

Pre-aspiration and the problem of zeroes: Phonological rules can be variable¹

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Abstract

Pre-aspiration can be defined as a period of glottal friction, [h], which is found in the sequences of sonorants and phonetically voiceless obstruents, as in *map* [ma^hp^h] (e.g. in Welsh English, Hejná 2015). This chapter problematises the default approach to pre-aspiration shown in a number of studies, which assume that unless pre-aspiration applies obligatorily it is subject only to phonetic constraints rather than, at least potentially, both phonetic and phonological constraints. As a result, instances where pre-aspiration reaches the duration of 0 ms, i.e. where it does not apply (*mat* [mat^s]), are typically included in the analyses of its *phonetic* conditioning. This can be problematic in cases where zero values reflect a variable *phonological* rule rather than the output of solely phonetic constraints as such an approach may obscure our understanding of the constraints on pre-aspiration.

[I]t may be time to consider the zero.
(Tanning 2011)

1. Introduction

This chapter problematises the default approach to a phenomenon known as pre-aspiration (defined in Section 2 below). As Sections 3–4 discuss, pre-aspiration studies frequently assume that, unless pre-aspiration applies

¹ I am grateful to Anna Jespersen for comments on an earlier version of this chapter. As always, I am also grateful to Yuni Kim, who introduced me to the world of phonological theory and the phonetics-phonology interface through frequent conversations in 2012–2015. I would also like to thank the reviewer.

obligatorily (in 100% of the appropriate contexts), it is subject to phonetic constraints rather than, at least potentially, phonetic and/or phonological constraints.² Where pre-aspiration does not apply, its duration is then considered to be that of 0 ms. In other words, instances where there is no pre-aspiration (*mat* [mat^s]) are typically included in the analyses of the *phonetic* conditioning of pre-aspiration, such as the effects of the place of articulation (/p/ vs /t/ vs /k/) or vowel height (high vowels vs low vowels) on its duration. I argue that this can be problematic in cases where zero values do reflect a variable phonological rule rather than the output of solely phonetic constraints. I call this issue the problem of zeroes.

2. Defining pre-aspiration

Pre-aspiration can be defined as a period of (primarily) glottal friction found in the sequences of sonorants and phonetically voiceless obstruents. Instances of pre-aspirated obstruents in English could be transcribed as *map* [ma^hp^h], *mat* [ma^ht^s], and *mac* [ma^hk^h] (e.g. in Welsh English, Hejná 2015). From an articulatory point of view, the phenomenon includes a spread state of the glottis, associated with more lax phonatory settings, in which the intrinsic laryngeal muscles are more relaxed. Some languages can develop a fricative component produced in the oral cavity as well (e.g. Scottish Gaelic – e.g. Bosh 2006/2007). Regarding the voicing aspects of pre-aspiration, we find two different approaches to the phenomenon. Pre-aspiration defined *broadly* can include two phases: a voiced component and a voiceless component. The voiced component, which can be labelled local breathiness, involves the vibration of the vocal folds associated with an increased amount of airflow coming through the glottis as compared to the usual phonatory settings of the relevant pre-aspirating speaker. This results in a laxer phonatory setting, and that in turn results in a breathier phonation. The voiceless component can be labelled pre-aspiration in its narrower sense, and involves voiceless friction. In voiceless pre-aspiration, the vocal folds do not vibrate, but they are close enough to generate glottal friction. Acoustically, the voiceless component lacks periodicity in the acoustic signal in contrast to the voiced component. The voiced component differs from modal phonation acoustically in that it is associated with a more quasi-sinusoidal waveform and friction above the second formant frequencies, and general dampening of the formant structure. The two

² A combination of phonetic and phonological constraints, as well as that of different phonological constraints, is common. See Iosad (2016) for a discussion of rule scattering and further relevant references.

phases, local breathiness and voiceless pre-aspiration, are shown in a spectrogram and a waveform in Figure 1, which displays the acoustic information of the English word *backer* as uttered by a speaker from Aberystwyth, mid Wales.

