Yorkshire Assimilation

An Experimental Investigation of Gradient Phonological Alternation

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Abstract

This thesis investigates Yorkshire Assimilation (YA) in relation to both the phonology-phonetics and the categoricality-gradience distinction. Importantly, it is not assumed that the distinction between phonology and phonetics is based on that between categoricality and gradience. Firstly, regarding the phonology-phonetics distinction, it is argued on articulatory phonetic grounds that if YA is cued by segmental duration, this must be the result of a phonological process. Secondly, regarding the categoricality-gradience distinction, it is argued that if YA involves incomplete neutralisation of a voicing cue, this would point towards a gradient process. A production experiment was conducted which tested if these assumptions were borne out. It compared the mean vowel-consonant duration ratio (V/C ratio) of assimilated items with that of unassimilated voiced and voiceless items. The results showed that, for the majority of the participants, the mean V/C ratio of assimilation items was significantly different from that of the voiced and the voiceless items. This means (1) that, as most speakers showed assimilation of a durational cue, YA must be phonological, and (2) that, as this assimilation was incomplete, YA must also be gradient.

Contents

1. Introduction

Certain Yorkshire dialects have been reported to exhibit a phenomenon which entails voiced final obstruents becoming voiceless when they are followed by another voiceless obstruent (Wells, 1982, pp. 366-367). The list in (1) reproduces the examples given by Wells.

(1)	a. *bed-time*	[bɛttaɪm]	
	b. *subcommittee*	[sʊpkəmɪtɪ]	
	c. *headquarters*	[hɛtkwɔːtəz]	
	d. *a big piece*	[ə bɪk piːs]	
	e. *live performance*	[laɪf pəfɔːməns]	
	f. *wide trousers*	[waɪt traʊzəz]	
	g. *frogspawn*	[frɒkspɔːn]	
	h. *old people*	[oːlʔ piːpɫ]	
	i. *Bradford*	[bræʔfəd][1]	(Wells, 1982, pp. 366-367)

According to Wells, this is a categorical process which should not be confused with the phonetic devoicing of final obstruents that has been reported for Standard British English (1982, p. 367). As such, he posits a derivational rule (see 2) for this alternation. Perhaps the most convincing piece of evidence for the "complete neutralization of the voicing […] opposition" (Wells, 1982, p. 367) is the observation that the process can result in a glottal stop (Wells, 1982, p. 367; see 1h-i), a sound which, in English, is usually regarded as an allophonic variant of the /t/ phoneme (Wells, 1982, p. 44).

(2) Obstruent → voiceless / __# [voiceless C] (Wells, 1982, p. 367)

Wells comments that this type of assimilation is characteristic of the West Yorkshire and South Yorkshire accent, and that it can be found throughout the greater area that is historically known as the West Riding (1982, p. 367). Subsequent mentions of this process, which Wells dubbed *Yorkshire Assimilation*, are in accordance with Wells' description (see Petyt, 1985, p. 148; Hughes & Trudgill, 1987, p. 63; Trudgill, 1990, pp. 67-68; Akamatsu, 2009), although they provide little additional evidence. Hughes and Trudgill's (1987) book is accompanied by recordings of the accents they discuss and a single instance of Yorkshire Assimilation can be heard in their Bradford recording: *could sing* (misinterpreted by the authors as *could swing*) is transcribed as [kʊt sɪŋ]. Additional audio evidence is provided by the recordings made for *The Survey of English Dialects* (Orton et al., 1962-9). The recordings from Leeds, Ecclesfield and Heptonstall each contain one instance of the phenomenon, as reflected in the accompanying transcriptions, which can be found in (3). On the basis of the glottal reinforcement in (3a) and the glottal replacements in (3b-c), it seems that, at least to the transcriber, these are instances of what Wells would call a "phonological rule" (1982, p. 367).

(3)	a. *paid for*	[peːʔt fɒ]	(British Library, 1974a)
	b. *Bradfield*	[bræʔfiːld]	(British Library, 1974b)
	c. *old shirt*	[ɔːlʔ ʃət]	(British Library, 1974c)

[1] The example in (1i) has also been mentioned separately in the literature (Ward, 1945, p. 135) and seems to be the most stereotypical instance of the phenomenon.

The earliest evidence for Yorkshire Assimilation can be found in a 19th century account of the Windhill dialect (Wright, 1892). Wright does not himself mention the process, but inspection of his transcriptions for a selection of dialect stories reveals the alternation in (4).

(4)	clothes[2]	[tlʊəz]	clothes to	[tlʊəs tə]
	clothes brushed	[tlʊəz brʊʃt]	clothes cord	[tlʊəs kʊəd]
	clothes lines	[tlʊəz laɪnz]	clothes post	[tlʊəs pʊəst]
	is a	[ɪz ə]	is peace	[ɪs pɪəs]
	is that	[ɪz ðat]	is sound	[ɪs saːnd]
	as usual	[əz ɪʊzl]	as she	[əs ʃʊ]

(Wright, 1892, pp. 176-181)

However, Wright's transcriptions also reveal forms that would be expected to assimilate on the basis of the contemporary rule but which are unaffected in the 19th century transcriptions, see (5).

(5)	bedstead	[bɛdsteɪd]	(Wright, 1892, p. 36)
	pig-cot	[pɪgkɔɪt]	(Wright, 1892, p. 41)
	red faced	[rɛd feəst]	(Wright, 1892, p. 209)
	good-for-nowt (= good-for-nothing)	[gʊɪd fə nəʊt]	(Wright, 1892, p. 211)
	goes to	[gʊəz tə]	(Wright, 1892, p. 176-177)

Judging from the forms in (4) and (5), it seems that the process only applied to fricatives or, at least, that, to Wright, the assimilation was more salient in fricatives. However, even those are sometimes transcribed as voiced, see the final example in (5). If Wright's transcriptions are accurate[3], they show that, at least in the 19th century, the process might not have been as robust as Wells and others have claimed.

Contradictory accounts of speech processes emphasise the need for empirical evidence. This is especially important if those speech processes are used in theoretical arguments, as inaccurate descriptions may lead to defective theories. In the case of Yorkshire Assimilation, very little empirical evidence is available. Moreover, previous descriptions and studies have not used acoustic analysis or statistical methods to support their claims. This study will use both to examine to what extent the terms *categorical* and *phonological* can be applied to Yorkshire Assimilation, and it will consider the consequences of its findings for any phonological theory that aims to account for Yorkshire Assimilation.

Before the research question can be laid out in more detail, some theoretical background is needed. Therefore, this thesis begins by providing a discussion of previous accounts of assimilation in the light of the specific theories that inform them. It then introduces the theoretical assumptions of this thesis, relates these assumptions to phonetics, and presents hypotheses that can be tested using empirical methods. Subsequently, a specific experiment is outlined followed by a discussion of the results and how those relate to the hypotheses. Finally, the conclusion gives a summary of the main findings and provides suggestions for further research.

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[2] Words starting with a [kl] cluster were produced as [tl] in some English dialects (Blevins and Grawunder, 2009). All transcriptions have been updated to IPA standards.

[3] See Broadbent, 2008, pp. 149-151 for arguments in support of Wright's transcriptions.

