

Lexical Morphology and Lexical Access

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Research on morphology in word recognition has been plagued by conflicting results (McQueen & Cutler, 1998, give a recent review). Some findings suggest that words are accessed as full forms, while others suggest that words are accessed in terms of their component morphemes. The answer may lie in the properties of the affixes themselves: Kiparsky's (1982) Lexical Phonology and Morphology assigns affixes in English to different "levels" of attachment, based on their productivity, order of attachment, and phonological interaction with roots. We present data suggesting that productive, phonologically neutral, semantically transparent "Level 2" suffixes are "decomposed" for analysis in some cases, but that words with idiosyncratic, structure-changing, semantically opaque "Level 1" suffixes are not. © 1999 Academic Press

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Historically, two competing models have characterized morphological structure during lexical access. Taft and Forsters (1975) "Affix-Stripping" model, argues that listeners must break words into their component morphemes for analysis, and that each morpheme is listed individually in the lexicon. Butterworth's (1983) Full Listing Hypothesis maintains that words are available for recognition in the lexicon with their morphology complete.

More recently, several mixed models have been proposed. For example, Marslen-Wilson, Tyler, Waksler, and Older (1994) and Wurm (1997) have maintained that decomposition is more likely when the relationship between an affixed word and its root is semantically transparent. Ito, Sugioka, and

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Hagiwara (1996) suggested that only regular prefixes are attached (and therefore decomposed) by rule. Alternatively, Colé, Segui, and Taft (1997) suggested a modification of the full-listing model where suffixed words and their roots compete based on lexical frequency.

We introduce a mixed model loosely based on Kiparsky's (1982) Lexical Phonology and Morphology, which divides affixes into different levels of attachment based on proximity to the root and interaction with phonological processes (including stress assignment). More idiosyncratic, structure-changing derivational affixes are attached at the earliest levels of composition (Level 1), and more productive, phonologically neutral derivational affixation takes place at Level 2 (Katamba 1990). The motivation for this arrangement was initially distributional: a Level 1 affix cannot be attached to a stem containing a Level 2 affix, although a Level 2 affix can be attached to a stem containing a Level 1 affix, (e.g., *grievousness*). Both levels of affixes may be attached to stems containing other affixes of the same level, but only Level 1 affixes can attach to bound stems (Mohan 1986). In addition, there are phonological processes that apply to words containing Level 1 affixes but do not apply to those with Level 2 affixes.

We test the hypothesis that readers access words with Level 1 and Level 2 morphology differently: suffixed words are stored in the lexicon with Level 1 morphology intact, so morphological decomposition takes place only when words carry Level 2 suffixes.

EXPERIMENT 1

We used a lexical decision paradigm adapted from Taft (1979) and Bradley (1979): participants decided whether a string of letters is a word and responded accordingly with a button-press. This paradigm is grounded in the assumption that frequency effects in lexical decision primarily reflect lexical access time. We manipulated the root and whole-word frequency values (Kucera & Francis, 1967) of suffixed forms. (Root frequency is the total frequency count of all forms including this root). Thus, there were two types of stimuli pairs. In Root-Contrast pairs, words have very different root frequencies, but are matched for whole-word frequency. For example, in the pair *worthless/seamless*, *worth* is much more frequent than *seam*, but *worthless* and *seamless* are equally frequent. Thus, all other things being equal, decision times should be equivalent if the words are accessed in their suffixed form, but *worthless* should be faster than *seamless* if the words are accessed by their roots. In Whole-Word (WW) Contrast pairs, whole-words vary in frequency, but are matched for root frequency. For example, in *endless/pointless*, *endless* is much more frequent than *pointless*, but *end* and *point* are about equally frequent.