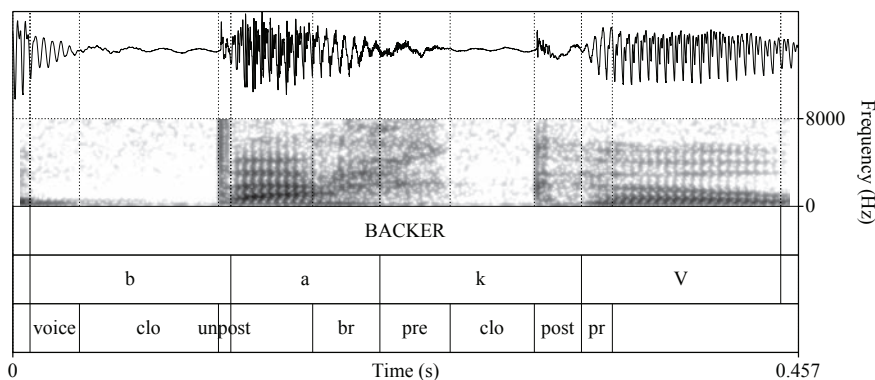


Figure 1. Identification and segmentation of pre-aspiration and local breathiness. ‘clo’ = closure, ‘unpost’ = unaspirated release, ‘br’ = pre-aspiration induced local breathiness, ‘pre’ = voiceless pre-aspiration, ‘post’ = post-aspirated release, ‘pr’ = vowel-initial breathiness, ‘V’ = unstressed vowel.

Whether both the voiced and the voiceless pre-aspiration phases are indeed treated as two phases of a single phenomenon depends on the individual study of pre-aspiration. Some researchers define pre-aspiration broadly and do not distinguish the voiced and the voiceless components in their analyses (van Dommelen 1999, 2000; van Dommelen & Helgason 2003; Helgason & Ringen 2008; Svantesson et al. 2005; Svantesson & Karlsson 2012; Morris 2010; Ringen & van Dommelen 2013; Stevens 2010, 2011; Stevens & Hajek 2004a, 2004b).³ Others only target the voiceless component (Hejná & Jespersen 2019; Hejná & Kimper 2019). Some studies do not provide sufficient information for the reader to know if pre-aspiration involves only voiceless or also voiced glottal friction (Helgason 1998; McRobbie-Utasi 2003; Tronnier 2002). Yet we also find studies which focus on *both* components and distinguish these two components in the analyses (Hejná 2015; Kingston 1990; Morris & Hejná 2019; Nance & Stuart-Smith 2013; Ní Chasaide 1985). The last type of pre-aspiration

³ Although these authors may distinguish the two in their annotation at some point, they do not report the results separately for the two, nor is it discussed whether these pattern in the same way.

studies typically show that the voiced and the voiceless components can display different patterns regarding their intra- and extra-linguistic conditioning (Hejná 2015; Kingston 1990; Morris & Hejná 2019; Nance & Stuart-Smith 2013; Ní Chasaide 1985).

Pre-aspiration is most frequently analysed in terms of its frequency of occurrence, or the rate of application: How frequently do we find pre-aspiration in the sequences of sonorants and phonetically voiceless obstruents in variety X? The other frequently studied aspect of pre-aspiration is its duration: how long is pre-aspiration? Finally, a limited number of studies also focus on the noisiness of pre-aspiration (Gordeeva & Scobbie 2010; Gordeeva & Scobbie 2013; Morris & Hejná 2019; Nance & Stuart-Smith 2013).

3. Pre-aspiration as a (phonologically) rare phenomenon

It has generally been accepted that pre-aspiration is a (very) rare linguistic phenomenon (see Hejná 2015: 29–31 for an overview). The reported rarity of the phenomenon increases even further if it is *phonological* pre-aspiration which is considered (Clayton 2010: iii). This is because pre-aspiration has been claimed to only be of interest to phonology if it applies in 100% of the cases in which it could possibly apply and if it cues a phonological contrast.⁴ These assumptions are problematic not only because of the growing body of evidence showing that there are more pre-aspirating languages than previously thought, but also because the claims related to the rarity of pre-aspiration have sometimes been based on counting only those languages in which pre-aspiration is seen as phonologically relevant. However, establishing phonological relevance is not a straightforward task.

