Phonological and phonetic variability in complex words: An uncharted territory [1]

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This paper discusses a long-standing problem in morphology, the relation of form and meaning. It is demonstrated that there is an unexpectedly large amount of phonological and phonetic variation in morphologically complex words. This variation has either been widely neglected in the past, or it has been dealt with in an unsatisfactory manner in terms of general rules and lexicalized exceptions. The paper discusses pertinent examples from English, covering phenomena from derivation, compounding and inflection, looking at morpho-phonological alternations (i.e. stress preservation, stress shift, (de)gemination, resyllabification, compound stress assignment), and at variation in phonetic implementation (i.e. phonetic reduction and the phonetic implementation of homophonous affixes). It is argued that the hitherto neglected phonetic-phonological variation presents a big challenge for many current theories of the lexicon, morphological theory, and theories of lexical processing.

1 Introduction

Traditional approaches to the role of sound structure in the description of complex words have usually focused on phonologically conditioned allomorphy or morphologically conditioned segmental or prosodic alternations (such as stress shift, stress preservation, truncation, degemination, or syllabification in English). Such studies have detected interesting generalizations across sets of words but also exceptions to the observed regularities. The general amount and the nature and significance of unexpected variation in morpho-phonological alternations is not very often discussed, however. For example, there is an abundance of studies of stress preservation in English, but only a single study (Collie 2008) devoted to the problem of variation. In that study it is shown that stress preservation often fails to apply unexpectedly. The frequencies of bases and derivatives seem to play a role in determining the application of stress preservation but overall the variation is still ill-understood and under-researched.

Similarly, the amount of variation observable at the phonetic level has never been looked at systematically, although it has been frequently noted that phonetic reduction may have some relation to morphological complexity. Consider, for example, the word *government*. It is mostly pronounced [gʌvmənt] or [gʌvəmənt], and this phonological opacity goes together with semantic opacity: *government* does not primarily denote 'action of VERBing' (as is standardly the case with *-ment* derivatives), but rather denotes the people who govern, or, more

generally, 'political authorities'.[2] It can thus be argued that *government* is morphologically less easily segmentable than, say, *discernment*, where there is no phonetic reduction and full semantic transparency.

These two kinds of variation (phonological and phonetic) are worth investigating in greater detail because of the potentially very important implications for theories of the lexicon, morphological theory, and theories of lexical processing. This paper is a *tour d'horizon* of the problems and challenges the area of morpho-phonology and morpho-phonetics offers. I will outline these problems in some detail, referring where possible to pertinent existing research. The discussion will be largely restricted to English, but analogous issues can be found in other languages. Very often, a given problem has not even been recognized as such and no (or insufficient) research results are available. Hence this article can only provide a sketch of a yet uncharted territory instead of a full-fledged colored atlas of a well-traveled country.

I will prepare the ground for our discussion in the next section by outlining some basic consideration concerning the role of formal and semantic relationships in the lexicon. In section 3 I will turn to a discussion of morpho-phonological variation. Section 4 will discuss the role of phonetic detail in morphology, section 5 will summarize the findings.

2 *Morphological relatedness in the lexicon: sounds and meaning*

Morphologically complex words and their bases, such as *blueness* ◆ *blue*, or *kicks* ◆ *kick*, are related to each other in at least two respects, semantically and phonologically (I use diamonds to indicate morphological relatedness between forms). In particular, one can say that any complex word stands in a paradigmatic morphological relationship to those words that contain the same base, or contain the same affix. A set of words with the same affix, such as *leader, reader*, *singer*, *walker* etc. is known as a 'morphological category', and a set of words with the same base, e.g., *impress, impression, impressive*, is known as a 'morphological family'. The psycholinguistic reality of such paradigmatic relationships has been shown in many studies. For example, reaction times in lexical decision tasks vary significantly across morphological categories (e.g. Plag & Baayen 2009). And reaction times in visual word recognition are, among other things, also dependent on the size of the morphological family of a given complex word (e.g. Schreuder & Baayen 1997).

