English auxiliary realization and the independence of morphology and phonetics

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1 Introduction

Patterns of linguistic variation can provide striking evidence for abstract representation and processes. A textbook example of this is Labov's (1969) study of copula variation in African-American English. Labov demonstrates that the shared conditions on variable copula deletion and contraction are explained if the two are represented in the synchronic grammar as separate processes ordered in a feeding relationship. Accordingly, he demonstrates the importance of quantitative data for answering questions of linguistic theory.

The present paper presents another case study along these lines, in which the quantitative patterns of a variable process are taken as evidence supporting a particular grammatical architecture. The process under investigation is the variable deletion of /h/ in function words (e.g., *he, her, himself*) in connected speech; the broader question at issue is whether this process of phonetic lenition shows sensitivity to particular lexical items, as would be predicted under an exemplar-based model of the grammar (Pierrehumbert 2002). Using quantitative data gathered from a large speech corpus, we show that *h*-deletion does not show lexical specificity, but rather applies at a uniform rate across lexical items. This uniform rate is demonstrated despite the various lexical items' differing in predictability and probability: characteristics which, under an exemplar-based account, should result in different rates of lenition. We argue that the uniform rate instead supports a modular, feed-forward model of the grammar (Chomsky and Halle 1968), under which a phonetic process like *h*-deletion has no access to information about lexical identity.

2 Background

2.1 The architecture of the grammar

At issue in the present study is the empirical viability of the separation between morphology and phonetics inherent to particular grammatical architectures. Under classical grammatical models (Chomsky and Halle 1968), surface forms have passed through a number of linguistic levels before being output. Crucially, these levels are ordered, with morphology preceding the phonology and the phonetics (and see Bermúdez-Otero 2010 for a summary of architectural specifics). Accordingly, the selection of morphological variants takes place prior to the application of phonetic processes, like the lenition processes attested in connected speech. Communication between levels can occur only at interfaces; thus, processes at the level of the phonetics may make reference to phonological characteristics, but may not "reach backward" to "see" elements of the morphology. These models thus do not predict word-specific phonetic behavior except when those word-specific characteristics are represented in the phonology. Instead, stored lexical items are maximally abstract, and phonetic processes apply to all relevant lexical items equally.

Under exemplar-based theories of the grammar, by contrast, linguistic structure is emergent from experience, and language production is shaped by the input a speaker has received over time. Specifically, as Pierrehumbert (2002) describes it, words are represented cognitively by clouds of remembered tokens ("exemplars"). These exemplars are maximally phonetically detailed, and tagged with a variety of information, including context of use, function, and social characteristics of the speaker. Production of a given word consists of computing a weighted aggregate over the exemplar cloud for that word. Given this level of phonetic detail in linguistic representation, then, word-specific effects may arise in cases where some factor differentiates words from one another.

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One such factor is word frequency, which, most pertinently to this paper, Bybee (2006) argues to affect the application of lenition processes. Because frequent words are pronounced so often, her argument goes, the gestures needed to produce them are particularly efficient, leading to gestural overlap and, consequently, reduction. This effect of frequency on lenition also extends to cases in which an item is particularly frequent in a particular linguistic context (the notion of "predictability" or "conditional probability"). Frequently-uttered collocations are more likely to be "chunked" in memory, again leading to greater efficiency in production and reduction of those items that occur frequently in particular contexts.

