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WHAT CONSTRAINS POSSIBLE SUFFIX COMBINATIONS? ON THE INTERACTION OF GRAMMATICAL AND PROCESSING RESTRICTIONS IN DERIVATIONAL MORPHOLOGY

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ABSTRACT. There is a long-standing debate about the principles and mechanisms that constrain the combinatorial properties of affixes, in particular of English suffixes. One group of scholars argues for the existence of lexical strata with strong restrictions holding between the different strata. This view is disputed by scholars who claim that it is selectional restrictions of individual suffixes that are responsible for the combinatorial properties of suffixes. Most recently, Hay (2000, 2002) has proposed a psycholinguistic model of morphological complexity, according to which an affix which can be easily parsed out in processing should not occur inside an affix which cannot. This model has been called "complexity based ordering". The general claim is that affixes can be approximately ordered along a hierarchy of complexity, with more separable affixes at one end, and less separable affixes at the other end. More separable affixes can attach outside less separable affixes, but not vice-versa. The goal of this paper is to test the predictions of complexity based ordering through an investigation of 15 English suffixes and their potential 210 two suffix combinations. Using large data-bases such as the British National Corpus, the CELEX lexical data-base, the *OED* and the internet, we investigate whether the attested and non-attested combinations are best explained by complexity based ordering or by the individual selectional properties of these suffixes. We show that in most cases selectional restrictions and parsing restrictions coincide. Where selectional restrictions underdetermine possible combinations, complexity based ordering makes correct predictions. Only well parsable combinations are possible combinations, and this range of possible combinations is then further curtailed by selectional restrictions. In sum,

we argue that both selectional restrictions and parsing constraints are instrumental in determining possible and impossible suffix combinations.

1. INTRODUCTION[1]

In English (and presumably in all other languages with derivational morphology), there are severe restrictions on possible combinations of affixes and bases. A given derivational affix attaches only to bases that have certain phonological, morphological, semantic, or syntactic properties. For example, the verbal suffix *-ize* only occurs on nouns and adjectives that end in an unstressed syllable (see Plag 1999 for details). Similar, or even more complex, restrictions seem to hold for affix-affix combinations. For instance, the word *atomic* can take the suffix *-ity* as a nominalizing suffix, whereas the word *atomless* can not take *-ity*, but can take the competing nominalizing suffix *-ness* (**atomlessity* vs. *atomlessness*).

There has been a long debate about whether there are general principles or mechanisms that constrain the combinatorial properties of affixes, but no consensus has yet been reached. There are basically three approaches to the problem. First, there are stratum-oriented models (e.g. Siegel 1974, Allen 1978, Selkirk 1982, Kiparsky 1982, Mohanan 1986, Giegerich 1999) that claim that the lexicon has a layered structure and that this structure largely determines the combinatorial properties of affixes. Second, there are scholars who argue that affix-particular selectional restrictions (of a phonological, morphological, semantic or syntactic nature) are responsible for possible and impossible combinations of affixes (e.g. Fabb 1988, Plag 1999). Most recently, a third theory has been proposed in Hay (2000, 2002), which says that constraints on the processing of morphological structure control affix combinations.

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[1] Earlier versions of this material were presented at: the International Morphology Meeting, Budapest; the Linguistics and Phonetics Conference, Meikai University, Japan; the DüKöMarSie Phonology and Morphology Meeting, University of Düsseldorf; the Justus-Liebig-Universität Gießen; Ludwig-Maximilian-Universität München; Max Planck Institute for Psycholinguistics; and the University of Siegen. We would like to thank these audiences for their helpful and encouraging comments. We are also grateful to Harald Baayen, Maria Braun, Sabine Lappe and our anonymous referees for their close reading of earlier versions and their critical and constructive feedback. The order of authors is alphabetical.

In this paper we will study the three models and test how they can account for the potential 210 two-suffix combinations of 15 English derivational suffixes (most of them stratum 2 suffixes). The article is structured as follows. In the following section we will review the two older models, dismissing stratum-oriented models as inadequate for the solution of the problem at hand, which leaves us with only two models to test (the selectional restriction approach and the processing approach). In section 3 we will introduce Hay's model of complexity based ordering, and develop two competing hypotheses that follow from the two models. In section 4 we will then test the two hypotheses using large amounts of data from the BNC, the *OED* and the internet. Section 5 discusses our results in the light of other issues; section 6 summarizes our findings.

2. Earlier Models: Lexical strata and selectional restrictions

Until recently the debate on stacking restrictions was characterized by two opposing views. Proponents of stratum-oriented models (e.g. Siegel 1974, Allen 1978, Selkirk 1982, Kiparsky 1982, Mohanan 1986) assume that most, if not all combinatorial restrictions among English suffixes can be explained by the fact that these suffixes belong to different lexical strata and that these strata interact phonologically and morphologically in intricate ways. This is known as level-ordering, which in turn is part of most models of Lexical Phonology.[2] According to the level-ordering hypothesis, English suffixes and prefixes belong to the following classes or strata:

(1) Class I suffixes: +ion, +ity, +y, +al, +ic, +ate, +ous, +ive, +able, +ize
Class I prefixes: re+, con+, de+, sub+, pre+, in+, en+, be+
Class II suffixes: #ness, #less, #hood, #ful, #ly, #y, #like, #ist, #able, #ize
Class II prefixes: re#, sub#, un#, non#, de#, semi#, anti#

[2] As pointed out by Booij (1994), the main insight of Lexical Phonology is that phonology and morphology work in tandem. This is logically independent of the idea of level ordering. What concerns us here is the level ordering hypothesis. In what follows the discussion of level ordering will focus on suffixes, since this is the topic of the present article.

(from Spencer 1991:79)

The suffixes belonging to one stratum share a number of properties that distinguish them from the suffixes of the other stratum. Stratum 1 suffixes tend to be of foreign origin ('Latinate'), while stratum 2 suffixes are mostly Germanic. Stratum 1 suffixes frequently attach to bound roots and tend to be phonologically and semantically less transparent than stratum 2 suffixes. Stratum 1 suffixes cause stress shifts, resyllabification, and other morphonological alternations, stratum 2 suffixes do not. Stratum 1 suffixes are less productive and less semantically compositional than stratum 2 suffixes, and, crucially, stratum 1 suffixes do not occur outside stratum 2 suffixes. Thus, suffixes can only combine in such a way that they attach to suffixes of the same stratum or of a lower stratum. This is perhaps the most important generalization concerning suffix combinations that emerges from stratum models, since impossible combinations such as the one given in the introduction, **atomlessity*, are ruled out on principled grounds. However, there are serious problems with this approach.

The obvious empirical problem is that the model does not say anything about possible and impossible combinations within a given stratum, thus leaving large amounts of data unaccounted for. In order to explain combinations within strata, individual selectional restrictions are needed in any case, and, as argued in Plag (1996, 1999), these selectional restrictions then also account for the would-be stratal behavior of sets of affixes (see more on this below).

One major theoretical weakness of level ordering is that the two strata are not justified on independent grounds. In other words, it is unclear what is behind the distinction between the two strata, and which property makes a suffix end up on a given stratum. It has been suggested that the underlying distinction is one of etymology (borrowed vs. native, e.g. Saciuk 1969), but this does not explain why speakers can and do master English morphology without etymological knowledge. It has also been argued that the stratum problem is in fact a phonological one, with differences between different etymological strata being paralleled by phonological differences (see e.g. Anshen et al. 1986, or Booij 2002, van Heuven et al. 1993 for Dutch). This approach has the advantage that it would allow speakers to distinguish between the strata on the basis of the segmental and prosodic behavior of derivatives. However, explaining the nature of the strata as an epiphenomenon of underlying phonological properties of suffixes weakens the idea of strata considerably, because, as shown by Raffelsiefen (1999), not even two of the many suffixes of English trigger exactly the same type of morpho-phonological alternations, so that we would need as many sub-strata as we have suffixes that trigger morpho-phonological alternations. Thus we end up with a continuum, rather than with a discrete dipartite system.

