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Phonetic Enhancement and Three Patterns of English a-Tensing

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Abstract
English *a*-tensing has received numerous treatments in the phonological and sociolinguistic literature, but the question of why it occurs (i) at all and (ii) in seemingly unnatural disjunctive phonological environments has not been settled. This paper presents a novel phonetic enhancement account of *a*-tensing in Philadelphia, New York City and Belfast English. I propose that *a*-tensing is best understood as an allophonic process which facilitates the perceptual identity and articulatory ease of nasality, voicing and/or segment duration in the following consonant. This approach unifies the apparently unnatural phonological environments in which the two *a* variants surface and predicts the attested dialectal patterns. A synchronic account of *a*-tensing also provides an explanation for the suprasegmental and morphological factors that condition the process.

Phonetic Enhancement and Three Patterns of English a-Tensing

Yining Nie*

1 Introduction

English *a*-tensing has received numerous treatments in the phonological and sociolinguistic literature (e.g., in the OT era: Benua 1997, Morén 1997, Ash 2002, McHugh 2003, Thomas 2006, Labov 2007, Becker and Wong 2010), but the question of why it occurs (i) at all and (ii) in seemingly unnatural disjunctive phonological environments has not been settled. This paper presents a novel phonetic enhancement account of *a*-tensing in Philadelphia, New York City (NYC) and Belfast English. Each dialect exhibits an alternation between a short lax [æ] and a longer, tense, raised diphthongal variant, transcribed in this paper as [eə]. I propose that *a*-tensing is a phonetically-motivated allophonic process that enhances the perceptual identity and articulatory ease of the following consonant.

The core *a*-tensing phenomena are illustrated below with data from the Philadelphia dialect. Lax [æ] always surfaces in stressed open syllables, as shown in (1). In closed syllables, either lax [æ] (2) or tense [eə] (3) may surface; the variant depends on the voicing and manner of articulation of the coda consonant (Benua 1997, McHugh 2003, Labov 2007).

(1) [æ] in all (stressed) open syllables

[ˈpæ.mə.lə]	‘Pamela’
[ˌkæ.fə.ˈti.riə]	‘cafeteria’
[ˈplæ.nət]	‘planet’
[ˈpæ.səʤ]	‘passage’

(2) [æ] before tautosyllabic stops and voiced fricatives

[ˈkæt]	‘cat’
[ˈtæp]	‘tap’
[ˈtæg]	‘tag’
[ˈhæv]	‘have’

(3) [eə] before tautosyllabic nasals and voiceless fricatives

[ˈheəm]	‘ham’
[ˈkeəf]	‘calf’
[ˈpleən#ət]	‘plan it’
[ˈpeəs]	‘pass’

The distribution of [eə] is the most restricted in Philadelphia English. In NYC, [eə] also occurs before tautosyllabic voiced stops (Kiparsky 1995, Labov 2007); in Belfast, the tense variant surfaces before all coda stops and fricatives (Harris 1985, 1989). The coda conditioning environments for each dialect therefore cannot be characterised in terms of natural classes or any harmonic scale, leading some to suggest that *a*-tensing has been lexicalised (e.g., Kiparsky 1995, Labov 2007). A lexicalisation account, however, does not explain why tensing is phonologically predictable.

In this paper, I propose that *a*-tensing is best understood as an allophonic process which enhances the phonetic properties of coda consonants. In Section 2, I compare the phonological conditioning environments of *a*-tensing in Philadelphia, NYC and Belfast English. Section 3 motivates *a*-tensing as a phonetically-driven allophonic process which facilitates nasality, voicing and frication in codas. This approach unifies the apparently unnatural phonological environments in which the two *a* variants surface and also predicts the attested dialectal patterns. In Section 4, I discuss the advantages of my analysis, showing that it can also account for the non-segmental factors that condition *a*-tensing. Section 5 concludes.

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2 Three Patterns of *a*-Tensing

2.1 Philadelphia English

Much of the support for a lexicalisation account of *a*-tensing (e.g., Kiparsky 1995, Labov 2007) comes from its unnatural class of conditioning environments in Philadelphia English. As shown in the data in (3), *a*-tensing applies before anterior nasal and voiceless fricative codas (though not [ʃ]) and also lexically before [d, l], e.g., in *mad, bad, glad, pal* and *alley* (Labov 2007). The coda consonants which co-occur with tense [eə] are listed in (4).