2. Theoretical Framework

2.1 Review of Existing Theories

Traditionally, voicing assimilation, and assimilation more generally, has been described in phonological terms. In this terminology, assimilation falls under the broader moniker of neutralisation, which can be described as "a conditioned limitation on the distribution of a system's contrastive values" (Silverman, 2012, p. 4). Phonological models often posit that speakers have a psychologically real equivalent to such a description (Silverman, 2006, p. 20). In those models, the contrastive value of voicing assimilation is voice[4], with a contrast being made between its presence and absence or between a positive and a negative specification in a binary feature system. On the other hand, the alternations in the phonetic realisation of either of these voicing qualities have often been described in articulatory phonetic terms. In English, phonologically voiced word-medial obstruents are usually produced with sustained vibration of the vocal cords, whereas voiced obstruents at the end of words are often produced with little vocal cord vibration (Jansen, 2004, p. 46-49). The reason for this is often said to be the physical difficulty of sustaining vocal cord vibration at the end of words because of lower transglottal pressure (Westbury & Keating, 1986, p. 157). More generally, alternations such as these are often considered to be the result of physical influences, and they used to be viewed as completely separate from phonological alternations (Kawahara, 2011, p. 2283). There is, of course, an obvious and, as it turns out, problematic link between phonetics and phonology. For the present, however, this link will be ignored and phonological accounts of voicing assimilation will be discussed separately from phonetic accounts of voicing assimilation.

Phonological accounts of assimilation are often rooted in the generative approach to phonology, in which phonological processes are assumed to be categorical. Lombardi has developed formal models of voicing assimilation in the Principles and Parameters framework (Lombardi, 1991) as well as in Optimality Theory (Lombardi, 1999). Both models are based on a few key "mechanisms" (Lombardi, 1991, p. 37) (see 6), which are formulated as universal parameters or constraints, depending on the framework.

(6)
a. Privative Voice: the phonological value of voice is either present or absent
b. Voice Constraint: obstruents can only be voiced if they are followed by a vowel or sonorant in the same syllable.
c. Spreading: the voicing quality of a voiced obstruent can spread to an adjacent voiceless obstruent.
d. Final exceptionality: an exception to the Voice Constraint is made for voiced obstruents in word-final position.

(Lombardi, 1991, p. 38-41)

One of the key advantages of Lombardi's approach is that, once the principles in (6) are translated into Principles and Parameters or Optimality Theory, a constrained typology of assimilation and devoicing processes can be made. However, by treating devoicing and assimilation as part of the same process and by positing a privative value of voice, such a typology cannot account for each known assimilation and devoicing process, Yorkshire Assimilation being one of those (Wetzels & Mascaró, 2001, p. 227).

[4] In this context and throughout this thesis, *voice* or *voicing* will be used as cover terms for a phonological distinction. As such, they should not be directly linked to the phonetic property of vocal fold vibration.

Perhaps the main problem for these models, however, are claims that some voicing assimilation and devoicing processes turn out to be incomplete on a phonetic level. Previously investigated instances of gradient voicing assimilation (e.g. Kuzla et al., 2007; Jansen, 2007) are problematic for generative phonology if they are regarded as phonological processes. In terms of a strictly phonological model of assimilation, these findings would mean that a mental representation of a sound which has acquired a different voicing value through some mental process is somehow still realised differently from a mental representation of a sound which has had that same value for voice all along. This is problematic because such a model has no way of accounting for these differences. However, as will be shown below, such instances of incomplete assimilation can be reanalysed as phonetic processes, because the cues that assimilated in those experiments, such as glottal vibration, are subject to the coordination of subsequent articulations in connected speech. With regard to these processes, solving the problem in phonetics maintains the generative assumption that all phonological processes are categorical (Ernestus, 2011, p. 2120).

Investigations into incomplete final devoicing have posed greater challenges for that assumption. Studies in Dutch and German final devoicing (Port & O'dell, 1985; Warner et al. 2004) found that certain cues that are not influenced by coarticulation, such as segmental duration of final stops and preceding vowels, are incompletely neutralised in those languages. If similar cues are found to play a role in Yorkshire Assimilation it would be interesting to see whether it produces incomplete realisations similar to those found in final devoicing processes, as this would mean that assimilation can be equally problematic for theories that conceive of phonology as categorical. Moreover, because English does not have a final devoicing process, investigating incomplete neutralisation in Yorkshire Assimilation is facilitated by the fact that assimilated segments can be compared to both phonologically voiced and voiceless segments in final position. It should further be noted that questions have been raised about the methods used in the experiments on final devoicing which find incomplete neutralisation. Realisations in such experiments are often elicited by asking participants to read out a text and, therefore, spelling of neutralised segments may influence their pronunciation (Fourakis & Iverson, 1984; Warner et al., 2006). Then again, that argument only really holds for languages in which the spelling in non-neutralising environments consistently reflects voicing distinctions. Furthermore, Ernestus notes that listeners also make use of incomplete neutralisations in their perception of voicing quality, regardless of spelling (2011, p. 2123).

Now that it has been suggested that an utterly top-down (*top* being psychological and abstract, *down* being physical and concrete) approach to assimilation has its problems, it is only fair to review an exclusively bottom-up approach to sound alternations. Articulatory Phonology is a phonological theory which is completely inspired by phonetics in that its contrastive units, or *gestures*, can be described in terms of so-called *tract variables*, which in turn are grounded in articulatory gestures (not to be confused with the phonological *gestures*). According to Browman and Goldstein, phonological structure can be seen as the result of "the patterns of how *gestures* are coordinated in time with respect to one another" (1992a, p. 28). In this way, the mechanism of gestural overlap is used to account for both coarticulatory alternation (Browman & Goldstein, 1992a, p. 31) and assimilation. As a result, there is no longer a need for an exclusively phonological mechanism such as spreading; the assimilation is simply the result of concurrent gestures (Browman & Goldstein, 1992a, p. 29). Browman and Goldstein go as far as to say that "[*gestures*] are never changed into other gestures, nor are gestures added" and that all alternations are the result of gradient "increase in overlap" or decrease in "gesture magnitude" (1992a, p. 37). This is a very strong claim to make, as it predicts that no alternations exist, be they phonetic or phonological, that involve deletion and insertion of gestures. This is a serious problem with Articulatory Phonology and it is rooted in its assumption of the *gesture* as the "primitive phonological [unit]" (Browman & Goldstein, 1992a, p. 23). Such an assumption implies that allophones must make use of the same *tract variables* (Browman & Goldstein, 1992a, p. 30). Therefore, according to Articulatory Phonology, speaker-listeners would not be able to interpret allophones involving completely different articulators as sharing some meaning-distinguishing quality. It has been noted before that allophony of this kind does in fact occur (see Sebregts, 2014, p. 9-11 for an example involving Dutch rhotics), and as will be shown in this thesis it is also applicable to Yorkshire Assimilation to some degree.

As pointed out by Strycharczuk (2012, p. 36-39; see also Jansen, 2004), the main problem with both the phonological and phonetic models discussed above is their interpretation of the phonology-phonetics distinction. The early generative accounts posited a clear distinction between phonology and phonetics. In these models phonetic processes had no influence whatsoever on phonological alternations as they were not thought to be part of an individual's phonological knowledge (Strycharczuk, 2012, p. 36-37) even though remarkable similarities between phonological and phonetic processes can be noted (Strycharczuk, 2012, p. 37). The phonological mechanisms of devoicing and spreading in (6b-c), for example, are very similar to the account of phonetic devoicing in English and the principle of coarticulation, respectively. Theories such as Articulatory Phonology capture these similarities brilliantly, but they do not provide for alternations that are motivated by "the interaction of grammatical pressures" (Strycharczuk, 2012, p. 36), i.e. processes that have no direct relation to phonetics. In Articulatory Phonology, then, there is no distinction between phonology and phonetics because all of phonology consists of phonetic knowledge. What is needed, it seems, is a model which distinguishes between phonology and phonetics but does allow the two to interact with each other. As summarised by Strycharczuk (2012, p. 41-43), it is not yet entirely clear how this interaction should be modelled. Part of the solution can be found by taking a diachronic perspective of the interplay between phonetics and phonology (Strycharczuk, 2012, p. 39): similar and dissimilar phonological and phonetic phenomena can be interpreted as the results of phonetic biases and grammatical forces that have interacted over time (see Silverman, 2006, Ch. 5-6 for a step by step exposition). This thesis will not further develop such an approach, focussing instead on the synchronic classification of the nature of Yorkshire Assimilation and what this entails.

