# A Link Between Phonology and the Lexicon: Morphophonological Exceptionality and Decomposition in English Stress Shift

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## 1 Introduction

When a phonological process applies to one type of domain, it is usually expected to apply to all other domains of the same type. For example, when a rule applies to a complex word, it is assumed that it should also apply to all other complex words. However, this does not always turn out to be true, and we instead see significant variation in the application of phonological processes across morpheme boundaries. Even within the same language, there can be variation in whether a phonological process will apply across this boundary. One such example of this variation can be found in the process of English stress shift (Chomsky and Halle, 1968; Kiparsky, 1982; Kaisse, 2005). English primary stress is typically placed on the rightmost stressed syllable which has at least one syllable after it (Kaisse, 2005). Examples include *díalèct*, and *óriènt*, which both have primary stress on the initial syllable, and are also followed by additional syllables. However, when suffixes attach to these words, the rightmost stressed syllable will no longer be the initial syllable. As a result, the primary stress shifts to the last syllable of the stem after suffixes are added (e.g. *dìaléct-al*).

But stress shift does not always apply so perfectly across stem-affix boundaries, with some affixes behaving as if they are not a part of the stem phonologically, exhibiting some exceptional morphophonological behavior. Essentially, some English suffixes do not affect the primary stress location for the words they attach to (e.g. *díalèct-hood*). These are referred to as *non-cohering suffixes*, while suffixes that do affect stress placement are referred to as *cohering suffixes*. Examples of each suffix type can be found in Table 1.

| | | |
|---|---|---|
| **cohering suffixes:** | (stress shifts) | |
| díalèct | → | dìaléct-al |
| rígìd | → | rìgíd-ity |
| mómènt | → | mòmént-ous |
| | | |
| **non-cohering suffixes:** | (no stress shift) | |
| díalèct | → | díalèct-hood |
| rígìd | → | rígìd-ness |
| mánifèst | → | mánifèst-er |

**Table 1:** Examples of cohering and non-cohering suffixes from Kaisse (2005).

Previous work on these kinds of exceptional stem-affix interactions has proposed that differences in the tendency for an affix to cohere to the stem are due to phonological cyclicity, meaning cohering and non-

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cohering affixes are applied to stems at different times (Kiparsky, 1982). Others analyze them by detaching the non-cohering affixes from stems and placing them in separate phonological domains (Nespor and Vogel, 1986; Poser, 1990; Hannahs, 1995; Hsu, 2015). These accounts serve as a reasonable way to account for these patterns, but nonetheless leave open questions about what leads them to behave exceptionally in the first place. Can we predict when an affix does/does not cohere to a stem? And which factors are correlated with each of these possibilities? These questions are the central focus of this study.

## 2 Background

**2.1** *Exceptionality and Morphological Decomposition* Previous research suggests that one relevant factor to understanding the behavior of different affixes is decomposability, which can be thought of as how likely a morpheme is to be separated from another morpheme in the lexicon. In the context of affixed words, it would be how likely an affix is to separate from the stem. Early theories of decomposability found that frequency had a large effect in deciding whether or not a complex form would be decomposed into its composite morphemes (Baayen, 1992). However, Hay (2001) finds that decomposability can be more accurately characterized by relative frequency, which is a comparison between the frequency of the base of a complex word and the full derived form. She finds that when a base is more frequent than the derived form, it is more likely to be decomposed than when the derived form is more frequent that the base. For instance, a word like *movement* is likely to be decomposed because its base *move* is more frequent than the full derived form *movement*. Conversely, the word *judgment* is more frequent than its base *judge*, so it would be accessed whole, without decomposition. Hay (2001) backs up this intuition experimentally, finding that words where the derived form is more frequent than the base (like *judgment*) are rated by participants as less morphologically complex than words where the base is more frequent than the derived form (like *movement*). This shows that participants recognized a word as having multiple morphemes more easily when the base had a higher frequency than the derived form. This suggests that the frequency of the base form is involved in facilitating decomposability, providing evidence that when the base is more frequent than the derived word, the word is more readily decomposable.

