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FROM SPEECH PERCEPTION TO MORPHOLOGY: AFFIX ORDERING REVISITED

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This article presents corpus and experimental evidence in support of a parsability-based account of affix ordering in English: an affix that tends to be easily parsed out during speech perception should not occur inside an affix that does not. This generalization holds both at the affix level and the word level. At the affix level, this maxim, when combined with an understanding of the role of frequency and phonotactics in morphological processing, can account for the patterns generally attributed to level ordering. At the word level, it can explain the so-called dual-level behavior of some affixes—an affix may resist attaching to a complex word that is highly decomposable but be acceptable when it attaches to a comparable complex word that favors the direct access route in speech perception. Only a parsing account can afford this set of phenomena a unified explanation.*

INTRODUCTION. One of the most debated problems of English morphology is that of stacking restrictions amongst derivational affixes. Of the many potential combinations of affixes, only a very small proportion are actually attested. Many attempts to account for apparent restrictions on affix ordering have invoked some form of the AFFIX-ORDERING GENERALIZATION (Siegel 1979). The basic claim of the affix-ordering generalization is that affixes can be divided into two sets: level 1 and level 2. Level 1 affixation occurs prior to level 2 affixation, and so no level 1 affix can attach outside of any level 2 affix (hence **-ness-ic*, **-less-ity*, and so on).

I argue here that early accounts of affix ordering were overly restrictive and drew the line at the wrong level of abstraction. But more recent work, which has discarded the idea that there are any restrictions on ordering (beyond selectional restrictions), misses a number of important generalizations. Many facts about English stacking restrictions can be predicted if we reduce the problem to one of parsability. This can capture not only the range of generalizations about English stacking restrictions but also a large number of systematic, word-based exceptions to these generalizations.

In a paper widely cited as responsible for disproving the affix-ordering generalization, Fabb (1988) argues against a stratificational approach to affix ordering. He demonstrates that the affix-ordering generalization fails to rule out a large number of affix combinations, which nonetheless do not occur. He argues that affix ordering is constrained only by selectional restrictions:

all but a few non-occurring pairs of suffixes can be ruled out solely by a combination of selectional restrictions, of which one of the most extensive in its effects is a restriction against attachment to an already suffixed word. (Fabb 1988:538)

One of Fabb's observations, then, is that there seem to be a large number of affixes that do not attach to already affixed words. This observation, I argue, holds the key to understanding restrictions on affix ordering in English. Many affixes are sensitive to internal structure in potential bases. While some affixes basically tolerate no internal structure, others will tolerate structure to some minimum degree. The degree of internal

* This article is based on chapter 9 of my Northwestern University dissertation (Hay 2000). For comments and discussions I am grateful to Harald Baayen, Mary Beckman, Andrew Carstairs-McCarthy, Brian Joseph, Chris Kennedy, Janet Pierrehumbert, Ingo Plag, Lance Rips, two anonymous referees, and audiences at Northwestern University, Victoria University of Wellington, and the affix ordering workshop at Max Planck Institute, Nijmegen.

structure tolerated by an affix is not determined by selectional restrictions, but, rather, by how much structure that affix itself creates. Phrased in terms of processing, *an affix that can be easily parsed out should not occur inside an affix that cannot*. Details on how to operationalize the notion of ease of parsing are provided below.

I demonstrate that this maxim, when combined with an understanding of the role of frequency and phonology in morphological processing, accounts neatly for restrictions on affix ordering in English. We do not find any cases in which an affix attaches only to forms that are maximally decomposable, and not to forms that are relatively opaque, though there are large numbers of cases where the opposite holds true. The range of results put forward here cannot be accounted for by the classical affix-ordering account, nor by any account involving selectional restrictions.

The account presented here takes as its starting point some fundamentals of speech perception. Before turning to affix ordering, then, I will outline some basic assumptions about the nature of morphological processing.

1. MORPHOLOGICAL PROCESSING. This article assumes a dual-route access model of morphological processing. Morphologically complex words may be accessed either by a decomposed access route (e.g. *climber* may be accessed via the representations for *climb* and *-er*), or a nondecomposed whole-word access route (e.g. *climber*); see Baayen 1992, Frauenfelder & Schreuder 1992, Caramazza et al. 1988, Wurm 1997. These two routes compete during access and whichever route is fastest on a particular encounter dominates.

How do we know, for any given word, whether a decomposed access route or a whole-word route is likely to dominate? Obviously this will depend on numerous factors we cannot predict, such as the lexicon of the person encountering the word, and the specific context in which they are encountering it. But there are some factors we know facilitate decomposition. This article discusses just two—the phonotactics across the morpheme boundary, and the relative frequency of the derived form and the base.

1.1. PHONOTACTICS AND MORPHOLOGICAL DECOMPOSITION. Language-specific phonotactic patterns have been shown to affect various aspects of speech perception. Importantly, they appear to be one cue used in the segmentation of speech. Saffran et al. 1996a shows that, when presented with a string of nonsense words, eight-month-old infants are sensitive to transitional probabilities in the speech stream. This is also true of adults (Saffran et al. 1996b). This result suggests that sensitivity to probabilistic phonotactics plays a role in the segmentation of speech. McQueen 1998 and van der Lugt 1999 provide further evidence that phonotactics are exploited for the task of locating word boundaries. Mattys et al. 1999 demonstrates that English-learning infants are sensitive to differences between inter- and intra-word phonotactics. In addition, computer models demonstrate that probabilistic phonotactics can significantly facilitate the task of speech segmentation (Brent & Cartwright 1996, Cairns et al. 1997, Christiansen et al. 1998).

Recent results reported by Pitt and McQueen (1998) and Vitevitch and Luce (1998) suggest that knowledge of probabilistic phonotactics must be represented independently of specific lexical entries. In brief, a phonological prelexical processor appears to be sensitive to distributional cues—positing boundaries inside phoneme transitions that are unlikely to occur word internally and speeding access to lexical entries that are well aligned with those boundaries.

This has important implications for morphologically complex words. If the phonology across the morpheme boundary is highly unlikely to occur morpheme internally, then the preprocessor is likely to posit a boundary, and so advantage the decomposed route. Indeed, Hay (2000) trained a connectionist network to recognize word boundaries in strings of monomorphemic words. When the network was tested on multimorphemic words, it correctly identified 89% of word-internal morpheme boundaries. That is, because many morpheme boundaries resemble word boundaries, it would be impossible for a prelexical processor that posits word boundaries not to also have some effect on morpheme boundaries.

Pipeful is an example of a word that contains a low-probability phonotactic transition. The /pf/ transition is highly unlikely to be found within a simple word, and so the processor will hypothesize the presence of a boundary. The direct route will be disadvantaged in comparison with the decomposed route because it does not align with hypothesized boundaries.

Indeed Hay et al. 2002 and Hay 2000 demonstrate experimentally that English speakers do use phonotactic information to segment words into component morphemes. This is shown both for nonsense words (*strinthy*, for example, is treated as more morphologically complex than *strimpy*), and for real words (subjects rate *pipeful* as more complex than *bowful*).

Phonotactics therefore appear to provide one type of evidence about the likelihood that a word will be decomposed during access. The evidence outlined above suggests that morphologically complex forms with low-probability phonotactics across the morpheme boundary are more likely to bias the decomposed access route than forms with fully legal phonotactics.

1.2. RELATIVE FREQUENCY AND MORPHOLOGICAL DECOMPOSITION. There is a large body of evidence supporting the claim that words compete, resulting from a variety of experimental tasks (McQueen et al. 1994, Norris et al. 1995, Vitevitch & Luce 1998). Lexical competition is therefore incorporated into most current models of speech perception, including MERGE (Norris et al. 2000), TRACE (McClelland & Elman 1986), NAM (Luce & Pisoni 1998), SHORTLIST (Norris 1994), and ART (Grossberg 1986).

One factor that is highly relevant to lexical competition is lexical frequency. Frequent words are accessed faster. In speech perception, ambiguous stimuli tend to be identified as the higher frequency member of the pair (Connine et al. 1993), less acoustic information is required to identify high-frequency words than low-frequency words (Grosjean 1980), and lexical decision times are negatively correlated with lexical frequency (Balota & Chumbley 1984). Frequency also affects speech production: High-frequency words are accessed more quickly, produced more fluently, undergo greater reduction, and are less prone to error (see Whalen 1991, Levelt 1983, Dell 1990, Wright 1997, Hay et al. 1999).

For both the decomposed access route and the whole-word access route, then, we expect lexical frequency to affect speed of access. If the derived form is more frequent than the base it contains (*illegible* is more frequent than *legible*), then the whole-word route will have an advantage. If the derived form is less frequent than the base it contains (*illiberal* is less frequent than *liberal*), then the decomposed route will be advantaged. Note that this generalization involves relative frequency and not absolute frequency. While many have claimed that high-frequency forms are not likely to be decomposed and are prone to semantic drift (see Modor 1992, Baayen 1992, 1994,

Baayen et al. 1997, Bybee 1988, 1995), Hay (2001) argues that this emphasis on absolute frequency is misguided.

Derived forms that are more frequent than their bases are rated less complex than derived forms that are less frequent than their bases, and, in speech production, they contain fewer phonetic cues to juncture. In addition, derived forms that are more frequent than their bases are significantly more prone to semantic drift. High-frequency forms, on the other hand, display no such tendency (Hay 2000, 2001).

2. A PARSING ACCOUNT. In this article I explore the hypothesis that affix-ordering constraints are related to the perception and storage of morphologically complex forms. This account was proposed in Hay 2000, and Plag (2002) has dubbed it COMPLEXITY BASED ORDERING (CBO). CBO claims that affixes likely to be parsed out during perception are restricted from occurring inside affixes less likely to be parsed. This hypothesis is explored in the context of the two factors described above, which provide an index of the inherent decomposability of any given morphologically complex form—the phonotactics across the morpheme boundary, and the relative frequency of the derived form and the base.

