

Pre-aspiration: manual on acoustic analyses 1.1

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October 2016

1 Introduction: why do we need a manual for pre-aspiration analyses?

This manual is intended to help anyone who has decided to analyse pre-aspiration acoustically. I have been investigating the phenomenon in various British English accents, Welsh, and Icelandic since 2012; many things took me a while to figure out on my own, or even with the help of others, and there are things I am still figuring out. I have encountered fellow researchers who have recently become interested in pre-aspiration, and a manual of this kind would have saved them time and energy. This led to the creation of this manual.

The main role of the manual is to make analyses easier and to make the reader aware of various issues associated with acoustic analyses of the phenomenon *before* any data is even collected.

The structure of this manual is as follows. Firstly, I discuss the definition of pre-aspiration and how choosing a definition affects approaching pre-aspiration analyses. I then go on to briefly offer some tips to Praat users, which is followed by a discussion on what to do with noisy recordings. Next, there are four sections that touch upon pre-aspiration with respect to related phenomena. The first two are pre-affrication and approximant-like pre-aspiration: these are phenomena that are very closely related to pre-aspiration, indeed if not just variants of pre-aspiration, but they have not yet enjoyed too much attention in the literature, and encountering them may therefore be puzzling at first. The manual is finished off with a section on pre-aspiration occurring with glottalisation, which presents at least one challenge, and a section on pre-aspiration and its relationship with spirantisation. Glottalisation and spirantisation may not seem particularly relevant now, but they will become perhaps a bit surprisingly relevant when we get there.

Relevant sources are provided as we go along, but this document certainly does not aim to serve as an exhaustive overview for all the fascinating work that has been done on pre-aspiration.¹ This manual is full of visual examples because, after all, a picture is worth a thousand words, and I've always felt regretful about the fact that most publications are limited in the number of

¹A fairly long list can be found in Hejná 2015. Chapter 1 is a good starting point.

visual examples in their methodology section. In this manual, I use some of the examples from my own data (Aberystwyth English) and also employ materials collected by Joel Wallenberg and Claire Cochrane for Tyneside English.

Please, use this manual, enjoy this manual, and send me your feedback so I can keep on updating the document and make it more helpful for future pre-aspiration fans.

2 How should we define pre-aspiration and why does a definition matter?

There are at least two decisions to make when approaching pre-aspiration. Firstly, do we want to use the term in its phonetically narrow sense or in its broader sense? Secondly, which acoustic criteria will we consider crucial in defining, and therefore quantifying, pre-aspiration?

2.1 To be narrow or broader?

What is meant by narrow and broader definitions of pre-aspiration? Let's start with a broader definition. Some researchers (e.g. van Dommelen 1999; van Dommelen 2000; van Dommelen, Holm and Koreman 2011; Morris 2010; Morris and Hejná in prep) focus on the presence of (primarily) glottal friction found in the sequences of sonorants and voiceless obstruents. What glottal friction in the acoustic signal may look like is shown in Figure 1, where you can observe that the formant structure of the vowel is becoming much less distinct, if not gone entirely, and there is energy present across more or less all the frequencies:

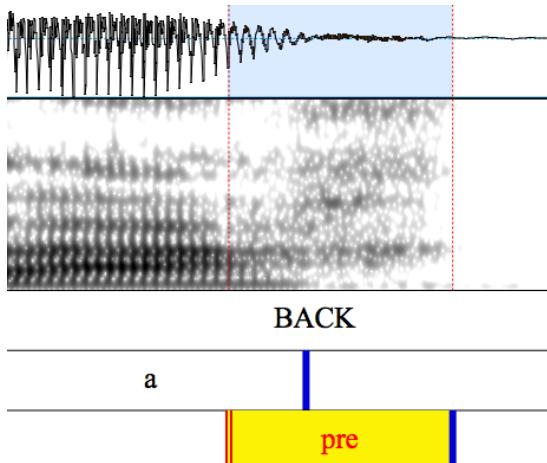


Figure 1: Broadly defined pre-aspiration.

However, other researchers distinguish two components of this interval of broadly defined pre-aspiration, which are related to voicing: a voiced interval

(breathiness) and a voiceless interval (pre-aspiration, or pre-aspiration proper). See Figure 2 to see how that maps onto the same interval we saw in Figure 1. The voiced interval, or the breathy interval, is highlighted and labelled as "br", whilst the voiceless one is labelled as "pre".

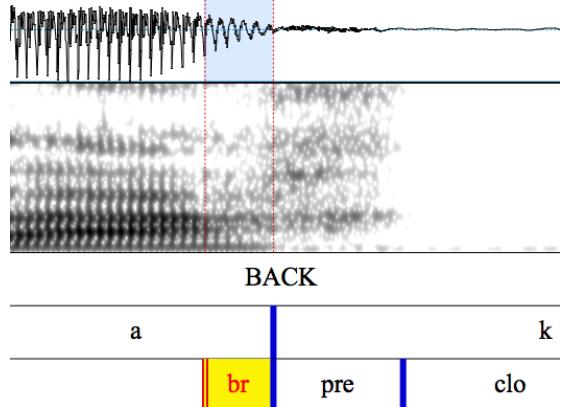


Figure 2: Narrowly defined pre-aspiration and preceding breathiness. "br" stands for breathiness; "pre" stands for pre-aspiration.