Studies such as Krug (1998) and Jurafsky et al. (2001) have tested this prediction and have indeed found increased reduction (auxiliary contraction in Krug's case; duration, vowel reduction, and *t/d*-deletion in Jurafsky et al.'s) of frequent and/or predictable items. That said, there is still more work to be done on this point. Krug's findings, for instance, lend themselves to skepticism. He argues that his data show a positive correlation between contraction rate and the string frequency of a pronoun-auxiliary collocation. But scrutinizing his results reveals that it is personal pronoun–auxiliary collocations that are high-frequency and high-contracting, and *wh*-pronoun–auxiliary collocations that are low-frequency and low-contracting, and he does not test for the effect of frequency *within* pronoun types. (See MacKenzie 2012 for an analysis which does provide this.) It is thus possible that some syntactic confound—for instance, the fact that *wh*-pronoun–auxiliary collocations have undergone subject-auxiliary inversion—accounts for the differences in contraction rate rather than string frequency. Jurafsky et al. find effects of predictability and collocation frequency only on vowel duration and reduction, not on final coronal stop deletion, implying a potential difference between types of lenition processes (something which we return to at the end of the paper). Their study of coronal stop deletion also conflates several deletion processes: both the well-studied sociolinguistic variable of consonant cluster simplification (Guy 1980), which has been argued to be partly morphological in nature (Fruehwald 2012), and the deletion of final coronal stops not in consonant clusters, which may be accompanied by extensive deletion of other segments (they give examples including *most* → [m] and *about* → [bæ]). It is thus unclear where exactly the frequency effect may be localized. Finally, they fail to control for the nature of the segment preceding the coronal stop, which has been found in numerous studies to play a strong role in consonant cluster simplification (e.g. Guy and Boberg 1997).

Accordingly, further studies of deletion processes are warranted to broaden the testing ground of the two competing architectures described above. The present paper provides one such study.

2.2 *h*-deletion as a test case

The phenomenon that we use to adjudicate between the two theories presented above is the variable deletion of initial /h/ in function words. This process has not yet been studied quantitatively, though it has been acknowledged as characteristic of fast speech (Kaisse 1985, Zwicky 1970). Studies do exist that examine deletion of /h/ in **non**-function words (Bell and Holmes 1992, Tollfree 1999, Trudgill 1974), but that deletion process, a well-known sociolinguistic variable in dialects of British English, is not attested in the dialects of American English that we study. We presume, instead, that that the process of *h*-deletion under investigation here applies at a lower level of the grammar (though characteristics that would identify it as phonetic rather than phonological, such as increased application at faster speech rates, remain to be confirmed empirically). The set of function words beginning with /h/ to which this deletion process applies comprises pronouns (*he, him, her, himself, herself*) and auxiliary verbs (*has, have, had*). Under the modularity hypothesis, *h*-deletion should apply to all of them at the same rate, irrespective of their frequency or predictability.

Our primary interest in this study is in testing this hypothesis as it applies to the auxiliaries *has* and *had*. This interest stems from a recent analysis of auxiliary contraction (MacKenzie 2013) which hypothesises a constant rate of *h*-deletion across auxiliaries, in keeping with the modularity hypothesis. Thus, not only does the present paper contribute a novel case study toward the theoretical debate outlined in the previous section, it also provides needed empirical confirmation of the model put forth in MacKenzie 2013.

The connection between *h*-deletion and auxiliary contraction should be elucidated briefly. MacKenzie observes that /h/-initial auxiliaries such as *has* and *had* surface in three distinct phonological shapes in natural speech: a consonant-initial, syllabic form (1), a vowel-initial, syllabic form (2), and a non-syllabic, single-consonant form (3). Under her analysis, the alternation between the two syllabic forms (1 & 2), on the one hand, and the non-syllabic form (3), on the other, stems from an underlying morphological alternation between one long and one short allomorph, respectively, of each auxiliary (and see Kaisse 1983 for a precursor to this idea). The long allomorph of *has* and *had* has all phonological material intact (i.e., /hæz/, /hæd/); the short allomorph consists of only a single consonant (/z/, /d/). The alternation between the two syllabic forms (1 & 2) stems from phonetic *h*-deletion, the process we examine here, having variably applied to the long allomorph to delete its initial consonant.