Thus, Ladefoged & Maddieson (1996: 73) state that pre-aspiration is not “a feature [necessarily] required for distinguishing underlying forms”. Contrast is undoubtedly at the centre of phonological theory, but how is contrastiveness established exactly? Hejná (2015: chapter 6) engages with this question: Phonological contrasts are well-known to be implemented

⁴ Much of the pre-aspiration literature (e.g. Morris 2010; Wretling, Strangert & Shaeffler 2002) adopts the dichotomy of normative and non-normative pre-aspiration introduced by Helgason (1999b, 2002). It is somewhat unfortunate that Helgason presents us with two rather different definitions of normative and non-normative pre-aspiration. According to the first definition, pre-aspiration is normative if it is phonologically relevant (Helgason 1999a) and obligatory (Helgason 1999b: 1854; 2002: 8). According to the other definition, pre-aspiration is normative if it is used by all of the speakers in a community in the same way (Helgason 2002: 21). The first definition is the one adopted also by Morris (2010) and Wretling, Strangert & Shaeffler (2002).

by a wide range of correlates and cued via a number of cues; as long as pre-aspiration contributes to the implementation of a contrast in some way, we cannot but consider it contrastive. However, pre-aspiration has been traditionally described as contrastive only in Icelandic, Faroese, Scottish Gaelic, and Lule Sami (Ladefoged & Maddieson 1996: 70). Silverman (2003) adds three more languages in which pre-aspiration is contrastive, including Chamicuro, Oraibi Hopi, and Tarascan. In addition to the contrastively pre-aspirating languages mentioned in Ladefoged & Maddieson (1996) and Silverman (2003), pre-aspiration has more recently been found to correlate with fortis as opposed to lenis plosives⁵ in Aberystwyth English (Hejná 2016), Manchester English (Hejná & Kimper 2019), Scottish English (Gordeeva & Scobbie 2010, 2013), in the speech of 5 speakers representing Canadian English, Irish English, Welsh English, and SSBE (Hejná & Jespersen 2019), various dialects of Norwegian (van Dommelen 1999, Ringer & van Dommelen 2013), San Martín Itunyoso Trique (DiCanio 2012: 252–254), Central Standard Swedish (Helgason & Ringen 2008), and Bethesda Welsh (Morris & Hejná 2019). Pre-aspiration has been investigated as a potential cue of the fortis-lenis contrast for Norwegian (van Dommelen 1998) and Northern England English (Hejná & Kimper 2019) and has indeed been found to function as a cue to the contrast in these two languages. Stevens & Hajek (2004a) also present evidence of pre-aspiration occurring in fortis geminate plosives but not the lenis ones in Italian.

Contrastiveness is nevertheless not the only gate to the realm of phonology. It has been established that variable outputs can be due to variable phonological rules (e.g. Antilla 2006; Coetzee & Pater 2011; Guy 19991; Sebregts 2014: chapter 6, and the references therein). This means that even if a phenomenon applies in fewer than 100% of the cases, it can still be subject to phonological constraints. For instance, Coetzee & Pater (2011) mention *t/d*-deletion, as in *west* being pronounced as [wɛs] rather than [wɛst], a variable which is sensitive to phonological and morphological characteristics of the words affected (Guy 1994). This being the case, we simply cannot assume that non-obligatory application of pre-aspiration on its own justifies our choice to include zero values in our analyses of the

⁵ Although using the terms fortis and lenis may be controversial to some (see for instance the overview on the different uses of the terms in Ladefoged & Maddieson 1996: 95), the two terms are adopted here as convenient labels to distinguish the two phonological series of /p, t, k/ and /b, d, g/ in order “to avoid potentially confusing situation where one speaks of voiceless voiced stops, i.e. phonologically voiced stops with no phonetic voicing” (Ni Chasaide 1985: 105).

phonetic constraints on the phenomenon.

When the relevant literature on pre-aspiration is inspected in detail, we find that often enough pre-aspiration has not been approached from a phonological point of view, but typically from a phonetic or a predominantly sociophonetic point of view (e.g. Foulkes et al. 1999; Helgason et al 2003; Jones & Llamas 2003; Morris 2010; Roos 1998; Su 2007). There is a good reason for this. Since pre-aspiration has been considered so rare, the main goal of a number of pre-aspiration studies is to acknowledge that the phenomenon occurs in a language/variety in the first place. Furthermore, sociophonetic analyses often concentrate on issues other than contrastiveness. Future studies therefore remain to show whether pre-aspiration is contrastive and/or otherwise phonologically conditioned in the relevant languages/varieties. The next section focuses on the problem of zeroes, and the problem of potentially conflating phonetic and phonological outputs in general.