You need to decide whether you want to adopt a broader or a narrower definition of pre-aspiration. Depending on the purposes of the analysis, you may be better off distinguishing them, or not, or it may simply not matter that much. For example, as I suggest elsewhere (Hejná 2015, especially Chapters 3 and 7), distinguishing pre-aspiration and breathiness may provide us with better understanding of how pre-aspiration develops historically. However, you may not be interested in historical aspects of the phenomenon... And maybe it is the case that the voiceless pre-aspiration always co-occurs with voiced breathiness in your data and that voiced breathiness always co-occurs with voiceless pre-aspiration, in which case it doesn't really matter at least for analyses of how frequently your speakers pre-aspirate (it might matter for durational analyses though). But it is certainly the case that at least sometimes voiceless pre-aspiration occurs on its own and breathiness not infrequently occurs on its own in some languages (e.g. Figures 3 and 4).

Whatever the purpose of your study is, bear in mind that breathiness and voiceless pre-aspiration may behave differently in some respects but similarly in others.

Reading pre-aspiration studies, sometimes we as readers simply don't know whether breathiness is included in pre-aspiration or not (e.g. Helgason 1998, McRobbie-Utasi 2003, Tronnier 2002). You'll help to advance our knowledge of the phenomenon if you make sure to say what exactly you mean by pre-aspiration in your study with respect to the voicing component of the signal.

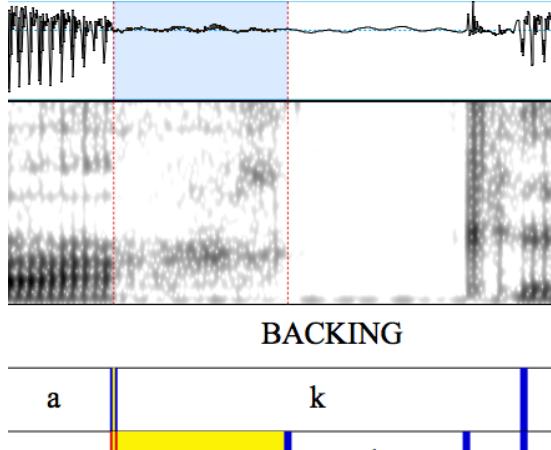


Figure 3: Voiceless pre-aspiration occurring without voiced breathiness.

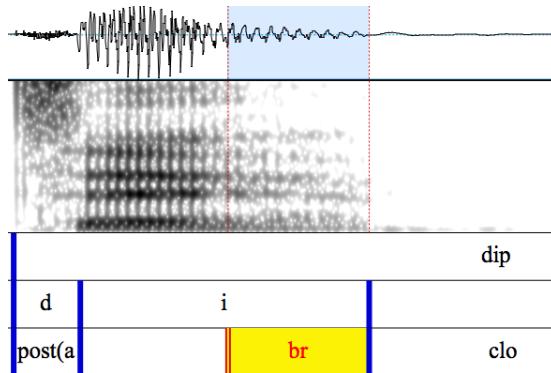


Figure 4: Voiced breathiness occurring without voiceless pre-aspiration.

2.2 Voicing or noisiness?

If you adopt a narrow definition of pre-aspiration, most often the main criterion to identify the phenomenon will rest on the presence of (primarily) glottal friction and absence of voicing. It's likely you'll also be interested in "local" breathiness, for which your primary criterion will be the presence of (primarily) glottal friction and the presence of voicing. However, not all researchers rely on voicing when approaching pre-aspiration. Van Dommelen (1998), for example, who distinguishes pre-aspiration from breathiness, does so via inspection of the level of noisiness of the signal rather than presence or absence of voicing. So, for him pre-aspiration differs from breathiness by the presence of "clear friction of relatively strong amplitude" (1998: 2037). There's at least one more option to consider then, but it would be nice if future researchers turned "relatively

strong amplitude" into something more specific (if at all possible).

2.3 Ways to quantify pre-aspiration

There are several ways to quantify pre-aspiration that have been employed so far with acoustic evidence.

Frequency of occurrence

The most frequently used method is counting the number of tokens that show pre-aspiration as opposed to those that could have it but do not. This variable can be referred to with a number of terms: frequency of occurrence of pre-aspiration, pre-aspiration frequency, presence of pre-aspiration. Most often pre-aspiration of 0ms is considered a case where pre-aspiration is absent, and anything above 0ms is considered a positive case, i.e. as pre-aspiration being present. Nevertheless, there are researchers who have set a point higher than 0ms to distinguish pre-aspiration as "absent" and "present". See for example Helgason (2002: 152), who counts pre-aspiration as present only if it reaches 15ms and above. This is supposed to be based on perceptual evidence, but be careful: there isn't that much perceptual evidence available and what there is is limited to very specific languages and styles/tasks.

Duration

Another property we may be interested in is the duration of pre-aspiration. There are several dragons here: we need to define what we consider the onset of pre-aspiration and what we consider its offset. Whilst this may sound easy enough, it is actually not that straightforward (see the discussions on defining pre-aspiration above and discussions on segmenting pre-aspiration below). Another beast is normalising for the effects of speaking rate, and a possibly unpleasant spectre is related to what I call the problem of zeroes. Let's discuss normalisation first, then the problem of zeroes, and then ways to define the landmarks for segmentation purposes.

Normalisation

Speaking rate differences can affect raw duration, and normalisation is therefore in place. As Hejná (2015: 56) summarises, many researchers report unnormalised, raw values for pre-aspiration duration. If our analysis is a case study of one or two speakers, normalisation is not necessary (for most purposes anyway). But we do need to normalise if we're working with a higher number of speakers.