Such an account incorporates one of the main insights of lexical phonology—affixes create different boundary strengths, and boundary strength is related to ordering. But CBO extends the insight by moving to an account of boundary strength which is gradient and which is closely tied to decomposability in speech perception. The account relies on the assumption that degrees of parsability exist, such that even different words containing the same affix may contain different degrees of decomposability (*discernment* vs. *government*).

We can view words containing a particular affix as together forming a distribution of varying juncture strengths. *Tasteless*, for example, has a stronger juncture (is more easily decomposable) than *listless*, and these words probably occupy opposite extremes of the *-less* distribution. Similarly, *warmth* is more decomposable than *health*, and these two words tend towards opposite extremes of the *-th* distribution. However, there is (probably) no word affixed in *-th* that is more decomposable than some word affixed in *-less*. That is, these two distributions do not overlap. While *-less* words occupy a range of juncture strengths, and *-th* words occupy a range of juncture strengths, the entire *-less* distribution represents higher levels of decomposability than the entire *-th* distribution. Other affix pairs, however (*-less* and *-ness* for example), may exhibit overlapping distributions. Thus, while the average juncture strength of one affix may be lower than a second, the most decomposable word containing the first affix, may still be more decomposable than the least decomposable word containing the second.

The overall separability of an affix has an effect on any individual word and is a cumulative effect of its level of separability in all words. This leads to a number of predictions. Consonant-initial suffixes, for example, should tend to be more separable than vowel-initial suffixes because they tend to enter into more illegal phonotactic combinations, which leads to increase rates of parsing, and so increases the overall resting activation level of the affix. In addition, consonant-initial affixes in words actually containing illegal phonotactic transitions should be more decomposable than in words without such transitions. The hypothesis that decomposability is related to ordering, together with the above view of decomposability, and the results outlined above about phonotactics and lexical frequency, lead to five specific predictions, which are articulated below.

2.1. HYPOTHESES.

1. The same suffix will be differently separable in individual words depending on the phonotactics. Individual words containing the same suffix will tend to be more decomposable if they contain a low probability phonotactic transition than if they do not (*pipeful* is more decomposable than *bowlfu*).

If a prelexical processor posits boundaries based on phonotactics and speeds access to entries that are well aligned with those boundaries, then words containing low-probability or illegal phoneme transitions will be more likely to be decomposed than words containing the same affix, which exhibit fully legal phonotactics. Evidence suggesting that this is true was summarized in §1.1. Evidence that it affects ordering is given in §4.

2. The same suffix will be differently separable in individual words depending on the frequency. Individual words containing the same suffix will tend to be more decomposable if they are less frequent than their base than if they are more frequent than their base (*discernment* is more decomposable than *government*).

Words that are frequent relative to their bases are prone to whole-word access. Affixes that appear in such words (*government* is more frequent than *govern*) are likely to be less separable than the same affix in words that are less frequent than the bases they contain (*discernment* is less frequent than *discern*). Evidence suggesting that this is true was summarized in §1.2. Evidence that it affects ordering is given in §3 and §4.

Note that the theory also predicts that a word for which the base is much more frequent than the derived form should be more decomposable than a word for which the base is just slightly more frequent than the derived form. What we are really dealing with here is not two classes of words (parsed and not parsed) but a continuum, on which we have placed a relatively arbitrary dividing point for reasons of convenience.¹

3. Suffixes beginning with consonants will tend to be more separable than suffixes beginning with vowels (*-ness* tends to be more separable than *-ess*).

The resting activation level of an affix is a function of how often it has been accessed. Highly frequent, often-utilized affixes will have high resting activation levels. It follows that affixes represented by a large number of words that tend toward decomposition will have higher activation levels than affixes that are represented primarily by words that are prone to whole-word access. That is, the more an affix is used in general, the more likely it is to be used for the access of any particular word. Another way of viewing this hypothesis is that frequency facilitates access. Affixes that are more often used in access are, from the perspective of the processor, more frequent affixes. This, together with hypothesis 1, predicts that suffixes beginning with consonants will tend to be more separable than suffixes beginning with vowels (all other things being equal). Because suffixes beginning with consonants more often form illegal phonotactics across the morpheme boundary, they are likely to be represented by a greater number of individual words highly prone to decomposition than suffixes beginning with vowels. The result is that, even in individual cases where there is no phonotactic violation, consonant-initial affixes are likely to be more readily activated than vowel-initial affixes.

¹ There is no a priori reason why base frequency = derived frequency is the most relevant dividing point, and indeed Hay and Baayen (2002b) argue that such a threshold could be more accurately positioned in a slightly different place. Here I use base frequency = derived frequency as a relatively crude dividing line simply for clarity of exposition and to facilitate hypothesis testing.

As with hypothesis 2, this prediction takes a continuum and chops it in two, purely for reasons of convenience. Affixes vary in terms of the degree of phonotactic juncture they tend to create. Some consonant-initial suffixes create more consistently low-probability junctural phonotactics than others. The same stands for vowel-initial suffixes. And these differences, too, are predicted to be relevant to ordering.² The division between consonant-initial and vowel-initial consonants is simply a convenient place to draw the line and divide the affixes into two sets for the purposes of hypothesis testing.

4. Suffixes represented by a relatively high proportion of words that are less frequent than their bases will tend to be more separable than suffixes represented by a relatively low proportion of words that are less frequent than their bases (-ish tends to be more separable than -ic).

The logic here follows the same path as above. If an affix is represented by a substantial proportion of words that are more frequent than the bases they contain, then the affix itself is not often activated. This should make it, overall, a less separable affix than a comparable affix represented by a strong majority of words that are less frequent than the bases they contain. Ninety-three percent of the monomorphemic bases listed in the CELEX lexical database (Baayen et al. 1995) as affixed with *-ish*, for example, are more frequent than the corresponding derived *-ish* words. Seventy-three percent of bases of *-ic* are more frequent than the derived *-ic* words. Thus if we compare two words that are otherwise matched for frequency, we expect a word containing *-ish* to be more decomposable than a word containing *-ic*. *Grayish* and *scenic*, for example, have roughly similar frequency profiles (per 17.4 million: *gray*: 32, *grayish*: 1542, *scene*: 30, *scenic*: 1995). However because the affix in the first word has a higher resting activation level than the affix in the second word, we expect *grayish* to be more decomposable than *scenic*.

5. More separable affixes will occur outside less separable affixes.

Hypothesis 5 is the fundamental hypothesis under investigation in this article. Together with the other four hypotheses, it predicts that we should find effects of complexity-based ordering at both the affix level and the word level. At the affix level, I argue below, the combined hypotheses can account for the set of phenomena that motivated level ordering. At the word level, I argue in §§3 and 4, it accounts for a large number of word-based 'exceptions' to level-ordering phenomena—cases in which an affix may attach to just a subset of words containing a second affix, namely, those with low levels of decomposability.

It is important to note that I do not wish to argue that phonotactics and frequency are the only factors that influence decomposition. There are likely to be many others, including stress pattern, semantic and phonological transparency, and syntactic context.

² Hay and Baayen (2002a) calculate the average probability of the phonotactic junctures created by 52 English suffixes—high-probability junctures are phoneme transitions that are highly likely to occur inside monomorphemic words, low-probability junctures are unlikely to occur inside monomorphemic words. The probabilities for average junctures created by the consonant-initial suffixes ranged from .000016 (*-hood*) to .000926 (*-some*). The probabilities for the vowel-initial suffixes ranged from .000155 (*-oid*) to .009004 (*-ive*). There were two vowel-initial affixes (*-oid* and *-eer*) that tended to create worse (i.e. lower-probability) phonotactics across the morpheme boundary than the consonant-initial affix that created the best phonotactics (*-some*). This prediction, then, is a crude generalization that follows from a more complex set of overlapping probability distributions, and the generalization as stated has several exceptions. But the division between consonant-initial and vowel-initial consonants is a very convenient place to draw the line and divide the affixes into two sets for the purposes of hypothesis testing.

Hypothesis 5 predicts that any factor that influences decomposition will also influence ordering. I investigate just two factors here. They are not necessarily the most important, but they are sufficiently well understood that we can use them to begin to untangle the unarguably intricate relationship between complexity and ordering.

The most common account of restrictions on affix-level cooccurrences is level ordering, which claims that affixes attached at level 1 cannot attach outside affixes attached at level 2. If the account proposed here is consistent with the set of facts generally attributed to level ordering, then hypotheses 3 and 4, together with hypothesis 5, suggest that affixes which are generally analyzed as level 1 and level 2 affixes should show different characteristics from one another. We expect level 2 affixes to enter more often into phonotactic violations (i.e. to begin with consonants), and we expect them to be represented by many words that have frequency profiles that facilitate decomposition. If this is the case, then no explicit stratification is required. This would lead level 2 affixes to be generally more separable than level 1 affixes, and so (by hypothesis 5) would predict that they should occur outside level 1 affixes. I therefore now turn to an exploration of the phonotactic and frequency characteristics of English affixes.

2.2. FREQUENCY AND PHONOTACTIC PROFILES OF LEVEL 1 AND 2 AFFIXES. In this section I demonstrate that affixes commonly categorized as level 1 tend to have attributes that would encourage whole-word access, whereas affixes categorized as level 2 tend to have attributes that would facilitate parsing. This does not constitute an endorsement of the division into two levels: the division is stipulative and nonexplanatory, and is in any case highly questionable (see Fabb 1988, Plag 1996). I argue at length in this article that it is not a necessary or desirable division. It is, however, useful to explore the affixes traditionally assigned to each of these classes as a first step towards investigating the plausibility of a parsing account. Minimally, we expect CBO to be able to account for the set of facts generally attributed to level-ordering. To do this, I explore the characteristics of a set of affixes analyzed by Hay and Baayen (2002b). Hay and Baayen calculate the productivity and frequency characteristics of a range of English suffixes, but here I analyze only those for which a relatively clear consensus as to their level has emerged in the literature (see Siegel 1979, Aronoff 1976, Kiparsky 1982, Selkirk 1982, Fabb 1988, Szpyra 1989). Giegerich (1999) provides a thorough overview discussion of the level status of individual affixes and highlights the apparently dual nature of many affixes.