(4) Philadelphia English *a*-tensing
[eə] occurs before tautosyllabic [f, s, θ, m, n, (d, l)].

It is not immediately clear why nasals and voiceless fricatives should pattern together in this way, leading some other scholars to analyse *a*-tensing as arising from two independent phonological processes (e.g., McHugh 2003). There is also the question of why the velar nasal [ŋ] does not also condition *a*-tensing in Philadelphia English, or indeed any of the three dialects under discussion. In Section 3, I show that a phonetic enhancement analysis of *a*-tensing accounts for all of these patterns.

2.2 New York City English

In both Philadelphia and NYC English, fricatives exhibit split behaviour: voiced fricatives condition [æ] (5) and voiceless fricatives [eə] (6). Stops are also split in NYC English, but in the opposite way: voiceless stops condition [æ] (7) and *voiced* stops [eə] (8).

(5) [æ] before voiced fricatives
['hæv] 'have'
['ʤæz] 'jazz'

(6) [eə] before voiceless fricatives
['leəf] 'laugh'
['meəs] 'mass'
['treəʃ] 'trash'

(7) [æ] before voiceless stops
['tæp] 'tap'
['bætʃ] 'batch'
['tæk] 'tack'

(8) [eə] before voiced stops
['keəb] 'cab'
['beəʤ] 'badge'
['teəg] 'tag'

The tense variant [eə] therefore surfaces preceding coda nasals, voiced stops and voiceless fricatives in NYC. The list of all [eə] coda environments is given in (9).

(9) New York City English *a*-tensing
[eə] occurs before tautosyllabic [f, s, θ, ʃ, tʃ, m, n, b, d, ʤ, g].

Again, the question arises as to what nasals, voiced stops and voiceless fricatives have in common for them to pattern alike, to the exclusion of voiced fricatives and voiceless stops. In Section 3, I suggest that these classes of coda consonant have phonetic similarities in English, and tensing the preceding vowel facilitates their nasal or laryngeal articulation.

2.3 Belfast English

Harris (1985, 1989) characterises the tense variant in Belfast English as long and back and transcribes it as [ɒːᵊ], despite [ɒ] being a lax vowel. For consistency, I will represent the relevant Belfast variant as [ɐə], where both components are [+ATR]. Of the three dialects, the tense variant has the widest distribution in Belfast English, extending to voiced fricatives (10) and the lateral approximant [l] (11) in addition to the Philadelphia and NYC contexts.

(10) [ɐə] before voiced fricatives
['hɐəv] 'have'
['ʤɐəz] 'jazz'

(11) [ɐə] before laterals
['pɐəl] 'pal'
[kə.'nɐəl] 'canal'

In other words, the only obstruents that do *not* trigger *a*-tensing is [ʃ] and the class of voiceless stops; coda [ʃ] is somewhat of an anomaly as it only conditions *a*-tensing in the NYC variety.

Table 1 provides a summary of the different coda conditioning environments for *a*-tensing in the three dialects, organised from left to right in decreasing sonority. What emerges is a continuum from Philadelphia (where tensing is most restricted) to Belfast (where tensing occurs in almost all closed syllable contexts); however, the classes of triggering consonants in Philadelphia and NYC English cannot be characterised in terms of natural classes or any harmonic scale.

	SONORANTS		VOICED OBSTRUENTS		VOICELESS OBSTRUENTS	
	Laterals [l]	Nasals [n, m]	Fricatives [v, z, ð]	Stops [b, d, ʤ, g]	Fricatives [f, s, θ, ʃ]	Stops [p, t, tʃ, k]
Philadelphia	lax	tense	lax	lax	tense, *[ʃ]	lax
NYC	lax	tense	lax	tense	tense	lax
Belfast	tense	tense	tense	tense	tense, *[ʃ]	lax

Table 1. Distribution of tense and lax *a* in Philadelphia, NYC and Belfast English.

In the next section, I argue that the classes of codas which trigger *a*-tensing are not as unnatural as they might first appear. So far we have only discussed the segmental phonological environments relevant to *a*-tensing; however, the process is also sensitive to suprasegmental and morphological factors. I return to these non-segmental conditions in Section 4.

3 Phonetic enhancement

In this paper, I propose that *a*-tensing is best understood as a phonological process that enhances the phonetic characteristics of coda consonants in English. Vowel tensing, which involves tongue root advancement and/or raising the tongue body (Archangeli and Pulleyblank 1994, De Decker and Nycz 2012), helps to ease the articulation and perception of nasality, voicing and fricative duration.