Various normalisation methods have been used. The most frequent type is employing ratios: of pre-aspiration duration and vowel duration, pre-aspiration duration and consonantal duration, and pre-aspiration duration and the rhyme duration. Researchers vary in which bits of the signal are included in the ratios. If that's an option you're considering, I'd also suggest considering the phonological properties of the language of the studies you decide to follow before deciding on which ratio to choose. The ratio options could be expanded by a ratio between non-modal and modal parts of the interval that includes the

unambiguous vowel and pre-aspiration. Finally, pre-aspiration duration can be normalised as a percentage of the overall word duration. With the last, the differences reported will be of a small magnitude, and more data may be needed to reach statistically significant results.

The problem of zero values

Normalisation is not the only thing that we have to face when it comes to durational measures. There's also the problem of zero values: should cases where there is no pre-aspiration, i.e. cases where pre-aspiration has a duration of 0ms, be taken into consideration in durational analyses of pre-aspiration? I personally don't think this is a straightforward question to answer. If you answered "no" to the question in your head, you may be surprised that most researchers actually do include zero values in their durational analyses of pre-aspiration (see Hejná 2015: 122-4, 146 for references). As with everything, the answer to the zero problem may depend on the character of your research question. For some analyses, including zeroes may be crucial, but for others it may not be desirable. If you get pre-aspiration in all tokens, you don't have to face the problem at all! To rephrase the problem: pre-aspiration could be purely phonetic, in which case including zeroes in durational analyses would be justified. But it could be the case that it's also sensitive to the phonology of the language, in which case it's bloody difficult to tell which zeroes may be due to a rule (Do not pre-aspirate in context A.)² and which due to more subtle phonetic conditioning (E.g. pre-aspiration tends to be short with /p/, maybe sometimes it's as "short" as 0ms).

I think a step forward here certainly is being explicit about whether you include zero values in your durational measurements or not!

Other measures

Gordeeva and Scobbie (2010) have been the first to employ a measure that captures the noisiness of pre-aspiration: BP ZCR, which stands for Band-Pass Zero-Crossing Rate. You can read more about this measure in the study of Scottish English pre-aspiration by the two authors. So far, few other researchers have used this measure (Nance and Stuart-Smith 2013; Morris and Hejná in prep; Hejná Under revision). All these studies have shown that this dimension of pre-aspiration is certainly worthwhile to investigate. An important thing to bear in mind though is that the recordings we are comparing should be recorded in comparable conditions: i.e. we shouldn't compare a speaker with a beautifully quiet recording to a speaker with a lot of background noise when it comes to pre-aspiration noisiness, simply because we may not be able to tease apart which noisiness is of linguistic significance and which isn't. Or we may, but it certainly won't be a straightforward kind of endeavour!

There are certainly more dimensions of pre-aspiration that would be worthwhile to pursue. Dynamically captured spectral changes would be an interesting

²This will probably be of interest to you only if you adopt probabilistic approaches to phonology. See e.g. Hall 2009.

avenue to explore, and Gordeeva and Scobbie's measure certainly allows for such an analysis to some extent. If it was expanded by tracing where in the frequency range at time A we get most noisiness and the exact level of that noisiness, this could be used as a way to quantify to what extent pre-aspiration is purely glottal as well.

2.4 Identifying pre-aspiration and breathiness

Depending on our definition of pre-aspiration, there are a number of ways to identify the presence of the phenomenon and also its starting point. From now on, I will be using the term pre-aspiration in its narrow sense, relying on the absence of voicing. In other words, pre-aspiration will be used to refer to voiceless friction, as opposed to breathiness. However, I will often discuss local breathiness as well.

Plosives and affricates

First of all, pre-aspiration is easier to identify with plosives and affricates than with fricatives (at least if you have good quality data), so let's start with plosives and affricates.

Regarding pre-aspiration, the easiest onset landmark is a. the presence of glottal friction and b. cessation of voicing. As shown in Figures 5 and 6, glottal friction of pre-aspiration ("pre" in the figures) shows presence of energy across a range of frequencies (y axis) in the spectrogram. The offset of pre-aspiration can be identified by the presence of silence, which is the acoustic correlate of the closure of the plosive/affricate gesture.

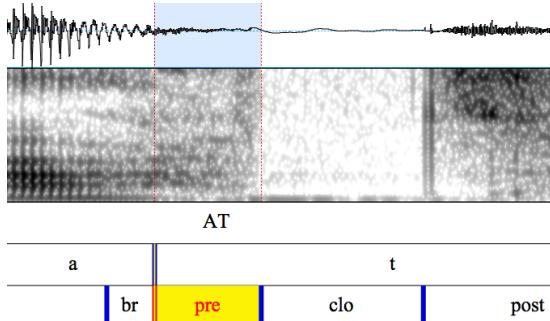


Figure 5: Identification of pre-aspiration in the plosive context.

I would expect differences of approximately 5ms across different annotators regarding the segmentation of the left boundary of (voiceless) pre-aspiration, depending on the interpretation of the soundwave as indicating (or not indicating) that voicing is still present - sometimes the soundwave shows slightly less regular vibration associated with the abduction and some annotators may be more generous in what they still see as voicing.

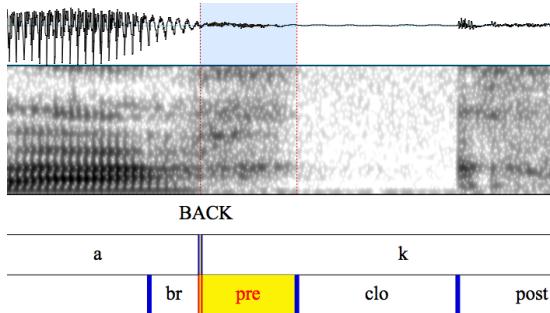


Figure 6: Identification of pre-aspiration in the plosive context II.