Another serious problem is that a stratum cannot be defined by the set of suffixes it contains, because many suffixes (at least in English) must belong to more than one stratum. This set of affixes show stratum 1 behavior in some derivatives, whereas in other derivatives they display stratum 2 behavior, with sometimes even doublets occurring (cf. *compárable* vs. *cómparable*). Futhermore, there are a number of unexpected suffix combinations. Thus stress-neutral *-ist* appears inside stress-shifting *-ic* (as in *naturalistic*), or stress-neutral *-ize* appears inside stress-shifting *-(at)ion* (cf. *colonialization*). In order for the model not to make wrong predictions, dual membership of affixes (or some other device weakening the overall model) becomes a necessity.

Giegerich (1999) discusses cases of apparent dual membership of affixes in great detail and - as a consequence - proposes a thoroughly revised stratal model, in which the strata are no longer defined by the affixes of that stratum, but by the bases. This base-driven stratification model, which is enriched by many suffix-particular base-driven restrictions, can overcome some inadequacies of earlier stratal models, but at the cost of significantly reducing the overall predictive power of the model. These restrictions are a well-taken step towards making predictions concerning suffix order within strata, and therefore represent a significant step forward from earlier Lexical Phonology models. Certain problems remain, however.

For example, Fabb (1988) and Plag (1996, 1999) point out that there are numerous other important (phonological, morphological, semantic, syntactic) restrictions operative in English suffixation. Level ordering says nothing about these restrictions. For example, Fabb finds that the 43 suffixes he investigates are attested in only 50 two suffix combinations, although stratum restrictions would allow 459 out of the 1849 possible ones. He replaces stratal restrictions by individual selectional restrictions and proposes four classes of suffixes:

(2) Fabb (1988): 4 classes of suffixes

a. Group 1: suffixes that do not attach to already suffixed words (28 out of 43)

b. Group 2: suffixes that attach outside one other suffix (6 out of 43)

c. Group 3: suffixes that attach freely (3 out of 43)

d. Group 4: problematic suffixes (6 out of 43)

As pointed out in Plag (1996, 1999), this classification has also serious shortcomings. Firstly, there are numerous counterexamples to the above generalizations, secondly, the classes of suffixes are arbitrary and it is not clear why a given suffix should belong to a certain class and not to a different one, and thirdly, the classification does not account for all restrictions on possible combinations. The latter point is crucial, as we will shortly see. For any given affix, its phonological, morphological, semantic and syntactic properties and / or the properties of its derivatives must be stated in its lexical entry. Plag (1996, 1999) shows that these diverse properties together are responsible for the possible and impossible combinations of a given affix both with stems and with other affixes. Imagine, for example, a suffix X that only attaches to monosyllabic stems (the verbal suffix *-en* would be a case in point). As a consequence, this suffix X may never combine with a suffix Y that is syllabic itself, because the combination of syllabic Y with a stem would automatically create a disyllabic word, which in turn would not be an eligible base for suffix X. Thus, restrictions holding between (non-suffixed) bases and suffixes may in general also constrain possible suffix-suffix combinations, to the effect that what has been analyzed as would-be stratal behavior falls out from the phonological, morphological and semantic properties of the affix. Since these properties must be stated anyway to account for the particular behavior of a given affix, Plag argues that no further stratal apparatus is necessary.

In addition to traditional affix-driven restrictions, Plag (1996, 1999) incorporates the idea of base-driven suffixation to explain apparent idiosyncrasies in suffix combinations. For illustration of what is meant by base-drivenness, consider the deverbal suffixes of Fabb’s ‘Group 1’, which are said not to attach to any suffixed word.

(3) deverbal nominal suffixes not attaching to an already suffixed word

-*age* (as in *steerage*)

-*al* (as in *betrayal*)

-*ance* (as in *annoyance*)

-*ment* (as in *containment*)

-*y* (as in *assembly*)

Why should these suffixes behave in this way? And is this a property that has to be stated in the lexical entry of each of the nominal suffixes? In an affix-driven approach this would be essential. In a base-driven approach, however, this is not necessary, because it follows from independently needed specifications of the pertinent base words. The argument goes as follows: the only suffixed words that could in principle appear before deverbal *-age, -al, -ance, -ment* and *-y* are verbs ending in *-ify, -ize, -ate,* and *-en*. However, *-ify, -ize,* and *-ate* require (a suffix-particular allomorph of) the nominalizer *-(at)ion*:

(4)	magnification	verbalization	concentration
	*magnify-ation	*verbalize-ification	*concentrate-ation
	*magnify-ion	*verbalize-ion	*concentrate-ification
	*magnify-ance	*verbalize-ance	*concentrate-ance
	*magnify-al	*verbalize-al	*concentrate-al
	*magnify-age	*verbalize-age	*concentrate-age
	*magnify-y	*verbalize-y	*concentrate-y
	*magnify-ment	*verbalize-ment	*concentrate-ment

These facts suggest that the behavior of verbalizing and nominalizing suffixes is best analyzed as base-driven: combinations of the verbal suffixes *-ify, -ize, -ate* with *-age, -al, -ance, -ment* and *-y* are ruled out because it is the verbal suffix (or the verbal base with this suffix) which selects its nominalizing suffix *-ion*, and it is crucially not the nominal suffix which selects its base.

To summarize, we can say that level ordering has serious empirical and theoretical weaknesses. Models that focus on suffix-particular affix-driven and base-driven restrictions are empirically more adequate, but they could be criticized for their lack of generalizations across suffixes. After all, linguists want to believe that language in general and derivational morphology in particular is not just an accumulation of idiosyncrasies. This is the point where Hay's psycholinguistic model comes in.

3. COMPLEXITY BASED ORDERING (HAY 2000, 2002)

Hay (2000, 2002) proposes an account of ordering based on parsability – an account which Plag (2002) has dubbed "complexity based ordering". Complexity based ordering maintains that processing constrains ordering. The general claim is that affixes can be approximately ordered along a hierarchy of processing complexity, with more separable affixes at one end, and less separable affixes at the other end. Some affixes are highly parsable, and words containing these affixes tend to be accessed via their parts in speech perception. Other affixes are less parsable, and words containing them tend to be accessed whole. Less parsable affixes, maintains Hay, cannot attach to more parsable affixes.

Complexity based Ordering (CBO):

> "While some affixes basically tolerate no internal structure, others will tolerate structure to some minimum degree. The degree of internal 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*" (Hay 2002: 527-528)

Hay's account therefore captures one of the main insights of Lexical Phonology - that affixes create different boundary strengths, and that boundary strength is related to ordering. However this account is extended by considering boundary strength to be gradient, and a function of decomposability in speech perception. 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.

Central to this account is the claim that any individual affix occupies a range of separability - it is more separable in some words than others. As such, there are systematic word-based exceptions to ordering generalizations - cases in which words with low levels of decomposability can take an affix that comparably highly decomposable words might not (e.g. *government* is less decomposable than *bafflement*, leading *governmental* to be more acceptable than *bafflemental* - see the experimental data on *-mental* affixation in Hay 2002). The fact that the prediction extends to the parsability of affixes as they occur in specific words accounts for the so-called dual-level behavior of some affixes. An affix may resist attaching to a complex word which is highly decomposable, but be acceptable when it attaches to a comparable complex word which is less decomposable.

CBO predicts that it should be possible to arrange affixes into a loose hierarchy of juncture strength, such that (allowing for syntactic, semantic and pragmatic restrictions) any suffix below a given suffix on the hierarchy can precede that given suffix, but not follow it, and any suffix above a given suffix on the hierarchy can follow that given suffix but not precede it. Importantly, and as discussed by Plag (2002), such a hierarchy would not be workable if completely deterministic and categorical. CBO thus also allows for affixes to occupy overlapping regions on the hierarchy. For example, if suffix B is generally more parsable than suffix A, and therefore higher in the overall hierarchy, it may nevertheless be the case that the most highly decomposable words with suffix A are more decomposable than the least decomposable words with suffix B (see also the discussion in section 5). In other words, the highly decomposable words containing one affix (our A) may be positioned above the less decomposable words containing a second affix (our B).