These pairs were constructed using suffixed words with three different suffixes. The first was the Level 2 suffix, *-less* and the Level 1 suffixes:

-ity and *-ation*. We included both *-ity* and *-ation* to examine the effect of phonological change within Level 1 suffixation: for the majority of *-ity* words, suffixation induced a segmental phonological change (i.e. trisyllabic shortening) to the root, such as in *severe/severity*. However, none of the *-ation* stimuli in this study involved a segmental change, though there was a stress shift from a monosyllabic root to the suffix in some cases, for example *tax/taxation*.

Bradley (1979) found that in words containing Level 2 suffixes, there was a frequency-based difference in response-time for the Root-Contrast pairs. For the WW-Contrast pairs, there was no frequency effect. The fact that root frequency contributed to RT suggests that these words were decomposed. For words with Level 1 suffixes, Bradley (1979) found a frequency effect for WW-Contrast pairs, but not for Root-Contrast pairs. Because *only* Whole-word frequency influenced RT, there is no evidence of decomposition.

Our results should be similar to those of Bradley (1979): for *-less* pairs, there should be a frequency effect for Root-Contrast pairs. For *-ity* and *-ation* pairs, there should be a frequency effect for the Whole-Word Contrast pairs. This pattern would indicate that words with different levels of suffixation are accessed differently.

Method

Materials. Eight Root-Contrast and eight WW-Contrast pairs using *-less* and *-ity* were selected. Due to frequency matching constraints, only six root-contrast and only six WW-contrast pairs were designed using *-ation*. Different roots were used with each suffix. Frequency contrasts were maximized: root frequency contrasts were generally larger than WW contrasts, but this was consistent across the three suffixes. Log frequency means for each set are given in Table 1.

All pairs were matched as closely as possible for number of characters (mean length 9.2). Some words were included in more than one stimulus pair for a given suffix, again due to frequency matching, though each word was presented only once. Included in the stimulus list were 140 nonsuffixed pronounceable nonwords (70 of which were nine characters long to match the mean length of the suffixed words) and 70 monomorphemic real words.

Design and procedure. Targets were presented on a computer screen. Before each one, a visual warning signal of three asterisks appeared. This remained for 500 ms, then the visual target word appeared. Participants made a lexical decision by pressing one response key for real words, and another for nonwords. The target word disappeared upon response.

TABLE 1
Mean Log Frequency for Stimuli in Experiment 1

Suffix	High frequency roots	Low frequency roots	High frequency whole words	Low frequency whole words
<i>-less</i>	2.36	1.32	1.29	0.15
<i>-ity</i>	2.32	1.16	1.82	0.60
<i>-ation</i>	2.23	1.03	1.48	0.26

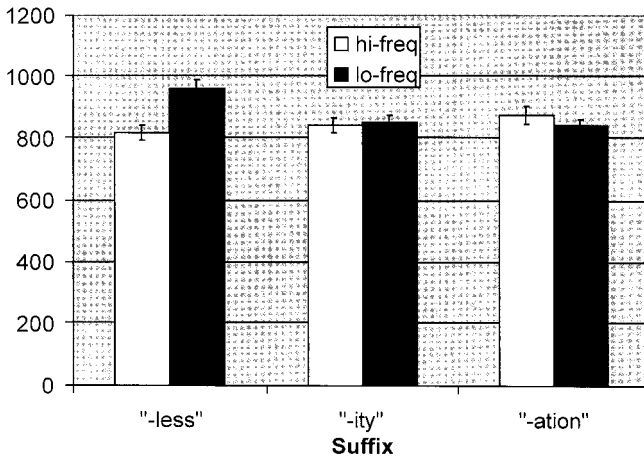


FIG. 1. Mean Response times for Root-Contrast Pairs in Experiment 1.

Participants. Fifty Ohio State University students participated in the experiment for course credit or a nominal fee. All were native speakers of English with normal or corrected-to-normal vision.