(1) [həz], [həd]
(2) [əz], [əd]
(3) [z], [d]

Not every linguistic environment permits all three of these phonological shapes. Each auxiliary actually surfaces in its full range of forms only in particularly restricted environments. For *had*, its full range of shapes is attested only after personal pronoun subjects. (After non-pronoun subjects, i.e., full noun phrases, there is a restriction against the single-consonant form of *had:* observe the ungrammatical **Sue'd* [sud]. Only forms 1 and 2 are attested in this environment.) For *has*, its full range of shapes is most robustly attested after non-pronoun subjects. (After personal pronoun subjects, despite the fact that *has* is grammatical in all three of its phonological shapes, MacKenzie (2013) finds that its single-consonant form drastically outperforms the others, surfacing approximately 90% of the time in two corpora.)

h-deletion cannot be studied in these environments where all three forms are not attested. For *has*, this is quite simply because the near-avoidance in conversational speech of forms 1 and 2 after pronoun subjects renders the question moot: there is next to no data to study. For *had*, the reason is more complicated. MacKenzie observes that *had* does not surface in its single-consonant form after noun phrases (hence **Sue'd* [sud]), but does not take this as evidence that *had*'s short allomorph categorically fails to be inserted in that environment. Rather, she proposes (and provides corpus data to support this) that *had*'s short allomorph **may** be inserted, but can surface after noun phrases only with an epenthetic schwa ([əd]). This creates a form which is homophonous with the output of *h*-deletion on *had*'s long allomorph (again, [əd]), despite not representing a case of *h*-deletion itself. This homophony artificially inflates the rate of *h*-deletion; accordingly, all tokens of *had* in this environment must be omitted from our study.

Given MacKenzie's hypothesis that the alternation between the two syllabic forms is attributable to *h*-deletion, the rate of *h*-deletion can be calculated, once the envelope of variation is appropriately delimited, as the number of vowel-initial syllabic forms (2) over the total number of syllabic forms (1+2). MacKenzie does this, and calculates quite comparable rates of *h*-deletion, ranging between 35% and 39%, for the two lexical items *had* and *has* in two corpora.

Though these rates are indeed quite comparable, they await statistical testing as well as confirmation with additional *h*-initial lexical items. The present paper provides this in Section 4. Moreover, the fact that both lexical items undergo deletion at a consistent rate is not in itself confirmation of the modularity hypothesis. If frequency and predictability of these items are **also** identical, our findings would equally support an exemplar-based theory of grammar. Section 5 tests this.

3 Methodology

The data for this study were collected from Switchboard (Godfrey and Holliman 1997), a 3-million word corpus of recorded telephone conversations between strangers on provided topics. 284 syllabic tokens of *had* after vowel-final personal pronoun subjects (*I, you, he, she, we, they*)[1] and 250 syllabic

[1]Tokens of *had* after *it* were excluded because the full range of phonological shapes in 1–3 is not attested there: the single-consonant form may not surface (*[ɪtd]). Instead, MacKenzie (2013) argues that the short

tokens of *has* after non-pronoun subjects[2] were selected at random from the corpus and coded auditorily by the first author. Tokens were coded for whether or not their initial /h/ was retained, as well as for properties of their subject and the identity of surrounding words. Tokens were excluded from analysis if they contained an auxiliary in one of several contexts that are well-known to prohibit the appearance of that auxiliary's single-consonant form (3): for instance, before an ellipsis or movement site (King 1970, and see MacKenzie 2012 for an extended list of such environments). Again, this is because the envelope of variation was restricted to environments where all three phonological shapes are attested, as described in Section 2.2.

Alongside *has* and *had*, we coded 273 tokens of the pronoun *he* as a control. If *h*-deletion is truly a phonetic process, then under the modular, feed-forward model, it should apply at a consistent rate to all three words, all of which fit Kaisse's (1985) description of the process as applying in "moderate speech" to "most pronouns and auxiliaries" (34). Preliminary analysis of the data revealed that *h*-deletion does not affect all instances of *he*. Rather, the envelope of variation for this lexical item appears to encompass only those cases in which the pronoun cliticizes to the preceding lexical item, the two forming a prosodic word (Selkirk 1995). We identified four environments in which this occurs, exemplified in 4–7 with examples taken from Switchboard, and restricted our coding to just those four.[3]