Affixes not much discussed in the literature, of unclear status, or commonly regarded as having dual membership, are omitted from the analysis. The affixes analyzed are listed in 1.

- (1) a. Level 1: -al, -an, -ary, -ate, -ese, -ette, -ian, -ic, -ify, -ity, -or, -ory, -ous, -th
- b. Level 2: -age, -dom, -en, -er, -ful, -hood, -ish, -less, -let, -like, -ling, -ly, -most, -ness, -ship, -some

PHONOTACTICS. These two lists reveal that level 1 affixes more often tend to begin with vowels than do level 2 affixes. Significantly more consonant-initial suffixes occur at level 2 (Fisher exact test, $p < .001$).³ The difference is so marked, in fact, that Raffelsiefen (1999) argues that the true distinction among English suffixes should be drawn between vowel-initial and consonant-initial suffixes.

³ The Fisher exact test is very similar to a chi-square, but more appropriate in cases that include cells with very few observations (i.e. less than five, as is the case here).

As outlined above, phonological transitions appear to be used in online morphological parsing, and so affect a word's compositionality. Words that contain phonotactic violations are more likely to favor the parsing route and remain robustly decomposed than words containing no such violations. The nature of English is such that most low-probability or illegal junctures involve clusters of consonants. The likelihood of a word with a consonant-initial suffix containing a phonological violation across the morpheme boundary in English is much higher than the likelihood of a word with a vowel-initial suffix containing a violation. Words with consonant-initial suffixes should therefore tend to be more decomposed.

Consider now the following excerpt from Plag (1996), in which he argues that general semantic factors may rule out a large number of affix combinations in English.

It is the oddness of the denotation and not of the morphological form that makes *kafkaesquism* a presumably unacceptable derivative. Parallel arguments hold for putative derivatives involving other adjectival suffixes, consider *?girlishism*, *?peacefulness*, *?wholesomeism*. Factors like blocking may additionally be involved (as always), as can be seen with *?helpfulness*, which is probably blocked by *altruism*.

(Plag 1996:794)

While blocking and semantic unlikelihood may well be at play in the examples Plag lists (on the importance of blocking see also Aronoff 1976 and Kiparsky 1983), there is also an independent reason why such forms should tend to be dispreferred—the phonotactics lead to an unhelpful parse. Consider the behavior of the processor on encountering the form *helpfulness*. The phonotactics across the first boundary (together with an overall high rate of parsing of *-ful*) will lead to a decomposition hypothesis: *help#ful*. The suffix *-ism*, however, does not have properties that would lead it to be as easily parsed out. A prelexical processor, then, is likely to parse the word with a single boundary: *help#fulness*. Hardly a helpful parse in terms of recovering the semantics.

The optimal arrangement of suffixes would be one in which affixes favoring whole-word access occurred inside of affixes favoring decomposition. Or, even more generally, affixes favoring decomposition should not be particularly sensitive to the internal structure of a word, but affixes favoring whole-word access should disfavor words with internal structure.

Phonotactics, however, is not the only factor which influences the likelihood of parsing. A second factor is frequency.

FREQUENCY. Hay and Baayen (2002b) argue that parsing rates causally influence the productivity of affixes. We calculated statistics for individual affixes which reflect the frequency and likelihood that the affix is likely to be parsed in perception, based on the frequency characteristics of the words that contain it.

Based on relative frequency ratios, we calculate, for any given affix, in how many different words the affix is likely to be parsed.⁴ For example, *-ment* is probably parsed in *discernment* (because *discern* is much more frequent than *discernment*), whereas it is probably not parsed out in *government* (because *government* is more frequent than *govern*). So the word *discernment* would contribute to this figure but the word *government* would not. We also calculated the total number of tokens containing the affix that are likely to be parsed (i.e. the sum of the words prone to parsing, each weighted

⁴ Hay and Baayen motivate a **PARSING THRESHOLD** of how frequent a base should be, relative to the derived word, in order for the word to be prone to parsing. These calculations are not based simply on whether a base is more or less frequent than the base, but are based on relative frequency, in relation to the proposed parsing threshold. See Hay & Baayen 2002b for details.

by its lexical frequency). For each affix, parsing ratios were also calculated. A parsing ratio indicates the proportion of types (the type-parsing ratio) or tokens (token-parsing ratio) containing an affix that are likely to be parsed. For example, if an affix was represented only by words unlikely to be parsed, the type-parsing ratio would be 0. If it was represented only by words likely to be parsed, the type-parsing ratio would be 1. The higher the type-parsing ratio, the greater the proportion of types that are prone to parsing.

For affixes that are highly separable, and highly prone to parsing, all four of these calculations are likely to be high. For affixes not prone to parsing and which are prone to relexicalization, these calculations will be low. We demonstrated that these calculations correlate well with different aspects of morphological productivity. In addition to the parsing statistics, I therefore also show here two measures of productivity—the number of words containing the affix that are encountered in the corpus just once (the hapaxes: V1), and the hapax-conditioned degree of productivity *P* (Baayen & Lieber 1991, Baayen 1992), which calculates the likelihood, given we are encountering a new word containing a particular affix, that that word would have been productively coined. Table 1 shows the average figures calculated by Hay and Baayen for affixes generally classified as level 1 and level 2. These figures demonstrate that, by all of these frequency-based measures, level 1 affixes are predicted to be markedly less decomposable and productive than level 2 affixes. Thus, both the phonotactic and the frequency profiles of level 1 and level 2 affixes predict that level 2 affixes tend to be prone to parsing whereas level 1 affixes are not.

	LEVEL 1 AFFIXES	LEVEL 2 AFFIXES
Average number of types parsed	34.64	143.81
Average type-parsing ratio	0.3	0.61
Average number of tokens parsed	1139.21	3711.44
Average token-parsing ratio	0.12	0.34
Average number of hapaxes (V1)	22.79	77.31
Average productivity (<i>P</i>)	0.002	0.030

TABLE 1. Averaged figures for affixes typically classed as level 1 and level 2.

This suggests that the affix-ordering generalization can be largely reduced to a perceptually grounded maxim: An affix that can be easily parsed out should not occur inside an affix that cannot. As a result, the less phonologically segmentable, the less transparent, the less productive an affix is, the more sensitive it will be to internal structure. We predict that highly parsable affixes, however, will contain predictable meaning, and will be easily parsed out. Such affixes can pile up at the ends of words, and should display many syntax-like properties.

This, in conjunction with the fact that most level 1 affixes start with vowels and most level 2 affixes start with consonants, captures the set of facts that the affix-ordering generalization sets out to explain. No explicit stratification is necessary.

The generalization correctly rules out practically every combination of nonoccurring affixes cited as evidence for the affix-ordering generalization, providing a straightforward explanation for why the highly productive, highly decomposable, mostly consonant-initial suffixes of level 2 do not occur inside the less productive, less decomposable, mostly vowel-initial suffixes of level 1 (e.g. **homelessness*, **helpfulness*, **sadness*, **wistfulness*, **gratefulize*).

Not only is *-less* much more frequent and represented by a larger proportion of words with frequency profiles that facilitate parsing than *-ity* (type-parsing ratio .86 vs .17),

it is also much more productive ($P = .017$ vs $.001$) and begins with a consonant, so it is much more likely to create a low-probability juncture. The same type of relationship holds between the other pairs of nonattested affix combinations cited above. I am not arguing that this is the only reason these specific examples are unacceptable, but I am arguing that if all other restrictions such as Latinateness, semantic anomaly, blocking, and so on, were removed, these should still be independently dispreferred for processing reasons.

In addition to ordering consonant-initial and vowel-initial suffixes correctly, the parsing account explains a large number of facts relating to the interaction of decomposability with stacking restrictions, which have previously gone unnoticed. These are word-based effects, which speak to hypothesis 2. These are discussed in the following sections, in the context of Fabb's critique of level-ordering approaches (Fabb 1988).

3. FABB'S AFFIX CLASSES. Fabb 1988 divides English suffixes into four classes, according to the types of selectional restrictions they display. Plag (1996, 1999), argues against affix-driven selectional restrictions, arguing instead that much of the data can be explained by base-driven selectional restrictions. He steps through Fabb's four classes individually, reanalyzing the data.

In the next four sections I, too, step through these four classes. By discussing Fabb's analysis, and Plag's (1996, 1999)⁵ objections to Fabb's analysis, I demonstrate that the four classes are, in fact, variants on a single theme. The facts at hand can be explained by the general processing account outlined above. In addition, many previously unnoticed and unexplained patterns receive a natural explanation when processing is taken into account.

3.1. SUFFIXES THAT NEVER ATTACH TO AN ALREADY SUFFIXED WORD. Fabb lists 28 suffixes which he claims never attach to an already suffixed word. He argues that a selectional restriction is at work, which has the result that these particular suffixes cannot attach to any word that has already undergone suffixation. He argues that this explanation goes beyond level ordering, by having increased predictive power.

Taking the level 1 suffix *-ify* as an example, level-ordering predicts that it does not attach outside any level 2 suffix (hence **derivable-ify*); this is alternatively predicted if the suffix is prevented by the above-mentioned selectional restriction from attaching outside any suffix, and this second approach also makes a further prediction not made by level-ordering, which is that *-ify* does not attach outside any other level 1 suffix either (e.g. **personalify*, **destructivify*). The restriction against suffixation to an already-suffixed word cuts down the number of potential suffix pairs considerably, and at the same time does a large part of the work of level-ordering of suffixes. (Fabb 1988:533)⁶

From the point of view of a parsing account, Fabb's generalization would seem sensible—the natural behavior of a set of affixes that tend to strongly favor the whole-word access route. For affixes represented predominantly by words that favor whole-word access, any degree of internal structure in potential bases is likely to be dispreferred. That is, if affixes may not attach to other affixes that are more separable than

⁵ Plag 1999 contains a slightly revised version of Plag 1996. Here, citations and page numbers come primarily from Plag 1996, though I also note places where the Plag 1999 version differs in substance.