From a structural point of view, these two kinds of paradigm (i.e. morphological categories and morphological families) may impose conflicting requirements on a given derivative. Thus, all derivatives with a given base ideally have the same formally and semantically recognizable base, as in, for example, *crystal, crystalize, crystalline*. If they do not, we refer to the relationship between the bases as 'allomorphy', or as a case of 'semantic opacity'. We speak of allomorphy if the difference concerns their phonological shape, as in, for example, *prodúce* ◆ *próduce* ◆ *prodúction*, and of semantic opacity if apparent bases do not share the same meaning, as in, for example, *listless* 'indifferent' and *list*. Note that semantic opacity is

often accompanied by phonological opacity, as in the case of *listless*, which is mostly pronounced without base-final [t], unlike the similar form *fistless* (Hay 2003).

At the same time, each of the different derivatives with a given base has to conform to the formal and semantic requirements of its particular morphological category. This may result in conflicts between the two paradigmatic dimensions, for example, if a particular morphological category imposes a prosodic restriction on its derivatives that would involve some adjustment of the phonological shape of a given base. This can lead to base allomorphy, as for example, with the base EXPLAIN, which appears as [ɪksˈpleɪn] in *explain*, *explains, explaining, explained, explainer*, *explainable*, but with two other, different, base allomorphs in *explanatory* or *explanation* ([ɪkˈsplæn] and [ˌɛkspləˈn]) due to the phonological requirements imposed by the morphological categories of *-ory* and *-ation*, respectively.

Such conflicts often lead to non-uniform paradigms (from the perspective of the morphological family of the base), where the same base has different realizations in different derivatives (as we saw with the base EXPLAIN). Or, as a second type of conflict, we find the seemingly exceptional behavior of individual derivatives in a particular morphological category. For example, *predáte* 'to act as a predator' fits segmentally and semantically into the category of *-ate* verbs, but does not conform to the prosodic pattern of this category, which is characterized by antepenultimate primary stress and a secondary stress on the suffix, as in *hýphenàte* (e.g. Plag 1999: 210, see Plag, Kunter & Schramm 2011 for the phonetic correlates of primary and secondary stress in such words).

The two kinds of paradigmatic conflict also have a bearing on how much morphological structure may or may not be represented in the mental lexicon. Derivatives that have lost much of their phonological relatedness to the base (cf. for example the word *business*, in which the base *busy* is hardly recognizable) may be argued to be less morphologically segmentable than derivatives that are phonologically more transparent (cf. *blueness*) (e.g. Hay 2003).

Recent psycholinguistic research has substantiated the important role of paradigmatic relationships for lexical access and processing (e.g. Baayen, Wurm & Aycock 2007, Milin et al. 2009, Kuperman et al. 2009), but it is far from clear how linguistic modeling and theorizing can deal with the wealth of paradigmatic relationships that seem to play a role in the processing of complex words and in the emergence of the diverse properties such words can have.

From the above consideration a number of interesting questions emerge:

(i) How does morphological structure affect the articulatory, acoustic and phonological properties of complex words? What is the role of paradigmatic relatedness in the pronunciation of complex words?
(ii) Seen from the reverse angle, what do the phonological and phonetic properties of complex words reveal about paradigmatic relationships and morphological structure?

(iii) What are the implications of the answers to the above questions for the organization of the mental lexicon and for models of lexical processing, of speech production and speech perception?

In what follows will discuss these questions in more detail, using English as the language of exemplification. Other languages, it seems, have similar problems in store.

3 Morpho-phonological rules and alternations

The pronunciation of morphologically complex words has traditionally been dealt with under the label of morpho-phonology. With very many complex words the phonological relationship of base and derivative or between the derivatives of a given morphological category seems straightforward. For example, all derivatives with the suffix *-less* end in the string /ləs/ and their bases are considered homophonous with their corresponding free variants. Thus, *speech* in *the speechless candidate* does not seem to be phonologically or phonetically much different from *speech* in *the speech by the president*, if we abstract away from speech context-dependent variables such as rate of speech or speech style.