2.2 Theoretical Assumptions

The classification of a sound pattern as phonological or phonetic is frequently based on the distinction between categorical and gradient patterns (Ernestus, 2011, p. 2116). In such an approach it is argued that all phonological processes are categorical while all phonetic processes are gradient (e.g. Myers, 2000, p. 245). Following this line of thought, the only way to distinguish between coarticulation and assimilation is through statistical analysis (Myers, 2000, p. 259). However, it has since been argued that the division of phonology and phonetics into categorical and gradient does not always hold (Pierrehumbert et al., 2000, p. 287; see Scobbie, 2005; Cohn, 2007 for theoretical discussions). Therefore, this thesis does not assume such a clear-cut difference between the phonetic and the phonological. Furthermore, although quantitative techniques are definitely valuable to determine whether a process is categorical or gradient, other strategies of determining whether a process is phonological are explored. This thesis will follow Strycharczuk (2012, p. 44) in specifying its assumptions one by one (see 7a-d) rather than adopting a framework that encompasses them along with other assumptions that are unnecessary in the current study.

(7) a. An alternation is likely to be *categorical* if it is *complete*, i.e. if every alternant clearly belongs to a category.
b. An alternation is *gradient* if it is *incomplete*, i.e. if there is a continuum between multiple categories and one of the alternants can be placed somewhere between those categories.
c. If an alternation is *phonetically unmotivated*, i.e. if it cannot be accounted for on a physical, (co)articulatory basis, it must have a *phonological* element.
d. The difference between *complete* and *incomplete* alternation as well as the qualification as phonetically unmotivated can be expressed in phonetic terms.

Note that these assumptions have been chosen very carefully to avoid any unwanted claims about the relationship between phonology and phonetics. For instance, it is not claimed that complete alternations cannot be the result of a gradient process, as this is a logical possibility. Furthermore, the assumptions make no statements on the interface between phonetics and phonology. The only distinction that is made between the two is that processes based in phonology can be "unnatural" (Anderson, 1981), whereas processes based in phonetics are not. Thus, following (7c), lack of articulatory phonetic explanations for an alternation will be taken as evidence for the "un-naturalness" that is associated with phonology (Scobbie, 2005, p. 11). The assumptions in (7) also allow for the possibility that phonetic and phonological alternations have both gradient and categorical aspects to them, but, following one of the key principles of Laboratory Phonology, the current study will not confirm or deny this possibility *a priori* (Kingston & Beckman, 1990:3). Rather, it will attempt to establish whether Yorkshire Assimilation is phonological or phonetic on the basis of the phonetic *naturalness* of the cues that are involved in the assimilation and whether it is categorical or gradient on the basis of quantitative evidence. In doing so, more insight is provided into the relationship between those two distinctions for this particular process.

2.3 Acoustic Correlates of Obstruent Voicing and the Role of Coarticulation

As both Ernestus (2011, p. 2121) and Strycharczuk (2012, p. 45) mention, the most commonly used technique to test for incomplete assimilation is to measure the acoustic cues that are associated with the phonological feature in question. This is done for segments that have neutralised towards a certain value of the relevant feature and for unassimilated segments that have the same value for that feature. A significantly large difference between these two measurements would point towards the assimilation being incomplete.

The most important acoustic cues for voicing in obstruents are listed in (8) (see Jansen 2004, Chapter 2 for a summary of the research on these and other cues).

(8) a. Vocal fold vibration
b. Quality of the stop release burst
c. Segmental duration of the obstruent and the preceding vowel
d. F_0 and F_1 differences
e. Relative frication intensity in the case of fricatives

As Ernestus (2011, p. 2118) points out, the many cues for voicing make it harder to determine whether a neutralising case is complete or incomplete. Iverson and Salmons (2011, p. 1634) stress that trading relations among these cues need to be taken into account. After all, the extent to which a speaker-listener relies on different cues in their realisation and perception of voicing distinctions will be subject to contextual and individual variation. An ideal account of neutralisation would weight the respective cues accordingly. Unfortunately, such meticulous attention to detail falls outside the scope of this investigation. Instead, this study will focus on only one aspect: the segmental duration of the final obstruent and the vowel preceding it. Consequently, the results of this study should be considered with appropriate care. Nevertheless, the choice to look at segmental duration can be grounded in empirical observations. Compared to other languages, vowel length is a prominent cue for the voicing distinction in word final obstruents in English (reviews in Jansen, 2004, p. 49 and Sóskuthy, 2013, p. 196-197). The relationship between vowel length and voicing of a final obstruent has been called *the voicing effect* (Sóskuthy, 2013, p. 191) and the current discussion will adopt this term for further reference to this principle. It has been shown that the voicing effect manifests itself to a greater degree in vowels that: (a.) are part of a stressed syllable, (b.) are longer by phonological or phonetic nature, and (c.) are followed by fricatives rather than plosives (see Sóskuthy, 2013, pp.197-198 for a review). As Sóskuthy mentions, these are important considerations for any research that involves the voicing effect (2013, p. 197). Other cues such as vocal fold vibration (Jansen, 2004, p. 49) and stop release bursts (Ladefoged & Maddieson, 1996, p. 50; Jansen, 2004, p. 49) often do not occur at all in English final voiced stops and the F_0 and F_1 differences of vowels preceding plosives are often very small (Jansen, 2004, p. 52). It will be assumed, then, that the voicing distinction in final obstruents is most consistently realised through differences in vowel and obstruent length. Longer vowels and shorter obstruents would point to phonologically voiced obstruents, whereas shorter vowels and longer obstruents would indicate voiceless plosives and fricatives (Jansen, 2004, p. 54). Vowel length and obstruent length can be merged into a single variable: vowel-consonant duration ratio (henceforth V/C ratio, cf. “C/V ratio” Port & Dalby, 1982). The V/C ratio is obtained by dividing the vowel length by the obstruent length. Consequently, a high V/C ratio would suggest that the speaker aims to cue a voiced obstruent and a low V/C ratio would suggest a voiceless target. The benefit of taking a proportional approach to segmental duration is that the resulting variable might be more stable as a perceptual cue than vowel and consonant duration as separate cues, which are more sensitive to overall speaking rate (Port & Dalby, 1982, p. 142). Positing V/C ratio as a cue also has certain practical advantages which will be discussed further in the Methods section.