Results

Mean RTs across participants and items were calculated for each suffix and are shown in Figs. 1 and 2. Incorrect responses were removed from the data set prior to analysis (5.2% of responses to *-less* words, 5.4% to *-ity* words, and 5.6% to *-ation* words). Participant and item means were submitted to a 2 (Whole-Word or Root-Contrast pair) \times 2 (high or low frequency) \times 3 (suffix group) ANOVA. By participants,¹ there was a three-way suffix \times pair type \times frequency interaction, [$F1(2, 98) = 8.5, p < .05; F2 < 1.0$] (there was also a main effect of suffix group [$F1(2, 98) = 13.4, p < .05; F1(2, 76) = 3.07, p < .052$] and of frequency [$F1(1, 49) = 42, p < .05; F2(1, 76) = 7.22, p < .05$]). To explore the nature of this interaction, *t* tests were performed on each set of Root-Contrast and Whole-Word Contrast pairs.

-less words. In Root-Contrast pairs: words with high-frequency roots were accessed more quickly [$t1(49) = -2.06, p < .05$ though not by items, $t2(14) = -1.66, p = .11$]. Whole-Word Contrast pairs showed the same pattern of results, [$t1(49) = -2.14, p < .05$ though not by items, $t2(14) = -1.67, p = .11$]. In these words, both Root and Whole-Word frequency affected RT.

¹ While we report the ANOVA using the items means for both experiments, its interpretation is problematic because the same words were sometimes used in Root and WW-Contrast pairs for a given suffix.

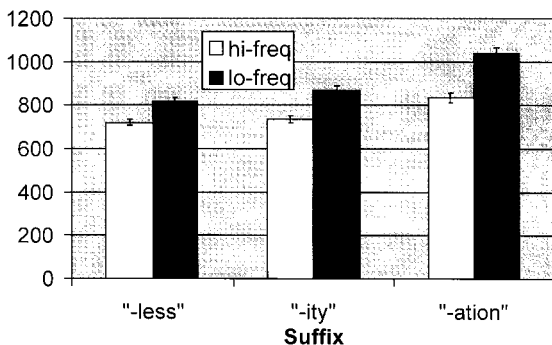


FIG. 2. Response times for Whole Word-Contrast Pairs in Experiment 1.

-ity and -ation words. No frequency effect was observed in Root-Contrast pairs, but a frequency effect was evident in Whole-Word Contrast pairs [for *-ity*, $t_1(49) = -2.49$, $p < .05$; $t_2(14) = -1.99$, $p = .06$. For *-ation*, $t_1(49) = -2.98$, $p < .05$; $t_2(10) = -1.99$, $p = .06$]. Only Whole-Word frequency affected RT to these words.

Discussion

Consistent with Bradley (1979), these results suggest that suffixes of different lexical levels may indeed have different status in the lexicon, as predicted by the level-based model. In words with the Level 2 suffix, root frequency influenced recognition time, indicating that the roots themselves are accessed in these cases. However, in words with the Level 1 affixes, root frequency did not affect RT. It was only the frequency of the full suffixed forms that affected response times, indicating that the full form is the only one the reader is accessing.

EXPERIMENT 2

Kiparsky (1982) separated affixes into level of attachment based on proximity to the root and interaction with phonological processes. While there is this linguistic motivation to group a variety of derivational suffixes into these levels, it is an open question whether Level 2 affixes, as a group, will be decomposed like *-less* above. Experiment 2 investigated response times to three groups of suffixed words, instead of examining many pairs of words with the same suffix. The first group of words had the Level 2 suffixes, *-ship*, *-ness*, *-less*, *-hood*, *-er*. The second group had Level 1 suffixes, *-ous*, *-ory*, *-ity*, *-ian*, *-ation*, but no segmental phonological change in the root. The third group included words with a variety of Level 1 suffixes (*-ous*, *-ity*, *-ian*, *-ary* or *-ion*) that did induce a phonological change in the root.