A look at a larger sample of complex words reveals, however, that the formal relation, i.e. the phonetic or phonological relation between base and complex word, is not necessarily straightforward. One of the complications is what is known as morpho-phonological alternations, a prominent example of which are stress alternations in derived words.

3.1 Stress alternations

The words in (1) illustrate some such alternations with stress. One can see that the members of the respective morphological categories display a particular kind of prosody which disturbs the phonological relatedness of the derivative and the base. When part of the derivative, the base stress shifts to a different syllable (1a) and (1b), sometimes accompanied by changes in the quality of the vowels, as in the first two pairs of (1b).

(1) a. cónjugate ◆ conjugátion
hýphenate ◆ hyphenátion
íodate ◆ iodátion
b. cúrious ◆ curiósity
frúgal ◆ frugálity
prodúctive ◆ productívity

These alternations have been described (in rule-based and constraint-based frameworks alike) as categorical in nature (and not gradient or probabilistic) and with the assumption that words not undergoing an alternation can be regarded as idiosyncratic lexicalized exceptions.

However, recent research has identified at least two major problems with such approaches, both of them still unsolved. First, the morpho-phonological alternations are much more variable than previously conceived. For example, while some variation of stress shift with *-able* has always been noted with lexicalized forms like *cómparable* ~ *compárable*, Bauer, Lieber & Plag (2013: ch. 9, ch. 14) show that many polysyllabic forms in *-able* show stress shift hitherto unnoted in the literature, either apparently consistently, see (2a), or variably, see (2b).

(2) a. állocate ◆ allocátable
arómatize ◆ aromatízable
cátegorize ◆ categorízable
b. ánalyze ◆ ánalyzable ~ analýzable
cértify ◆ cértifiable ~ certifíable
ítemize ◆ ítemizable ~ itemízable

Such variability in stress shift is unexpected under traditional approaches and is not easily accommodated by theories of lexical phonology (e.g. Kiparsky 1982 and similar approaches). Similarly problematic facts are discovered by Collie (2008), who finds a large number of derivatives that, according to pronunciation dictionaries, do not undergo the expected stress preservation, i.e. the preservation of a base main stress as a secondary stress in the derivative. (3a) lists the expected pattern, (3b) the unexpected pattern and (3c) variable cases.

(3) a. accéptable ◆ accèptabílity
coágulate ◆ coàgulátion
b. decónsecrate ◆ dèconsecrátion
repátriate ◆ rèpatriátion
c. authórity ◆ authòritárian ~ àuthoritárian
impéccable ◆ impèccabílity ~ ìmpeccabílity

Collie (2008) shows that frequency plays a role in the presence or absence of stress preservation (lower frequency of the derivative and higher frequency of the base favor stress preservation). Given that such frequency effects are indicative of morphological processing during speech production, and thus of morphological structure, variability in morpho-phonological alternations can provide significant evidence about the organization of complex words in the mental lexicon. In this particular case, the patterning of the data supports models in which complex words, even if completely regular, can be stored in the lexicon (e.g. de Vaan et al. 2007, 2011). This runs counter to some models of the mental lexicon which assume that only morphemes and irregular complex words are stored (e.g. Clahsen 1999, Marcus et al. 1995, Prasada & Pinker 1993, Pinker 1998).

Turning to prefixes it can be observed that some prefixes may be variably stressed, and this kind of variability is too pervasive to be dismissed as occasional exceptions. For example,

the prefixes *micro-* and *nano-* can carry primary or secondary stress on the first syllable (e.g. *mícrobrèwery* vs. *mìcrobiólogy*; *nánomachìne* vs. *nànotechnólogy*), with the distribution of the two patterns being essentially unclear (Bauer, Lieber & Plag 2013: ch. 18).