Hay (2001) also finds that words which are likely to be morphologically decomposed are more semantically transparent, which she determines by assessing whether the dictionary definition for a complex word contains its base. For example, the definition of a word like *dishorn* is "to deprive of horns". Here the definition of the complex word *dishorn* contains the base *horn* in its definition, which Hay interprets as evidence that the complex form is transparently related to its base meaning. This is contrasted with a more semantically opaque word like *dislocate*, which is defined as being "put out of its proper place, esp. a bone". The definition for this complex word does not contain its base, and is interpreted as less semantically transparent than *dishorn*. Hay (2001) finds a correlation between this semantic transparency measure and relative frequency, lending further support to the idea that not all complex words are processed in the same way, and these differences can also correspond to linguistic differences.

In a neurological study, Carota et al. (2016) investigate which regions of the brain are active in the recognition of different types of Italian complex words. Consistent with Hay's (2001) conclusions, they find that semantically transparent complex words with productive affixes are associated with regions of the brain which are frequently activated in decomposition processes. Furthermore, semantically opaque words with non-productive affixes were found to be treated similarly to morphologically simplex forms (i.e. as if they were non-decompositional forms). These behavioral findings line up with Hay's (2001) conclusions for the relationship between semantic transparency and decompositonality, further validating her use of the relative frequency measure in determining decompositionality.

In addition to semantic transparency, connections have also been made between decomposability and the morphological productivity of derivational affixes (Hay and Baayen, 2002). In a study of bimorphemic (1 stem + 1 affix) words from the CELEX corpus (Baayen et al., 1995), Hay and Baayen (2002) show that decomposability (measured by relative frequency) is positively correlated with affix productivity. Essentially, they show that affixes which are frequently decomposed from the stems they attach to are also highly productive, meaning that speakers reach for them more often when creating novel complex forms. Hay and Baayen interpreted this result to mean that affixes which were decomposed more frequently received more activation in the lexicon because they are more often recognized as separate morphemes from stems. Affixes which were not often decomposed were less likely to be separated from their stems in the lexicon

and received less activation as a result. Affixes with more activation would then be more readily available for the creation of new words. This posits a close connection between the properties of the lexicon and the morphological properties of words, such as affix productivity.

**2.2** *Morphological Decomposition and Phonology* Previous work from Hay and Baayen (2003) has shown that, in addition to productivity, decomposability also has strong connections to characteristics of the phonological grammar. Investigating phonotactic probabilities at the junctures between derivational affixes and stems, they find that the types of phonotactic sequences at these junctures correspond to differences in decomposition. A high-probability phonotactic sequence is defined as a sequence which is likely to be found word-internally, while a low-probability phonotactic sequence is one that is unlikely to be found word internally. Hay and Baayen (2003) show that the creation of a low-probability phonotactic sequence at a stem-affix boundary corresponds to a higher likelihood for that affix to be decomposed from its stem. The reasoning being that the low-probability phonotactic sequence signaled that a word boundary was likely to exist at that location. High-probability phonotactic sequences are likely to occur word-internally, so affix-stem combinations with these sequences did not denote the existence of a word boundary. This corresponded to a lower level of decomposability for those affixes. Hay and Baayen (2003) conclude that phonological properties of a complex word (like their phonotactics) can influence the way that word is represented in the lexicon, showing that low-probability phonotactic junctures pushed certain affixes to be more decomposable.

Hay and Baayen (2002, 2003) establish that decomposability has a strong connection to the behavior of individual affixes (productivity), and that it also has strong connections to phonological characteristics like phonotactics. Hay and Baayen (2003) even predict that "any factor which is used for the purpose of word-boundary spotting in speech perception will be relevant to morphological parsing" (pg 127). This predicts that gaps in the application of phonological alternations may also indicate a boundary between affixes and stems, which would reflect differences in decomposability. Given this prediction, decomposability is an especially promising factor to investigate in order to understand which properties are correlated with phonologically exceptional affixes. The remainder if this study will adopt an approach similar to that of Hay and Baayen (2002, 2003) to investigate whether the tendency for affixes to pattern separately from the stem phonologically is related their likelihood of being decomposed from the stem in the lexicon.