Complexity based ordering is hypothesized to hold for all affixes, i.e. for prefixes and suffixes. In the following, we focus our attention on suffixation.

(5) **HYPOTHESIS 1: THE HIERARCHY HYPOTHESIS** (cf. Hay 2002)

Suffixes can be ordered in a hierarchy of juncture strength, such that affixes following an affix A on the hierarchy can be freely added to words containing A, but affixes preceding A on the hierarchy cannot freely attach to words containing A.

A hypothetical hierarchy of affixes is shown in (6a). The suffix A tends to be more separable than suffixes X, Y, and Z. However it tends to be less separable than suffixes B, C and D. Complexity based ordering would therefore predict the combinations shown in (6b). However the combinations in (6c) should be ruled out.

(6) a. Hierarchy of suffixes: X-Y-Z-**A**-B-C-D

b. Possible combinations: **BASE-A**-B, **BASE-**X-**A**-C, **BASE-**Y-Z-**A**

c. Impossible combinations: ***BASE-A**-Z, ***BASE-**Y-**A**-Z, ***BASE-**X-**A**-Y

Plag (2002) has argued against the hierarchy hypothesis, claiming that parsing criteria alone cannot possibly account for patterns of affix co-occurrence in English, because they underdetermine the range of possible combinations. Rather, he argues, the ordering of affixes is determined by a set of selectional restrictions. This leads to the competing hypothesis as given in (7).

(7) **HYPOTHESIS 2: THE SELECTIONAL RESTRICTION HYPOTHESIS** (cf. Plag 2002)

The order of suffixes is determined by selectional restrictions

In the following section the two hypotheses will be tested.

4. TESTING COMPETING HYPOTHESES

4.1. Suffixes and procedures

The purpose of our investigation was not only to determine whether one of the two hypotheses can be falsified, but also to investigate in more detail the relationship between processing constraints and grammatical constraints. Are they in conflict? Do they coincide? Do they depend on one another?

To examine the hypotheses we have taken 15 suffixes of English as our testing ground. 13 of our suffixes were taken from a recent article by Aronoff & Fuhrhop (2002). By taking a set of suffixes that had been selected by other scholars, and for different purposes, we avoided any potential bias by the present authors with regard to the selection of the suffixes to be investigated. The set of 13 suffixes was complemented by the completely unproductive suffix *-th*, and by the nominal suffix *-ful* (as in *cupful*). These suffixes were included to enlarge the data base, and nominal *-ful* in particular was included because it had to be dealt with anyway in order to separate it in the data from adjectival *-ful* (which was part of Aronoff and Fuhrhop's set). Overall, a set of 15 suffixes seemed large enough to find significant and clear patterns because it yields 210 potential two-suffix combinations. The suffixes are listed in (8):

(8) The 15 suffixes under investigation

suffix	**Examples**
-dom	*freedom, stardom*
-ee	*employee*
-en	*deepen*
-er	*baker, Londoner*
-ess	*princess*
-ful (adjectival)	*careful*
-ful (nominal)	*cupful*
-hood	*childhood, falsehood*
-ish	*Jewish, schoolboyish, greenish, fortyish*
-less	*careless*
-ling	*duckling*
-ly	*fatherly, deadly*
-ness	*kindness*
-ship	*friendship*
-th	*depth, growth*

(Multiple examples are given for those categories that allow different base categories, such as adjective and noun)

To see which combinations of these suffixes are possible we took two different approaches. The first was to check all 210 potential two-suffix combinations[3] for attestations in the BNC, CELEX, the *OED* and the internet. The results of this investigation

[3] We did not check combinations of the same suffix, because recursion of the same suffix is generally ruled out on semantic grounds. There are only certain prefixes that can be stacked recursively (e.g. *great-great-grandfather, mega-mega-event*)

are presented in section 4.2. The second procedure was to predict all potential combinations on the basis of the selectional restrictions of the 15 suffixes and compare them to the actually attested combinations. This will be done in section 4.3.

Before presenting our results, we will briefly describe our data sources. The BNC is a 100 million word corpus, with data from all kinds of discourse. For our study we have used the complete BNC word list, from which the pertinent words have first been extracted automatically. The resulting lists of raw data were cleaned manually to arrive at lists that only contain the words belonging to the morphological categories in question. A similar procedure was employed with the *OED*. For a detailed discussion of the problems involved in this kind of data collection see Plag (1999: chapter 5, Plag et al. 1999). The usefulness of the BNC as a data source for morphological investigations has been demonstrated before in a number of studies (e.g. Plag et al. 1999, Dalton-Puffer and Plag 2001). The CELEX Lexical Database (Baayen, Piepenbrock, and Gulikers, 1995) is based on an early version of the Cobuild corpus (Renouf, 1987) that contained some 18 million words. The English database in CELEX provides the morphological segmentation for a great many complex words: all the words in the LDOCE machine-readable dictionary, as well as all words in the Cobuild corpus down to a frequency threshold of 15 occurrences per 18 million - we refer to this as the segmentation list. CELEX also provides a separate, unanalysed list of all character strings occurring in the Cobuild corpus, together with their frequency of occurrence in the corpus (the string list). We checked both the string list and the segmentation list for attested combinations.

If the affix combination under investigation was not attested in any of the above sources, a final check was made by searching for plausible combinations on the internet, using the Google search engine. This was done because we were reluctant to take combinations' nonappearance in sources such as the OED as evidence that the affix combinations are not possible, or not well-formed. The use of dictionaries can be problematic for the study of the productivity of affix combinations, because usually only words and affix combinations which occur relatively frequently are listed in a dictionary. For example, the frequency of use of the affix *-ee* is fairly low. If we use the frequency counts in CELEX as an indication, then the probability, on encountering any given word, that it will be affixed with *-ee* is .001. The probability that it will be affixed with *hood* is .0006. Thus, assuming that the combination *-eehood* is actually possible, the probability of actually encountering such a combination given any given word (abstracting away from token frequency) is 0.0000006. That is, we need a corpus containing at least 1666666 different words (i.e. different types), before we even expect to find a single example of a word containing *-eehood*. And we need a much bigger corpus before we can conclude that the absence of encountering such a word is actually linguistically significant. One should be careful, then, about concluding that affix combinations are ungrammatical, based solely on their absence from the OED, or from moderately sized corpora.

For this reason, we conducted a series of web searches for words containing the affix combinations which were unattested, but not ruled out, in order to gauge the degree to which they are truly unacceptable, versus just extremely low probability. The size of the internet for English was estimated at 47,264,700,000 words in 2000 (Grefenstette and Nioche 2000), and this estimate has recently been updated to at least 76 billion (Grefenstette 2001). A web search therefore enables us to gauge the degree of use of affix combinations which have vanishingly low probabilities.

For example, the combination *-eehood*, was searched for by selecting potential *–ee* bases from the CELEX string list (e.g. *nominee, refugee, detainee* etc), affixing them with *–hood*, and searching for occurrences. The combination *-eehood* was multiply attested with a variety of roots. Examples are given in (9). We therefore classify it as “attested.”

(9) a. **Refugeehood**, therefore, represents an imposed state of being that is the result of the trauma of persecution.

b. ... it pretty much ruined me for conventional **employeehood**

c. As though she had temporarily set aside the morality of motherhood and **divorceehood**.

The absence of a combination from sources such as the OED, BNC and CELEX indicates that the combination is of extremely low frequency. However the appearance of a combination on the internet indicates that, while of low frequency, it is not completely ruled out.