3.2 Gemination and resyllabification

Another area where there is unexplained variation is gemination and resyllabification. I use the term 'gemination' here for the pronunciation of two adjacent identical consonants as if it was one long consonant.[3] This happens in English only in certain kinds of complex word, i.e. across morpheme boundaries, as in *keenness* or *wheelless*. There is variation, however. The examples in (4) illustrate variable gemination with the adverb-forming suffix *-ly*. In some forms, we find a long /l/ being pronounced ('gemination'), in others the two /l/'s are merged into one short /l/ ('no gemination'), in again others both kinds of variant are attested.

(4) -ly
gemination: stalely, vilely
no gemination: fully, really
variable gemination: dully, wholly

Works such as Bauer (2001:82) mention the variability, but fail to provide an account of what determines which behavior a given word will show.

Syllabification across morpheme boundaries presents another set of rather puzzling facts. (5) gives examples of the variable syllabification of base-final /r/ under suffixation. While, for example, *murderous* has three syllables, preserving the number of base syllables, *monstrous* has only two syllables.

(5) a. -ous
preservation: mur.de.rous, fe.ver.ous (*mur.drous, *fe.vrous)
non-preservation: di.sa.strous, mon.strous
b. -y
preservation: but.te.ry, lea.the.ry
non-preservation: an.gry, wri.ggly
variable preservation: win.te.ry ~ win.try

The theoretical literature is silent about what exactly might determine the kinds of variability illustrated in (2) through (5).

The second major problem with morpho-phonological alternations concerns the nature of the phonetic or phonological categories involved in these alternations. Traditionally, morpho-phonology has been treated in terms of phonemic alternations, largely disregarding phonetic detail. This seems to be problematic with at least some of the phenomena involved.

For example, claims about degemination effects across morphological boundaries have been put forward mostly on the basis of anecdotal evidence, individual speaker intuitions or transcriptions as found in dictionaries. There is one acoustic-phonetic study available that investigates the prefixes *un-* and *in-* (Oh & Redford 2012), and this study underscores the point that claims about degemination effects need to be based on solid phonetic evidence instead of the intuitions of researchers that participate in the pertinent debates. The right kind of evidence is still largely lacking in spite of its being crucial for an adequate account of the data. There is, however, one area that has seen significant progress in understanding what looked like a morpho-phonological rule, compound stress.

3.3 Stress in noun-noun compounds

The compound stress rule (e.g. Chomsky and Halle 1968) states that noun-noun compounds are stressed on the left constituent (e.g. *wórd formation, ópera glass*, *bútterfly*). It is well-known, however, that there is a substantial amount of compounds that are stressed on the right constituent (e.g. *silk shírt, brick wáll, kitchen sínk, summer dréss*). In fact, about one third of the noun-noun compounds in running texts are right-stressed (see, for example, Sproat 1994, Plag et al. 2008, Bell & Plag 2012), a proportion that can't be dismissed as a mere set of exceptions. In fact, Chomsky and Halle themselves (ibid: 156) acknowledge that the domain of application of the compound stress rule is not clearly delimited and that there is a need for "an investigation of the conditions, syntactic and other, under which the Compound Rule is applicable".

In recent years, quite a number of empirical investigations have been carried out to address this issue (e.g. Plag 2006, Plag et al. 2007, 2008, Plag 2010, Plag & Kunter 2010, Arndt-Lappe 2011, Kunter 2011, Bell & Plag 2012, 2013, Bell & Arndt-Lappe 2013). These studies have tested a wide range of different kinds of potentially influential factors, such as argument structure, semantics, lexicalization, spelling, length, constituent-based analogy, and informativity. All of these factors have turned out to have a say in predicting stress placement, though to varying degrees (see Bauer, Lieber & Plag 2013: ch. 19.3.3 for a summary). And all of these studies demonstrate that probabilistic and analogical models far outperform traditional, deterministic rule-based approaches.