The hypothesis is that if phonological exceptionality and morphological decomposition are indeed linked, an affix which patterns separately from the stem phonologically should be more likely to decompose from the stem when being stored in the lexicon. On the other hand, affixes which pattern phonologically with the stem should be less likely to decompose.

In terms of the English stress shift example in Table 1, the hypothesis predicts that suffixes which exceptionally fail to trigger stress shift (non-cohering) are predicted to be more likely to decompose from their stems than suffixes which trigger stress shift (cohering).

## 3 Corpus study

In order to test the hypothesis, a corpus study was performed on English suffixes involving in stress shift. Like Hay and Baayen (2002, 2003), this study examined only bimorphemic derivational affixes. The study is limited to bimorphemic words in order to avoid having to make extra assumptions about the hierarchical structure of derived words Booij (2010). When a word has multiple affixes, how can we be sure that the base is really the bare root form? Since evaluating the frequency of a base form compared to a derived form is crucial to measuring decomposability, it is especially important to remove this extra assumption in order to avoid confounding the relative frequency calculations.

Additionally, only derivational affixes were used in this study due to the common assumption that the lexicon stores inflectional forms as part of the same lexical entry as their stems (lemmas). Derivational affixes on the other hand are assumed to be stored as separate entries from the base lemma, and they combine with one another in derivational compounding processes (Stump, 2017). Since one of the central claims about decomposability involves the storage and access of stems and affixes, it is important to look only at affixes which are assumed to be available in the lexicon. While some have challenged the idea of there being large differences between derivational and inflectional affixation processes (Bochner, 1992), this study will focus only on derivational morphemes in order to avoid making any extra assumptions (though it is worth investigating whether inflectional affixes also display decomposition effects in future work).

The corpus used in the present study is the Morpholex-En corpus (Sánchez-Gutiérrez et al., 2018). This corpus was chosen because it contains measures of affix frequency and productivity which are important to making comparisons to Hay and Baayen (2002, 2003). The source for frequency information is the Hyperspace Analogue Language (HAL) corpus (Lund and Burgess, 1996), which contains roughly 130 million tokens of conversational text gathered from Usenet (an online news platform). However, it does not contain base or whole word frequency by default, so these had to be imported into the corpus from HAL (obtained via the South Carolina Psycholinguistic Metabase from Gao et al., 2022). Following Hay and Baayen (2002, 2003), only complex words which have bases that are stand-alone words were evaluated. After subsetting the corpus to only words with bimorphemic derivational affixes with real-word bases, there were a little over 8,064 data points (corpus entries) remaining (both prefixed and suffixed words), which is a small portion of the total 68,000 entries of the entire corpus (12% of the total data).

This corpus study operationalizes decomposition using relative frequency, and investigates whether a tendency for complex words to be decomposed in the lexicon correlates significantly with affixes which tend to behave separately from the stem in phonology. Various other indicators of decomposition were evaluated as well, including absolute frequency and an approximation of Hay and Baayen's (2002, 2003) parsing ratio, but since relative frequency is more well-supported by the literature, it is the only measure discussed in detail (though it is worth noting that the other decomposability measures used also pattern in the same direction as the relative frequency measure).

**3.1** *Relative frequency* Hay (2001) showed that bases which are more frequent than the derived word they are a part of are more likely to be decomposed in the lexicon. This means that relative frequency evaluates decomposability as a comparison between how often speakers encounter the base in its bare form vs how often they encounter the full derived form. The intuition here is that if two morphemes occur together a lot, they will be represented that way in the lexicon. If they do not often occur together, they will be represented separately in the lexicon. Also notice that affix frequency is not part of the calculation here. This means that accurate characterization of data using this measurement would indicate higher importance of the base, rather than the affix, in understanding decomposition and exceptionality. This measure is calculated by dividing the token frequency of the base morpheme by the token frequency of the entire derived word and taking the natural log of it (LN(base freq. / derived freq.)). Since the base frequency is the numerator, a higher number would indicate that a word is more likely to be decomposed.