⁶ The examples given may be poorly chosen ones for the point Fabb is making, as Plag (1999:82ff) argues that 'the domain of *-ify* derivatives (denominal and deadjectival alike) is restricted by the fact that bases must have either ultimate primary stress or must end in [ɪ]'.

they themselves are, then it follows that there will be a set of affixes that display minimum decomposability and so are not able to attach to any other affix.

Plag (1996), in his reply to Fabb, argues that Fabb's claim is hugely oversimplistic, presenting evidence that a large number of the affixes do, in fact, occur on suffixed bases, and that many combinations are ruled out by independent constraints such as type-blocking, the Latinate constraint, or phonological constraints on bases.

The most relevant part of this discussion is Plag's discussion of those affixes for which he claims Fabb was wrong; Plag claims these affixes do occur with suffixed bases. Some of the examples he provides involve suffixed bases that contain bound roots.

With derivatives of the form *V-ory* we find lots of counterexamples to Fabb's claim that deverbal *-ory* does not attach to already suffixed verbs. In fact, verbs ending in *-ate* may take *-ory* as an adjectival suffix productively, for example *assimilatory*, *emancipatory*, *stimulatory*. (Plag 1996:785)⁷

While it is not clear whether exceptions involving bound roots are problematic for Fabb's account, they are certainly predicted under an account in which parsing is central. A form with a bound root is a clear example of a case in which whole-word access dominates and parsing is highly unlikely. As such, bases containing bound roots have a very low level of decomposability. If *-ory* disprefers affixation with decomposable bases, it should come as no surprise that the examples Plag cites are well-formed. They stand in strong contrast to the unacceptability of forms containing bases with a higher degree of decomposability, such as **pollinatory*, **alienatory*, **activatory*, **validatory* and **orientatory*.

Not all of the exceptions cited by Plag involve bound roots however. For example, he takes issue with Fabb's characterization of *-ist* as an affix that cannot attach to already suffixed words.

... we find numerous examples of already suffixed nouns that take *-ist* as a suffix, such as *abortionist*, *expansionist*, *consumerist*, *conventionalist*. (Plag 1996:783)

I first discuss *consumerist* and *conventionalist*, and then turn to discussion of the *-ionist* combination below. While the affix *-er* doesn't create a strong phonotactic juncture, it is highly frequent and highly regular, and so more likely to be parsed out than its counterpart *-ist*. One might therefore predict this to be a nonoptimal combination of affixes. In fact, a search through the CELEX lexical database (Baayen et al. 1995) lists no words displaying this combination of affixes (not even *consumerist*). Moreover a moment's reflection reveals that this is generally a dispreferred combination (cf. **writ-erist*, **defenderist*, **climberist*). What, then, makes *consumerist* acceptable? Here we see further evidence that affix ordering is intricately linked to decomposability—relative frequency matters. *Consumer* is more frequent than *consume* (CELEX listed frequency of 627 per 17.4 million as opposed to 423). As argued above, this fact reflects a low level of decomposability. Because *consumer* favors whole-word access, it contains a minimum of structure: *-er* is therefore unlikely to be parsed out, and so *-ist* is able to attach unproblematically.

Conventional has a listed frequency of 834 and so is more frequent than its base, *convention* (470). Relative frequency facts, then, predict that both *conventional* and

⁷ In Plag (1999:79)—a slightly reworked version of Plag 1996, this quote is slightly altered—the examples given are *acceleratory*, *calculatory*, and *stipulatory*. These are all cases with bound roots, consistent with the discussion here.

consumer should favor whole-word access, making them more acceptable bases of *-ist* affixation than base forms that are more prone to decomposition. Note however, that the existence of *conventionalist* is not a good counterexample to Fabb's claim that denominal *-ist* cannot attach to suffixed forms—*conventional* is an adjective, so more properly belongs in Fabb's 'problematic suffixes' category, in which he includes de-adjectival *-ist* (see discussion in §3.4).

The other two examples listed by Plag end in *-ionist*. The affix combination *-ionist* occurs more frequently than either *-erist* or *-alist*. However, we should still predict that, if *-ist* is only able to attach to a restricted range of *-ion*-final forms, it will display a preference for forms which are minimally decomposable. Indeed, CELEX contains no shortage of forms in which the base of *-ion* is bound, such as *abolitionist*. It also, however, lists a number of forms that do not contain bound roots.

Table 2 lists all such forms, together with their frequency, the frequency of the innermost base, and the *-ion*-final base. Of the twenty *-ion*-final bases, fourteen are more frequent than the roots they contain, indicating low levels of decomposability. The other seven are less frequent than their roots, although not by much. Of the forms affixed in *-ion* that *-ist* appears with, then, 70% are more frequent than the bases they contain.

abort	35	abortion	351	abortionist	18
collaborate	72	collaboration	102	collaborationist	1
conserve	116	conservation	554	conservationist	119
contort	55	contortion	19	contortionist	3
deviate	33	deviation	51	deviationist	6
divert	216	diversion	108	diversionist	0
exhibit	218	exhibition	410	exhibitionist	19
express	1874	expression	1669	expressionist	32
extort	0	extortion	11	extortionist	1
impress	689	impression	1128	impressionist	16
isolate	212	isolation	312	isolationist	8
obstruct	66	obstruction	79	obstructionist	0
perfect	94	perfection	204	perfectionist	17
prohibit	134	prohibition	114	prohibitionist	2
project	399	projection	236	projectionist	5
protect	1534	protection	978	protectionist	22
revise	154	revision	93	revisionist	25
secede	14	secession	19	secessionist	3
vacate	48	vacation	270	vacationist	2
vivisect	1	vivisection	42	vivisectionist	3

TABLE 2. *-ionist* forms listed in CELEX, with lexical frequency of the base, *-ion* form, and *-ionary* form.

This is a very high percentage, given that the vast majority of affixed forms are less frequent than the bases they contain (Harwood & Wright 1956, Hay 2000). To compare the frequency distribution of these forms, in relation to other forms suffixed with *-ion*, I extracted all forms ending with this morpheme from CELEX. I restricted the set to only those forms with a monomorphemic base (excluding forms such as *acclimitisation*), so as to avoid taking into consideration the separate frequency contributions from the root, and the base of affixation. CELEX lists 741 entries representing monomorphemic bases affixed with *-ion*. Of these, there are 262 cases in which the derived form is more frequent than the base (35%). Therefore *-ion*-final forms that can be bases of *-ist* affixation are more frequent than the bases they contain twice as often as would be

expected by chance. A chi-square comparing the number of derived *-ion* forms that are more/less frequent than their base in this restricted set, versus the larger set from CELEX, reveals this difference to be highly significant (chi-square = 7.36, df = 1, $p < .01$). Note that this is not an artifact of absolute frequency. The average listed frequency of *-ion* forms in CELEX is 300.2. Of the twenty *-ion* forms listed in Table 2, thirteen are associated with below-average frequency. This pattern is also present in other affixes discussed by Plag.

The denominal suffix *-ize* seems to attach quite often, and naturally, to suffixed nouns of various types. Consider for example *computerize*, *christianize*, *preacherize*, *protestantize* (if one assumes that the stem is a noun and not an adjective). (Plag 1996:787)

The forms listed by Plag are relatively opaque, with the exception of *preacher*, and *preacherize* seems to me to be marginally acceptable in any case. Again, note it would not be particularly problematic for us if *-ize* could freely attach to forms that are affixed, as long as those forms were not highly decomposable (as would be the case with consonant-initial suffixes). To the degree that we do find it occurring with forms with internal structure, we expect it to be preferred on forms that display minimal decomposability, that is, following hypothesis 2, we do not expect to find any cases in which an affix attaches only to forms that are maximally decomposable and not to forms that are relatively opaque. But we expect to find large numbers of cases where the opposite is true.

3.2. SUFFIXES THAT ATTACH OUTSIDE ONE OTHER SUFFIX. In his second category of affixes, Fabb (1988) lists a number of affixes that each appear to be licensed to attach outside just one specific affix. For example, *-ary* can attach only outside *-ion* as in *revolutionary*, and deadjectival *-y* can attach outside *-ent* as in *residency*. If the affixes in this category really do not occur outside any affix other than that listed, then these affixes display a general dispreference for attaching to forms with internal structure. It is no problem to assume that they can occur outside specific affixes, if those affixes are not highly decomposable or parsable. We might predict some variability, however, even with affixation to the licensed affix. If, for example, *-ary* displays a general dispreference for affixing to decomposable words, then we might expect it to appear more on *-ion*-final bases that display minimal structure than on *-ion* forms that are maximally decomposable. More highly decomposable *-ion* forms may avoid affixation with *-ary*.

Since some general properties of forms affixed in *-ion* were already calculated for the previous section, this is not difficult to test. Fabb lists three suffixes that can attach only to *-ion* bases: noun-forming *-ary* (as in the noun *revolutionary*), adjective-forming *-ary* (as in the adjective *revolutionary*), and denominal *-er* (*vacationer*).

I begin with the first two examples together. Table 3 lists all the examples appearing in CELEX with a potentially free base, and *-ionary* affixation. The base is listed, with its frequency, together with the *-ion* and *-ary* final forms. Note first, that absolute frequency does not appear to be playing a role here. The average frequency of *-ion* forms is 300.2 occurrences per 17.4 million. Of the ten examples in Table 3, five are below average frequency, and five are above average. For eight out of the ten examples listed, however, the derived form is more frequent than the base it contains. For the remaining two the difference is not large. Recall that, of *-ion*-final forms as a group, 35% are more frequent than the bases they contain. That 80% of forms that can be

deflate	39	deflation	29	deflationary	15
discrete	47	discretion	157	discretionary	31
divert	216	diversion	108	diversionary	25
evolve	438	evolution	455	evolutionary	180
expedite	8	expedition	326	expeditionary	8
inflate	59	inflation	677	inflationary	80
probate	8	probation	83	probationary	17
react	510	reaction	1288	reactionary	96
revert	0	reversion	18	reversionary	1
revolve	123	revolution	1596	revolutionary	802

TABLE 3. *-ionary* forms listed in CELEX, with frequency of base form, *-ion* form, and *-ary* form.

further affixed by *-ary* are more frequent than the bases they contain indicates that *-ary* disprefers highly decomposable bases (Fisher exact test, $p < .005$).⁸

Only five *vacationer*-type forms are listed in CELEX; these are given in Table 4. Four out of the five *-ion* forms are more frequent than the bases they contain. Again, a rate of 80% is found, as opposed to the 35% which would be expected by chance (Fisher exact test, $p < .06$).

execute	231	execution	206	executioner	21
exhibit	218	exhibition	410	exhibitioner	0
extort	0	extortion	11	extortioner	31
probate	8	probation	83	probationer	5
vacate	48	vacation	270	vacationer	4

TABLE 4. *-ioner* forms listed in CELEX, with frequency of base, *-ion* form, and *-er* form.