4. The problem of zeroes

Before the problem of zeroes is discussed here in detail, it is important to outline some of the assumptions made in this chapter. Firstly, as perhaps obvious by this point, phonetics and phonology are seen as distinct, i.e. there is a difference between phonetics and phonology. Secondly, diagnosing whether a phenomenon is subject to phonetic as opposed to phonological phenomena can be determined by a careful inspection of the acoustic or articulatory evidence available. If variation in a certain sound can be explained via physiological, aerodynamic, or acoustic accounts, then this variation is considered a *phonetic* type of variation. Thus, for instance, if there is a positive correlation between the duration of aspiration and the posteriority of the articulation, across and within different places of articulation (e.g. /p/, /t/, /k/), it is a phonetic type of conditioning we are dealing with. On the other hand, if there is no such correlation within the category of /p/, the variation found cannot be accounted for by phonetic explanations (alone). These two assumptions are in line with other studies focusing on the phonetics-phonology interface (e.g. Cohn 1998, 2006; Keating 1990, 1996; Strycharczuk 2012; Turton 2014, 2015, 2017; contra to Ohala 1990, depending on the exact definition of the term). As shown by the studies referenced here, phonetically conditioned variation displays gradient effects, whereas phonologically conditioned variation displays phonetically abrupt effects in the temporal-spacial domain of the

specific acoustic and/or articulatory properties that are being quantified (e.g. aspiration duration, formant value associated with a certain phoneme, tongue root retraction, glottal open/contact quotient, etc.).

Let us return to the problem of zeroes in the context of pre-aspiration studies. Frequency of occurrence, at least at first, seems a relatively simple way of quantifying pre-aspiration. If pre-aspiration reaches the duration of 0 ms, it is absent from the signal, and should be counted as a negative instance of the phenomenon – its absence. Any other values should then be considered positive cases of pre-aspiration. Although this is the mainstream approach to quantifying the frequency of application of pre-aspiration, there are nevertheless researchers who have set a point higher than 0 ms to distinguish pre-aspiration as “present” and “absent”. Thus, Helgason (2002: 152) counts pre-aspiration as present only if it reaches 15 ms and higher. Similarly, when quantifying the frequency of occurrence of pre-aspiration in their Scottish English data, Gordeeva & Scobbie (2010: 13) set the threshold for annotating pre-aspiration as present only if it reaches 30 ms, which is motivated by perceptual evidence related to pre-aspiration in Norwegian (van Dommelen 1998): If the listeners can register pre-aspiration only if it has at least 30 ms, we should only count instances of 30 ms and higher as positive instances of pre-aspiration. Nonetheless, this approach is problematic. Firstly, we do not in fact have the perceptual evidence relevant for most pre-aspirating languages. Gordeeva & Scobbie (2010) use perceptual evidence available for Norwegian for analyses of *English* pre-aspiration. We can expect perceptual thresholds to vary from language to language (and from accent to accent). Indeed, if we inspect the perceptual literature available, this concern proves to be substantiated (van Dommelen 1998; Hejné & Kimper 2019; Pind 1996a, 1996b, 1998). In addition, however, and perhaps more importantly, we may be interested in factors such as biomechanical constraints on pre-aspiration, in which case all the values measured above 0 ms are surely of interest to our understanding of why the phenomenon patterns the way it does, irrespective of the perceptual properties of the phenomenon.

There is nevertheless a more serious problem related to the importance of zero values. This problem is linked with the second aspect of pre-aspiration which is usually quantified in pre-aspiration studies: pre-aspiration duration. As shown in Figure 2, when we inspect the duration of (voiceless) pre-aspiration in 12 speakers of English spoken in Aberystwyth, mid Wales (see Hejné 2015 for more details on these speakers), we find that all of the twelve individuals show that zero values pattern rather differently

from the non-zero values.