4.2. Attested suffix combinations

In the following table, we list all two-suffix combinations attested in the said sources in alphabetical order. Examples of the attested combinations can be found in the appendix. Attested two-suffix combinations are indicated by ‘yes’, the first suffix of each combination is given in the leftmost column, the second suffix in the top row. Blank cells are unattested combinations.

Table 1: Attested suffix combinations (BNC, *CELEX*, *OED*, internet), alphabetical order

	dom	***ee***	***en***	***er***	***ess***	***ful(a)***	***ful(n)***	***hood***	***ish***	***less***	***ling***	***ly***	***ness***	***ship***	***th***
dom	-						yes			yes					
ee		-			yes			yes						yes	
en		yes	-	yes											
er	yes			-	yes		yes	yes	yes	yes	yes	yes		yes	
ess	yes				-			yes		yes		yes		yes	
ful (adj)						-							yes		
ful (n)							-								
hood								-		yes					
ish									-				yes		
less										-			yes		
ling								yes		yes	-			yes	
ly								yes	yes			-	yes		
ness													-		
ship						yes				yes				-	
th			yes			yes				yes					-

Out of the 210 potentially possible combinations, only 36 are attested (17%). This means that, unsurprisingly, there must be severe restrictions at work. These restrictions are unaccounted for by traditional level-ordering, because only two suffixes, -*th* and -*ee* could be said to be stratum 1, while all other suffixes would be stratum 2. Hence level ordering would only rule out 26 combinations, which would still leave us with 184 possible ones, of which, however, only 36 are attested. This is another indication of the insufficiency of level ordering as an explanation of suffix ordering restrictions.

Let us now turn to complexity based ordering and the hierarchy hypothesis following from it. According to this hypothesis it should be possible to rearrange table 1 in such a way that we end up with the predicted hierarchy of suffixes. This is done in table 2 below. Note that tables 1 and 2 show ‘yes’ even if there was only a single derivative of its kind attested in the vast data base. We deliberately did not impose a threshold on the number of attested forms, in order to increase the chance of falsifying the hierarchy hypothesis. Thus, one attested form of a given suffix combination could have in principle falsified the hierarchy hypothesis. As shown in table 2, this did not happen. We achieve 100 % scalability, the hypothesis is fully supported by the data.

Table 2: Attested suffix combinations, hierarchical order (100 % scalability)

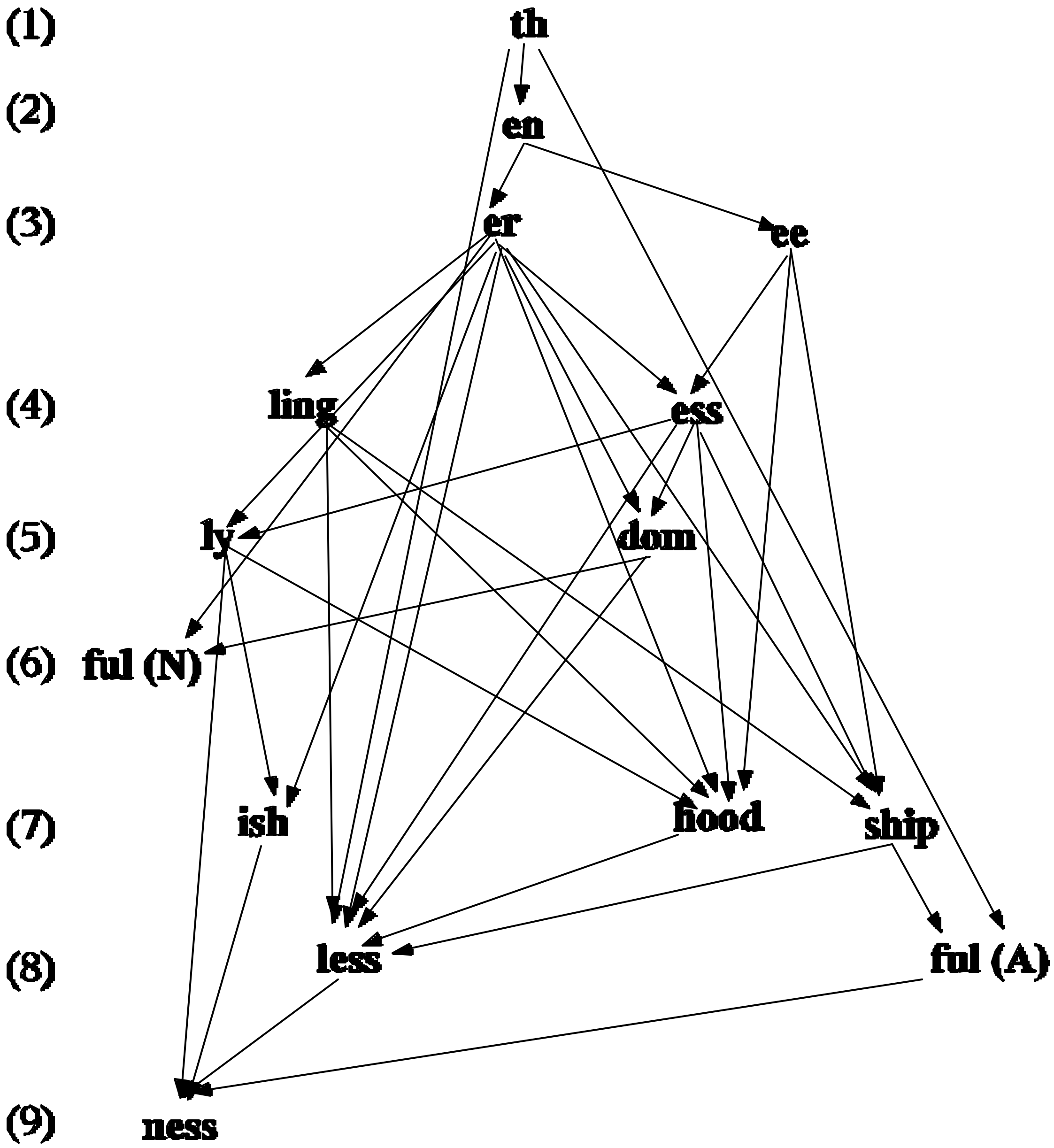
	th	***en***	***er***	***ling***	***ee***	***ess***	***ly***	***dom***	***hood***	***ship***	***ish***	***less***	***ful (a)***	***ness***	***ful(n)***
th	-	yes										yes	yes		
en		-	yes		yes										
er			-	yes		yes	yes	yes	yes	yes	yes	yes			yes
ling				-					yes	yes		yes			
ee					-	yes			yes	yes					
ess						-	yes	yes	yes	yes		yes			
ly							-		yes		yes			yes	
dom								-				yes			yes
hood									-			yes			
ship										-		yes	yes		
ish											-			yes	
less												-		yes	
ful (adj)													-	yes	
ness														-	
ful (n)															-

There is no ‘yes’ below the diagonal, which means that there is no combination attested in which an outer suffix occurs inside an inner suffix. Placing this particular set of affixes in this order then, achieves a high level of explanatory power. Of course the order was achieved by trial and error - and not by independent means. However, the probability of such an order existing purely by chance cannot be high. Moreover, the order in which the affixes occur does not look completely random. The leftmost affix is clearly non-productive and forms a very weak boundary, the rightmost affix is highly separable and highly productive. We explore below the degree to which the ordering correlates with measures of boundary strength.

It is important to note that the unidimensional hierarchy (*-th* << *-en* << *-er* << *-ling, -ee* << *-ess* << ...) in the top row of table 2 is slightly underdetermined, because not all of the suffixes can be ranked with regard to each other. For example, *-ling* and *-ee,* or *-hood* and *-ship,* are arbitrarily placed in their respective orders and could exchange their respective places in the hierarchy. Furthermore, the nominal suffix *-ful* could have been placed further to the left without violating the hierarchy. Since *-ness* and nominal *-ful* are the only suffixes that are never followed by any other suffix from our set, they were placed at the end of the hierarchy, i.e. in the rightmost columns.