As you can see in the same figures, local breathiness ("br" in the figures) also shows presence of friction. Its offset can be based on the absence of voicing. Determining its onset is however a trickier matter. The example in Figure 6 shows an abrupt onset of breathiness: we see a sudden loss of the formant structure in the region of several formants, most often involving F2 and higher formants. Figure 5 nevertheless illustrates a more contentious example: the breathy interval as segmented is the most conservative segmentation choice. The onset of breathiness is gradient rather than abrupt in that example, and the researcher needs to decide whether presence of any amount glottal friction should be considered the onset of local breathiness (this would be very generous), whether the most abrupt point regarding spectral changes should be identified as the onset of breathiness (the most conservative choice), or whether the onset should be placed in the middle (I'm not sure how much we'd be gaining from that that we don't gain already from the other two approaches though.). Another option would be having several different intervals of breathiness OR a generous interval that would be supplemented by dynamic information on the spectral properties of the signal.

Notice also that the onset of breathiness is associated with the simplification of the soundwave, which can be relatively abrupt even though the information in the spectrogram is not necessarily abrupt in quite the same way, or not much really. You may therefore decide to identify the onset of local breathiness on the basis of the soundwave alone.

Finally and a bit unrelatedly, we shouldn't be surprised to find cases where breathiness affects the whole vowel, as shown in Figures 7 and 8. Such cases also need to be borne in mind when we decide what our criteria for the onset of local breathiness are.

Fricatives

As shown in Figure 9, the left boundary of pre-aspiration onset in the fricative context can be identified in the same way described for the plosive context (and the same goes for breathiness).

However, the right boundary is trickier, because fricatives do not have a closure and we cannot therefore rely on a period of silence in the signal. As

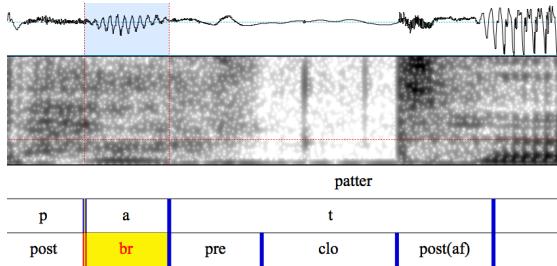


Figure 7: Breathy vowel I.

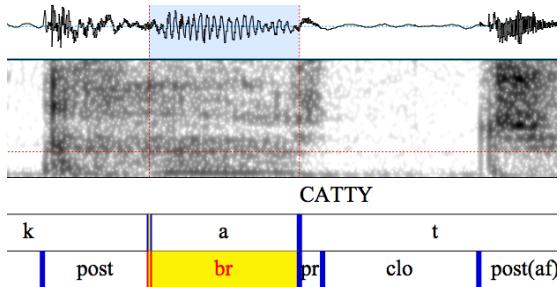


Figure 8: Breathy vowel II.

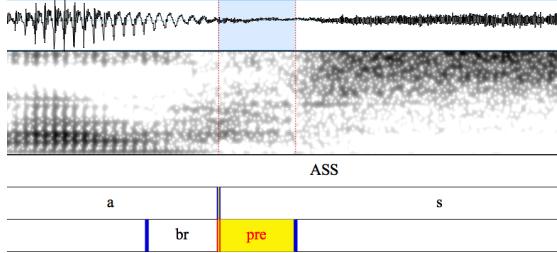


Figure 9: Identification of pre-aspiration in a sibilant context.

visible in Figure 9, pre-aspiration friction differs from the friction of /s/ and /ʃ/. The presence of pre-aspiration can be reliably spotted in sequences of sonorants and quiet fricatives (for English /f/ and /θ/) only with good quality data. As Figure 10 shows, there are differences between glottal friction and that of /f/, reflected mainly in a continuation of the formant structure of the sonorant into the pre-aspiration. Sometimes, however, pre-aspiration may be more approximant-like rather than fricative-like (more on that further below), which makes distinguishing pre-aspiration from quiet oral fricatives more difficult and, indeed, impossible with bad quality data.

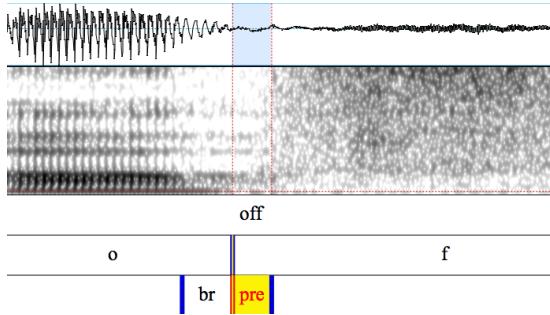


Figure 10: Identification of pre-aspiration in a non-sibilant context.

3 Tips for Praat users

There are certain ways to manipulate Praat default settings that can make analysing pre-aspiration less painful (and, believe it or not, more fun as well). Firstly, it is useful to set the view range to 0-8,000Hz rather than the default 0-5,000Hz. Secondly, the dynamic range can be lowered (differently depending on the recording/speaker in question) and make the acoustic information more contrastive, which can help to differentiate between pre-aspiration and background noise. For specific illustrations with different spectral settings, see Hejná (2015: 69-72).

4 Is the recording noisy?

You may be thinking that your spectrograms are not quite as clear as those we have seen in this manual so far. Maybe yours look a bit more like those in Figure 11?