Another reason to focus on the possible assimilation of segmental duration is that it might provide deeper insight into the nature of the process. If significant durational neutralisation is found, be it complete or incomplete, it can be argued that Yorkshire Assimilation must be, at least partly, phonological. This follows from the observation that there is no articulatory reason that a vowel should be shorter and a subsequent obstruent should be longer if they are followed by a voiceless obstruent. This conclusion is strengthened by Jansen’s (2007) study of voicing assimilation in British English. Neither obstruent length nor vowel duration were influenced by the voicing quality of the following obstruent (Jansen, 2007, p. 282-285; see Myers, 2010 for similar results in American English). Two other cues were affected by assimilation: vocal fold vibration, and F1 of the vowel preceding the assimilating obstruent. The first of these can easily be modelled as the result of a coarticulation, and F1 of the preceding vowel could also possibly be explained by overlapping gestures (Jansen, 2007, p. 289). Moreover, as articulatory accounts of the voicing effect have generally been rejected (see Soskuthy, 2013, p. 195-196), it can be stated, as Jansen does, that “a coarticulation-based model predicts that coarticulation in obstruent sequences does not have any effects on the duration of preceding vowels, simply because no gestures related to vowel length control are implemented during the realisation of such obstruent sequences” (2007, p. 289).

Other realisations that would lead to a classification of Yorkshire Assimilation as phonological are the glottal forms that have been reported by previous researchers. Such forms can be identified using the cues in (9).

(9) a. an irregular voicing pattern indicating creaky voice (Docherty & Foulkes, 1999, p. 55; Rietveld & Van Heuven, 2009, p. 137)
b. a visible “transient” in the spectrogram (Docherty & Foulkes, 1999, p. 55)
c. no or reduced formant transitions (Docherty & Foulkes, 1999, p. 57; Ladefoged & Maddieson, 1996, p. 73)

The fact that it is not possible to account for glottalisation solely through articulatory processes can be nicely illustrated by compiling an Articulatory Phonological *gestural score* for the *glottal aperture* during a /dp/ sequence, see Figure 1.

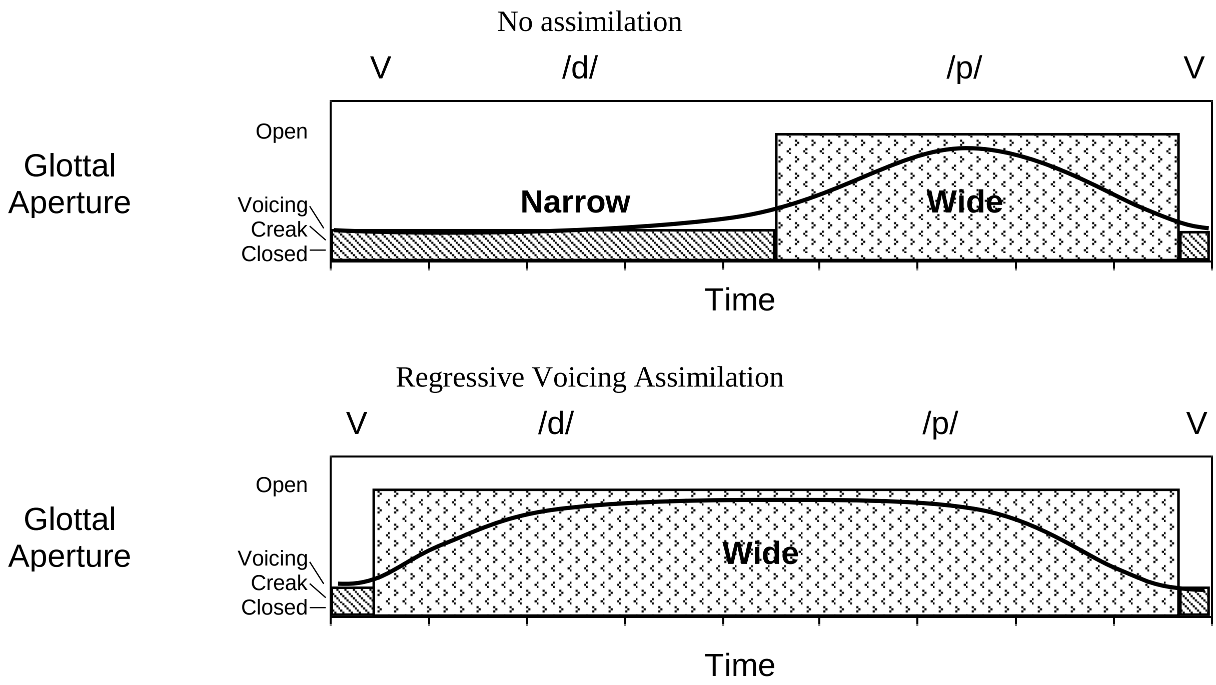


Figure 1: Glottal gestures for a d#p sequence without (upper) and with (lower) assimilation. It should be noted that Browman and Goldstein (1992a) do not make distinctions between glottal aperture for voicing, glottal aperture for creaking and complete closure but this is a necessary addition if creak and glottal stops are to be described at all within this framework.

As the vocal cords are not as tightly adduced during modal voice as during creaky voice (Laver, 1980, pp. 111-123), and as the glottis is wide open for the subsequent /p/, there is simply no articulatory reason for glottals to emerge. This point is supported by Kohler’s work on glottal stops in German. He concludes: “connected speech processes involving glottal stops and glottalization […] cannot be explained solely by temporal sliding, magnitude reduction in space and time and temporal extension (Browman and Goldstein, 1992b) but require the provision of gestural substitution and change” (Kohler, 1994, p. 51).

2.4 Hypotheses

As noted in previous sections, this thesis aims to make statements on the nature of Yorkshire Assimilation with regard to both the phonetics-phonology and the gradient-categorical distinction. Because these distinctions cannot be equated, two sets of hypotheses will have to be posited. Firstly, regarding the phonetics-phonology question, the hypotheses in (10) are proposed.

(10) H_0: Yorkshire Assimilation involves no phonological element.
H_1: Yorkshire Assimilation involves a phonological element.

As this study only considers V/C ratio, any form of assimilation that is found points towards a phonological element, as defined in 7c. Therefore, H_1 must be accepted—and this will be the assumption in the remainder of this section—before any statements on categoricality and gradience are made. Such statements can be couched in terms of the hypotheses in (11).

(11) H_0: Given a population of speakers displaying some form of Yorkshire Assimilation, this process is categorical for all of them.

H_1: Given a population of speakers displaying some form of Yorkshire Assimilation, this process is gradient for all of them.

H_2: Given a population of speakers displaying some form of Yorkshire Assimilation, this process is both categorical and gradient.

Before these are discussed in more detail, it is useful to consider an important issue concerning the nature of statistical research. Although it is theoretically possible to confirm the hypotheses H_0 and H_1, in practice, studying all speakers who display Yorkshire Assimilation is not feasible. These hypotheses can only be supported—rather than confirmed—by the evidence in this study. The hypotheses in (11) can be related to the research question with the help of the statements in (7a-b), which are reproduced below for convenience.

(7) a. An alternation is likely to be *categorical* if it is *complete*, i.e. if every alternant clearly belongs to a category.
b. An alternation is *gradient* if it is *incomplete*, i.e. if there is a continuum between multiple categories and one of the alternants can be placed somewhere between those categories.

H_0 in (11) is supported if (7a) applies to all speakers in the population; i.e. for all speakers the process must be complete. If the evidence does support H_0, it can be concluded that Yorkshire Assimilation has a phonological element and is likely to be categorical. On the other hand, H_1 is supported if (7b) applies to all speakers in the population; i.e. for all speakers the process must be incomplete. If H_1 is confirmed, Yorkshire Assimilation can be described as—at least partly—phonological and gradient. Finally, H_2 is supported if (7a) applies to some speakers in the population and (7b) applies to other speakers in the population. If H_2 is confirmed, the (partly) phonological process of Yorkshire Assimilation is gradient or categorical depending on the speaker.