It is however possible to establish another, related, hierarchy by arranging the suffixes only with regard to suffixes with which they actually interact. This brings about the graphical hierarchy in figure 1, in which arrows connect suffixes that are attested as suffix combinations. Position in this hierarchy is created on the basis of attested combinations only – affixes are placed as early in the hierarchy as possible combinations will allow. This makes clear that, while there are some affixes whose rank cannot be determined with respect to one another, a strict hierarchical organization nonetheless holds. This is graphically represented by the fact that all arrows point downwards, and that there is no loop back to a suffix at a higher level of the hierarchy.

Figure 1: Graphical hierarchy of suffixes. Suffixes at the beginning of arrows immediately precede suffixes at the end of arrows in attested combinations (BNC, OED, CELEX, Internet). The figures in parentheses indicate planes in the hierarchy. Position in this hierarchy is created on the basis of attested combinations only – affixes are placed as early in the hierachy as possible combinations will allow.



The empirical data thus strongly speak in favor of the idea that suffixes form hierarchies, there is not a single datum that goes against the hierarchy hypothesis. And it is unclear why such a hierarchy should exist in the first place, if not for the reasons that underlie the hierarchy hypothesis, i.e. complexity based ordering.

Now, if processing factors are responsible, we would expect the hierarchy to reflect the order of suffixes established on the basis of their parsability. Thus, a given suffix should, across all derivatives with that suffix, be more easily separable in parsing than all the suffixes to the left of it (in the unidimensional hierarchy in table 2) and less easily separable in parsing than all the suffixes to its right. Overall, the most easily separable suffix should be at the end of the hierarchy, and the least separable suffix at the beginning. Thus, *-ness* should be most easily separable suffix, *-th* the least separable.

In order to test this we have used parsing ratios and productivity measures as computed by Hay and Baayen (2002). On the basis of the analysis of 80 English affixes Hay and Baayen show that parsing ratio and productivity are strongly correlated. Roughly speaking, those affixes that are easily separable from their bases in parsing are also those suffixes that are most productive, an idea that is in line with the observation that productive processes are semantically and phonologically transparent. To determine the type and token parsing ratios, Hay and Baayen calculate, for any given affix, in what proportion of words the affix is likely to be parsed, based on the frequency characteristics of the affixes and the words which contain it.[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* - see Hay (2001) for the importance of relative frequency in morphological processing). They also calculate the proportion of tokens containing the affix which are likely to be parsed. The resulting parsing ratios therefore indicate the *proportion* of types (the type parsing ratio) or tokens (token parsing ratio) containing an affix which are likely to be parsed. For example, if an affix was represented only by words which are unlikely to be

[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. Thus, these calculations are not based on simply 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 and Baayen (2002) for details.

parsed, the parsing ratios would be 0. If it was represented only by words which are likely to be parsed, the parsing ratios would be 1. The higher the type (or token) parsing ratio, the greater the proportion of types (or tokens) which are prone to parsing.

For the computation of productivity, Hay and Baayen (2002) use the corpus-based, hapax-conditioned productivity measure *P*, which is the number of hapaxes with a given affix divided by the number of tokens with that affix (for a comparative discussion of different productivity measures see, for example, Plag 1999: chapter 5). For reasons of space the intricacies of these calculations cannot be dealt with here, the reader is referred to Hay and Baayen (2002) for full discussion. What is important for our paper is that these authors have dealt with 80 affixes, a subset of which is the set of suffixes under investigation. We could therefore exploit Hay and Baayen's results, which were obtained for purposes entirely different from the ones of this paper.

Given the information on the parsability and productivity of our suffixes provided by Hay and Baayen (2002), we correlated the rank of the suffixes in the hierarchy shown in Table 2 with the rank of the suffixes established on the basis of the type and token parsing ratios and productivity as calculated by Hay and Baayen (2002)[5]. In the following table the four rankings are given. Also shown is an overall figure designed to assess the overall ranking in boundary strength. This figure takes the rank of each affix for each of productivity, token parsing ratio and type parsing ratio, and averages these to come up with an overall approximate number reflecting the boundary strength created by the affix. In cases where ranks were tied, the mean of the appropriate rank values was applied. E.g. *-en* and *-er* tie for 6^{th} / 7^{th} position in terms of productivity, so both were assigned a rank of 6.5.

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[5] Hay and Baayen (2002) collapse together their calculations for adjectival *-ful* and nominal *-ful*. These have therefore been calculated independently here (using exactly the same procedure) for the purposes of this exercise.

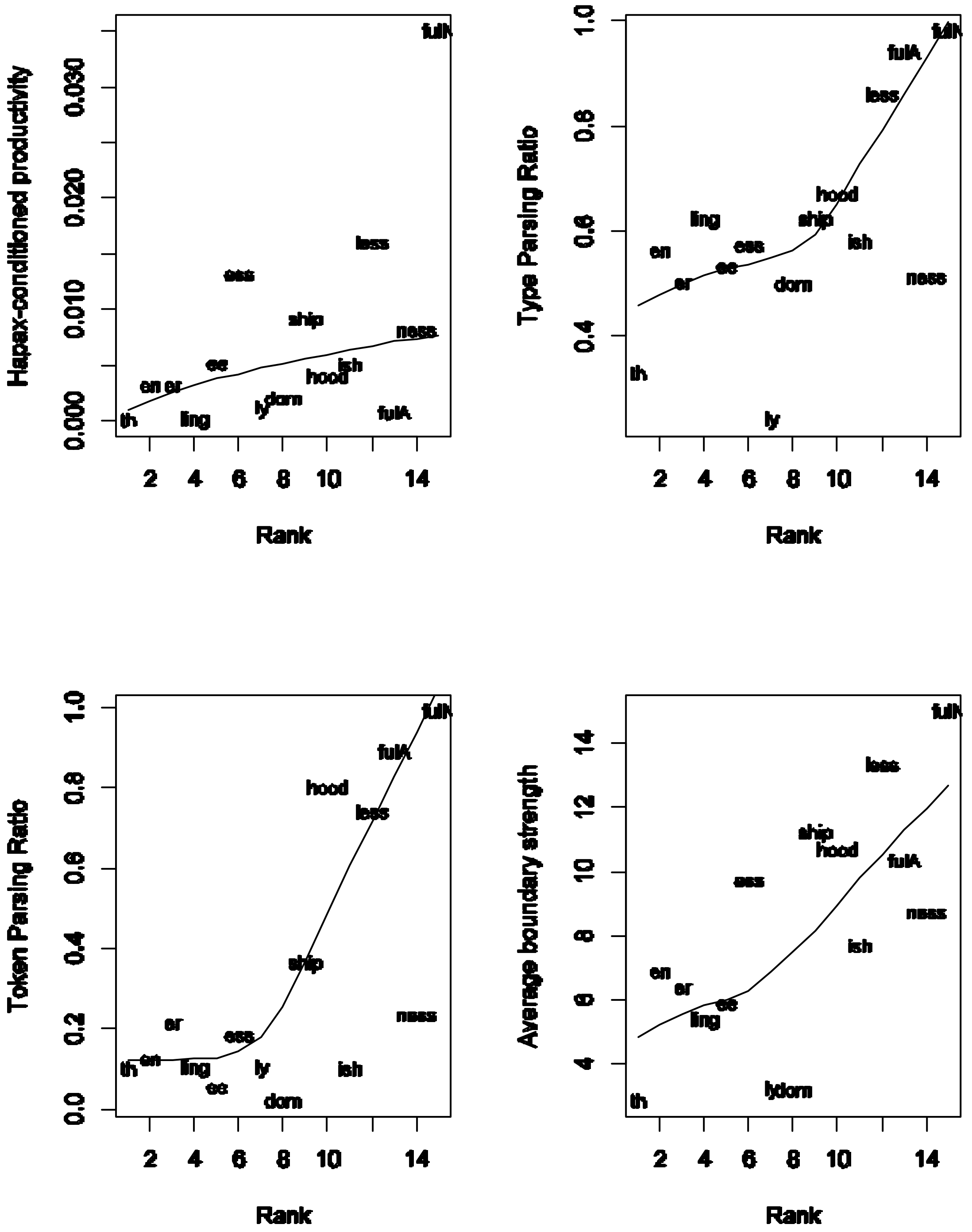
Table 3: Suffix ranking according to different measures