First off, however, we must ask why [æ] and [eə] appear to alternate and not other vowels. Low, open vowels are inherently longer than higher vowels and require more articulatory effort to reach its articulatory target. van Santen (1992), for example, reports an average intrinsic length of 203ms for [æ] but only 143ms for [ɛ]. Raising a low vowel therefore reduces articulatory effort. Lengthening this raised vowel ensures it is still perceived as a low vowel. For instance, a vowel of an intermediate quality between [ɛ] and [æ] is more likely to be judged as low if it is long than if it is short (Krakow et al. 1988). Similarly, lengthened mid vowels are perceived as being lower than their normal-length counterparts, such that [ɛː] is frequently perceived as [æ] (Hillenbrand et al. 2000). It is therefore unsurprising that it is a short low vowel like [æ] that alternates with a longer, raised [eə].

3.1 Nasality

Anterior nasals trigger *a*-tensing in most English dialects with an alternation involving *a*, including the three dialects under discussion as well as the nasal or ‘Western’ systems found in much of the rest of the US and Canada (Boberg and Strassel 2000).

Nasals are produced by lowering the velum and diverting airflow in through the nasal cavity. Vowels in American English tend be to nasalised under the influence of a following nasal consonant; the velum lowers while the vowel is being produced, allowing air to flow through the nasal cavity. Because of the position of the tongue in low vowels, however, the velum must lower further in order for nasalisation to be perceptible (House and Stevens 1956). Raising the tongue body reduces the distance the velum needs to lower in order to generate nasalisation on the low vowel, thereby facilitating nasal articulation. In an ultrasound study, De Decker and Nycz (2012) show that some New Jersey speakers produce *a* with a higher tongue body when followed by a nasal stop than when followed by a non-nasal obstruent (Figure 1); this is typical of *a*-tensing in a nasal system. Therefore the process of *a*-tensing, which involves raising of the tongue body in this case, both enhances vowel nasalisation and facilitates the articulation of the nasal consonant itself. This effect is greatest for vowels whose normal tongue position is farthest from the velum, which offers an explanation for why nasal-induced tensing only occurs with the low front [æ] and not other vowels.[1]

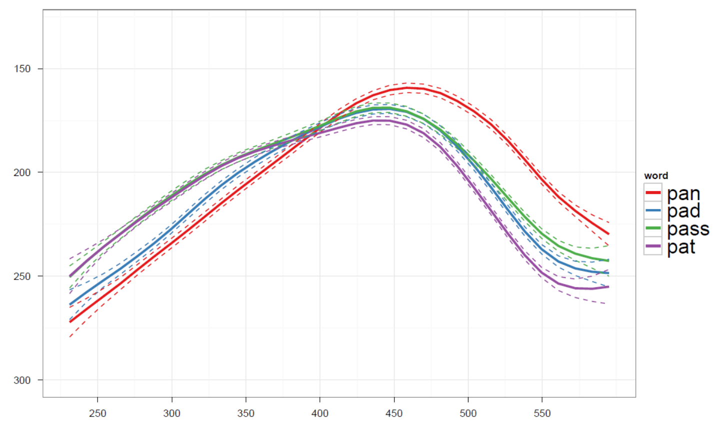


Figure 1. Leftward-facing ultrasound tongue trace of *a* articulation in four environments (De Decker and Nycz 2012:818).

In addition, nasal coarticulation can itself influence the perceived height of a vowel due to the interference of nasal formants with F1 perception, resulting in the lowering of high vowels and raising of low vowels. Nasalised [æ̃], for instance, is perceived as having a lower F1 and thereby a higher place of articulation than its oral counterpart (Beddor 1983, Wright 1986). *a*-tensing therefore helps to reinforce vowel nasalisation, in both perception and production. Since it improves the phonetic conditions for nasality, we expect [eə] to be more preferred in nasal contexts than in non-nasal contexts. This prediction, stated in (12), is borne out in all *a*-tensing dialects.

(12) Nasalised vowels ≻ Non-nasalised vowels

However, while the anterior nasals trigger *a*-tensing in the dialects under consideration, the velar nasal does not. Because [ŋ] already involves a raised tongue body, the velum need not lower as far in order to produce nasality. Tense [eə] thus does not occur with [ŋ] as it does not signficantly improve the conditions for nasalisation. Viewing *a*-tensing as a phonological process with a phonetic basis can therefore account for why the tense variant co-occurs with anterior but not velar nasals.