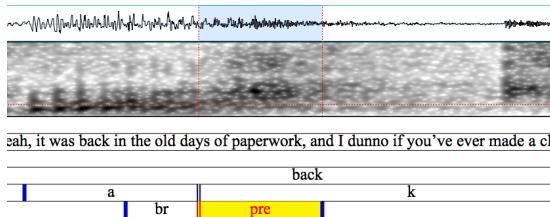


Figure 11: Non-optimal recording quality for pre-aspiration analyses.

There may be ways to still get some information out of such data quality, but let's see how to ensure as good a quality as possible before we discuss how to milk messy data.

4.1 What equipment should we use?

I have been a very happy user of H4 Zoom Handy Recorder, but it's the AKG C520 head-mounted microphone I'm really in love with. I'd certainly recommend using a head-mounted microphone of good quality, as that ensures that the microphone is close to what you are after. Avoid Lavalier lapel microphones. The lapel microphones from Sennheiser are good and more suitable for sociolinguistic work than head-mounted microphones, but they are also more expensive.

If you can't get a head-mounted microphone and have to use the microphone inbuilt in the recording machine, place the recording machine close to the speaker: even if the speaker can see the machine; you don't want to risk having echoing in your recordings, which may ruin your analyses entirely, in which scenario it really doesn't matter whether your participant saw the machine constantly in the first place. The recorder should be positioned so that it does not move, on surface that does not move. So don't put it on your lap - your however minor movements may lead to acoustic trouble, especially as the microphone would be closer to you than your speaker's mouth. Similar trouble is connected to placing microphones onto clothes (This cannot be emphasised enough: avoid, avoid, avoid Lavalier lapel mics for your own pre-aspiration sake.).

The room shouldn't be echoey - avoid high ceilings and vast rooms, especially if there's a lot of space in them (i.e. as a result of not too much furniture, not too many textiles, etc.), unless you have a head-mounted microphone (AKG C520 can beat so many problems!). The more textiles there are in a room, the better, because textiles absorb sounds better than e.g. plastic, metal, or wood, and are safer when it comes to echoing.

I usually place my recorder onto a robust scarf, which also helps to make the speakers pay less attention to it. Although I use a head-mounted microphone, most speakers forget they are wearing it during the session. Glass wearers are more likely not to forget, but even they can forget they are wearing a head-mounted microphone (distract them with cake and other appropriate items).

But it may be the case that you have to work with data recorded by someone else or data that was recorded for different purposes initially, for which its quality was perfectly appropriate, but it's not proving easy for pre-aspiration analyses. Any way all the analytical pain can be taken away from your shoulders?

4.2 Stuck with noisy data...

For a number of reasons, you may have to work with data with variable background noise. This is not optimal, but it's bound to happen at least sometimes. Frequently, bad-quality recordings will contain reflections or even echoes. There's no need to lose hope - you can still use such noisy data to some extent but don't be surprised if you have to discard many tokens entirely. So, yes, there are ways to take some of your analytical pain away, but unfortunately not all of it.

Firstly, do manipulate spectrogram settings as discussed above. This will

help at least in some cases and especially in the contexts of vowels and sibilants, which are associated with a high intensity release.

The problems tend to be most severe in tokens with high vowels, long vowels, and /p/, where pre-aspiration is shortest and quietest. Contexts with quiet fricatives also suffer considerably from noisy data. This is because even a small reflection of the sound wave can make it impossible to say with certainty whether pre-aspiration is indeed missing, because we can expect that it can be really short in such contexts. See Figure 12 - can you say whether there's pre-aspiration in the interval I highlighted and made easier to interpret by manipulating Praat settings?

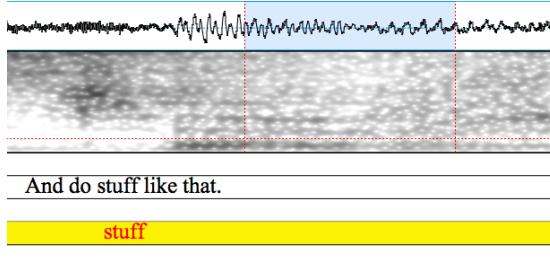


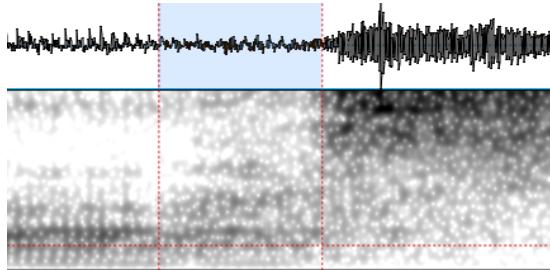
Figure 12: Non-optimal recording quality for pre-aspiration II.

In similar cases, the start of the local breathiness may still be identifiable, but the problem arises with the right boundary, i.e. with determining where the voicing ends. With reflections and echoes, we may get fake "voicing" in the signal taken from the voicing of the vowel. You can inspect the shape of the sound wave to see whether you can decide whether this is a case of a genuine reflection/echo and whether it is too loud to potentially mask pre-aspiration. Inspecting spectral properties also helps: the soundwave may indicate voicing but the spectrogram may not, for example. See Figure 13 for an example of the last.

It also helps if the token in question contains glottalisation/laryngealisation immediately before pre-aspiration, because it's easier to tease apart voiceless glottal friction from relatively intense irregular glottal pulses (Figures 14 and 15).

Bearing these problems in mind, you may decide to adopt a broad definition of pre-aspiration because the quality doesn't allow you to reliably distinguish between local breathiness and voiceless pre-aspiration. But do say, please, if that's what you'll decide to do, that this is what you are doing and also why you're doing it. It would make readers like me less puzzled about your methodological decisions.