Fabb's explanation for affixes that can occur outside just one other affix is as follows, using the specific example of *-ionary*.

-ary selects for a non-complex host. However, it is unusual in that while the unmarked case for most suffixes is that they select for words, *-ary* has the option of also selecting for one specific suffix, *-ion*.
(Fabb 1988:534)

Fabb's generalization, while clearly on the right track, misses the fact that the two options he describes are not insignificantly related. *-ary* is not a highly parsable affix, and so I predict that it will be ill-formed when attaching to highly decomposable bases. Affixes that are unlikely to be parsed out do not occur outside of affixes that are likely to be parsed out. As such, many affixed words are ill-formed as bases of *-ary*. Now if *-ary* simply selected for the affix *-ion*, there would be no clear explanation for the fact that not all *-ion* forms are equally well-formed as bases of *-ary* affixation. But the fact that *-ary* preferentially attaches to *-ion* bases with low levels of decompositionality, follows naturally from the analysis presented here.

Plag's critique of Fabb's analysis of these types of verbs consists largely of pointing out that the 'suffixes which occur outside just one other suffix' in fact can attach to a wider range of bases than Fabb suggests. He offers *-ate* and *-ment* as suffixes that can also occur before *-ary*. He gives *commendatory*, *complementary*, *sacramentary*, *sedimentary*, and *supplementary* as examples. Since all of these examples involve bound bases, they fall in nicely with the analysis.

⁸ See note 3.

3.3. FREELY ATTACHING SUFFIXES. Fabb lists three suffixes he claims attach freely outside other affixes: *-able*, *-ness*, and deverbal *-er*. As *-ness* is consonant initial, and highly productive, I predict that it should be able to stack up after other parsable affixes, and so the fact that it attaches relatively freely is predicted by the approach being argued for here. I would not, however, predict that *-able* and *-er* can occur outside affixes that are more likely to be parsed out than they themselves are—and in particular we should be concerned if these affixes attached freely to consonant-initial affixes. Investigation of the possibilities, however, reveals that this claim is not problematic, because both *-able* and *-er* attach to verbal bases, and English contains no verbalizing suffix that creates marked phonotactic junctures. All of the possibilities for suffixes that could occur before these two, then, are suffixes that are not phonotactically highly decomposable. Plag notes that the three suffixes do not attach as freely as Fabb suggests. Rather, there are some restrictions, which ‘involve morphological, semantic, and phonological properties of the base or derivative’ (Plag 1999:86). None of the observations about the behavior of these three affixes contradicts an account in which highly parsable affixes are restricted from occurring before less parsable ones.

3.4. PROBLEMATIC SUFFIXES. Fabb lists six affixes that are problematic for his approach. They attach to more than one affix but are not completely unrestricted. These affixes are problematic in Fabb’s affix-driven account, but are less problematic for Plag, who sees them as ‘not more problematic than any others, since they’re subject to the same kind of idiosyncratic, paradigmatic, and semantic-pragmatic constraints as are all the supposedly nonproblematic ones’ (Plag 1996:793).

From the point of view of my analysis, I predict that there will be some suffixes that can attach to some suffixes (i.e. those which are not highly parsable), and not others (i.e. highly parsable affixes). Thus the fact that such a set exists is unproblematic for my account. Moreover, I expect that, to the degree that some affix combinations are not completely productive, they are restricted in a way that reflects the decomposability of the base. This does indeed appear to be the case. For example, Fabb lists adjective-selecting *-ist* as a problematic suffix, because there are four affixes to which it can attach: *-ive*, *-ic*, *-an*, and *-al*. An examination of entries listed in CELEX, however, reveals that *-ist* does not attach unrestrictedly to these affixes. Only five forms are listed with *-ivist* forms. Of these, four of the *-ive* bases contain bound roots (*archivist*, *positivist*, *prescriptivist*, *recidivist*). The fifth form is *activist*—a form that has itself undergone some semantic drift. The form *-ist*, then, does not affix to *-ive* in a fully unrestricted manner (compare the ill-formedness of **combativist*, **addictivist*, **protectivist*).

Seven forms are listed in *-icist*: *classicist*, *empiricist*, *geneticist*, *lyricist*, *physicist*, *publicist*, *romanticist*. Of these, six have bound roots (assuming no relation between *empire* and *empiric*). The seventh, *romantic*, is not highly decomposable, as evidenced by the fact that it is more frequent than the root *romance* (545 vs. 207). All listed *-anist* forms contain bound roots (*botanist*, *humanist*, *organist*). The combination *-alist* is less restricted. There are many bases with bound roots (*fatalist*, *pluralist*, *vitalist*), many of which are not highly decomposable (*rationalist*, *colonialist*, *formalist*), and a reasonable number of which contain roots that are frequent relative to the *-al*-final base (*conversationalist*, *sentimentalist*, *herbalist*). The affix *-al* is able to occur relatively unrestrictedly inside *-ist*, because it is not a highly parsable affix. Baayen and Lieber (1991:830), for example, demonstrate that it is on the borderline of productivity—scor-

ing the same on their measure of productivity as simplex nouns. And Hay and Baayen (2002b) calculate a higher productivity score, and higher type- and token-parsing ratios for *-ist* than *-al*, pointing to its higher level of separability.⁹

Plag claims that *-ist* is restricted only by semantics.

... in addition to the four suffixes Fabb finds, the adjectival suffixes *-ile*, *-able* and *-ar* are also attested to precede *-ism* (as in *infantilism*, *probabilism*, *particularism*), and it seems that only semantic-pragmatic factors speak against forms involving other more picturesque adjectival suffixes like *-esque* preceding *-ism/ist*. Consider the putative *kafkaesquism*, which could certainly denote a theoretical framework developed by a circle of literary critiques who try to find kafkaesque traits in any piece of fictional writing (with a *kafkaesquist* being a member of this circle). (Plag 1996:793)

The three examples given by Plag all involve bases with bound roots, further supporting a model in which the decomposability of the base is central. He also argues that forms like *-esque* could even occur inside *-ist* or *-ism*, given the right context. That restricting the reference of *kafkaesquism* to a particular literary framework increases its potential well-formedness supports models in which there is an explicit interaction between decomposability and well-formedness.

Fabb lists denominal *-al* as another problematic affix, citing its attachment to *-ment*, *-ion* and *-or*. The claim that *-al* can freely attach to *-ment* forms is an oversimplification, as attested by the large literature dealing with this particular combination of affixes. In the following section I investigate denominal *-al* in depth.

4. DENOMINAL *-al*. The affixation of *-al* to forms in *-ment* is widely cited as evidence that *-ment* can attach at both level 1 and level 2: *-ment* can attach both to bound roots and Latinate verbs, as shown in 2a and 2b respectively.

- (2) a. ornament, increment, regiment, fragment
- b. employment, discernment, containment, derangement

The level 1 suffix *-al* can attach to the bound forms affixed in *-ment* (e.g. *ornamental*), but not to the Latinate forms (**employmental*). Thus, Aronoff (1976), Giegerich (1999) and others, argue that *-ment* affixation is able to occur at two distinct levels. The examples in 2a represent words formed at level 1, and the examples in 2b were formed at level 1. Crucially, level 2 affixed forms cannot be followed by *-al*.

There are three exceptions to the rule that *-al* cannot affix to *-ment* forms with Latinate bases. *Governmental*, *developmental*, and *judgmental* are possible forms. This is accounted for by assuming that these base forms are unique in allowing *-ment* affixation at level 1. One property generally associated with level 1 affixation is a relative lack of semantic transparency. Thus, the fact that at least two of these three forms are not particularly semantically transparent is taken as support for this interpretation.¹⁰ *Departmental* is also well-formed. This plays a lesser role in the relevant discussions, due to general agreement that it bears no synchronic relationship to the base *depart*

⁹ Plag 2002 discusses *-alist*, demonstrating at length that the combination can occur relatively freely, and arguing that this provides counterevidence for a parsing account. However, all that is required for *-alist* to be consistent with this account is for *-ist* to be more parsable/decomposable than *-al*, and all evidence points to this indeed being the case.

¹⁰ Giegerich (1999:48) explains that '*governmental* can only occur in the sense referring to the (concrete) institution of the government; the theory of government (in syntax or political science) is not a *governmental* theory. And the meaning of *judgemental* contains a subjective element not predicted by the components of the form'.

(for experimental verification of this widespread intuition, see Marslen-Wilson et al. 1994). This form too, then, must be formed at level 1.

Mohanan's analysis is representative of the level ordering approach.

... *dis-* and *-ment* are affixed at stratum 2 in a productive fashion, creating semantically transparent results, while the same affixes attach unproductively at stratum 1, creating semantically opaque forms. We shall see in chapter III that a similar contrast appears in Malayalam, in which compounding at an 'early' stratum creates more semantically opaque results. My guess is that if a language has two strata of affixation or two strata of compounding, the earlier stratum would be the one that yields more opaque forms. If this is a correct observation, it merits further study. (Mohan 1986:57)

Mohan's guess is almost guaranteed to be confirmed by all work that assumes two levels of affixation, as lack of transparency is commonly used as a diagnostic of a process's location on level 1.