**3.2** *Data* To compare cohering and non-cohering suffixes in the English stress shift process outlined in Section 1, a list of both types of suffixes from Kaisse (2005) was used (listed in Table 2 for reference). The only suffix listed by Kaisse (2005) which is not in the current study is *-y*. This is because the Morpholex-En corpus does not distinguish between affixes which have the same form but different functions, and Kaisse (2005) notes that the adjective-forming version of *-y* is non-cohering, while the noun-forming version is cohering. Since there is no way to distinguish between them in this corpus, they were not included in the comparison.

The cohering suffixes trigger the expected stress shift pattern in the stem, while the non-cohering suffixes do not trigger the stress shift pattern, instead appearing to be exceptions. To find evidence in favor of the hypothesis, results would need to show that non-cohering suffixes are significantly more likely to undergo decomposition compared to cohering suffixes. In other words, suffixes that pattern separately from stems in phonological alternations should also have a higher likelihood of being stored separately from stems in the lexicon. Suffixes which pattern with stems in phonological alternations should also be stored together with stems in the lexicon, being less likely to undergo decomposition.

| |
|---|
| **cohering suffixes:** |
| -age, -al, -an, -ant, -ance, -ary, -ate, -ic, -ion, -ify, -ity, -ory, -ous |
| |
| **non-cohering suffixes:** |
| -able, -er (agentive), -en, -ful, -hood, -ish, -ism, -ist, -ize, -less, -like, |
| -ment, -ness, -ly, -wise |

**Table 2:** List of cohering and non-cohering suffixes used in this study (from Kaisse, 2005).

**3.3** *Results* All data analyses were completed using R Studio (Team, 2019) and linear models for statistical analyses were performed using the *lme4* package (version 1.1.21) (Bates et al., 2015).

Recall that the hypothesis predicts that suffixes which affect the placement of primary stress in the stem (cohering suffixes) should be less decomposable than suffixes which do not affect placement of primary stress in the stem (non-cohering). Words which contained the suffixes listed in Table 2 were pooled together from the bimorphes in the Morpholex-En corpus (Sánchez-Gutiérrez et al., 2018), which resulted in there being 5,051 data points available for analysis.

Figure 1 shows the decomposability of cohering and non-cohering suffixes as measured by token relative frequency. A particular word form which has a base that is more frequent than the derived form will be more likely to decompose than one with a derived form which is more frequent than the base. Since relative frequency is determined by dividing the base frequency by the derived frequency (base freq / derived freq), a higher number would indicate a higher base frequency and a higher likelihood of decomposing. In terms of the plots in Figure 1, this means that the non-cohering suffixes (gray) should have higher relative frequencies than the cohering suffixes (white), indicating that the non-cohering suffixes are more likely to decompose from the stem.

In the token relative frequency plot in Figure 1, we see a clear divide between cohering and non-cohering suffixes in the expected direction. Non-cohering suffixes trend toward being more decomposable than cohering suffixes. The correlation between cohering-ness and decomposability is also significant (-0.34, $p = < 0.001$)[1], showing that cohering suffixes are less likely to decompose, consistent with predictions made by the hypothesis. Using correlation to determine effect size once again, we can interpret the effect size between relative frequency and coherence as a medium sized effect (around 0.30). Although, there are still some suffixes which do not fall into the trend. Notably, *-ment* is less decomposable than expected for a non-cohering suffix, and *-ify* is more decomposable than expected for a cohering suffix. It is unclear why these outliers exist, and future work should focus on investigating these cases more carefully.