Finally, prepare yourself for the fact that noisy data are more difficult and therefore more time consuming to work with. Factor that into your scheduling. Really - this is not to be underestimated and more so if you are making undergraduates do this for you.



, I'm not stand-offish, it was just certain pec

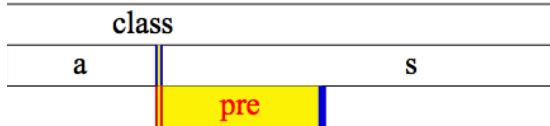


Figure 13: Non-optimal recording quality for pre-aspiration III.

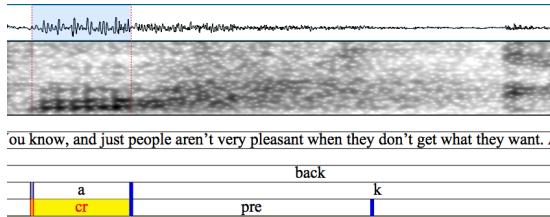
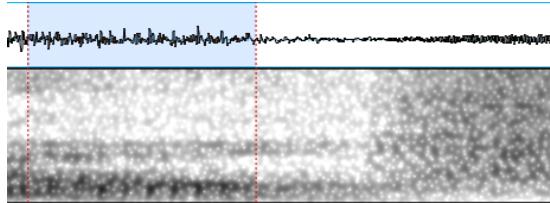


Figure 14: Glottalisation and pre-aspiration.



written off, I dunno if it still exists, but in thos

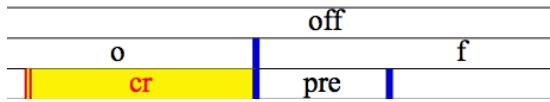


Figure 15: Glottalisation and pre-aspiration II.

It also helps if your pre-aspiration is actually not purely glottal. Occasionally in English, and much more frequently in Scottish Gaelic, pre-aspiration friction

may be produced in the oral cavity. When that happens, we talk about pre-affrication, and this is associated with friction of higher intensity than purely glottal friction, which makes its identification easier even in noisier data!

5 Pre-affrication

You may have wondered: what on earth is that strange high-intensity friction in the high frequencies of the signal occurring just before the plosive closure? This is likely to be pre-affrication. As alluded to in the paragraph just above this one, pre-affrication is a fairly frequent phenomenon which is sometimes considered pre-aspiration. Pre-affrication happens when the closure of a plosive is preceded not with glottal, but oral friction. The two can be differentiated based on the spectral quality. Figures 16-18 show cases of pre-affrication, which you can contrast with all the examples of pre-aspiration shown up to this point.

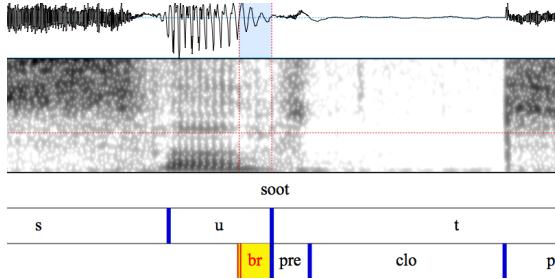


Figure 16: Pre-affrication I ("pre").

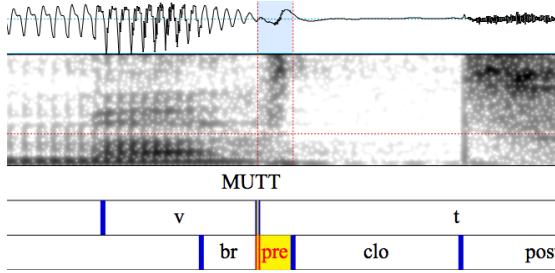


Figure 17: Pre-affrication II.

We can see that the friction in the "pre" (pre-aspiration) interval doesn't have comparable energy intensities across a wide range of frequencies. We can see that especially if we compare it to the beginning of the "post" (post-aspiration) interval, which actually starts off as affricated, as seen in the high intensity high frequency friction. We can also notice that the friction of pre-affrication doesn't have a formant structure that would mirror that of the vowel / modal and breathy phonation, unlike pre-aspiration.

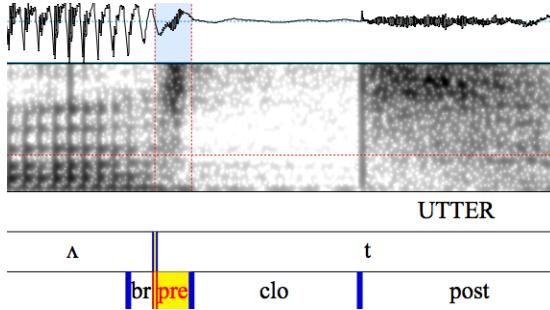


Figure 18: Pre-affrication III.

We can get cases where pre-aspiration and pre-affrication co-occur. See Figures 19 and 20.

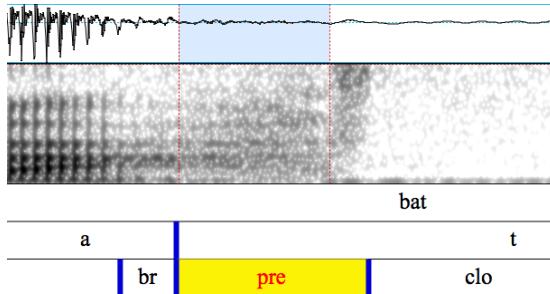


Figure 19: Pre-aspiration co-occurring with pre-affrication I.