Giegerich (1999) uses affixes' tendency to recur at both levels to argue for a base-driven stratificational model. In this type of model, the bases *govern*, *develop*, and *judge* (together with all the relevant bound roots) are marked in the lexicon as possessing the potential for *-ment* affixation in the first stratum. As such, this set of *-ment* forms may feed into the cyclic rules of level 1. One of these rules allows for *-al* affixation to *-ment*-final forms. The fact that these three Latinate bases may be affixed in *-mental*, then, is due to an idiosyncratic marking on the bases in the lexicon. A consequence of the fact that they are allowed to occur at level 1, is that they are not particularly transparent. Other *-ment* forms, such as *employment* and *discernment*, are not prone to *-al* affixation because *-ment* affixation generally occurs at level 2.

This level-ordered approach is not particularly satisfying. It essentially reduces the problem to a diacritic, in terms of which bases take *-ment* at level 1, and which at level 2. But Fabb's alternative (that *-al* simply selects for *-ment*-final bases) fails to distinguish between occurring forms like *governmental* and nonoccurring words like *discernmental*. Plag (1996) seeks to explain the range of affixes that *-al* can attach to with reference to a Latiniteness constraint. This, too, seems to have lost the generalization that level ordering was attempting to capture: *-al* attaches to only a specific limited range of *-ment*-final bases. Level-ordering approaches at least allow for such limitations, without necessarily explaining them.

Goldsmith (1990) develops an account of *-mental* affixation that draws on patterns of stress assignment in English. His basic claim is that stress clash—a pattern of two adjacent stress-bearing syllables—is avoided across a level 2, or 'open' juncture in English. While such clashes are possible in monomorphemic words (*nylon*), and words with level 1 affixation (*abnormality*), they are not permitted across words with open junctures. This is the principle, claims Goldsmith, that rules out words like **racistic* and **careeristic*—they contain a stress clash across an open juncture, unlike *communist* and *regalistic*, for which the stress of the stem is not stem final. Goldsmith argues that this analysis extends straightforwardly to the problem of *-mental* affixation: *-ment* affixation to bound roots does not involve an open juncture, and so a form like *fragmental*, while it contains a stress clash, is legal because that stress clash does not straddle an open juncture. Forms like *developmental* and *governmental*, according to Goldsmith, are also well-formed because, while they contain an open juncture, there is no stress clash across that juncture. Forms like **employmental* and **recruitmental*, however, are ruled out because they contain a stress clash that straddles an open boundary.

While stress patterns may play some role in ruling out some *-mental* combinations, this cannot be the full story. Goldsmith's analysis fails to account for the well-

formedness of *judgmental* and *departmental*, and incorrectly predicts that *-ment* forms with bases that don't carry stem-final stress should have well-formed counterparts in *-al*. Words like **discouragement*, **nourishment*, and **management*, however, are not well-formed.

The approach advocated here potentially provides a clear explanation of the facts. I predict that those *-ment* forms which *-al* attaches to are ones that display low levels of decomposability. With this prediction in mind, I turn to a closer examination of this data set, which has been so important for discussions on level ordering.

Table 5 shows the lexical frequency of the bases and the derived *-ment* forms discussed by Aronoff and Giegerich, with frequencies taken from the CELEX lexical data base. I have listed the forms in order of relative frequency, from *discernment*, which is much less frequent than the base it contains, to *government*, which is much more frequent than the base it contains. Ordering is based on the figure in the final column—the natural log of the ratio of base frequency to derived frequency (n.b. this is equivalent to the difference between log base frequency and log derived frequency). This calculation minimizes the importance of small differences in the higher frequency ranges. For example, $\ln(\text{base/der})$ for a difference of 1100 and 1010 is 0.085, whereas for a difference of 100 and 10 it is much larger: 2.3. When the frequencies are identical, this figure is 0.

BASE WORD	BASE FREQUENCY	DERIVED WORD	DERIVED FREQUENCY	LN(BASE/DER)
discern	84	discernment	4	3.04
contain	2244	containment	17	2.83
derange	43	derangement	12	1.2
develop	4492	development	3707	.19
employ	1110	employment	967	.14
judge	718	judgment	1053	-.38
govern	340	government	7693	-3.12

TABLE 5. Frequency counts for Latinate bases suffixed with *-ment*, ordered for relative lexical frequency.

A fourth form mentioned by both Aronoff and Giegerich is the form *departmental*. It is worth noting that like *judgment* and *government*, *department* is more frequent than the base it contains.

Now, if the suffix *-al* shows a dispreference for affixation to words with internal structure, this would account straightforwardly for the fact that it can apply to *-ment* forms with bound roots (cf. *ornamental*, *regimental*). The forms in Table 5, then, should show increasing acceptability with *-al* as one moves down the table. *Discernmental* should be very bad, whereas *governmental* should be perfectly acceptable. This explanation accounts nicely for the extremes of the table, but the relative ordering of *developmental* and *employmental* seems to be in the wrong order. The ordering in the table suggests that *employmental* should be more acceptable than *developmental*. But a glance at the relative frequency numbers illustrates that these two words are extremely close in relative frequency—both around the borderline—with the base and derived form roughly equally frequent for both. This is exactly the part of the distribution where we expect some instability and where we might expect some arbitrariness in terms of degree of internal structure. While *employmental* is not particularly well-formed, and has not been lexicalized, the relative-frequency facts predict that it should be a more likely word of English than *discernmental* or *containmental*.

We expect *-al* to display this sensitivity with other affixes, as well as *-ment*, and so can look elsewhere in the lexicon for independent evidence that the suffix *-al* disprefers

bases that are highly decomposable. While Fabb's (1988) claim is that denominal *-al* can occur after *-ion*, *-ment*, and *-al*, Plag (1996) claims that this set of affixes is too small, and that *-al* can actually attach to a large set of derivatives.

Contrary to Fabb's claim, denominal *-al* attaches not only to *-ion*, *-ment*, and *-or*, but also to derivatives involving nominal bases in *-ure* (*apertural*, *cultural*), *-entlant* (*residential*, *componential*, *consonantal*), *-ancel-ence* (*concordantial*, *conferential*), *-cide* (*insecticidal*, *suicidal*), *-ory* (*laboratorial*), *-ary* (*secretarial*), *-ive* (*relational*, *substantival*). Most of these nominal suffixes take the adjectival suffix *-al* regularly, but rival processes, especially *-ous*, may intervene. (Plag 1996:791)

Most of the examples cited by Plag involve bound roots, which have the minimum possible internal structure. And, indeed, *-al* affixation to most of the affixes he cites do appear to be sensitive to internal structure. For example, while *-al* affixes readily to *-or*-final bases (*pastoral*, *mayoral*, *ambassadorial*, *tutorial*, *manorial*), it is dispreferred in cases in which *-or* represents a salient parse within the word (**exhibitorial*, **actorial*, **sailorial*, **ejectorial*, **creditorial*). CELEX lists only two *-orial* forms for which the root stands in a semantically transparent relation to the whole: *editorial* and *senatorial*. In both cases the relative-frequency facts strongly favor the whole-word route in access. *Editor* is more frequent than *edit*, and *senator* is more frequent than *senate*. The parsing route is unlikely to win in access for these two words, thus minimizing the salience of their internal structure. That is, the relative-frequency facts lead *editor* to be less decomposable than *creditor*. If *-al* disprefers bases with internal structure, it should be preferred on the former rather than the later.

Similarly, while *-al* is possible on *-ive*-final bases, the attested bases tend to be nondecomposable. Plag lists *substantival* and *relational*. Neither *substantive* nor *relative* stands in a phonologically transparent relation with its base, and so the whole-word route is likely to be strongly favored and the internal structure eroded. The only additional example listed in CELEX is *adjectival*—with a clearly bound root. Note the impossibility of *-al* affixation to *-ive*-final bases that are semantically and phonologically transparent: **supportival*, **conservational*, **activational*, **digestival*, **protectival*. Again, while *-al* can attach to suffixed forms, it displays a strong preference for forms for which the internal structure is absent or eroded.

The only affix to which *-al* can attach in a relatively unrestricted manner is the nominalizing *-ion*. CELEX lists many words in which these affixes occur together, including *educational*, *congregational*, *conversational*, and so forth.

It appears that denominal *-al* affixation is tolerant of some degree of internal structure, but not much. The sensitivity of *-al* to internal structure is predictable from the fact that the suffix is associated with a low level of productivity, and so not readily parsed. As noted above, Baayen and Lieber (1991:830) argue that *-al* is on the borderline of productivity, scoring the same on their measure of productivity as simplex nouns.

It is not the case that *-ment* affixation occurs at two separate strata of affixation in English. Rather, factors like the relative frequency of the derived form and the base, and the degree of phonological transparency, lead some affixed words to be more decomposable than others. Like most affixes, *-al* is sensitive to this aspect of a word's representation. An affix-driven level-ordering account of this phenomenon is therefore not only not required but also unable to make the correct predictions.

The next section describes an experiment to test subjects' intuitions about the likelihood of *-al* affixation to a range of *-ment*-final forms. Do subjects' preferences about nonwords reflect the decomposability of the base?

4.1. EXPERIMENT 1: *-al* AFFIXATION AND RELATIVE FREQUENCY. The facts presented above suggest that *-al* is most likely to attach to simple bases, and should decrease in acceptability with the increasing decomposability of potential bases. An experiment was designed to test the psychological reality of this generalization.

METHODOLOGY AND MATERIALS. The stimuli consisted of sixteen pairs of words which were matched for syllable count, stress pattern,¹¹ and lexical frequency. An attempt was also made to match for the approximate probability of the phoneme transition across the word boundary. The members of the pair differed in the frequency of the embedded base. The stimuli are listed in Table 6. Word A of each pair is less frequent than the base it contains; Word B of each pair is more frequent than its base. I therefore predict that Word B of each pair should be more acceptable when suffixed with *-al* (cf. hypothesis 2). Note that while, in some cases, the frequency of the base and the frequency of the derived form is fairly close, in all cases, the difference in the log ratio of base and surface frequency is fairly sizeable across the two conditions.