The statements in (7a-b) may, however, be too simplistic to cover all possible findings. As Ellis and Hardcastle (2002) have shown, there are two ways in which an alternant—conceived of as a number of tokens—can be said to not clearly belong to a category. In their experiment on assimilation of place of articulation, Ellis and Hardcastle (2002, p. 384) found a group of speakers for whom items of the assimilatory alternant took part in incomplete assimilation in accordance with the statement in (7b). However, they also found another group of speakers for whom some items were completely assimilated and other items did not assimilate at all (2002, p. 386). For these speakers, then, the assimilatory alternant is ambiguously categorical without being properly gradient. These findings raise the question whether other types of intraspeaker patterning exist in addition to those found by Ellis and Hardcastle. The list in (12) notes all theoretical possibilities:

(12) a. no assimilation
b. no assimilation + incomplete assimilation
c. incomplete assimilation
d. complete assimilation + incomplete assimilation
e. complete assimilation
f. no assimilation + complete assimilation
g. no assimilation + complete assimilation + incomplete assimilation

It could be argued that a combination of categorical and gradient behaviour for the same speaker (12b, 12d & 12g) is not a separate possibility on the grounds that a solely gradient alternation might include some items that *appear* to have either fully assimilated or not assimilated at all, as was the case for the gradient assimilations in the study by Ellis and Hardcastle (2002, p. 384). However, statistical tests may be used to assess whether the presence and/or the number of outliers would be likely under the assumption that the items of a gradient alternant would be normally distributed. In the present approach, it is assumed that alternants which either do not assimilate (12a), incompletely assimilate (12c) or completely assimilate (12e) are normally distributed and, as a result, the ambiguous possibilities in (12b), (12d), (12f) and (12g) are only seriously considered if tests for normality on the suspected assimilatory alternant do not reach significance. If the patterns do turn out to be ambiguous they would point to the alternation being structurally and/or lexically more specific than previously held. Furthermore, if assimilation such as in (12d) or (12g) is found, it can be argued that H_2 is supported and that Yorkshire Assimilation is both categorical and gradient for that speaker. If (12b) or (12f) is found for a speaker, H_1 and H_2 respectively are supported.

3. Methods

The research for this study was conducted in two parts; a pilot experiment was performed at the University of York and a second experiment with more participants was carried out in Windhill, a district of Bradford. On the basis of the findings of the pilot study, a number of changes were made for the Windhill recordings. As the bulk of the evidence presented in the analysis is from those recordings, the focus of the Method section will be on the main experiment.

3.1 Subjects

The subjects of the pilot study were 3 students at the University of York. All participants originated from West Yorkshire and identified themselves as native speakers of West Yorkshire English. The participants of the main experiment consisted of 19 adults, most of whom were natives to West or North Yorkshire. All subjects were long term residents of West or North Yorkshire. The speech of both sets of participants showed varying degrees of dialectal features typical of the region[5]. Three participants' performance of the task was unsatisfactory[6] and two participants displayed features that were unusual for a Yorkshire accent[7]. As a result, their recordings were not used, which left 14 recordings for analysis.

3.2 Design and Materials

The stimuli consisted of English compound words in which the first word always ended in an obstruent (C1) and the second word always started with an obstruent or sonorant (C2). Whether C2 was a sonorant or an obstruent and whether the obstruents were voiced or voiceless depended on the experimental context of the item, see Table 1.

Table 1: Overview of experimental contexts and the phonological content of their consonant clusters.

Context	Combination	Example
Assimilation	voiced obstruent + voiceless obstruent	*food poisoning*
Voiced	voiced obstruent + voiced obstruent	*food bank*
Voiceless	voiceless obstruent + voiceless obstruent	*boot polish*
Sonorant	voiced obstruent + sonorant consonant	*food waste*

The *assimilation* context was expected to produce obstruents that showed some form of devoicing under influence of the voiceless C2. Those obstruents could be compared to obstruents in the *voiced* context, which were unassimilated voiced segments. If the degree of voicing (measured in V/C ratio) in the voiced context was greater than that in the assimilation context, it was likely that the voiced obstruent in the assimilation context had become less voiced under influence of the adjacent voiceless obstruent. A similar comparison with the *voiceless* context could then be used to determine whether the voicing contrast (expressed in V/C ratio) had been neutralised completely or incompletely. However, such conclusions could only be drawn if there was a difference in voicing quality between the voiced and the

[5] This was reflected, for instance, in interspeaker differences regarding the degree to which the FACE and GOAT vowels were realised as monophthongs and the frequency with which rhotics were produced as flaps.
[6] One participant had trouble operating the laptop, another's productions were rushed and a third speaker's realisations were mumbled.
[7] These participants showed influences of a second native language.

voiceless context, as this comparison established the validity of V/C ratio as a voicing cue. Finally, the *sonorant* context could be compared to the *voiced* context to verify that the baseline it provided was unbiased, meaning that the first obstruent in the *voiced* context had not become more voiced under influence of the second obstruent.

In choosing which sounds to use for the obstruents, a number of principles played a role (see 13).

(13) a. C1 should only vary in either place or manner of articulation.
b. There should be a maximum of 4 different combinations of C1 and C2 per context.
c. C1 and C2 should include both fricatives and plosives.
d. C1 should allow glottal stops in the *assimilation* context.
e. C1 and C2 should not contain obstruents with the same place of articulation

These considerations led to the selection of consonant clusters that are represented for each experimental context in Table 2.

Table 2: Overview of the experimental contexts and the sounds that were used to instantiate them.

Context	C1	C2	Possible Combinations
Assimilation	[d, z]	[p, f]	[d#p], [d#f], [z#p], [z#f]
Voiced	[d, z]	[b, v]	[d#b], [d#v], [z#b], [z#v]
Voiceless	[t, s]	[p, f]	[t#p], [t#f], [s#p], [s#f]
Sonorant	[d, z]	[Son]	2x [d#Son], 2x [z#Son]

To enable fair comparisons between these contexts, it was important to control for all other variables that might influence segment duration. The most prominent of these were the conditioning factors of vowel and obstruent type on the voicing effect. Therefore, the same set of vowels and the same number of plosives and fricatives was used for every context. The nature of the voicing effect also meant that the vowels should be long and part of a stressed syllable. Consequently, the 4 long vowels [u, i, o, e] were chosen, which after equal distribution over the different consonant clusters for each context resulted in a total of 4 x 4 x 4 = 64 combinations. For each combination, a compound that contained a monosyllabic first word was found, making for 64 stimuli. An additional 16 stimuli containing short vowels were added but these were not considered for the present study.

In order to limit listing and utterance final effects, the stimuli were presented as part of the framing sentence in (14).

(14) *How do you spell ___ again?* e.g.: *How do you spell food fight again?*

Although it was not expected that the participants would be able to grasp the purpose of the experiment, a number of fillers (40 items) were added as distractors. The item *Bradford* was added as a final stimulus due to its frequent use as an example of Yorkshire Assimilation in the literature. These additions amount to a total of 121 items (see Appendix A for the full list).