These results also stress the important role of interconnectivity in the lexicon, as the most important determinants, constituent-based analogy and informativity, are reflexes of the distributional properties of lexical items. For illustration, let us look at Bell & Plag's (2012, 2013) studies. These authors started from the assumption that compound stress is an accentuation phenomenon (e.g. Gussenhoven 2004, Kunter & Plag 2007, Kunter 2011): right-stressed compounds are characterized by two pitch accents (one on each constituent), while left-stressed compounds carry only one accent (on the left constiutent). Bell and Plag now tested whether the informativity of the compound constituents would play a role in the decision of whether the second noun ('N2') would get an accent or not. Informativity was measured in terms of semantic specificity and in terms of expectability, i.e. the probability of

occurrence. Whether a noun is expectable in a particular compound position in turn was measured in terms of family size. For example, in a compound with a large N2 family size, this constituent has a high probability of occurrence and is therefore expectable. This would predict that this constituent is not very likely to receive an accent. Both studies by Bell and Plag provide strong empirical evidence that probability-based informativity measures are highly predictive for compound stress assignment.

At the same time, several studies (Plag 2006, Plag 2010, Arndt-Lappe 2011, Bell & Plag 2013) have shown that there is another strong effect emerging from constituent families. Thus there is a strong tendency for compounds with a certain word in N1 or N2 position to have the same prominence pattern as other compounds with that word in the same position. The relation between this constituent family bias and the informativity effect is not entirely clear, but Bell & Plag (2013) argue that informativity underlies the effects of other constituent-based predictors of prominence, including constituent family bias. Thus, an effect of constituent informativity on stress will give rise to constituent identity effects like the family stress bias, but the constituent family bias would not automatically produce an informativity effect.

The take-home message from all the studies discussed in this subsection is that compound stress emerges from the lexicon, and that it does so in a probabilistic, non-deterministic fashion.

3.4 Summary

Let us summarize our overview of variation in the morpho-phonology of English. First, a look at a wider range of available data reveals much more variation than traditionally assumed. Second, the amount and structure of this variation is largely unknown and a lot of empirical research is necessary to address this problem. Third, for those areas where research has been carried out (e.g. compound stress or stress preservation), it can be safely said that the pertinent results seriously challenge existing models of lexical phonology and traditional ways of dealing with the status of complex words in the lexicon.

4 Morpho-phonetic detail

4.1 Phonetic reduction and morphological structure

In addition to the problems posed by morpho-phonological alternations, there is a related set of problems that are of empirical and theoretical interest for different subdisciplines of linguistics (phonetics, psycholinguistics, neurolinguistics, theoretical linguistics). As already mentioned above, morphologically complex words are often phonetically reduced (or otherwise phonetically variable) as compared to their citation forms or to the pronunciation of their constituents outside the word in question. The extent and nature of such reductions and their theoretical significance are still largely unclear.

In the introduction we already mentioned the phonetic reduction in the pronunciation of the word *government*. Other pertinent cases are *restless* and *exactly*, which are words that are

often pronounced without a /t/ (*listless* also belongs here, as already mentioned above). It has been suggested (e.g. by Hay 2003) that such cases of phonological opacity may not be idiosyncratic, but reflect different degrees of morphological segmentability. Thus, *government* is far more frequent than its base *govern* and is therefore less easily segmented than, for example, *enjoyment*, whose base is far more frequent than its base (Hay 2001, see Plag 2003: ch. 4 for an introduction to the notion of variable morphological segmentability). Similarly, *exactly* is far more frequent than its base (61,601 vs. 10,508 in *COCA*) and easily loses its /t/, while, for example, *abstractly* is much less frequent than its base (209 vs. 7,853 in *COCA*) and is unlikely to occur without its base-final/t/.