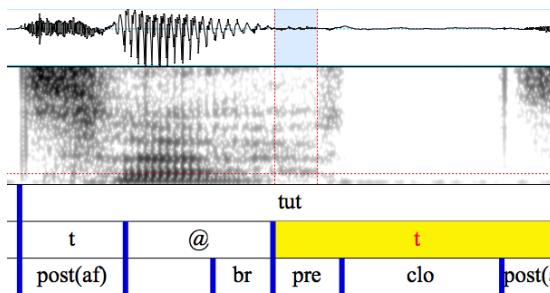


Figure 20: Pre-aspiration co-occurring with pre-affrication II.

There can also be cases which are a bit less straightforward.³

³I believe that we may be dealing with continua of glottal and oral frictions, at least in case of /t/ in many English accents. In your cinemas expected in the next few years...

6 Approximant-like pre-aspiration

We may encounter cases of pre-aspiration that, at least seemingly, lack friction and resemble very quiet approximants. See Figures 21 and 22.⁴ These cases of pre-aspiration haven't enjoyed much attention, so we know very little about them.

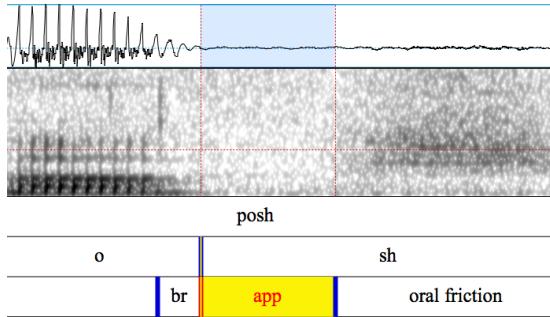


Figure 21: Approximant-like pre-aspiration. "app" = approximant-like interval.

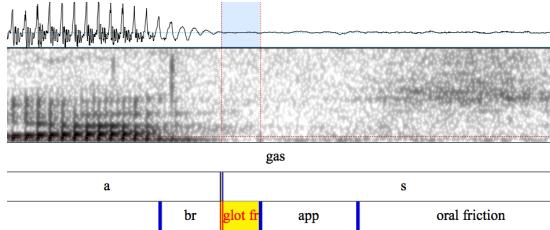


Figure 22: Approximant-like pre-aspiration II. "app" = approximant-like interval.

7 Pre-aspiration preceded by glottalisation

We've seen above that in noisy data pre-aspiration can be spotted more reliably if the phonation preceding pre-aspiration is glottalised/laryngealised/creaky (whichever term you feel more ok with). Another and a clearer example where glottalisation and pre-spiration co-occur is shown in Figures 23 and 24. I've never seen a case of pre-aspiration being *followed* by glottalisation - so do let me know if you come across any such case.⁵

⁴You may wonder whether this has to do with the sampling rate, especially looking at the spectral properties of the vowel and the /s/; this nevertheless doesn't seem to be the reason because the sampling rate was the same in this case as in the vast majority of the examples shown so far.

⁵There's some anecdotal evidence for this in Icelandic, but I haven't found any acoustic or articulatory evidence that would support that.

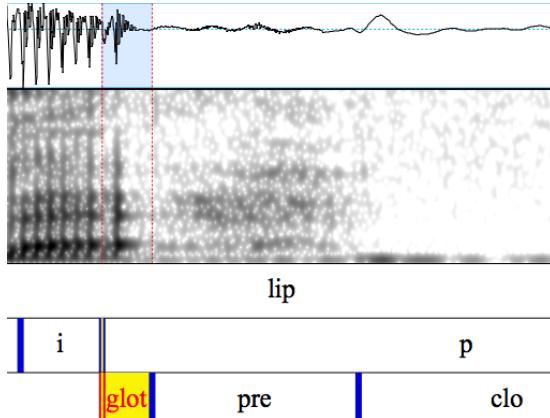


Figure 23: Glottalisation co-occurring with pre-aspiration.

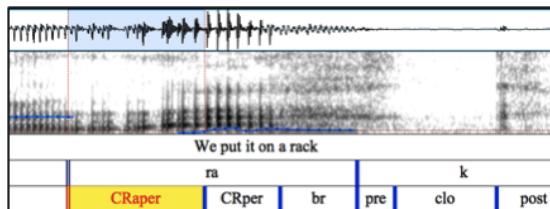


Figure 24: Glottalisation co-occurring with pre-aspiration II.

There is one sneaky glottal beast though, and that is the beast of the realm of glottal gaps. Glottal gaps are associated with glottal friction in the acoustic signal and some speakers are more prone to having gaps than others. Importantly then, some speakers show glottal friction in their voice quality which is not a result of a phenomenon known as pre-aspiration. Where the phonation involves constriction (associated with glottalisation/laryngealisation/creak...), this friction may become more easily observable in the acoustic signal, and this begs the question of whether all glottal friction following the last glottal pulse is necessarily that brought about by pre-aspiration (Quite devilish, isn't it?). The best diagnostics is to see whether the glottal friction associated with glottalisation which is found in the sequences of sonorants and voiceless obstruents is also found with glottalisation in other contexts (e.g. sequences of two vowels belonging to two different words). Another step is to compare the spectral properties for the different contexts. This is discussed in Hejná (2015: 167-8), and that's where you can find examples as well. (Good luck!)

8 Spirantised plosives

It is not at all unusual to come across cases of plosives which are completely spirantised (Figure 25, showing *pretty*).