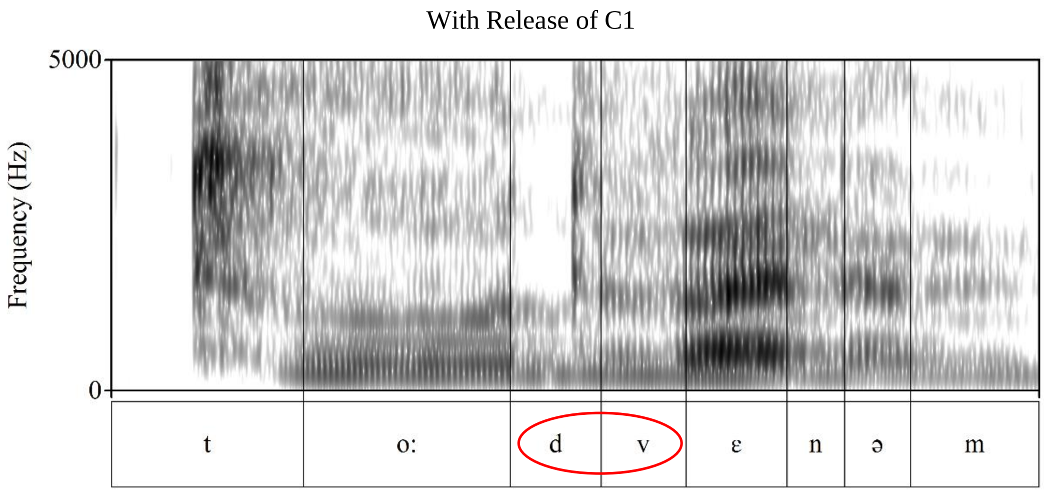
3.3 Procedures

Five quasi-randomised orderings of the items were made using *Mix* (Van Casteren & Davis, 2006; see Appendix B for the constraints that were used), after which these were manually entered into *Microsoft PowerPoint 2013* (Microsoft, 2012) presentations. The participants were then asked to click through one of the versions while producing the 121 sentences at their own pace as they went along.

The participants' productions were recorded in a closed room with no soundproofing using a Zoom H4n Handy Recorder. Following the recording session, the target stimuli were extracted from the framing sentence into separate sound files. These were then acoustically analysed and the relevant vowel and obstruent durations were manually demarcated using *Praat* (Boersma & Weenink, 2015). The files containing the time indications for the respective stimuli were then automatically compiled into a dataset for each participant using a *Unix* shell script (see Appendix C). These datasets were subsequently loaded into *R* (R Core Team, 2014) by a script (see Appendix D) that transformed the data into a useful format, produced visualisations of the descriptive statistics, checked for normality and calculated whether differences between the mean V/C ratio values of the different contexts were significant.

3.4 Acoustic and Statistical Analysis

Vowel boundaries were chosen as to only include fully formed waveforms; glottal vibration during the closure and release of initial and final consonants was not seen as part of the vowel. Reduced intensity in higher frequencies of the spectrogram was also used as an indication of the end of a vowel. The starting point of C1 was chosen to mark the start of frication, as exemplified by high frequency noise, or closure, as represented by silence or closure voicing. Glottalised C1 plosives were taken to start with the first irregular glottal pulse. The end of fricatives was found by locating the visible end or audible change in high frequency noise. Determining the endpoint of plosive C1s proved to be more problematic. If the plosive was released, the end of the accompanying high frequency burst was marked as the end of C1. Sometimes, however, the plosive was unreleased. In those cases, an equal amount of time was attributed to C1 and C2. Experience with C1 plosives that were released showed that this was a likely distribution, see Figure 2.



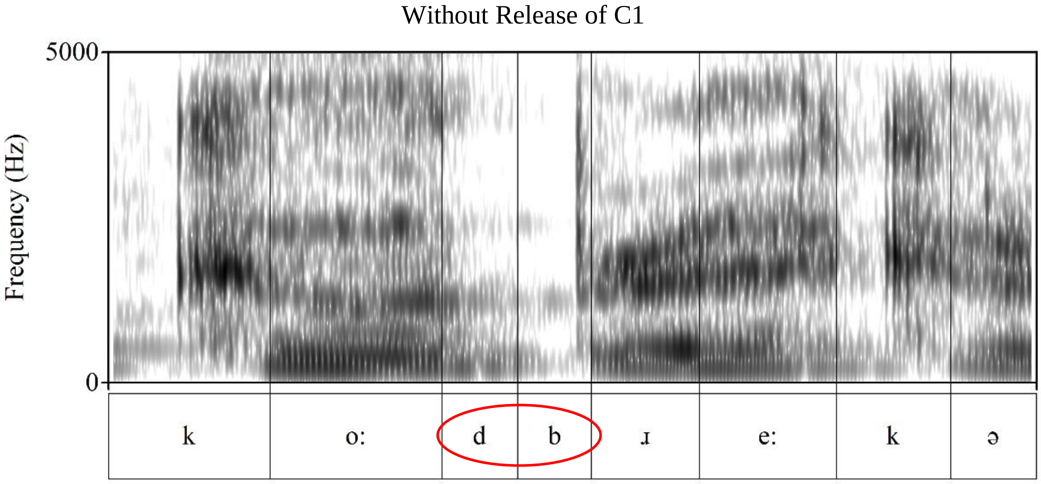


Figure 2: The segmented spectrogram of *toad venom* (above) shows that C1 and C2 have similar durations. As a result, the spectrogram of *code breaker* (below) was segmented according to this observation.

Once all relevant segmental boundaries were determined and loaded into *R*, the V/C ratio was calculated for every item. This was done for two reasons. Firstly, the participants' speech rate often varied during the experiment which resulted in a skewed distribution of length measurements. By converting the length measurements into a relative measure the data was normalised. Secondly, by turning two separate measurements into a single variable, the data analysis was greatly simplified.

The paired-samples *t*-test was selected because items from different contexts "[were] meaningfully paired" (Johnson, 2008, p. 79): they formed sets of 4 words with matching vowels and C1s. As a result, any set which contained an item that could not be segmented due to misinterpretation or hesitation was excluded from statistical analysis. One-tailed *p*-values were calculated for the *t*-tests because specific directional predictions could be made regarding the V/C ratios of the respective contexts[8]. The distribution of the items in the respective contexts was tested for normality using Shapiro-Wilk tests. In addition, the data were inspected visually using Q-Q plots and histograms.

[8] A sample of the participants was also analysed using two-tailed *t*-tests. The *p*-values of those tests were very similar to the *p*-values produced by the one-tailed tests.

4. Results

4.1 V/C Ratio

Table 3 is based on the previously established assimilation patterns and classifies the participants by the patterns that they showed. The compound patterns in the table were only considered if the Shapiro-Wilk test on the assimilation items reached significance, i.e. if their distribution was not normal.

Table 3: Speaker IDs are given followed by the number of sets that were considered in parentheses. The speaker ID is given in bold if fewer than 5 (of a total 16) sets of items were removed because of production errors. Speaker ID is given in grey if the classification is tentative rather than definitive.

No assimilation	No assimilation + Incomplete assimilation	Incomplete assimilation	Complete assimilation + Incomplete assimilation	Complete assimilation	Complete assimilation + No assimilation	Complete assimilation + No assimilation + Incomplete assimilation
W08 (11)		W01 (7)			W02 (10)	
W14 (6)		W03 (10)				
W16 (12)		W04 (10)				
W19 (13)		**W07** (13)				
		W09 (10)				
		W13 (15)				
		W15 (14)				
		W17 (11)				
		W18 (16)				
4 (29%)		9 (64%)			1 (7%)	

On first impression, then, it seems that most speakers assimilated, and that when they did, they did so incompletely. Some speakers did not assimilate at all and a single speaker displayed ambiguous assimilatory patterns. A representative example from each of the attested patterns will now be discussed in more detail (see Appendix E for full results). Firstly, consider the V/C ratio distributions for a non-assimilating speaker in Figure 3. The Shapiro-Wilk tests in Table 4 show that all distributions in the figure approach normality.