(4) After conjunctions (*and, but, or, so*): A guy does it and he has his own pigs. (sw_1071)
(5) After *wh*-words (*when, where, whether, who, what, how*): That's what he wants to do. (sw_1148)
(6) After complementizer *that*: We tried to argue that he should get more salary for that. (sw_1235)
(7) After the adverb *then* (and *than*): And then he tells you how to invest that money. (sw_1117)

Other phenomena attest to the close attachment of *he* to the word that precedes it in these environments. For instance, a preceding /t/ will flap when the /h/ of *he* is deleted, so *but he* surfaces as [bʌɾi]. The relationships between *h*-deletion and those phenomena which affect word-final consonants, such as flapping (Wagner 2010), *t/d*-deletion (Guy 1980), and, in certain dialects, glottalization (Fabricius 2000, Roberts 2006), provide an interesting area for future study, raising questions concerning the interaction between variable processes and the effects of production planning on variation (Wagner 2012), as a following *h*less pronoun must be planned in order for flapping to take place.

The pronoun *he* is typically unstressed in the environments given in 4–7 (a necessary precondition for *h*-deletion, according to Kaisse). Tokens in which *he* did bear stress were excluded from coding.

4 Results

Table 1 provides the proportion of deleted forms for each of the three lexical items under study.

	rate	N
had	0.35	284
has	0.38	250
he	0.31	273

Table 1: Rate of *h*-deletion for three lexical items.

allomorph gains an initial schwa before surfacing, and hence we get another form that is indistinguishable from the output of *h*-deletion—see Section 2.2.

[2]Tokens of *has* were excluded after sibilant-final subjects for the same reasons discussed in Section 2.2 and fn. 1.

[3]Numbers in parentheses are speaker identification numbers from Switchboard.

It's clear that *h*-deletion operates at a comparable rate across all three lexical items. This is confirmed when tokens from all three words are pooled for statistical analysis. We performed mixed effects logistic regression in R (using the `glmer` package) with lexical item as a fixed effect and random effects of speaker, preceding word, and following word. With *he* as the reference level for the predictor LEXICAL ITEM, we find no significant effects of LEXICAL ITEM = *had* (p = 0.61) or LEXICAL ITEM = *has* (p = 0.61 [sic]). Moreover, an analysis of variance finds that the model with the LEXICAL ITEM predictor removed is not significantly different from the model containing it (p = 0.86). Adding the LEXICAL ITEM predictor to the model additionally raises both AIC (from 1003 to 1006) and BIC (from 1021 to 1035) values.

On the face of it, then, *h*-deletion does indeed appear to apply at a constant rate to all three lexical items, providing support for the modular, feed-forward approach. But the exemplar-based approach cannot yet be ruled out. Under the exemplar-based approach, relationships between words, such as frequency and predictability, govern reduction. If all three lexical items under study are equally frequent, or equally predictable, the present findings will be equally compatible with an exemplar-based account. The next section tests this possibility.

5 Testing the exemplar-based model

5.1 Predictors

We tested a number of word-specific predictors as possible sources of the consistent rate of *h*-deletion across the three lexical items. These predictors were as follows:

- **Item frequency.** A range of work has found that high-frequency items favor processes of lenition. This has been demonstrated both for cases of sound change in progress, where leniting changes have been argued to affect high-frequency words first (Phillips 1984), and instances of stable variation, where frequent words are argued to be more likely to lenite (see Coetzee and Kawahara 2013 for a recent review).

  For the present study, we operationalized item frequency as the raw counts of the three items under study in the Switchboard corpus, in those environments which we deemed to be within the envelope of variation for *h*-deletion (outlined in Section 3). For *had* and *has*, care had to be taken to ensure that the homonymous main verb was not being counted, as it is only the auxiliary verb that is under study. This can be facilitated with the use of a probabilistic variant of the Brill tagger (Brill 1995), since the Switchboard corpus is not exhaustively manually annotated.