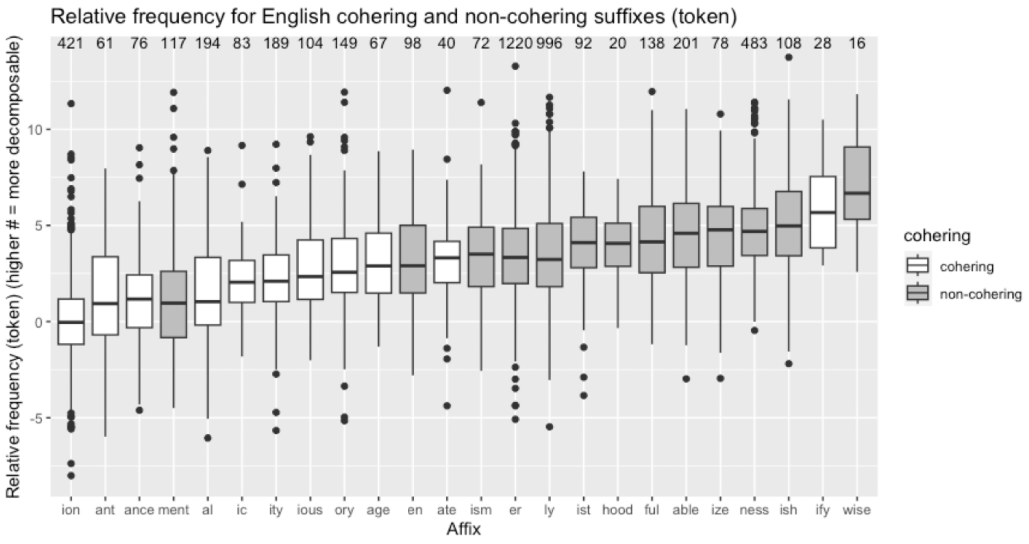


**Figure 1:** Plot of average decomposability for cohering and non-cohering English suffixes as predicted by token relative frequency. The numbers above the boxplots indicate the number of data points that each calculation is based on from the corpus.

**3.4** *Statistical Analysis* For additional statistical analyses, a generalized linear model was used to test to what extent suffix coherence can be predicted by decomposition (operationalized by relative frequency). Relative frequency was log transformed as part of its calculation, so further scaling functions were not needed to meet the assumptions of the model. Random intercepts that varied by each individual affix were included in an initial linear mixed effects model, but it failed to converge, which necessitated a switch to a linear

[1] The factor cohering/non-cohering was contrast coded with 1/0 respectively, so the negative correlation here shows that cohering suffixes (coded as 1) were significantly correlated with lower levels of decomposability.

model. Cohering suffixes are coded as 0 and non-cohering suffixes are coded as 1. When the estimate shows a positive increase, it indicates that decomposability is more likely for non-cohering suffixes (in line with the hypothesis), and when it decreases it means that decomposition is more likely for cohering suffixes. Other decomposition measures are also included in the model, labeled as *parsing ratio*, *decomp. score*, and *abs. freq*, but they are not discussed in detail. If relative frequency is found to be a significant predictor in the model, it would provide evidence for the hypothesis, that affix coherence and decompositionality are connected to one another.

Main effects of token relative frequency ($\hat{\beta}$ = 1.67, SE = 0.60, z = 2.77, p = 0.006), parsing ratio ($\hat{\beta}$ = 34.01, SE = 13.11, z = 2.67, p = 0.008), and absolute frequency ($\hat{\beta}$ = -5.14, SE = 0.26, z = -3.58, p $<$ 0.001) are reported by the model, but no significant effect of decomposition score was found. Parsing ratio and relative frequency both show effects in the expected direction: higher levels of decomposability are associated with non-cohering suffixes. Absolute frequency also shows effects in the expected direction: lower frequency levels are associated with non-cohering suffixes (and lower absolute frequency is associated with decomposability).

The model also reports some significant interaction effects between decomposability measures. This is expected, since these measures are all indicators of decomposability and make similar predictions about the suffixes in the dataset. Lastly, the R-squared value for the model is 0.64, which indicates that the model is a moderately good fit to the data. It seems that decomposition is quite effective in predicting whether a suffix will be cohering or non-cohering. This suggests that there is a connection between phonological coherence of an affix and decomposition in the lexicon. Although as Hay and Baayen (2003) report, there are other phonological factors that make predictions about the decomposability of affixes as well. Future work may find that incorporating facts about phonotactic probabilities into this model may result in an even better fit to the data.