Table 4: Results of Shapiro-Wilk tests for normality for speaker W19.

Context	**Test statistic *W***	**Shapiro-Wilk test *p*-values**
Assimilation	0.9551020	0.6771580
Voiced	0.9462231	0.5423147
Voiceless	0.9439823	0.5104898
Sonorant	0.9729971	0.9272774

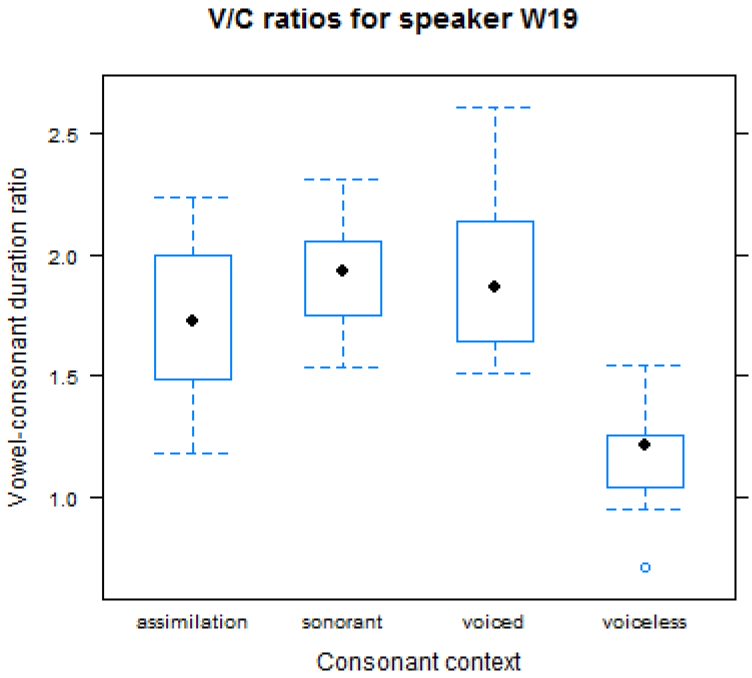


Figure 3: Boxplots of V/C ratio distributions for speaker W19.

Based solely on Figure 3, it seems that the V/C ratios of the voiceless context are considerably lower than those of the other contexts, which seem more similar, though it would be hard to draw any specific conclusions. The results of the paired *t*-tests in Table 5 shed some more light on these first impressions.

Table 5: Results of one-tailed paired *t*-tests for speaker W19. Significant *p*-values are in bold.

Tests for:	*t*-test samples	Test statistic *t*	*p*-values
V/C ratio as cue for voicing	Voiced – Voiceless	8.7484559	**0.0000007439437**
Yorkshire Assimilation	Assim. – Voiced	-1.7483280	0.0529590486311
Incomplete Yorksh. Assim.	Assim. – Voiceless	5.0995205	**0.0001310059000**
RVA in Voiced context	Voiced – Sonorant	0.3643748	0.3609590233431

The result of the first test in table above confirms the suspicion that the V/C ratio of the voiced context was significantly higher than that of the voiceless context, $t(12) = 8.75$, $p < .001$. This is in accordance with the idea that V/C ratio is a reliable cue for the voicing distinction in English. The second *t*-test shows that the mean V/C ratio of the assimilation context is not significantly lower than that of the voiced context, $t(12) = -1.75$, $p = .053$. This *p*-value, which is only slightly higher than the .05 significance threshold, indicates that this speaker does not assimilate. The third *t*-test shows that the mean V/C ratio of the assimilation context is significantly higher than that of the voiceless context, $t(12) = 5.10$, $p < .001$, which is unsurprising given the negative result for assimilation. Finally, the fourth test demonstrates that the mean V/C ratio of the voiced context is not significantly higher than that of the sonorant context, $t(12) = 0.36$, $p = .36$, which indicates that no regressive voicing assimilation occurred in the voiced context. This is important because it allows a fair comparison of the V/C ratios of the voiced context with those of the voiceless and the assimilation contexts.

A similar analysis can be applied to speakers who incompletely assimilate. Figure 4 displays the respective distributions of such a speaker and Table 6 shows that once again all distributions are close to normal.

Table 6: Results of Shapiro-Wilk tests for normality for speaker W13.

Context	**Test statistic *W***	**Shapiro-Wilk test *p*-values**
Assimilation	0.9164523	0.1700300
Voiced	0.9637235	0.7567542
Voiceless	0.9217102	0.2045459
Sonorant	0.9409303	0.3942120

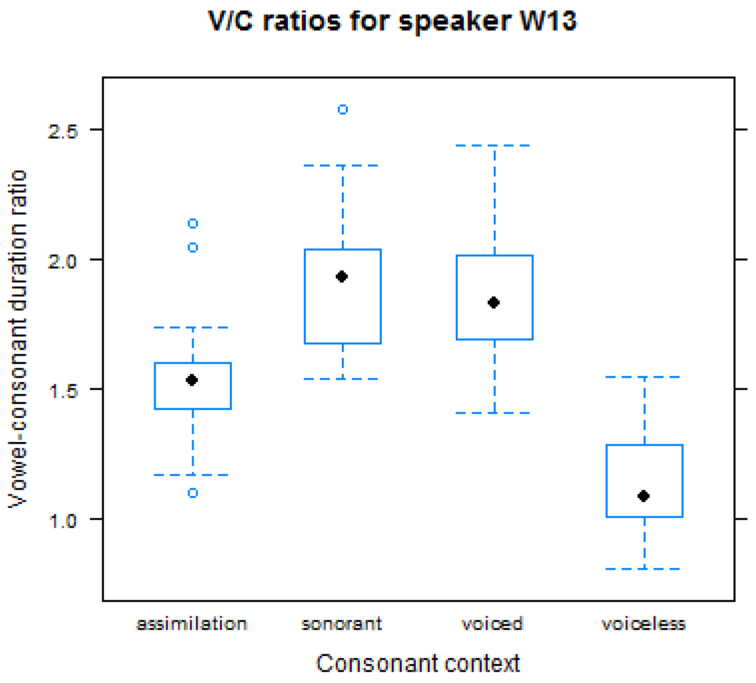


Figure 4: Boxplots of V/C ratio distributions for speaker W13.

Again a clear difference between the voiceless context and voiced and sonorant context can be noted and, in this case, the distribution of the assimilation context seems to differ from all other distributions. The assimilation also seems to have a few outliers at both ends of the V/C ratio spectrum, which might be to blame for the lower, though still non-significant, *p*-value of the Shapiro-Wilk test. Table 7 shows the results of different paired *t*-tests that were conducted.

Table 7: Results of one-tailed paired *t*-tests for speaker W13. Significant *p*-values are in bold.