3.2 Voicing

Just as *a*-tensing reinforces nasality, it can also reinforce the voicing of obstruents. Voicing involves vibration of the vocal folds, which requires airflow from the lungs through the glottis. This airflow is only maintained if the pressure below the glottis remains higher than the pressure above it (van den Berg 1958). Initiating and maintaining voicing is especially difficult in obstruents, because supraglottal pressure can quickly build up behind the constriction or closure, preventing airflow. Advancement of the tongue root widens the supraglottal cavity, increasing its volume and thereby reducing supraglottal pressure (Westbury 1983). In this way, tongue root advancement helps facilitate airflow through the glottis and consequently facilitates voicing as well.

It is well-known that English voiced obstruents frequently undergo partial devoicing at word edges. We might then expect tongue root advancement to occur in order to prevent such devoicing. ATR helps facilitate airflow and voicing, thereby mitigating the devoicing of [+voice] obstruents (Ahn 2015). In a recent investigation of obstruents in American English, Davidson (2016) reports that manner affects the rate of obstruent devoicing in phrase-medial, word-final position: while 79%

[1] McHugh (2003) claims that nasality correlates with tongue root advancement instead of vowel height, suggesting that "the slight acoustic effect that nasality has on F1 might be more likely interpreted by learners as a change in [ATR] rather than a change in tongue height" (McHugh 2003:165). However, this claim is only speculative and its explanation does not extend to the fricative conditions in Philadelphia English.

of voiced fricatives are partially or fully devoiced word-finally, only 55% of voiced stops undergo devoicing in the same position, as shown in Figure 2. Moreover, in any position in the word, voicing is present in the first half of 10–30% more stops than fricatives (Davidson 2016).

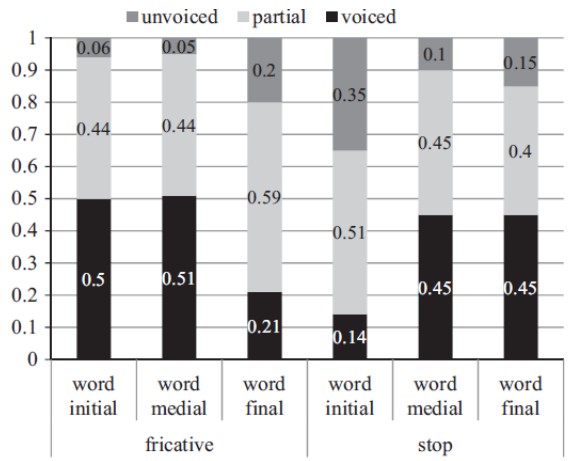


Figure 2. Proportions of obstruent voicing by word position (Davidson 2016:41).

I suggest that tongue root advancement occurs during a vowel in order to reinforce voicing in a following obstruent. This makes the prediction that obstruent voicing should co-occur with vowel tensing. Since word-final stops are phonated more frequently than fricatives in the same position in American English, final voiced stops are expected to trigger tensing more readily than final 'voiced' fricatives. Thus tensing should co-occur with voiced fricatives if and only if it also occurs with voiced stops. This prediction is indeed borne out in the comparison between Belfast, where *a*-tensing is triggered by all voiced obstruents, and in NYC English, where tensing is triggered by voiced stops but not voiced fricatives.[2] *a*-tensing therefore follows the voicing hierarchy in (13).

(13) Voiced stops $\succ$ Voiced fricatives

Because underlyingly voiced stops are more likely to be phonated than voiced fricatives in English, they are also more likely to trigger tensing.

Voiced obstruent codas not only correlate with tongue root advancement but also greater vowel duration in English. In production, vowels preceding voiced stops or fricatives are frequently 80ms longer than those preceding voiceless stops or fricatives (House and Fairbanks 1953, Lisker 1974, Klatt 1976). In perception, listeners judge coda consonants as voiceless when preceded by vowels of short duration and as voiced when preceded by vowels of long duration (Raphael 1972, Umeda 1975). In fact, "shortening the duration of vowels preceding final voiced stops and fricatives caused them to be perceived as voiceless" (Raphael 1972:1296); this voiced coda duration effect is consistent across utterance-medial and utterance-final positions (Myers 2012). Tensing before voiced codas should have additional effects on the vowel, since non-schwa tense vowels in English are always long and non-low in general. It should therefore come as no surprise that the tense variant of the vowel is longer and raised compared to its lax counterpart.