Affix	Rank in hierarchy, according to table 2	productivity	token parsing ratio	type parsing ratio	Boundary strength (average rank in productivity, token parsing ratio and type parsing ratio)
th	1	0.00005	0.1	0.33	2.83
en	2	0.003	0.12	0.56	6.83
er	3	0.003	0.21	0.5	6.33
ling	4	0	0.1	0.62	5.33
ee	5	0.005	0.05	0.53	5.85
ess	6	0.013	0.18	0.57	9.67
ly	7	0.001	0.1	0.24	3.17
dom	8	0.002	0.02	0.5	3.17
ship	9	0.009	0.36	0.62	11.17
hood	10	0.004	0.67	0.8	10.67
ish	11	0.005	0.1	0.58	7.67
less	12	0.016	0.74	0.86	13.33
ful_A	13	0.0007	0.89	0.94	10.33
ness	14	0.008	0.23	0.51	8.67
ful_N	15	0.035	0.99	0.98	15

We subjected the figures to a statistical analysis to see whether they correlate. It would be problematic for a complexity based ordering account, for example, if the affix with the lowest overall boundary strength could freely attach (i.e. was ranked high in the affix hierarchy), and the affix with the highest overall boundary strength was highly restricted in terms of ordering (i.e. was ranked low in the hierarchy). If complexity based ordering is correct, we expect a relationship between measures of boundary strength and affix position in the hierarchy. The results of this analysis are given in figure 2.

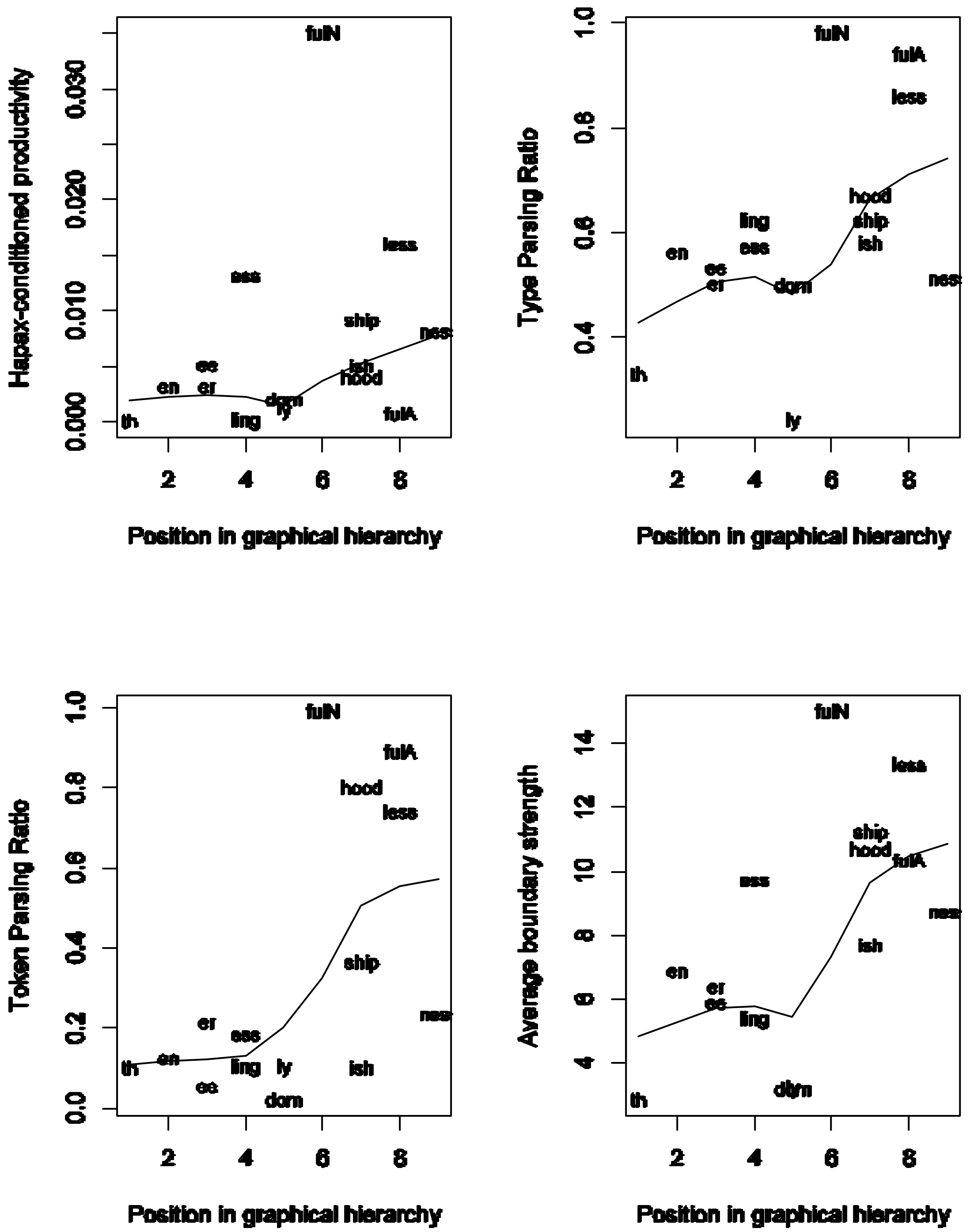
The affixes' position in the hierarchy correlates strongly with all four measures of decomposition. This result provides very strong support for a complexity based ordering account. Not only is there no a priori reason why affixes should organize into a hierarchy for ordering, but there is also no independent reason why affixes' position in such a hierarchy should relate to separability. Both of these facts provide strong support of hypothesis 1.

Figure 2: Suffix ranking as shown in Table 2, and its correlation with Productivity, Type Parsing Ratio, Token Parsing Ratio, and average "boundary strength" (average rank in former three measures). All four figures show significant correlations (Spearman's rank correlation: p<.05). The lines shown on the figures reflect a non-parametric scatterplot smoother fit through the data (Cleveland 1979).



Of course, the order investigated is not the only possible hierarchy which would conform to the hierarchy hypothesis. For example the order of *-ling* and *–ee* could be switched, as could *-hood* and *-ship* – these are indeterminate with respect to one another. As a second check on the degree to which complexity based ordering is supported, we checked how the various measures of boundary strength correlate with affixes' positions in the graphical hierarchy shown in figure 1. This diagram presents a conservative estimate of an affix's position by placing an affix as early on the hierarchy as its occurrence with other affixes will allow, and by leaving many affixes unranked with respect to one another. Figure 3 shows how position in the graphical hierarchy correlates with the measures of boundary strength discussed above.

Figure 3: Position in graphical hierarchy (cf. figure 1), and its correlation with Productivity, Type Parsing Ratio, Token Parsing Ratio, and average "boundary strength" (average rank in former three measures). The lines shown on the figures reflect a non-parametric scatterplot smoother fit through the data (Cleveland 1979).



Three out of the four measures return significant correlations, only the correlation with productivity (upper left panel) does not reach significance ($p<.15$), but the remaining three graphs reflect significant correlations (spearman's rank correlation, $p<.05$).

These results, together with those shown in figure 2, provide strong evidence in support of complexity based ordering. Not only can affixes be organized into a hierarchy according to possible co-occurrences, but the resulting ordering appears to be non-random: The affixes in the hierarchy are organised in approximate order of increasing boundary strength. The more separable an affix is in processing, the more likely it is able to attach relatively freely to other affixes. And affixes which can be easily parsed out do not occur inside affixes which can not.