**Model predicting suffix coherence with decomposition:**

| Fixed Effects | Estimate | SE | z-value | *p* |
|---|---|---|---|---|
| (intercept) | -2.28 | 9.31 | -0.25 | 0.81 |
| relative freq. | 1.67 | 0.60 | 2.77 | 0.006** |
| parsing ratio | 35.01 | 13.11 | 2.67 | 0.008** |
| decomp. score | 0.23 | 0.40 | 0.56 | 0.58 |
| abs. freq. | -5.14 | 0.26 | -3.58 | $<$ 0.001*** |
| parsing ratio:decomp. score | 0.57 | 0.15 | 1.66 | 0.10 |
| parsing ratio:relative freq | 0.88 | 0.15 | -4.45 | $<$ 0.001*** |
| decomp score:relative freq | 0.10 | 0.02 | 4.23 | $<$ 0.001*** |
| parsing ratio:abs freq | 5.93 | 2.06 | 2.88 | 0.003** |
| decomp score:abs freq | -0.25 | 0.06 | -3.79 | $<$ 0.001*** |
| relative freq:abs freq | -0.0007 | 0.10 | -0.007 | 0.95 |
| parsing ratio:decomp score:relative freq | 0.02 | 0.007 | -4.58 | $<$ 0.001*** |
| parsing ratio:decomp score:abs freq | 0.28 | 0.19 | 3.13 | 0.002** |
| parsing ratio:relative freq:abs freq | 0.08 | 0.26 | 0.51 | 0.61 |
| decomp score:relative freq:abs freq | -0.10 | 0.11 | -2.55 | 0.01* |
| parsing ratio:decomp score:relative freq:abs freq | 0.02 | 0.09 | 2.43 | 0.02* |

The results of the statistical model show that the decomposability measures used in this study found evidence in favor of the hypothesis. The linear model of the data showed a significant main effect of relative frequency as a predictor of suffix coherence (as well as other measures like parsing ratio, and absolute frequency). Plots and correlation values from the corpus also show quite clearly that non-cohering suffixes are indeed more likely to decompose from their stems than cohering suffixes using relative frequency as an indicator of decomposition. This suggests that the tendency for affixes to interact with stems in phonological alternations is connected to how they are represented in the lexicon. Specifically, suffixes which interact with the stem in

phonological alternations, like the English stress shift process, are more likely to be decomposed from stems in the lexicon than those which do not interact with the stem phonologically.

## 4 Discussion

Overall, this study finds evidence for a connection between decomposability and morphophonological exceptionality in the process of English stress shift. Namely, suffixes which are more likely to decompose from their stems in the lexicon are also more likely to behave separately from the stem phonologically. Suffixes which did not affect primary stress placement in the English stress shift pattern were found to be more likely to decompose from their stems than suffixes which did affect primary stress placement. A linear model finds main effects for relative frequency, as well as several interaction effects between relative frequency and other measures. The model shows that measures which are indicators of decomposability are able to predict whether or not affixes pattern with the stem in phonological processes, which suggests a link between morphological decomposability and phonological alternations. Broadly, the results show evidence for a correlation between morphophonological exceptionality and decomposition, with exceptional suffixes being more decomposable than non-exceptional suffixes.