The above voicing considerations also capture the fact that voiceless stops never trigger *a*-tensing. Phonation is not an articulatory goal in voiceless stops, so that tongue root advancement is unnecessary. Finally, since 90–95% of word-medial voiced obstruents remain fully or partially phonated in American English (Figure 2), we can account for the lack of *a*-tensing in open syllables, where the following consonant is word-medial.

[2] I assume that the phonetic voicing properties of obstruents in American English may apply to those of other rhotic varieties, such as Belfast English. This does not seem to be a completely unfounded assumption given that the effects of *a*-tensing processes are so similar across dialects.

3.3 V+C Duration

We have seen that the phonetics of English coda (de)voicing predict the preferential reinforcement of voiced stops over voiced fricatives by *a*-tensing, as well as the wholesale lack of tensing before voiceless stops. The next important question to address is why voiceless fricatives trigger *a*-tensing in each of the dialects discussed in this paper and, moreover, are the *only* class of coda obstruents which condition *a*-tensing in Philadelphia English.

I propose that voiceless fricatives induce tongue root advancement for exactly the same reason that voiced obstruents do. As discussed in the previous section, any constriction in the oral cavity causes a build-up in supraglottal pressure. Higher supraglottal pressure reduces the pressure differential above and below the glottis, which slows down airflow from the lungs. However, a fast, continuous stream of air is required to generate the turbulence that is characteristic of fricatives. Advancement of the tongue root increases the volume of the oral cavity, thereby lowering supraglottal pressure and facilitating airflow. Tensing therefore allows frication to be maintained for a longer period of time.

Following the same logic as in the previous section, then, we expect tongue root advancement to correlate positively with the duration of frication. In Philadelphia English, voiceless fricatives trigger *a*-tensing and voiced fricatives do not. Acoustic studies have shown that the duration of voiceless fricatives in American English is 50–90% longer than that of voiced fricatives (Crystal and House 1988, Stevens et al. 1992). The prediction is thus confirmed: *a*-tensing co-occurs with voiceless fricatives, which have greater duration. What results is the *a*-tensing hierarchy in (14).

(14) Voiceless fricatives $\succ$ Voiced fricatives

Voiceless fricatives are longer in duration than voiced fricatives and therefore more likely to be reinforced by *a*-tensing. As mentioned earlier, vowels are also systematically longer in duration before fricatives than before stops (House and Fairbanks 1953), indicating that *a*-tensing may positively correlate with vowel length as well as with length of the coda obstruent.

The interaction of the obstruent voicing hierarchy in (13) and segment duration hierarchy in (14) gives us two possible typologies of English *a*-tensing. If the reinforcement of voicing is a more important consideration than the reinforcement of V+C duration, then the relevant *a*-tensing hierarchy would be the one in (15a). If, on the other hand, duration outweighs voicing, then we would expect the hierarchy in (15b). These hierarchies are organised from left-to-right in decreasing likelihood of tensing environment; both disfavour tensing with voiced fricatives.

(15) a. Voicing $\succ$ V+C duration:
Voiced stops $\succ$ Voiceless fricatives $\succ$ Voiced fricatives
b. V+C duration $\succ$ Voicing:
Voiceless fricatives $\succ$ Voiced stops $\succ$ Voiced fricatives

A comparison of our three English dialects suggests that (15b) is the relevant hierarchy for *a*-tensing; Philadelphia has tensing before voiceless fricatives but not voiced stops. The reinforcement of segment duration thus outranks the reinforcement of voicing.

3.4 [ʃ] and [l]

This phonetic enhancement account also explains why [ʃ] does not pattern with the rest of the voiceless fricatives in Philadelphia and Belfast. According to the proposed reasoning, we might expect there to be other phonetic (or phonological) properties of [ʃ] which either render it articulatorily incompatible with tensing of the preceding vowel, or are such that the perceptual conditions for the segment are not considerably improved by tensing. Both of these possibilities hold true in this case. Alveopalatals have a highly constrained dorsum (Recasens et al. 1997), which makes manipulation of the preceding vowel more difficult. In addition, [ʃ] is among the most quickly identified fricatives in CV sequences (Jongman 1989); [ʃ, z] are identified in 30ms, compared with [f, s, v] at 50ms and [θ, ð] at 70ms. This suggests that *a*-tensing may not be needed to enhance the perception of [ʃ].