Phonetic variability may not only affect bases but also affixes. For example, the vowel of the prefix *un-* may be realized as a full vowel, as a schwa, or may even be completely absent in running speech, and the prefix may be realized with variable length (measured in milliseconds) within and across speakers, and across different derivatives. Hay (2007) shows that this kind of phonetic variation is not random and her results suggest that factors facilitating morphological decomposition (e.g. boundary-like phonotactics or high frequency of the derived form relative to the base) lead to phonetically longer pronunciations. Regional differences may also play a role and need to be investigated in more detail. For example, Hay and Kuperman (2012) find that diverging North American and New Zealand frequencies of plurals, for instance, correlate with the durations of the respective plurals.

Studies investigating the order of derivational affixes in English (e.g. Plag & Baayen 2009) have provided evidence that affix boundaries differ in boundary strength: in a word of the form [[base-X]-Y], the outer boundary between [base-X] and affix Y is stronger than the inner boundary between the base and affix X. Hay (2003) and Plag & Baayen (2009) argue that these strength differences affect the degree not only of decomposability, but also of phonological integration: affixes at weaker boundaries will show a higher degree of phonological integration than affixes at stronger boundaries. Obviously, different degrees of phonetic integration should have an effect on phonetic implementation.

Similar boundary effects are reported in Sproat (1993) and Sproat & Fujimura (1993), who investigate the phonetic implementation of the same segment string at different types of boundary (no boundary, affix, compound, phrasal, utterance). Their findings are compatible with the conclusion that weaker boundaries show more phonological integration: for instance, the acoustic duration of the same segments at an affix boundary is shorter than at a compound boundary. Likewise, Hay (2007) finds a difference in duration between the prefix *un-* and non-morphemic word-initial *un-*, as well as differences in vowel reduction.

Taken together, the results from the phonetic studies and the affix order studies predict that the phonetic implementation of a word with more than two morphological constituents will reflect its morphological structure, i.e. its internal bracketing. Kunter & Plag (2014) formulate the 'Embedded Reduction Hypothesis', which states that the embedded form shows more phonetic reduction than forms at higher derivational levels. To test this prediction, these authors analyzed triconstituent compounds.

Traditionally, the branching direction of triconstituent compounds (e.g. [*child care*] *center* vs. *university* [*textbook*]) has been extensively discussed in the context of stress assignment. According to the well-known Lexical Category Prominence Rule (LCPR, Liberman and Prince, 1977, see also Sproat 1994 for some variant of the LCPR), prominence assignment to triconstituent compounds depends on the branching direction. Left-branching compounds, i.e. compounds with an embedded compound as the left Immediate Constituent, are predicted to have highest prominence on the leftmost constituent, whereas right-branching compounds have highest prominence on the second of the three constituents. Recent studies (for example, Kvam 1990, Sproat 1994, Berg 2009, Giegerich 2009, Plag & Kösling 2009, Kösling 2013 and Kösling et al. 2013) have shown, however, that the branching direction of noun-noun-noun compounds cannot be read off from the stress pattern.

Kunter & Plag (2014) now used the data from Kösling et al.'s experiment and measured the phonetic duration of the constituents (instead of pitch as a correlate of stress). They found that, in general, the constituents of the embedded compound were significantly shorter than the single constituent at the higher compositional level. This effect holds for left-branching and for right-branching compounds. These results present clear evidence for the idea that the branching direction, i.e. morphological structure, is phonetically encoded.

Such results pose a challenge for most formulations of Lexical Phonology (e.g. Kiparsky 1982), which argue that the internal structure of morphologically complex forms is not accessible anymore at the post-lexical stage, with which phonetic variation like sub-phonemic durational differences or phonetic reduction are usually associated. If there is reliable evidence that the acoustic signal contains phonetic detail which reliably signals the internal structure of morphologically complex words, and if this detail affects the processing of the acoustic signal by listeners, the strict division between lexical and post-lexical components needs to be revised.