  We distinguish auxiliary *had/has* from main verb *had/has* by searching for instances of these lexical items when followed by a past participle, with at most one word intervening (to allow for intervening adverbs, e.g. *has probably been*). Finally, frequency counts were performed to match the envelope of variation for *h*-deletion in the present study: that is, *had* was counted only after pronoun subjects, and *has* after noun phrase subjects. Putting all this together, frequency counts for *had* were based on the string **pronoun + *had* + (at most one word) + past participle** and frequency counts for *has* on the string **NP + *has* + (at most one word) + past participle**. Likewise, *he* was counted each time it appeared in any of the environments enumerated in 4–7.

- **Item predictability.** The *predictability* of a lexical item—also known as its *conditional probability*—refers to its likelihood of following those words which it follows. Calculating the predictability of item [y] given preceding item [x] is equivalent to asking, "Out of all the words which follow item [x], how likely is [y]?" Under a usage-based account of variation, words which are more predictable followers of the item that precedes them are hypothesized to be more subject to lenition (Jurafsky et al. 2001).

  In the present study, we are asking whether any one of the three words under study is more likely to follow those words that it follows—is a more predictable follower—than any other, or, alternatively, whether all three items are equally likely to follow the words that they do—are equally predictable from the words that precede them. Accordingly, we calculated the mean predictability for each of the three words under study: its predictability over all the words that precede it. For each *h*-word, this was again calculated such that the envelope of variation for *h*-deletion was preserved (i.e. item predictability for *he* was calculated only when *he* surfaced in the environments in 4–7, etc.)

For all lexical items, we calculated two predictability measures: one which captures how predictable the lexical item in question is given all the *words* that it follows, and one which captures how predictable the lexical item in question is given all the *parts of speech* that it follows. The former measure is equivalent to asking, for instance, "Out of all the words that follow *she*, how likely is it that *had* is one of those words?" The latter measure asks the same, but with "pronouns" substituted for *she*.

- **Collocation frequency.** Usage-based accounts of lenition predict that frequent collocations will reduce more than infrequent ones (Krug 1998). Collocation frequency is also known in the literature as "string frequency," and refers to the raw frequency in the corpus of a (in this case) two-word string.

  For each of the three lexical items under study, we identified its most frequent successor in the corpus overall: the lexical item that follows it more often than any other.[4] We then compared the rate of *h*-deletion in this most-frequent collocation to the rate of *h*-deletion in all other collocations.

5.2 Results

The rate of *h*-deletion for each lexical item under study is reproduced in Table 2 as $P(d)$. Alongside this measure is each word's frequency, its predictability given the preceding word ($P(w|\text{prec-word})$), and its predictability given the preceding part of speech ($P(w|\text{prec-POS})$), with all measures having been calculated as explained in Section 5.1. Alongside these measures is each word's rate of *h*-deletion when followed by its most frequent successor ($P(d|w\text{ top})$) and across all other successors ($P(d|w\text{ other})$).

w	$P(d)$	frequency	$P(w\|\text{prec-word})$	$P(w\|\text{prec-POS})$	$P(d\|w\text{ top})$	$P(d\|w\text{ other})$
had	0.35	517	0.316	0.049	0.28	0.41
has	0.38	560	0.452	0.057	0.29	0.39
he	0.31	2121	0.336	0.158	0.37	0.33

Table 2: Values for three words based on the Switchboard corpus. See text for explanation of column headings and predictors.

We find no measure of frequency or predictability that matches the strikingly similar rates of *h*-deletion across lexical items. The closest is by-word predictability, for which all values hover between 0.30 and 0.50, though the highest and lowest predictability measures still differ by 0.136. For frequency and by-POS predictability, the values for the two auxiliaries are relatively close, but the value for *he* differs much more than its rate of *h*-deletion would lead us to expect under the exemplar-based model. In terms of collocation frequency, the *h*-deletion rate again remains relatively constant, whether a word's successor is frequent or not. Figure 1 plots the rate of *h*-deletion for all three lexical items under study with their various followers. The uniformity of *h*-deletion is clear.