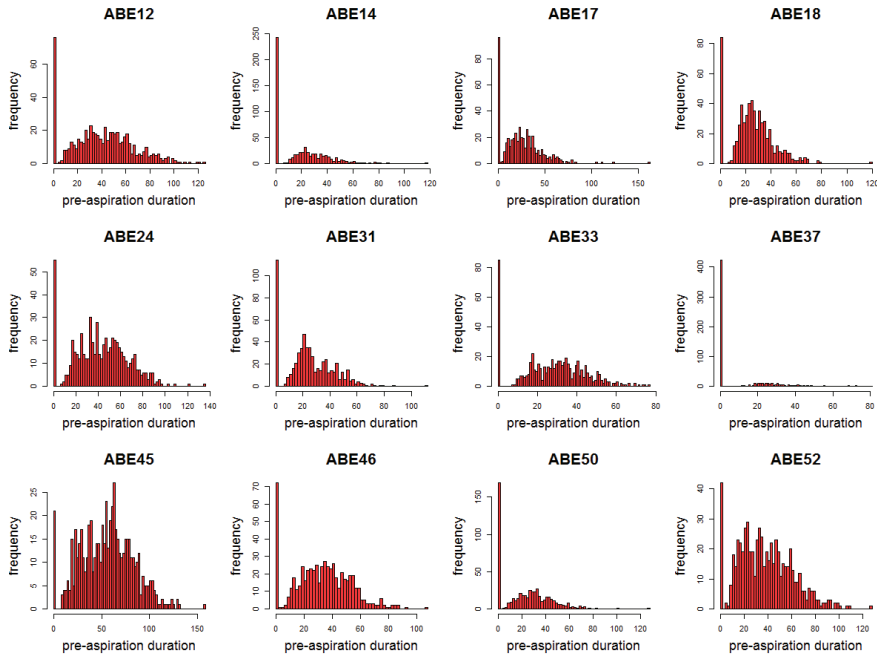


Figure 2. Distribution of the duration (ms) of voiceless pre-aspiration in 12 speakers of Aberystwyth English.

What we see is that there is one peak (or one mode) associated with zero and another peak (or another mode) which is centred around a non-zero value, e.g. around about 60 ms for speaker ABE45 and 30 ms for speaker ABE18. In addition, there is a gap between the first mode and the second mode; in other words, these two modes do not overlap.⁶ This detail reveals that pre-aspiration in Aberystwyth English is not subject solely to phonetic rules, for which a gradient (unimodal) outcome would be predicted. Instead,

⁶ The reviewer poses the interesting question of whether it is physiologically possible not to have this gap, i.e. whether it is possible for pre-aspiration to reach for instance 2 or 3 ms of duration. Physiologically, there does not seem to be any reason for pre-aspiration not to occur with the duration of 2 or 3 ms. However, two other possible explanations may be relevant. Firstly, there may be an annotation bias: is an annotator likely to spot pre-aspiration of 2 ms? Secondly, the gap may be related to perceptual biases: it may be that pre-aspiration is not perceptible unless it reaches a certain period of duration. This perceptual bias would however have to be linked with pre-aspiration being phonological in some (broad) sense, i.e. with pre-aspiration being subject to functional rather than purely phonetic – physiological and/or aerodynamic constraints.

we see a clearly bimodal distribution, which suggests the presence of two distinct categories. The distance between zero and non-zero values of pre-aspiration duration is an abrupt one. In the Aberystwyth data, lumping zero values together with non-zero values may therefore potentially skew the results related to the durational properties of pre-aspiration, and this may potentially lead to erroneous understanding of how pre-aspiration innovates and which constraints it is locally and universally subject to. To demonstrate this on a specific example, if pre-aspiration occurs the least frequently with high vowels (see e.g. Hejrná 2015: chapters 3 and 4, and Morris & Hejrná 2019), is it really surprising that it is *also* shorter in the context of high vowels, considering all the cases of pre-aspiration absence (i.e. those that reach the duration of 0 ms) are included in the durational measurements *as well*?

It may of course be the case that the presence of a bimodal distribution (such as the one shown in Figure 2; for classical examples see also Lisker & Abramson 1964: 400–408; Scobbie 2002) could be accounted for by confounding variables and/or a combination of a range of phonetic variables. However, the twelve speakers of Aberystwyth English used here show results based on their production of the same words, read in the same order across the speakers, and under the same conditions. Confounding factors therefore cannot account for the bimodal distribution observed. In addition, it is also not the case that the zero peak would be associated with any specific segmental or prosodic environment, or a combination of any of these. In other words, it is not the case that once we discard, for instance, foot-final cases of pre-aspiration (e.g. *bat* [bat^h]), the zero peak disappears. The author has inspected variables which include foot position, vowel height, vowel backness/rounding, vowel length, place of articulation of the plosive, and the type of the consonant preceding the vocalic sonorant and the pre-aspirated plosive, in all the possible combinations, and the conclusion is that the Aberystwyth English data presents us with no impossible environments that would account for the zero peak.