4.3. Structurally possible combinations

In this section we turn to a test of the competing hypothesis – the hypothesis that co-occurrence restrictions on English affixes are due to selectional restrictions. Is the hierarchy in table 2 a consequence of selectional restrictions? If grammatical restrictions are responsible, we would predict that most or all blank cells in table 2 are the consequence of a grammatical restriction. In order to test this prediction it is first of all necessary to determine for each suffix what kinds of restrictions come with it. We have consulted pertinent reference works on this question, such as Jespersen (1942), Marchand (1969), Bauer (1983), Adams (2001), Plag (in press), but also more specialized treatments on individual suffixes, such as Barker (1998), Ryder (1999), Dalton-Puffer and Plag (2001), Malkiel (1977), Riddle (1985), Ljung (1970), Plag (1999). The restrictions put forward by these authors hold between unsuffixed bases and suffixes, but, as already outlined in section 2 above, these restrictions also influence the range of possible suffix-suffix combinations.

The grammatical restrictions found are summarized in table 5:

Table 5: Suffixes and their grammatical restrictions

suffix	examples	derived category	base category	semantic restriction on base	semantic category of derivative	phonological restriction on base
-dom	*freedom* *stardom*	N	N / (ADJ)	?	'status, realm, collectivity'	?
-ee	*employee*	N	V / N	?	sentient being (non-agent)	-
-en	*deepen*	V	ADJ / N	?	change-of-state verb	- monosyllable - obstruent-final
-er	*baker* *Londoner*	N	V / N	?	person / instrument / etc.	-
-ess	*princess*	N	N	(male?) person / animal	female person / animal	-
-ful	*careful*	ADJ	N	abstract noun	qualitative adjective	-
-ful	*cupful*	N	N	concrete noun	partitive noun	-
-hood	*childhood* *falsehood*	N	N / (ADJ)	person noun	'state of being X'	-
-ish	*Jewish* *schoolboyish* *greenish* *fortyish*	ADJ / Num	N / ADJ / Num	N=person noun	similative	?
-less	*careless*	ADJ	N	?	'without X'	-
-ling	*duckling*	N	N	animate noun	young animal, (young) human being	?
-ly	*fatherly* *deadly*	ADJ	N / (ADJ)	N=person and time nouns	similative	?
-ness	*kindness*	N	ADJ / (any)	?	quality noun	-
-ship	*friendship*	N	N	person noun	status, collectivity	-
-th	*depth* *growth*	N	ADJ / V	?	quality noun	- monosyllable

The grammatical restrictions listed in table 5 refer to generally accepted grammatical properties of derivational morphological categories: the syntactic category of the derived word, the syntactic category of possible bases, the semantics of base and derivative, and the phonology of base and derivative. There are a number of problems involved with establishing these suffixal restrictions. First, most morphological categories contain words that do not neatly fit the generalizations that are often found in the literature. Some of these aberrant forms are truly idiosyncratic, others are so numerous that we might be dealing with a real sub-pattern. For example, most derivatives in *-dom* are denominal, but there are a few items that are de-adjectival (e.g. *freedom*). Since these are rather exceptional and their number very small, the table above mentions adjectival bases only in parentheses. With the suffix *-ee*, things are slightly different. While most treatments assume that this is a deverbal suffix, there is a non-negligible number of denominal derivatives. Apart from being denominal, these forms show exactly the properties of regular *-ee* formations, even in their semantics. Therefore, nominal and verbal bases are given an equal footing in the table. The same procedure was adopted for the other suffixes. What this boils down to is that some of the restrictions may occasionally be still a matter of some controversy.

This is, however, not the only problem with table 5. In quite a number of cells there are question marks, which means that it is unclear whether a restriction of this kind holds. These cases are numerous because very often subsets of derivatives show a certain pattern, but there are not enough forms in order to establish whether the pertinent generalization is indeed part of the word-formation rule or only an accidentally shared property of a limited set of related forms. This problem originates in the fact that not all of the processes are productive. An affix that has been around in the language for a while tends to have lexicalized derivatives that have developed various idiosyncrasies. In contrast to that, newly created forms with that affix are usually perfectly regular, and these regular forms exist side by side with idiosyncratic, lexicalized forms. Especially for affixes that are no longer productive or not fully productive, it is therefore not easy to decide what their general properties and restrictions are. In order to cope with these methodological problems we have included in the above table only those restrictions that are rather uncontroversial.

The following table lists those combinations that are structurally possible, taking into account all restrictions given in table 5. The entry 'yes' indicates that a combination is structurally possible *and* attested, the entry **'YES'** indicates that a combination is structurally possible but is *not* attested, and a question mark indicates a case where it is unclear whether the restrictions would allow the combination or not. Blank cells indicate structurally impossible combinations.

Table 6: Structurally possible suffix combinations. Possible and attested combinations are marked by 'yes**', possible but unattested combinations by 'YES'**

	th	*en*	*er*	*ling*	*ee*	*ess*	*ly*	*dom*	*hood*	*ship*	*ish*	*less*	*ful (a)*	*ness*	*ful(n)*
th	-	yes										yes	yes		
en		-	yes		yes										
er			-	yes		yes	yes	yes	yes	yes	yes	yes			yes
ling				-			**YES**	**YES**	yes	yes	**YES**	yes			
ee				**?**	-	yes	**?**	**YES**	yes	yes	**?**	**YES**			
ess				**?**		-	yes	yes	yes	yes	**?**	yes			
ly							-		yes		yes			yes	
dom								-				yes			yes
hood									-			yes			
ship										-		yes	yes		
ish											-			yes	
less												-		yes	
ful (adj)													-	yes	
ness												**YES**	**?**	-	
ful (n)															-

The most important thing table 6 shows is that the suffix-particular selectional restrictions rule out the vast majority of combinations, and that almost the same hierarchy as before emerges on the basis of predictions based on the grammatical properties of the suffixes. In other words, we can state that the blank cells and thus our hierarchy is largely constrained by selectional restrictions. Thus it seems that there is a tie between our two competing hypotheses. Under both hypotheses we end up with a hierarchy of suffixes. The crucial question however is the following: Why should selectional restrictions result in an hierarchy in the first place? This is a pure accident under the selectional restriction hypothesis but follows naturally from complexity based ordering. Furthermore, while the attested combinations are all above the diagonal, the selectional restrictions would allow at least one non-attested combination, *-ness-less*, plus perhaps a number of other combinations, indicated by a question mark in the table (*-ee-ling, -ess-ling, -ness-ful*).

According to complexity based ordering, it is to be expected that combinations below the diagonal are ruled out because of processing reasons.

The grammatical constraints can, however, explain a fact that we have not discussed yet, namely that complexity based ordering would allow all combinations above the diagonal. Obviously, only a small fraction of these combinations are in fact possible, due to the operation of grammatical constraints. We can therefore say that processing constraints and grammatical constraints work hand in hand. Almost all combinations that are below the diagonal are ruled out by both processing constraints and grammatical restrictions. And the number of possible (i.e. processable) combinations is then further curtailed by grammatical restrictions. Hence both selectional restrictions and processing constraints are instrumental in determining suffix ordering.

5. REMAINING PROBLEMS

While the correlation between boundary strength and ordering is very strong, it is not absolute. That is, if we consider the affixes on an item by item basis, there appear to be some anomalies. For example, *-less* is more separable than *–ness* by all measures considered. And yet *–ness* is very clearly positioned after *-less* in the ordering hierarchy. Such cases suggest that more careful work is ahead. There may not be a deterministic relationship between parsing and ordering, but rather a correlational one. However, without careful experimental work on online rates of decomposition, we are limited by our reliance on various heuristics for measuring separability – none of which are perfect. Measurements such as the hapax-conditioned degree of productivity, and the type and token parsing ratios are certainly correlated with rates of online decomposition, but by no means provide the last word. Much work therefore remains to be done.

