterminated	קֶטֶל	killing	קוֹטֵל	exterminates
קָצַף	raged	קֶצֶף	foam	קוֹצֵף	rages
גָּזַל	robbed	גֶּזֶל	robbery	גּוֹזֵל	robs
מָרַד	rebelled	מֶרֶד	rebellion	מוֹרֵד	rebels
טָרַף	devoured	טֶרֶף	prey	טוֹרֵף	devours

[a]Verbs are in the third person, singular and masculine [except when noted as feminine (f)].

Orthographically Continuous Roots[a]

Primes				*Targets*	
Inflectional		*Derivational*			
מַחְשֵׁב	computer	מְחַשֵּׁב	computes	מַחְשֵׁבִים	computers
רֶכֶב	vehicle	רָכַב	rode	רְכָבִים	vehicles
נֶפֶשׁ	soul	נָפַשׁ	rested	נְפָשׁוֹת	souls
עֶבֶד	slave	עָבַד	worked	עֲבָדִים	slaves
סַבָּל	porter	סָבַל	suffered	סַבָּלִים	porters
מִשְׂחָק	game	מְשַׂחֵק	plays	מִשְׂחָקִים	games
מִגְדָּל	tower	מְגַדֵּל	grows (tr)	מִגְדָּלִים	towers
מִכְסֶה	cover	מְכַסֶּה	covers	מְכָסִים	covers
שֶׁקֶל	Shekel	שָׁקַל	weighed	שְׁקָלִים	Shekels
גֶּבֶר	man	גָּבַר	overcame	גְּבָרִים	men
קֶשֶׁר	knot	קָשַׁר	tied	קְשָׁרִים	knots
גָּדֵר	fence	גָּדַר	fenced	גְּדֵרוֹת	fences
מִקְדָּשׁ	temple	מְקַדֵּשׁ	sanctifies	מִקְדָּשִׁים	temples
פֶּרַח	flower	פָּרַח	blossomed	פְּרָחִים	flowers
שֶׁבֶר	fraction	שָׁבַר	broke	שְׁבָרִים	fractions
מָסָר	message	מָסַר	handed over	מְסָרִים	messages
תֶּפֶר	stitch	תָּפַר	sewed	תְּפָרִים	stitches
רֶגֶשׁ	emotion	רָגַשׁ	was excited	רְגָשׁוֹת	emotions
אֲבְטָחָה	security	אִבְטַח	secured (f)	אֲבְטָחוֹת	securities
שַׁמָּשׁ	attendant	שִׁמֵּשׁ	attended	שַׁמָּשִׁים	attendants
מַשְׁדֵּר	transmitter	מְשַׁדֵּר	broadcasts	מַשְׁדְּרִים	transmitters
מַסְרֵק	comb	מְסָרֵק	combs	מַסְרְקִים	combs
פֶּתַח	entrance	פָּתַח	opened	פְּתָחִים	entrances
צֶמַח	plant	צָמַח	grew (intr)	צְמָחִים	plants

[a]Verbs are in the third person, singular and masculine [except when noted as feminine (f)].