TABLE 2
Mean Log Frequency for Stimuli in Experiment 2

Suffix	High frequency roots	Low frequency roots	High frequency whole words	Low frequency whole words
Level 2	2.24	1.00	1.66	0.10
Level 1/no phonological change	2.22	1.21	1.77	0.99
Level 1/with phonological change	2.34	1.23	1.77	0.96

Method

Eight Root-Contrast and eight WW-Contrast pairs were designed for each group. No suffix was used more than three times in a contrast set, and suffixes were matched across the two contrast sets in each suffix group. Frequency means for each set are given in Table 2.

The design, filler trials, and procedure were exactly as in Experiment 1, and participants were 44 Ohio State University students with qualifications as in Experiment 1.

Results and Discussion

Mean response times across participants and items were calculated for each suffix and are displayed in Figs. 3 and 4. Incorrect responses were removed from the data set prior to analysis (2.0% of Level 1 words; 2.1% of Level 2 words). A 2 (Whole-Word or Root Contrast pair) \times 2 (high or low frequency) \times 3 (suffix group) ANOVA revealed a pair type \times frequency interaction, by participants only [$F(1, 86) = 15.1, p < .05$; $F(1, 84) = 2.2, p > .10$], with a frequency effect for Whole-Word Contrast pairs, but not for Root-Contrast pairs. This pattern was confirmed by *t* tests on each

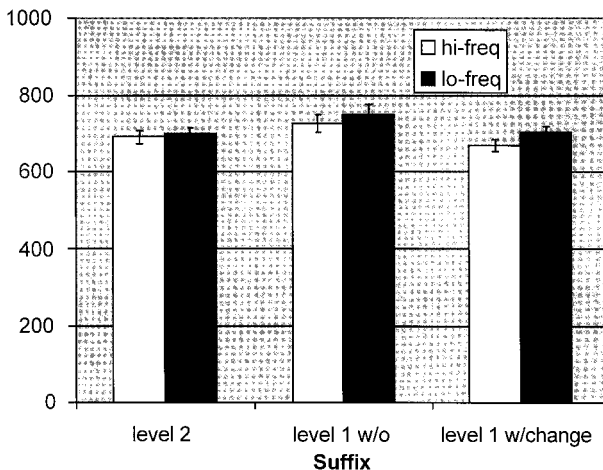


FIG. 3. Mean Response times for Root-Contrast Pairs in Experiment 2.

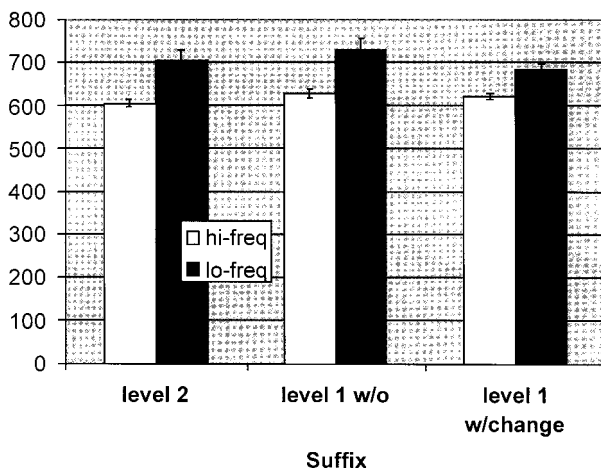


FIG. 4. Mean Response times for Whole Word-Contrast Pairs in Experiment 2.

set of Root-Contrast and Whole-Word Contrast pairs ($\alpha = .05$) [For Whole-Word Contrast Pairs: For Level 2, $t_1(43) = -3.86$, $p < .05$; $t_2(14) = -1.89$, $p = .07$. For Level 1 without change, $t_1(43) = -3.785$, $p < .05$; $t_2(14) = -1.92$, $p = .07$. For Level 1 with change, $t_1(43) = -2.77$, $p < .05$; $t_2(14) = -1.687$, $p = .11$]. (Though the three pairs of *-less* words included in this group showed a pattern of results similar to those in Experiment 1).