When we extend our work to investigate non-Germanic affixes, the picture becomes more complicated still. Some affixes appear to occur both inside and outside one another – an apparent systematic violation of hypothesis 1. This problem is discussed by Plag (2002:293):

> "In other words we have the problem that *–al* must be at the same time more easily parsable than *–ion* (cf. *sensational*) and less easily parsable than *–ion* (cf. *colonialization*)."

The key to this paradox lies in the observation that different words containing the same affix may contain different degrees of decomposability (Hay 2000, 2002). For example while *-ion*[6] may tend overall to display lower levels of decomposability than *-al*, it is quite possible that their distributions overlap, such that there is some subset of *-al* words which are less decomposable than some subset of *-ion* words. The combination *-ional* certainly appears to be fairly unrestricted – CELEX lists very many examples which contain this combination. In general, then, a CBO approach requires us to assume that *-ion* tends to create forms with lower levels of decomposability than *-al*. The potential problem for the approach comes from the existence of forms ending in *-alize*, as *-ize* productively takes (or "base selects") *-ion*. Because *-ize* can occur with ease inside *-ion* we should assume that it tends to create forms of lower decomposability than *-ion* does. Why, then, can it follow *-al*, which presumably creates forms of higher levels of decomposability than *-ion* does? This finding would only be consistent with a CBO account if *-ize* can only attach to some subset of *-al* forms - namely those with a relatively low level of decomposability.

In order to investigate this, we looked for *-al* forms, with monomorphemic bases, which are listed in CELEX as taking *-ize*. A total of 27 are listed. For 13 of these, the *-al* form is more frequent than the base it contains - a property which is associated with low levels of decomposability (Hay 2000, 2002). Forty-eight percent of these forms therefore contain a diagnostic of low levels of decomposability. Compare this with the complete set of monomorphemic bases affixed in *-al* - a total of 225. Of these, 62 forms have the derived form (in *-al*) more frequent than the base it contains – 28%. When we compare *-al* forms which take *-ize* with *-al* forms in general, the difference is significant (Fisher Exact Test = $p < .05$). This difference suggests that *-ize* forms preferentially attach to those *-al* forms containing low levels of decomposability - a finding which probably provides the crucial clue towards solving the paradox that Plag (2002) presents.

Hay (2002) discusses a number of affixes which display similar properties. Such

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[6] We use '*-ion*' to refer to the different allomorphs *-ation*, *-ication*, and *-ion* of this nominalizing suffix.

results suggest that a complete understanding of affix-ordering is likely to require a full understanding of factors influencing the parsing and storage of individual words.

6. CONCLUSIONS AND IMPLICATIONS

In this paper we have investigated possible combinations of 15 suffixes based on large amounts of data from the British National Corpus (BNC), the CELEX database, the *OED* and the internet. Our study has shown that the predictions of complexity based ordering developed in Hay (2000, 2002) are largely born out by the facts. We have seen that suffixes can be ordered on a hierarchy of boundary strength, with suffixes with weaker boundaries being located closer to the base, and with suffixes with stronger boundaries being located further away from the base. We have also seen that selectional restrictions of individual suffixes largely coincide with parsing restrictions, which means that both selectional restrictions and parsing constraints are instrumental in determining possible and impossible suffix combinations. Overall, it was observed that only combinations that are well processable are possible combinations, and that this range of possible combinations is further curtailed by suffix-particular phonological, syntactic and semantic restrictions.

Our findings have wider implications at least for two issues, i.e. the nature of constraints in morphology, and the question of the relationship between grammar and language processing.

Recently, a new type of morphological constraint (for English) was introduced by Aronoff and Fuhrhop (2002), the so-called monosuffix constraint. According to this constraint, if a suffix attaches to a given base that is of Germanic origin, this base will not contain a suffix. Viewed from a different angle, the constraint states that native suffixes only attach to suffixed bases if these bases are Latinate.

As shown in our tables and figures above, we find numerous examples of purely Germanic suffix-suffix combinations.[7] This already undermines the idea of a monosuffix

[7] *-ee* and *-ess* are also classified as Germanic by Aronoff & Fuhrhop (2002: 469f, 473) on the basis of the fact that they behave like other Germanic suffixes.

constraint, but there are other problems with this constraint. As already pointed out by Aronoff and Fuhrhop (2002), *-ness* and *-ess* systematically violate the monosuffix constraint. While *-ess* is explained away by these authors on the grounds that it is no longer productive, *-ness* remains a mysterious exception to the monosuffix constraint and it is left unclear from which property of *-ness* its exceptionality with regard to the monosuffix constraint would follow. *-ness* and *-ess* are not the only exceptions. In their own data, taken from the *OED*, *-able, -er, -ess,* adjectival *-ful (A), -hood, -ish, -less, -ling, -ness, -ship,* and *-ee* all have at least a few derivatives attested where the base contains a Germanic suffix. Not all of these combinations can be explained away as being unproductive, as our BNC and internet data show. For example, *refugee-ess, flattener, flattenee, childhoodless, princessly* are all newly coined words which should be impossible if the monosuffix constraint had any reality.

To make matters worse, there are more exceptions to the monosuffix constraint beyond the set of suffixes discussed in Aronoff and Fuhrhop (2002). In Plag (2002) it is mentioned that adverb-forming *-wise* and nominal *-ful* do not observe the monosuffix constraint.[8]

In sum, the monosuffix constraint wrongly predicts that many attested suffix combinations discussed in this paper (and other combinations not discussed here) are impossible. The fact that these allegedly impossible combinations even form a clear hierarchy is additionally problematic for the monosuffix constraint. As shown in this paper, possible and impossible suffix combinations can be correctly predicted by both individual selectional restrictions and processing constraints. The monosuffix constraint is empirically inadequate and theoretically superfluous.

We may now turn to the second issue for which the present study has wider implications, the relationship between grammar and processing. In syntactic theory, there has been a long debate about whether functionally motivated principles are responsible for the shape of natural language grammar (cf. e.g. Newmeyer 1998). One such functional principle, processing complexity, has recently gained a lot of attention through the work of Hawkins (e.g. 1992, 1994, 1999, 2000). In a nutshell, this approach tries to explain syntactic patterns on the bases of their processability. For example, with regard to word

[8] See Dalton-Puffer and Plag (2001) for a detailed discussion of the properties of these two suffixes.

order, Hawkins (1994, 2000) shows that the variability of possible word orders is heavily constrained by processing factors, and that grammaticalized word orders have processing advantages over potential alternative word orders. With regard to *wh*-questions and other filler-gap dependencies, it can be shown that the grammatical variation found in these constructions is dependent on semantic and syntactic processing complexity (see Hawkins 1999 for details). Among other things, such an approach has the considerable advantage that it can explain theoretical constructs such as the 'head parameter' or 'subjacency' by taking into account the human language processor.

The research on suffixes presented in this paper is another illustration of how processing and grammar interact, and how the architecture of grammar is at least in part dependent on processing factors. Difficulties in processing are directly reflected in conventions of grammar. Grammars define sets of permissible structures, with 'permissible' referring also to processing. Thus, to gain a deeper understanding of the organization of language, both structural and psycholinguistic aspects need to be taken into account.

APPENDIX

Examples of attested two-affix combinations (from *OED*, if not indicated otherwise)

lengthen	*depthless*	*flattener* (internet)	*flattenee* (internet)
preacherling	*breweress*	*loverly*	*printerdom*
loverhood	*controllership*	*robberish*	*leaderless*
tumblerful (BNC)	*saplinghood*	*ducklingship*	*seedlingless*
refugee-ess (internet)	*employeehood*	*assigneeship*	*princessly* (internet)
princessdom	*priestesshood*	*governessship*	*governessless*
knightlyhood	*wollyish*	*kingdomless*	*kingdomful*
courtliness	*childhoodless* (internet)	*censorshipless* (internet)	*kinshipful*
amateurishness	*aimlessness*	*carefulness*	*truthful*

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