The final phonetic consideration relevant to the coda conditioning of *a*-tensing is the articulation of laterals, which trigger tensing only in Belfast English. The central closure characteristic of laterals results in pressure build-up in the oral tract, much like in obstruents, so that tensing helps reduce supraglottal pressure and thus facilitate airflow. It is well-known that American English coda laterals are 'dark', meaning they have a secondary velar articulation; because the tongue body is already raised, tensing the previous vowel would not improve articulation of the lateral. In Belfast, however, the coda [l] is 'lighter' than in American dialects (although not as light as Southern Irish English) and is produced with a lower tongue dorsum (Wells 1982). Tongue root advancement therefore reinforces the secondary velar articulation and lateral airflow of coda laterals in Belfast, giving reasons for why the other English liquid [ɹ], for example, does not also trigger tensing or other types of diphthongisation associated with coda [l] (Sproat and Fujimura 1993).

In summary, this section has argued that the tense and lax *a* variants are not in fact distributed randomly in Philadelphia, NYC and Belfast English, but via a synchronic process of *a*-tensing that is phonetically-driven and phonologically predictable.

4 An Allophonic Process

Some linguists have claimed that the distribution of [æ] and [eə] must be specified in the lexicon, not only because of their apparently unnatural phonological conditioning but also because they are contrastive in some cases (e.g., Kiparsky 1995, Labov 2007). For example, *a*-tensing appears to be sensitive to the grammatical status of a word; there exist (near) minimal pairs in which the function word has the lax variant (16) and its lexical counterpart has the tense variant (17).

(16) [æ] in functional words

[ˈæm]	'am'
[ˈwæm]	'wham'
[ˈkæn]	'can (aux.)'

(17) [eə] in lexical words

[ˈheəm]	'ham'
[ˈkeən]	'can (n.)'

While [æ] ~ [eə] are lexically contrastive in these particular cases, they are nonetheless predictable by morphosyntactic category. Furthermore, [æ] only appears when the function word is stressed, but surfaces as [ə] otherwise. I therefore assume that the tense/lax distinction is non-contrastive but derives either from the prosodic status of the morphological word (Selkirk 1995), or from increased faithfulness to the underlying representation (/æ/) due to the effect of focus (Coetzee 2009).

There also exist well-known lexical exceptions to *a*-tensing, such as *mad* [meəd] and *bad* [beəd] in Philadelphia English, which normally has the lax variant before voiced codas. However, *a*-tensing is in general fully productive in the environments in which it is phonologically conditioned, and as Harris (1989:44) notes, "fully regular" at least in Belfast English. This predictability must therefore be represented in the grammars of all three dialects.

Furthermore, if the tense variant [eə] were phonemic, we might expect it to have a consistent articulatory target across phonological environments. However, De Decker and Nycz (2012) show that *a*-tensing has a range of articulatory implementations. For example, of coronal nasals and coronal obstruents in syllable codas, only the nasals condition significant raising of the tongue body. They also find varying degrees of tongue root advancement in *a* in the different environments, where the vowel in *pan* exhibited the most advancement, followed by *pass* and *pad*, then followed by *pat*.

4.1 Suprasegmental Conditions

Further evidence for *a*-tensing as a phonological process is its sensitivity to suprasegmental conditioning. As shown in (18), [eə] only occurs when it is stressed and followed by a coda consonant. This extremely restricted distribution would be unexpected if [eə] had a distribution independent of that of [æ] in the lexicon.

(18) [æ] in open syllables, [eə] in stressed closed syllables

[ˈpæ.mə.lə]	'Pamela'	[ˈheəm]	'ham'
[ˈpæ.sədʒ]	'passage'	[ˈpeəs]	'pass'

The distribution of the *a* variants also depends on the number of syllables in the word: *a*-tensing occurs less frequently polysyllabic words, likely due to a reduction in prominence in stressed syllables as well as overall in longer words (McHugh 2003, Thomas 2006).

4.2 Morphological conditions

In all three dialects discussed in this paper, *a*-tensing is also reported to be sensitive to morphological structure. We saw this exemplified by the lexical/functional word distinction in (16, 17). There are two additional morphologically-sensitive patterns worth mentioning in this paper. The first involves affixation; while [æ] surfaces in open syllables created by Class 1 suffixes (19), Class 2 suffixes condition the [eə] variant (20), subject to the same postvocalic consonant conditions as (3).