**4.1** *Implications for the relationship between phonology and the lexicon* The results of this study show that the relationship between processes that take place in the lexicon, like morphological decomposition, are closely related to phonological processes. This correlation shows an association between decomposability and morphophonological exceptionality - affixes which undergo phonological processes with stems are shown to be less likely to decompose from stems in the lexicon. Affixes which do not undergo phonological processes with the stem are more likely to undergo decomposition in the lexicon. The intuition here is that stem+affix combinations that pattern together in the phonology should also be more likely to be stored together in the lexicon. When affixes do not pattern with the stem in phonological alternations, they are more likely to be stored as separate units in the lexicon. A result like this one might imply that there is a causal relationship between the processes in each of these domains. However, the present study is not a behavioral one, and causality cannot be determined by comparing the measurements obtained from the corporus and their behavior in particular phonological processes alone. Nonetheless, we can still speculate about possible causal relationships, and how particular theories of phonological and lexical representations might account for them. This will also help to illuminate how questions about causality might be answered by future work.

**4.1.1** *The lexicon influences phonology* One possibility is that lexical representations affect phonological alternations. This would mean that phonological exceptionality across stem-affix boundaries is driven by decomposition. When an affix is more likely to be decomposed from the stem and stored separately from it, it also leads to a separation in phonological domains. This is potentially a result of the lexical representation, passed to the phonology by the lexicon, containing some information about the decomposability of the affix. This would in turn, affect how phonological processes apply to the affix and the stem. Essentially, in cases where there is no phonological explanation for the exceptional behavior of certain affixes, their tendency to behave separately from the stem may be traced to their high rate of decomposition in the lexicon.

In cases where an affix is not likely to be decomposed from the stem, phonological processes would apply to the entire complex word, meaning the affix would pattern with the stem in a given phonological process. When an affix is likely to be decomposed from stems in the lexicon, the affix would be treated by the phonology as a separate unit from the stem. This would explain why some affixes behave as if they are phonologically separate from the stem, while also accounting for the cases where affixes behave as if they are part of the same domain as the stem.

There are several ways that this type of relationship could be operationalized by the phonology, including base-derivative faithfulness theories (Benua, 1997), which utilize remote and local base faithfulness constraints (Stanton and Steriade, 2014; Stanton, 2014). This type of analysis could provide separate faithfulness constraints for decomposable and non-decomposable words by ranking faithfulness for words with highly decomposable bases (these would be the remote bases)[2] over whatever markedness constraint would usually trigger its interaction with the stem. This would prevent phonological alternations from

[2] This is consistent with Stanton and Steriade's (2014) assumption that remote bases are any lexically related form with a higher frequency.

being triggered across stem+affix boundaries for highly decomposable words. A separate local base faithfulness constraint could be utilized for words which are not likely to decompose, which would be ranked below the markedness constraint triggering the interaction between the affix and the stem. This would allow non-decomposable affixes to still undergo phonological alternations with the stem, while highly decomposable ones would not undergo those alternations. There is also precedence for this type of analysis, as other phonological processes affected by lexical variables, like frequency, have been indexed by similar phonological frameworks in previous work (Coetzee and Kawahara, 2013; Adams, 2014). In fact, similar models have been proposed by Dabouis (2019) and Breiss (2021).

**4.1.2** *Phonology influences the lexicon* Another causal possibility is that phonological alternations affect lexical representations and lead to higher levels of decomposability. This would mean that the tendency for particular affixes to be left out of phonological alternations with the stem would be mapped onto its lexical representation. Hay and Baayen (2003) also adopt this viewpoint with regard to phonotactic probabilities. They assert that phonotactics, along with other factors, can facilitate or hinder decomposability in the lexicon. Essentially, the phonotactic junctures between particular affixes and stems are perceived as word boundaries by the speaker, and these boundaries serve as cues to the lexicon that these morphemes should be stored separately.

It is also good to reiterate here that decomposability is closely tied to lexical access and the concept of resting activation. Hay (2001) provides very clear reasoning about this. She describes how frequent words are retrieved more quickly in lexical access, and this is usually explained by there being higher levels of resting activation for these more frequent forms (Norris et al., 2000; McClelland and Elman, 1986). She explains that a word like *insane*, which is an example of a derived word that is more frequent than its base (*sane*), would be recognized more quickly as a whole word form. This is because its higher frequency would mean that it has more resting activation than its less frequent base. A word like *infirm* is the opposite - it has a base, *firm*, which is more frequent than its derived form. Here, the base *firm* would have more resting activation than the derived form *infirm*, which would make decomposition a faster route to recognizing the full derived form.