In sum, there is some evidence that phonetic implementation reflects morphological structure. This in turn has implications for the organization of complex words in the mental lexicon. Models of the mental lexicon which assume that only morphemes and irregular complex words are stored (see again, for example, Clahsen 1999, Marcus et al. 1995, Prasada & Pinker 1993, Pinker 1998) would predict that segments are less reduced if they represent morphemes. In contrast, dual-route models assume that morphologically complex words are also stored in the mental lexicon, and predict that morphemes are less reduced only if they belong to more easily decomposable words.

Existing studies of fine phonetic detail in the pronunciation of complex words have yielded conflicting results and interpretations with regard to this particular controversy (see Hanique and Ernestus 2012 and Cohen-Goldberg 2013 for overviews and further references). For example, Pluymaekers, Ernestus & Baayen (2005) find that the degree of reduction of some Dutch affixes is dependent of the predictability of the item in question. Kuperman, Pluymaekers, Ernestus & Baayen (2007), however, found the opposite effect with Dutch compound interfixes. The more probable the interfix is, given the compound and its constituents, the longer its phonetic length. Most recently, Hay & Kuperman (2012) came up with conflicting interpretations of the phonetic variability observable with plural *-s* in New

Zealand English. In spite of the contradictory findings, there seems to be a general trend that the degree of reduction is correlated with the information load of the respective string, a finding that is most elegantly accounted for by models that allow for the storage of complex words in the lexicon. Furthermore, if we find that phonetic implementations are sensitive to morphological and lexical information, this would challenge theories of speech production that associate frequency information with the phonological level and that have nothing to say about post-lexical processing of morphological structure (e.g. Levelt, Roelofs, & Meyer 1999), and it would support models that include information on fine phonetic detail into lexical representations (e.g. Johnson 1997, Cohen-Goldberg 2013).

4.2 Articulation and morphology

A broader systematic study of the articulation of complex words has not been undertaken, in spite of some evidence provided by Cho (2001, for Korean) that morphological structure may directly influence articulation. In this study it is shown that articulatory gestures are more variable across morphemic boundaries, which is an indication that morphological structure plays a role in articulatory planning. This again speaks for a theory of speech production in which morphology plays a role in post-lexical processing, and challenges standard models like that of Levelt, Roelofs, & Meyer (1999), in which there is no difference in post-lexical processing between multi-morphemic and mono-morphemic words.

A recent study using electromagnetic articulography (Tomaschek et al. 2013) is highly suggestive in regard to the unresolved problems discussed in the previous paragraphs, although it does not deal with morphologically complex words. These authors show that when speakers articulate high-frequency words, the articulators reach more extreme positions in such words, indicating more precise articulation. In other words, the reduction in acoustic duration that we find with high-frequency words may go hand in hand with increased articulatory detail. This raises the question of to what extent previous studies reporting acoustic reduction in morphologically complex words (e.g. Pluymaekers, Ernestus and Baayen 2005) may have missed out on differences in the precision of articulatory execution. In short, articulatory studies of morphologically complex words are crucial for a proper understanding of the fine phonetic detail in the acoustic signal of morphologically complex words, and the theoretical implications of acoustic reduction.

4.3 Homophony of morphemes

A final area of research concerns the putative homophony of morphological entities. Thus, Kemps, Wurm, Ernestus, Schreuder & Baayen (2005) provide evidence that, contrary to what structural linguists would probably expect, free and bound variants of a base (e.g. *help* without a suffix as against *help* in *helper*) differ acoustically, even if no morpho-phonological alternations apply. Furthermore, these authors show that Dutch and German listeners do make use of such phonetic cues in speech perception (see also Kemps, Ernestus, Schreuder & Baayen 2005). These results on the phonetic variability of phonemically identical bases in different

morphological environments still await proper replication across more phenomena from various languages and morphological categories.