WORD A	FREQ.	BASE FREQ.	WORD B	FREQ.	BASE FREQ.
arrangement	1111	1587	investment	1294	525
attachment	196	878	detachment	133	99
attainment	153	234	amendment	163	83
curtailment	17	63	bereavement	21	0
containment	17	2244	atonement	27	15
appeasement	32	70	infringement	31	22
enchantment	26	115	impeachment	34	10
embarrassment	344	461	advertisement	346	277
involvement	418	3779	appointment	561	465
settlement	471	1428	punishment	629	421
commitment	743	958	excitement	690	207
achievement	713	2121	equipment	1352	179
adornment	41	75	alignment	57	44
advancement	77	944	bombardment	65	48
commandment	103	508	recruitment	103	102
effacement	1	13	abasement	6	2

TABLE 6. Experiment 1 stimuli.

These pairs of words were all suffixed with *-al* (*arrangemental*, *investmental*, etc.) They were counterbalanced for order of presentation and then presented to subjects, who were asked to indicate which member of each pair sounds more like a possible English word. The exact instructions were as follows.

This is an experiment about possible words. You will be presented with pairs of words, neither of which are actual words of English. Your task is to decide which sounds more like it could be a word of English. Read the two words silently to yourself, and then circle the word you think is more likely to enter the English language. There are no right or wrong answers, we are just interested in your intuition. It is very important that you provide an answer for every pair. Don't worry if you are not sure of your answer, just provide your best guess.

Thirty-five Northwestern University undergraduate students completed the task for class credit in an introductory linguistics class. The stimuli were present in written form, and subjects indicated their preference on an answer sheet.

¹¹ With the exception of *embarrassment* and *advertisement*, which are not matched for stress in American English. This was an oversight on the part of the New Zealand English-speaking author, using British-English-based CELEX for stimuli construction.

RESULTS. Overall, 56% of all responses favored affixation to derived forms that were more frequent than their bases, while 44% favored their matched counterparts.

A wilcoxon test reveals that subjects had a significant preference for *-al* affixation to *-ment* forms that were more frequent than their bases (by subjects wilcoxon: $p < .05$). The wilcoxon is a nonparametric paired test, which takes into account both the direction and the magnitude of the observed difference.

The by-items results fall slightly short of reaching significance on a wilcoxon test (by items, $p < .08$).¹²

Examination of the behavior of the individual items reveals that two items went strongly in the wrong direction: subjects preferred *adornmental* over *alignment* (22 to 13), and *advancemental* to *bombardmental* (21 to 14). The first pair shows the lowest difference in the log ratio of the base word to the derived word, and so we should perhaps expect the predicted preference to be weaker for this pair than most of the others.

This pair was also included in the stimulus set in an experiment described in Hay 2001 in which subjects were asked to indicate which word appeared more complex. We can refer back to subjects' impression of the morphological complexity of the words in this pair. Indeed, the word pair is unusual, in that ratings in the earlier experiment went the wrong way for this item. More subjects rated *alignment* as more complex than *adornment* than vice versa. Thus, while judgments of complexity for this specific word pair go in the opposite direction predicted based on relative frequency, their corresponding behavior in this rating task in fact provides evidence in support of the hypothesis that base decomposability is relevant to *-al* affixation. If the *alignment-adornment* pair is omitted from by-items analysis, then it reaches significance (wilcoxon: $p < .05$).

Note that this result is in the opposite direction from that predicted by frequency and familiarity facts alone. Subjects display a preference for the stimuli containing less familiar bases. All things being equal, subjects should rate derivations based on frequent words as being more likely to enter English than derivations based on infrequent words. Here we see the opposite trend, which can be explained only if we take into account the role of base frequency in maintaining morphological complexity.

In the next section, I investigate whether *-al* is preferred attaching to complex words that do not have a phonotactic cue to juncture.

4.2. EXPERIMENT 2: *-al* AFFIXATION AND PHONOTACTICS. I have argued that *-al* is not a highly parsable affix, and, as such, displays a dispreference for attaching to forms that are readily decomposable. The experimental evidence in the previous section supports this argument. In this section a second cue to decomposition is investigated experimentally—the phonotactics across the morpheme boundary. Low-probability phonotactics provide a cue to decomposition. I therefore predict that *-al* should preferentially attach to *-ment* forms displaying legal phonology over *-ment* forms containing a phonotactic transition that may facilitate decomposition (cf. hypothesis 1). This section describes an experiment designed to test this hypothesis.

METHODOLOGY AND MATERIALS. The stimuli consisted of 15 pairs of affixed words, as shown in Table 7. The members of each pair were matched for syllable count, stress pattern, and the frequency of both the whole word and the base. Word A of each pair contains an illegal or low-probability transition across the morpheme boundary. Word

¹² They are, however, significant on a t-test, which assumes normal distribution of responses, and has greater statistical power ($t = 2.158$, $df = 15$, $p < .05$).

B contains a highly probable transition; these transitions are all V-C transitions (with the V, in many cases, /r/-colored). As such, the phonology of Word A is much more likely to induce parsing than the phonology of Word B.

I predict that Word B should appear less complex, and so should be more acceptable when suffixed with *-al*.

WORD A	FREQ.	BASE FREQ.	WORD B	FREQ.	BASE FREQ.
improvement	756	1685	requirement	944	3391
recruitment	103	257	deployment	96	203
annulment	3	12	conferment	9	9
enforcement	66	294	endowment	66	112
escapement	1	1079	acquirement	1	1035
settlement	471	1428	measurement	140	1308
curtailment	17	63	impairment	18	93
management	1462	2289	argument	233	2130
arrangement	1111	1587	employment	967	1110
assessment	404	417	retirement	400	561
defacement	0	18	allurement	1	15
abridgement	3	15	deferment	5	5
bafflement	12	131	wonderment	10	668
announcement	271	1334	enjoyment	215	2656
discernment	4	84	interment	4	46

TABLE 7. Experiment 2 stimuli.

The word pairs in Table 7 were suffixed with *-al* and presented to subjects in written form. The word pair *improvemental/requiremental* was mistakenly included twice on the answer sheet. Subjects' responses to the second presentation of this pair were discarded. The order of presentation of pairs was counterbalanced and presented in a manner analogous to that described in §4.1. The instructions for this task were identical. Twenty different subjects completed the task.¹³ The subjects were students in a North-western University undergraduate linguistics class and received course credit for their participation.

RESULTS. As predicted, subjects displayed a strong preference for *-al* affixation to forms that contained legal phonotactics. This result is extremely robust. Of the twenty subjects, nineteen displayed this preference. The result is highly significant both by items (wilcoxon, $p < .005$), and by subjects (wilcoxon, $p < .0001$). Sixty-seven percent of all responses favored *-al* affixation to forms with vowel-consonant transitions across the morpheme boundary (*requiremental*), with only 33% of responses displaying a preference for affixation to matched counterparts containing consonant-consonant transitions (*improvemental*).

Together with the results of experiment 1, and the preceding examination of the stacking behavior of a range of affixes, this provides strong evidence in favor of an account of affix-ordering that involves parsability. Affixes that are not likely to be parsed out cannot occur inside affixes likely to be parsed out. This perceptually grounded restriction accounts for the range of affix ordering behavior commonly associated with level ordering, in addition to predicting differential behavior of individual forms. The experimental evidence presented shows that such differences do, indeed, occur. Only an account involving parsability can afford these phenomena a unified explanation.

¹³ The different numbers of students responding to experiments 1 and 2 is simply a function of the numbers of students present in the classes in which the experiments were conducted.

4.3. DISCUSSION. The results of these experiments cast considerable doubt on an affix-driven level-ordering account of denominal *-al* affixation. Recall that the standard level-ordering account of the *-al* affixation facts states that *-ment* affixation can take place at level 1 and level 2, whereas denominal *-al* affixation is a strictly level 1 phenomena. Under this account, *-ment* affixation to bound roots occurs at level 1, and a few select nontransparent words (*government*) may also be formed there. This accounts for the fact that *-al* affixation may attach to some forms in *-ment* but not others. Most words affixed with *-ment* occur at level 2, and so cannot take an *-al* affix. Level-ordering accounts require that all *-ment* forms that do not take *-al* affixation were created at level 2, and so do not allow for any distinction between them. That is, neither *requirement* nor *improvement* takes *-al*, and so both must be created at level 2. This account can not predict that *improvement* would be much less likely to take *-al* than *requirement*.

Rather, *-al* (like other affixes discussed above) is sensitive to the presence of internal structure. Some forms affixed with *-ment* favor the whole-word route on access, are minimally decomposable, and so may take *-al*. *Governmental*, *judgmental*, and so on, are possible and are listed in the lexicon. Other forms are highly decomposable, and, as such, are bad with *-al*. These forms include *improvemental* and *effacemental*. Still others do not have *-al* forms in the lexicon, but there is no particular reason why they should be excluded, and, indeed, if a need for these words developed, we might expect them to enter the language. *Requiremental* and *abasemental* are examples of such words. The degree to which *-al* suffixation is bad with *-ment* forms is related to the degree to which these words are decomposed.

The division of affixation into multiple strata was one way of accounting for the fact that level 1 affixes—nontransparent, nonproductive, nonneutral affixes—tend to occur before level 2 affixes, which are more transparent, more productive, and leave the phonology of the base untouched. This division appeared to be a natural one because of a perceptually driven restriction against placing affixes that are likely to be parsed out inside affixes that are not. This not only explains the ordering restrictions level ordering accounted for but also predicts that there will be a large number of cases in which one affix can attach only to a restricted set of words containing a second, specifically those words that have a minimal degree of internal structure. Indeed, I found a large number of cases in which one affix displays restricted behavior in terms of possible bases containing another. In all such cases, nondecomposable bases were favored. I did not find any cases in which an affix attaches only to maximally decomposable forms and not to relatively opaque forms.