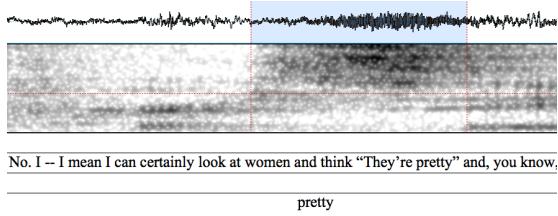


Figure 25: Fully spirantised plosive.

It is also not unusual to encounter examples where the plosive is spirantised partially and in such a way that a closure can still be identified (Figures 26 and 27). If the latter cases are pre-aspirated, the criteria to detect and segment pre-aspiration should not differ from those of pre-aspirated canonical plosives.

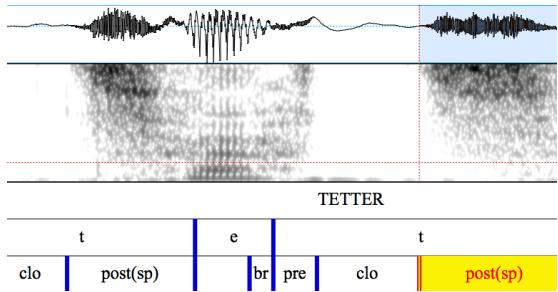


Figure 26: Partially spirantised plosive I.

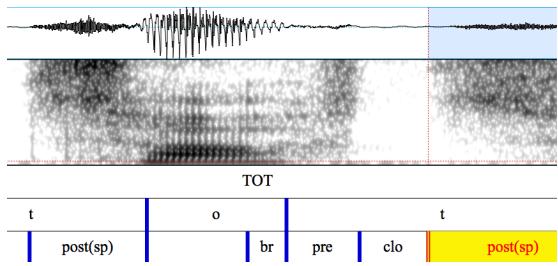


Figure 27: Partially spirantised plosive II.

Cases like those shown in Figure 25 can nevertheless be pre-aspirated as well⁶. Some of these cases can be analysed relatively without problems, but

⁶All the issues this raises... another devilish beastling... maybe in our cinemas in the next

others are more of a challenge. For example, in Figure 28 the glottal friction can be identified as illustrated in the annotation, following the same criteria we established for the identification of pre-aspiration in the context of fricatives.

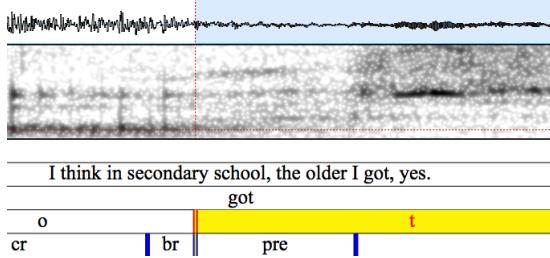


Figure 28: Fully spirantised pre-aspirated plosive.

However, the examples in Figures 29 and 30 are less straightforward. On one hand, we can clearly see one centre of high-intensity energy associated with the spirantised release of the plosive (to the right of the highlighted sections). On the other hand, we can also notice that a similar centre of energy is found before the release (those are the highlighted portions) and we face the decision of whether these cases should be considered pre-aspirated spirantised plosives and where the exact boundary of such pre-aspiration would be. If these are deemed to be examples of pre-aspiration (which has a fairly strong oral friction component), the criteria for the left boundary remain the same as those for canonical cases of pre-aspirated plosives. The right boundary, however, can either be determined on the basis of the intensity of the friction associated with the pre-aspiration, of the intensity associated with the plosive release, or placed in the midpoint of these two centres.

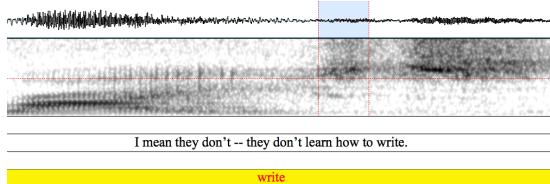


Figure 29: Fully spirantised, potentially pre-aspirated plosive I.

Not too dissimilar problems are encountered when the vowel is devoiced in the contexts with multiple sources of friction, such as in *hatter* or *pectin*, as shown in Figure 31. Such cases cannot be included in durational or noisiness analyses of pre-aspiration simply because it is not clear where the pre-aspiration friction starts! Very interesting for coarticulation questions though.

five to ten years?

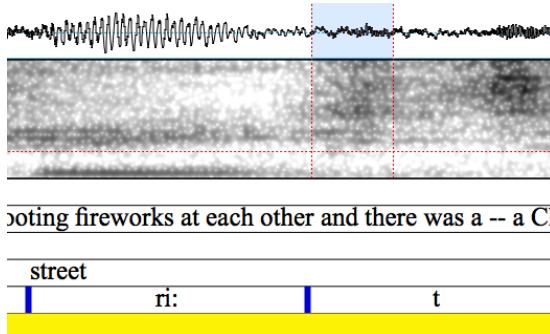


Figure 30: Fully spirantised, potentially pre-aspirated plosive II.

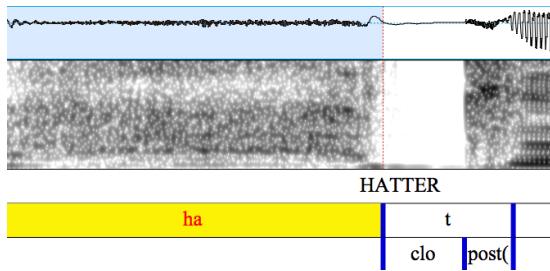


Figure 31: Pre-aspiration leading to vowel devoicing.

9 Conclusion

I hope this will make your analyses of pre-aspiration more fruitful and enjoyable.
Do let me know what you have found, so I can have some fun too.

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