Other tests are frequently used (and ideally combined with the bimodality test) to diagnose whether a phenomenon is subject to phonological conditioning within the same environment. In case of pre-aspiration, Hejrná (2015: chapter 4) designed a series of tests of the following type. If pre-aspiration is conditioned by phonetic vowel height as opposed to phonological vowel height, it should be the case that within each vowel phoneme, F1 is correlated positively with pre-aspiration duration, i.e. the higher the F1 (and the lower the vowel), the longer the pre-aspiration.

However, I find that this is not borne out in the Aberystwyth English data, and conclude that phonetic factors alone cannot account for the variation in the implementation of pre-aspiration as produced in the speakers analysed in the study.

Although I have shown an example in which zero values present a separate mode of the distribution of pre-aspiration duration, it may be the case that in some languages and varieties zero values form part of a *unimodal* distribution. In such cases, it is of course absolutely legitimate to include these in the analyses of phonetic constraints on pre-aspiration. That this does happen is illustrated in Figure 3, which displays the distribution of the duration of local breathiness for one of the Aberystwyth speakers (and thus also demonstrates that the voiced and the voiceless components of pre-aspiration may not be subject to the same constraints).⁷

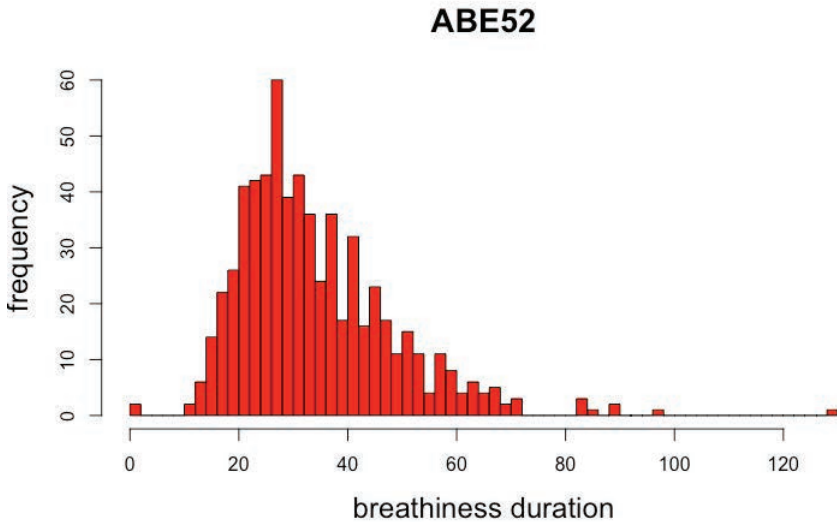


Figure 3. Distribution of the duration (ms) of local breathiness in 1 speaker of Aberystwyth English.

It may well be the case that in most of the studies of pre-aspiration in which zero values are included in the continuous measurements, the phenomenon does not display a bimodal distribution. Nonetheless, unless

⁷ However, in this case the few tokens associated with zeroes are historically a remnant of a bimodal distribution, as suggested by the apparent-time analysis conducted by Hejná (2015: chapter 7).

this is inspected first, zero values should not be by default included in such measurements and their interpretation. As such, researchers working on pre-aspiration should report whether zero values are part of a unimodal distribution.

5. Conclusion

To summarise, assuming that cases where pre-aspiration does not apply are necessarily due to phonetic constraints is problematic. Instead, zero values of pre-aspiration duration can reflect a variable phonological rule, or a mixture of a phonological rule and phonetic constraints, or even a mixture of multiple phonological and phonetic constraints. When approaching instances of non-obligatory pre-aspiration, we should ideally inspect our data to shed light on whether a phonological conditioning of such variation can be ruled out before proceeding to purely phonetic explanations.

Now the zero has a new name [...]
(Tanning 2011)

6. Happy birthday, Sten

Dear Sten, I will never forget your comment on English pre-aspiration that you made during a seminar session I gave on analysing variation and change in glottalisation and pre-aspiration in English accents. This session was part of a BA Project course which we co-taught in Autumn 2017 (“BA Project: Contemporary Variation in English Dialects – As the Music Changes, You Change Too”). Sadly, we didn’t have time to address your comment fully during the seminar (or after the seminar), but I hope that this paper will shed at least a wee bit of light on my hesitation as to the statement that pre-aspiration isn’t phonological in English accents, as opposed to the situation found in the traditionally pre-aspirating languages such as Icelandic. I also hope this paper will make you smile and, who knows, perhaps wiggle with a bit of joy too.

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