6 Conclusion & extensions

Usage-based models of grammar have recently been gaining currency as a means of explaining patterns of variation and change. Inherent to these models, in which detailed phonetic memories are

[4] For *had* and *has*, this most frequent successor is *been*; for *he*, it is *had*.

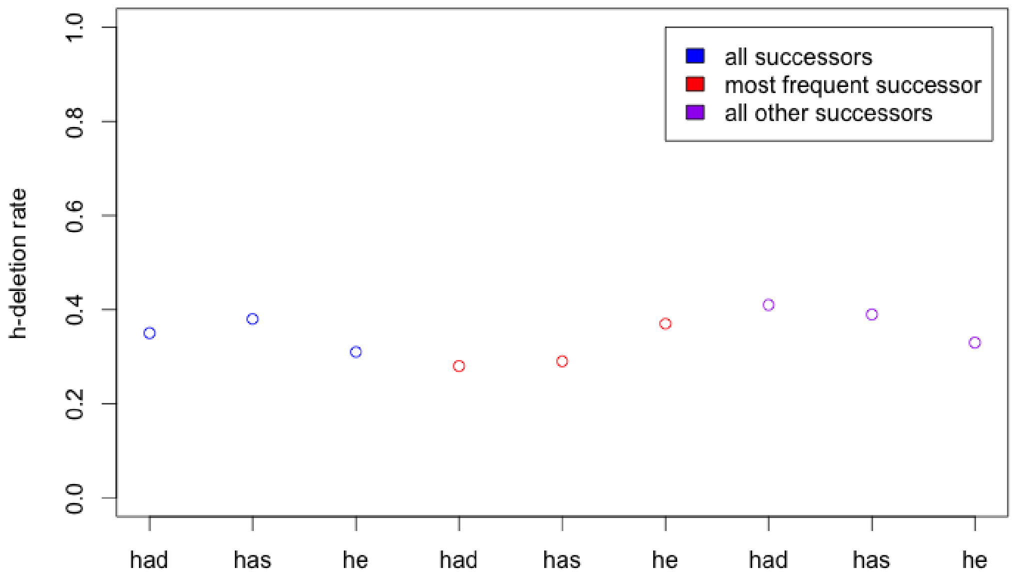

Figure 1: Rate of *h*-deletion for three lexical items in different collocations.

stored and built up over time, is the notion that more frequent and more predictable items are more likely to be lenited. This proposal is an intuitively appealing one, and one which can be easily tested. The present study demonstrates that it does not hold for all instances of lenition. Specifically, we find variable *h*-deletion in English to show no frequency or predictability effects in the Switchboard corpus. *h*-deletion applies to all three lexical items under study at a consistent rate, regardless of an item's frequency or its likelihood from surrounding words. This is as predicted under a modular, feed-forward model of grammar.

It is conceivable that probabilistic relations between words affect some types of lenition processes but not others. The determining factor may lie in differences between processes of deletion and those of reduction more generally. Predictability seems to have a demonstrated effect on duration and vowel reduction (which is itself most likely closely tied to duration), but not deletion (Jurafsky et al. 2001, 2002). Item frequency, as well, has been found to play a role in duration and reduction (ibid.), but as a factor affecting deletion it is not robust (Cohn 2006). Nevertheless, strong usage-based theories appear to make no such distinction; as a process of lenition, *h*-deletion is predicted by these models to behave like vowel reduction where frequency and predictability are concerned. Future work will ascertain whether *h*-deletion has characteristics of other lenition phenomena, like sensitivity to speaking rate, which has been connected with deletion and changes in vowel quality (Fosler-Lussier and Morgan 1999). We hope the study described here drives home the need for more empirical work on connected speech phenomena, as they raise important questions about the nature of grammatical representations and processes.

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