In contrast with the results of Experiment 1, these results did not support the claim that Level 1 and Level 2 suffixes have different lexical status. Root frequency did not impact response time to any of these words, suggesting that the roots themselves were not accessed, but each suffixed word was accessed from the lexicon as its own full form. Evidence for morphological decomposition of only Level 2-suffixed words that was clear with *-less* in Experiment 1 was not evident with a variety of suffixes.

GENERAL DISCUSSION

In two experiments, we tested the hypothesis that morphological level determines whether a suffixed word is decomposed for lexical access. While this hypothesis was supported in Experiment 1, the hypothesis cannot, by itself, account for the pattern of results in Experiment 2, where we examined a larger set of affixes from each level. We believe that some Level 2 affixes, such as *-less*, do require decomposition. However, other Level 2 affixes may not.

How might a listener acquiring these morphemes learn to organize the lexicon so that *some* Level 2 suffixes induce decomposition? Perhaps we are sensitive to certain properties of some suffixes which suggest they be stored in the lexicon like individual words. For example, the lack of phonological

TABLE 3
Mean Semantic Transparency Rating for Each
Suffix

	Suffix	Mean semantic transparency rating
Level 1	<i>-ary</i>	5.380
	<i>-ation</i>	6.674
	<i>-ian</i>	6.510
	<i>-ion</i>	6.154
	<i>-ity</i>	5.964
	<i>-ory</i>	5.743
	<i>-ous</i>	6.264
Level 2	<i>-er</i>	6.600
	<i>-hood</i>	6.535
	<i>-less</i>	5.708
	<i>-ness</i>	6.536
	<i>-ship</i>	6.095

effects in words that include the suffix may be an initial cue to its lexical status. Level 2 suffixes, as discussed earlier, never induce a phonological change in roots. Second, the distributional properties of the suffix might become apparent to the learner: Level 2 suffixes are able to appear further away from the root than Level 1 suffixes. Third, the productivity of a suffix may be a further cue. Some Level 2 suffixes like *-ness* are consistently more productive than other Level 2 suffixes used in Experiment 2, and also more productive than Level 1 suffixes like *-ity*, if we calculate productivity using Baayen's (1989) method (as cited in Lieber, 1992).

Another property of suffixed words that may give cues to lexical status is the semantic transparency of these words (Marslen-Wilson et al., 1994, for example, used this as a variable). In order to examine this factor, we asked 20 Ohio State University students to judge the semantic relatedness of each of the suffixed words (from the earlier experiments) to the corresponding root word. Additional suffixed words were included so that ten words with each suffix were rated; filler pairs were included as well. The participants rated the semantic relatedness of the pairs on a scale from 1 (unrelated) to 8 (very related); mean ratings for each suffix are in Table 3.

While the level 2- suffixed words (*-ship*, *-ness*, *-less*, *-hood*, *-er*) had generally higher ratings than those with Level 1 suffixes (*-ous*, *-ory*, *-ity*, *-ion*, *-ian*, *-ation*, *-ary*) these two groups were not significantly different. Interestingly, *-less*, which showed evidence of decomposition in Experiment 1, had one of the lowest semantic transparency ratings. Thus, semantic transparency itself cannot explain these results, but its interaction with some of the other factors described above may help listeners determine how to treat specific suffixes.

Phonological interaction, distribution, productivity, and semantic transpar-

ency, may all encourage language learners to store some Level 2 suffixes, like *-less*, separately from roots, and decompose them when they are encountered. Words with other suffixes, however, would be stored as whole-words because these suffixes do not exhibit the motivating properties for decomposition.

The lexical status of an affix depends on the properties of the affix itself, and how it interacts with roots. Lexical phonology and morphology makes an initial division, between affix types. The results described above suggest that while Level 1 morphology is intact in the lexicon, Level 2 morphology may in some cases be separated from its root. This model of the lexicon requires the integration of several types of information about an affix for effective storage and access.

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