How is the behavior of phonological alternations reflected in this process? If resting activation is operationalized by frequency, it is more difficult to understand how the phonology affects the lexical representation. However, Johnson (1997a,b) has also outlined a way for resting activation to be operationalized by exemplar representations, which can be more straightforwardly influenced by phonological alternations. Essentially, utterances that speakers hear/produce are evaluated by the similarity between new exemplars and the existing category exemplars in the model. This means that after enough similar instances of a word/morpheme are heard or produced, the category could contain information about phonological boundaries like those posed by gaps in application of phonological alternations.

This provides a clearer path for phonological representations to have an effect on the decomposability of particular morphemes in the lexicon. Affixes which do not pattern with stems in phonological alternations provide cues for the existence of some kind of boundary between an affix and a stem. Affixes that pattern with stems in alternations do not provide cues for a boundary between the affix and stem. Then, these different phonological representations are stored as exemplars as they are perceived or uttered by speakers. These exemplars can then affect the resting activation for different morphemes in the lexicon. For example, a complex word like *dialect-hood* contains a suffix that does not trigger stress shift in the stem. This means it would provide cues for the existence of a boundary between the stem *dialect* and the suffix *-hood*, making it more likely to be represented as two separate pieces that only sometimes get combined. On the other hand, a complex word like *dialect-al* does trigger stress shift. This word would not provide any cues for the existence of a boundary between the stem *dialect* and its suffix *-al*, and they would instead be more likely to be represented as a combined complex unit. If exemplar representations can be assumed, it is possible for phonological representations to influence the properties of lexical decomposition.

One weakness this direction of causality is that it still leaves open questions about why the phonology would treat some affixes as exceptional. If phonological representations influence decomposability, then we are left questioning why particular affixes behave exceptionally in the first place once again. If we are instead allowed to believe that decomposition affects the phonology, the reason that particular affixes behaved exceptionally could be explained by their tendency to decompose from stems in the lexicon. However, when the phonological representation affects the lexical one, it is still unclear why certain affixes have exceptional

behavior while others do not.

Regardless, the best way to provide evidence for either type of relationship is through behavioral experiments which can hold some factors constant, such as lexical frequency, while varying others, like phonological coherence. This study serves as a jumping off point for further investigation into each possible causal relationship.

## 5 Conclusion

This study used calculations that have been shown to be accurate indicators of decomposability to do a large-scale investigation of the behavior English suffixes. Results showed that suffixes which did not pattern with the stem phonologically were also more likely to be decomposed from the stem in the lexicon. The correlation between morphological decomposition and morphophonological exceptionality shows that there is a close connection between processes in the lexicon (like lexical access and decomposition) and phonological alternations. Given this result, we can now answer the research questions posed in Section 1. The first question asked whether we can predict when an affix will cohere or not cohere to a stem. The results suggest that when an affix has a high likelihood of being decomposed from its stem (i.e. a high base frequency), it is also likely to pattern separately from the stem phonologically. In other words, highly decomposable suffixes are more likely to be non-cohering/exceptional. The second research question asked which factors are correlated with exceptional and non-exceptional affixes. We now know that higher rates of decomposition are associated with exceptional affixes, while lower rates are associated with non-exceptional affixes.

Though this study was not designed to make any claims about causality, the finding that these two factors are related opens the door to reasoning about the types of causal relationships that are possible between them. Each possible causal relationship has implications for how phonological representations must look, and how the relationship between phonology and the lexicon must function. For instance, if it is the case that phonological representations influence the tendency for morphemes to decompose in the lexicon, exemplar representations in phonology become an important piece of the puzzle. Additional work is needed to be able to determine the directionality of any causal relationship between decomposability and morphophonological exceptionality. Nonetheless, this study has shown that they are indeed related (at least in English) and that the consequences of their relationship are central to modeling phonological representations and the link between the lexicon and the phonological grammar.

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