A natural extension of such work would look at seemingly homophonous affixes or clitics. English, for example, has many affixes and clitics that have different meanings or functions, but which are expressed by what has so far been considered homophonous morphs. For example, the genitive, the nominal plural and the 3rd person singular on verbs share the same exponents (/z/, /s/ and /ɪz/). The allomorphs of *-ed* denote either past tense, form the past participle or are used as ornative suffixes (e.g. *blue-eyed*). Or consider auxiliary clitics such as *'s* or *'d*, which can represent either *has* vs. *is*, or *would* vs. *had* vs. *did*. A similar problem concerns homophonous word pairs with one of the words being complex, the other simplex (e.g. *fined* vs. *find, laps* vs. *lapse*). Traditional wisdom has it that there is nothing in the speech signal that could differentiate the different forms. There is, however, reason for doubt.

First, there is evidence, as already mentioned above, that the same base may have systematically acoustically different bound and free variants. Similar acoustic differences might be found with phonemically identical affixes or clitics. Second, it has recently been shown that supposedly homophonous lexemes are actually phonetically different. Gahl (2008) demonstrates that homophonous words of different frequency (in her case *time* and *thyme*) show different phonetic length (with local speaking rate, predictability from neighboring words, position relative to pauses, syntactic category, and orthographic regularity being statistically controlled). In the same vein, Drager (2011) demonstrated that the acoustic properties of the form *like* differ systematically depending on whether the form represents a different lexeme, i.e. the discourse particle *like* (*It was **like** sobering*), the quotative marker *like* (*I was **like** "yeah okay"*), or the verb *like* (*I **like** your socks*).

It is an open question whether similar effects hold for affixes (e.g. plural *-s* and third singular *-s*) or clitics (e.g. *'s* for *is* and for *has*), or for pairs of complex and simplex words (like *missed* and *mist*). Only very few studies are available that investigate these problems. Walsh & Parker (1983), Losiewicz (1992) and Sugahara & Turk (2009), for instance, find significant duration differences between segments that represent morphemes (e.g. past tense /t/ or plural /s/) and the same segments in monomorphemic words, when comparing homophonous suffixed and simplex words (e.g. *missed* and *mist*). But the data sets investigated in these studies are very small, only experimental in nature, and the effects found are not always convincing due to various methodological shortcomings.

Given that there is morphologically relevant phonetic variation even between the tokens of the same affix (as discussed above), it would not come as a surprise if different, but seemingly homophonous, affixes could be phonetically differentiated. In a recent study, Homann, Plag & Kunter (2013) investigate the seemingly homophonous English morphemes denoting plural, genitive, plural-genitive and 3rd person singular, as well as cliticized forms of *has* and *is*. The data for that study comprise more than 500 tokens of the respective forms and come from natural conversations (Buckeye Corpus of Conversational Speech, Pitt et al. 2007). The statistical analysis of the acoustic measurements revealed significant differences in the

duration of *-s* between certain morphological categories. In particular, English plural *-s* is longer than all other *-s* morphemes.

This result is unexpected under any theory in which the form representation of morphemes is restricted to underlying representations or phonemes. The perhaps surprising results cannot be attributed to potentially intervening variables such as speech rate or frequency since these variables were statistically controlled for. The findings thus call for a modification of current models of speech production and the lexicon, and challenge what is the perceived wisdom in linguistic theory.

5 Conclusion

The discussion in this paper has shown that phonetic and phonological variation in complex words has generally been underestimated. Overall, this variation poses two big challenges to theories of the mental lexicon and grammar. The first challenge is that it is essentially unclear what is responsible for the large amount of variation we find with morpho-phonological aternations, and how models of grammar and the lexicon can accommodate it. The second, and more general, challenge is to determine the role of morphological structure in the phonetic realization of words.

Theories of speech production and lexical phonology alike need to accommodate the growing evidence that phonetic implementation is not independent of morphological structure and that phonological variation is not simply a matter of rule and exception. Obviously, to meet those challenges a lot of research needs to be done.

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[2] Note that there is another word that denotes the action or manner of governing, *governance*.

[3] Other authors sometimes refer to the phenomenon as ‘fake gemination’ (Oh & Redford 2012).