The proposal presented here resembles a principle offered by Burzio: ‘A structure with a degree of compositionality *n* may not contain a structure with a degree of compositionality greater than *n*’ (Burzio 1994:354).

Burzio offers this STRUCTURE-TRANSPARENCY PRINCIPLE as an explanation for the fact that Latinate affixes cannot occur inside Germanic affixes. He assumes that Latinate affixes all give rise to the same degree of compositionality and that Germanic affixes, too, are all equally decomposable. In this way he accounts for the relatively free attachment of affixes within each of the classes: if two affixes are in the same class ‘whatever internal structure one tolerates, the other will too’ (355). The discussion above reveals that the structure-transparency principle was on the right track, and in fact, turns out to be far more powerful and with far more nuanced consequences than conceived of by Burzio. In particular, the generalization extends well beyond a description of abstract

'structures', to have concrete and demonstrable consequences for individual word forms in the lexicon.

5. EXCEPTIONS TO LEVEL ORDERING. Aronoff and Sridhar (1983), and many others following, discuss three pairs of affixes that appear to be major exceptions to the affix-ordering generalization in English. The exceptions are the pairs of affixes that appear in the words *patentability*, *standardization*, and *governmental*, in which level 2 affixes appear closer to the root than level 1 affixes. Fabb (1988) also discusses the common pairing *-istic*. The combination *-mental* was discussed in depth above. The other three combinations are consistent with the phonotactic aspect of the hypothesis under investigation here. Because the phonotactics do not make *-able*, *-ist*, and *-ize* highly parsable affixes, nothing phonotactic makes forms such as *patentability*, *legalistic*, and *standardization* particularly ill-formed. But these pairings are still rather surprising under the account advocated here, due to the frequency characteristics of the affixes. In each of these three cases, the productivity and parsing statistics calculated by Hay and Baayen (2002b) suggest that, if decomposability were a sole function of frequency, the outermost affix in these combinations should be less separable than the innermost: *-able*, for example, is much more productive than *-ity*, and much more prone to parsing in speech perception. Future work will determine whether these combinations are truly anomalous or whether their well-formedness is explainable within the context of an enriched understanding of the relative contribution of phonotactics, frequency, and other characteristics, toward determining the decomposability of an affix.

These cases point to the danger of interpreting the hypotheses in §2.1 as absolutes. The hypotheses will sometimes make contradictory predictions, and untangling the exact manner in which they will interact in such cases is a complex matter. It is a tantalizing fact, however, that the number of cases in which contradictory predictions are made is minimized by the nonindependence of phonotactic patterns and frequency in the lexicon. At the word level, complex words that do not contain any phonotactic cue to juncture are significantly more likely to be more frequent than the bases they contain than words that contain a low-probability phonotactic transition (Hay 2000). And at the affix level, consonant-initial affixes tend to display frequency profiles that make them still more prone to decomposition (see §2.2). Indeed, Hay and Baayen (2002a) demonstrate that, for any given affix, the average probability of the phonemes straddling the morpheme boundary is highly correlated with the proportion of forms with frequency profiles facilitating parsing. This generalization is robust for both prefixes and suffixes.

It is certainly not my claim that complexity-based ordering is the complete story of English affixation. But the evidence presented here demonstrates that, when combined with other pertinent linguistic information, it has the potential to significantly advance our understanding of the constraints on possible affix orderings. As Plag (2002) rightly claims, there are many issues still to be clarified, not least how CBO combines with other linguistic constraints on affix ordering, and the exact factors that interact to lead to different degrees of decomposability. No single factor alone (such as relative-frequency effects or phonotactic profiles) can completely predict the parsability of an affix. Rather, we are dealing with a syndrome—a set of complex statistical generalizations that provides insight into the representation and organization of affixes and places constraints on their possibility of cooccurrence.

6. BRACKETING PARADOXES. This discussion has focused on suffixes, because stacking restrictions on English suffixes have formed the core of the debate about affix

ordering. Prefixes in English are much less likely to cooccur, but they are involved in one particular type of exception to level-ordering—bracketing paradoxes. Bracketing paradoxes are words in which selectional restrictions suggest that a level 1 suffix has attached before a level 2 prefix. Such cases have been widely debated in the literature (Williams 1981, Strauss 1982, Kiparsky 1983, Pesetsky 1985, Sproat 1985).

Ungrammaticality is a textbook case of a bracketing paradox: the level 2 *un-* attaches to adjectives and so must attach before the nominalizing level 1 *-ity*. Other examples (from Kiparsky 1983), include *decongestant*, *arch-ducal*, *vice-presidential* and *underestimation*.

Having dispensed with the affix-ordering generalization, the above forms are not explicitly ruled out as possible forms. But we should still predict that they are difficult to parse. We are likely to posit a strong boundary after *arch-*, for example, so we may have to do some back-construction in order to achieve the right parse for *arch-ducal*.

To understand why this type of paradox does not lead to rampant mis-parsing, we can compare them to the case of a second theoretically possible, and yet completely nonoccurring type of bracketing paradox. There are no attested cases of words in which a level 1 prefix attaches after a level 2 suffix. Where does this asymmetry come from?

The asymmetry receives a natural explanation when we consider the left-to-right nature of the speech signal, and, consequently, the left-to-right nature of parsing. Suffixes are biased towards decomposition. The base is encountered before the full form and so is likely to receive a high level of activation, biasing decomposition over a whole-word, nondecomposed analysis. In prefixes, however, the whole-word route is naturally biased. The onset of the base is later than the onset of the whole word, affording the whole-word route an advantage in access. As a result, prefixed words are, on the whole, less decomposable than suffixed words (see, e.g. Cole et al. 1989, Hay 2000).

Now, consider the nonoccurring bracketing paradoxes, which involve level 1 prefixes outside level 2 suffixes. *Unsuccessful* is an example given by Spencer (1991). Prefixes displaying characteristics traditionally associated with level 1 are highly unlikely to be parsed out. First, because they do not create salient junctural phonotactics; second, because they tend to be nonproductive in any case; and third, because they are prefixes, and so are naturally biased toward whole-word access. It is likely therefore that the processor will fail to posit a boundary at the first morpheme boundary in *unsuccessful*. The second morpheme boundary is associated with a suffix that contains level 2 characteristics such as high productivity and is highly likely to be parsed as a boundary, thus leading to the parse *unsuccess#ful*, which is inconsistent with the intended meaning and requires a fair amount of backtracking to repair. Because listeners are naturally inclined to treat the first two morphemes as a unit, the attempt to more closely associate the second two morphemes fails.

By comparison, the existing bracketing paradoxes are cases in which a level 2 prefix attaches before a level 1 suffix, as in *reburial*. Because of left-to-right parsing, the base *rebury* is encountered before the suffix. Even if there is evidence to posit a boundary between the first two morphemes, listeners will almost certainly entertain the possibility that they are intended to be associated as a unit. *Rebury* will receive some level of activation. Encountering a suffix that semantically modifies this unit, then, is not going to throw the processor completely. In sum, bracketing paradoxes are cases in which a highly parsable prefix appears to have attached before a marginally parsable suffix. This is one of four theoretically possible configurations of prefix-suffix pairs differing in parsability:

- (3) nonparadoxical configurations
 - a. [(marginally parsable affix)(base)] (highly parsable affix)
 - b. (highly parsable affix) [(base)(marginally parsable affix)]
- (4) paradoxical configurations
 - a. [(highly parsable affix)(base)] (marginally parsable affix)
 - b. (marginally parsable affix) [(base)(highly parsable affix)]

The two configurations in 3 are by far the most common patterns attested and this fact has been taken as evidence in favor of level ordering. It follows straightforwardly, however, from the same principles used to motivate the ordering of English suffixes in this article. The configurations in 3 are maximally well-formed in terms of maximizing the probability of successful online parsing. Affixes that are more marginally parsable are also closest to the base grammatically.

The configurations in 4 are nonoptimal in terms of parsing. However, 4b is much more nonoptimal than 4a. Because we process speech in a temporal manner, the prefix-base sequence is available as input to suffixation in 4a, even if it is not the preferred input. The configuration in 4b however is essentially nonparsable. Both the left-to-right nature of speech and the marginal parsability of the prefix will lead to an overwhelming tendency to parse the first two elements as a constituent, contrary to the intended analysis, in which the last two elements are a constituent.

I also predict that configurations of type 4a (traditional bracketing paradoxes), should be most acceptable when the prefix-base constituent is minimally decomposable. *Archducal*, for example, might be expected to be less acceptable than *reburial* (due to the difference in strength of the phonotactic cue to decomposition). While this prediction seems intuitively plausible, it remains to be empirically tested.

7. CONCLUSION. The problem of restrictions on affix ordering in English can be largely reduced to one of parsability: an affix that can be easily parsed out should not occur inside an affix that cannot. The overall result is that the less phonologically segmentable, the less transparent, the less frequent, and the less productive an affix is, the more resistant it will be to attaching to already affixed words. This prediction accounts for the patterns the original affix-ordering generalization was intended to explain. Importantly, the prediction also extends to the parsability of affixes as they occur in specific words. This accounts for the so-called dual-level behavior of some affixes. An affix may resist attaching to a highly decomposable complex word but be acceptable when it attaches to a comparable complex word that favors the direct route in access. Understanding affix ordering, then, requires a full understanding of factors influencing the parsing and storage of individual words. While previous approaches to affix ordering have focused on the affixes themselves, it appears clear that the properties of affixes cannot be sensibly detached from the properties of the specific words in which they appear.

The approach suggested here leads toward answers to long-standing questions about constraints on affix ordering in English, but it raises many more questions than it answers. What other affixal properties affect the decomposability of affixed words, and how do the range of relevant properties interact to determine an affix's overall separability? Exactly how much does the overall (global) decomposability of an affix interact with properties affecting its (local) decomposability in specific words? How does inflection fit into the picture—a question beyond the scope of this paper, but one that will clearly need to be addressed. And, perhaps the biggest question of all, how well can the account suggested generalize to other languages—languages both with

different parsing and segmentation strategies in speech perception, and with different morphological systems?

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