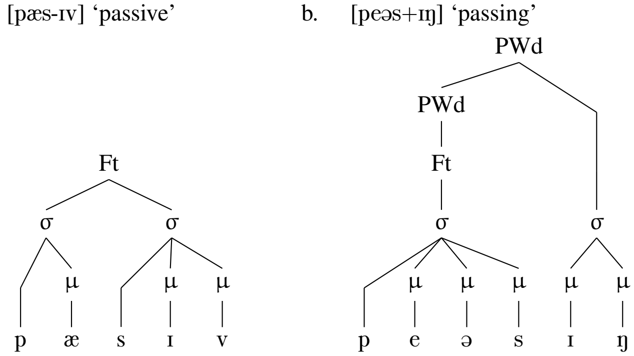
(19) [æ] with Class 1 affixes
['klæs-ɪk] 'classic'
['pæs-ɪv] 'passive'

(20) [eə] with Class 2 affixes
['kleəs+iː] 'classy'
['peəs+ɪŋ] 'passing'

Given the morphological alternations in (19, 20), it is preferable to posit a single underlying representation (UR) for *class* and *pass* rather than two distinct forms, where the UR with /æ/ is selected in Class 1 affix contexts and the UR with /eə/ in Class 2 contexts. The morphological condition seems to be consistent and identical across all three dialects under discussion, which would be surprising if the two variants were lexically specified.

I propose a prosodic structural account for this morphological conditioning, following Selkirk (1995). For example, the Class 1 affix in *passive* [pæs-ɪv] adjoins below the foot level and is syllabified as part of the foot; the lax variant [æ] occurs as normal in open syllables (21a). The Class 2 affix in *passing* [peəs+ɪŋ], however, attaches above the level of the phonological word (PWd) in order to create a new, recursive PWd. Because the [ɪŋ] affix is not within the same PWd as the stem, it does not trigger resyllabification of the coda [s] in *pass*; the stem therefore behaves as a closed syllable and undergoes *a*-tensing (21b).

(21) a. [pæs-ɪv] 'passive' b. [peəs+ɪŋ] 'passing'



Finally, *a*-tensing appears to underapply in morphologically truncated forms. For instance, while consonant-final truncations retain the [æ] calculated in their open syllable bases (22, 23), non-derived forms behave in the expected way (24).

(22) [æ] in open syllable base forms
['pæ.mə.lə] 'Pamela'
[ˌkæ.fə.'ti.riə] 'cafeteria'

(23) [æ] in truncations
['pæm] 'Pam'
['kæf] 'caf'

(24) [eə] in non-derived forms
['heəm] 'ham'
['keəf] 'calf'

Morphological truncations of this type are frequently analysed using Output-Output correspondence constraints (e.g., Benua 1997) or size restrictor constraints (e.g., Alber 2010). I assume that the relevant consideration here is one of prosodic faithfulness, where a truncated form is faithful to the prosodic structure of its base, such that the final consonant in *Pam* ['pæ.m] is actually an onset, as it is in *Pamela* [ˈpæ.mə.lə]. A more precise account of these morphological conditions is left for future research. It seems clear, however, that these patterns are perfectly compatible with a synchronic phonological analysis of *a*-tensing.

4.3 Variation

This study, with its focus on the phonetic factors influencing the distribution of *a*-tensing, has not touched on the sociolinguistic factors that must also be involved in a complete account of the process in the three varieties of English discussed. Changes reported to be in progress, however, do appear to support a synchronic account of *a*-tensing. Younger speakers of Philadelphia English, for example, seem to be developing a *a*-tensing nasal system (Fisher et al. 2015). A nasal system is already in place for speakers of ethnic minorities in NYC, the traditional dialect of which may also be developing a [ŋ] trigger (Becker and Wong 2010). Differences across dialects may reflect differences not only in realisation of the tense and lax variant and vowel systems as a whole, but also in the production of consonants, as shown, for instance, in our discussion of Belfast laterals (Section 3.4).

5 Conclusion

In this paper, I showed that *a*-tensing patterns in three dialects of English is predictable from the phonetic properties of their coda consonants, lending support for *a*-tensing as a synchronic phonological process. This phonetic enhancement approach may shed light on similar phenomena, such as *bag*-raising, in which coda [ɡ] conditions a third, intermediate *a* variant in Seattle English (Wassink et al. 2009), where the need to reinforce voicing may be minimised by its velar place of articulation.

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