Tests for:	***t*-test samples**	**Test statistic *t***	***p*-values**
V/C ratio as cue for voicing	Voiced – Voiceless	14.4801642	**0.0000000004054231**
Yorkshire Assimilation	Assim. – Voiced	-3.0603204	**0.0042372183887636**
Incomplete Yorksh. Assim.	Assim. – Voiceless	5.0318697	**0.0000916821714024**
RVA in Voiced context	Voiced – Sonorant	-0.4723676	0.6780283487885184

These results indicate that the mean V/C ratio of the voiced context was significantly higher than that of the voiceless context, $t(14) = 14.5$, $p < .001$. Furthermore, the mean V/C ratio of the assimilation context is significantly lower than that of the voiced context, $t(14) = -3.06$, $p = .004$, which shows that this speaker does in fact assimilate. However, the mean V/C ratio of the assimilation context is also significantly higher than that of the voiceless context, $t(14) = 5.03$, $p < .001$, suggesting that assimilation is incomplete for this speaker. Finally, the mean V/C ratio of the voiced context is not significantly higher than that of the sonorant context, $t(14) = -0.47$, $p = .68$, which indicates that no regressive voicing assimilation occurred in the voiced context. Therefore, the comparison between the mean V/C ratio of the voiced context with those of the voiceless and the assimilation context was fair.

Lastly, it seems that assimilation was variably present and absent for one speaker. This is hinted at in the results of the Shapiro-Wilk tests in Table 8 and the boxplots in Figure 5, which are visibly different from those based on the other speakers' data.

Table 8: Results of Shapiro-Wilk tests for normality for speaker W02. Numbers in bold represent significant *p*-values.

Context	**Test statistic *W***	**Shapiro-Wilk test *p*-values**
Assimilation	0.8387289	**0.04260333**
Voiced	0.9641088	0.83150933
Voiceless	0.9256732	0.40670614
Sonorant	0.9424411	0.58048216

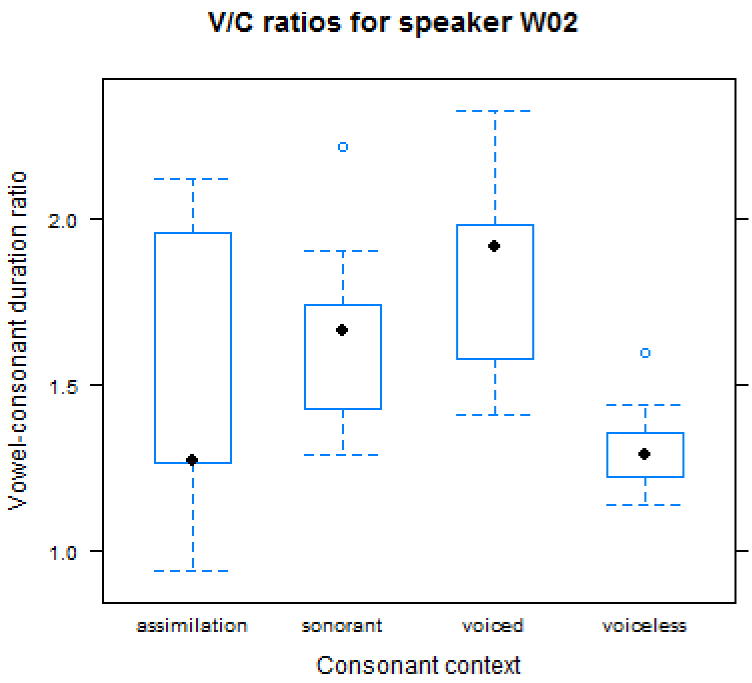


Figure 5: Boxplots of V/C ratio distributions for speaker W02.

First of all, the Shapiro-Wilk test on the V/C ratios of the assimilation context reached significance, $W = .84$, $p = .043$, which means that the distribution of values for that context was not similar to a normal distribution. Furthermore, inspection of Figure 5 reveals a very broad range of V/C values. In order to make sense of these results, a more detailed look at the assimilation data is required. This is provided by the histogram in Figure 6.

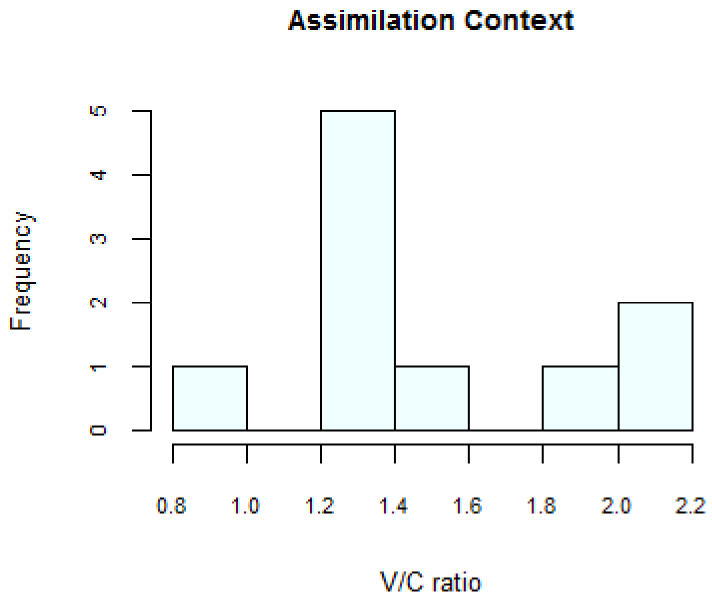


Figure 6: Histogram of the V/C ratio distributions for speaker W02's assimilation context items.

Although the low number of items makes it difficult to draw any statistically robust conclusions, it does seem as if there are two or even three separate groupings of V/C ratio values. The best strategy for normalisation seems to be the exclusion of the three items with the highest V/C ratios. Nevertheless, a Shapiro-Wilk test on the remaining values was only just non-significant, $W = .81$, $p = .053$. The usual *t*-tests in Table 9 reveal that the mean V/C ratio of the remaining items in the voiced context is significantly greater than that of the sonorant context, $t(6) = 4.00$, $p = .004$. As such, no definitive statements can be made on whether assimilation is complete or not, even though the non-significant *p*-value of the *t*-test comparing V/C ratios of the assimilation and voiceless contexts, $t(6) = -1.04$, $p = .83$, does suggest complete assimilation for these items. Speaker W02 is therefore only tentatively classified as either fully assimilating or not assimilating at all.

Table 9: Results of one-tailed paired *t*-tests for a selection of speaker W02's items. Significant *p*-values are in bold.

Tests for:	***t*-test samples**	**Test statistic *t***	***p*-values**
V/C ratio as cue for voicing	Voiced – Voiceless	5.196610	**0.0010107354**
Yorkshire Assimilation	Assim. – Voiced	-6.611598	**0.0002881155**
Incomplete Yorksh. Assim.	Assim. – Voiceless	-1.043000	0.8314307960
RVA in Voiced context	Voiced – Sonorant	4.001585	**0.0035530707**

It goes without saying that the results above should be interpreted with caution because of the extremely low number of items. It is perhaps more fruitful to ask whether the 3 items that seemed unaffected by their assimilatory context have anything in common. These items were: *food#fight*, *paid#for* and *toad#fish*. All of these have a plosive, [d], as C1 and fricative, [f], as C2. Moreover, the one remaining item which has the same configuration was excluded from analysis for W02 because of a hesitation in production. Further statistical tests would be required to determine whether this is a coincidence or a significant relationship which can be found in the other participants' data as well. The current investigation will not pursue this topic any further, apart from noting that the number of speakers for whom normality of the assimilation context would be improved by excluding this type of item is higher than the number of speakers for whom it would deteriorate (10 versus 3).

4.2 Glottalisation

Surprisingly, given previous descriptions, no glottal forms could be identified in any of the productions of the regular stimuli. The extra stimulus *Bradford*, included because of its frequent mentions in the literature, yielded one glottal form in the main experiment. The oscillogram and spectrogram of this realisation are given in Figure 7.

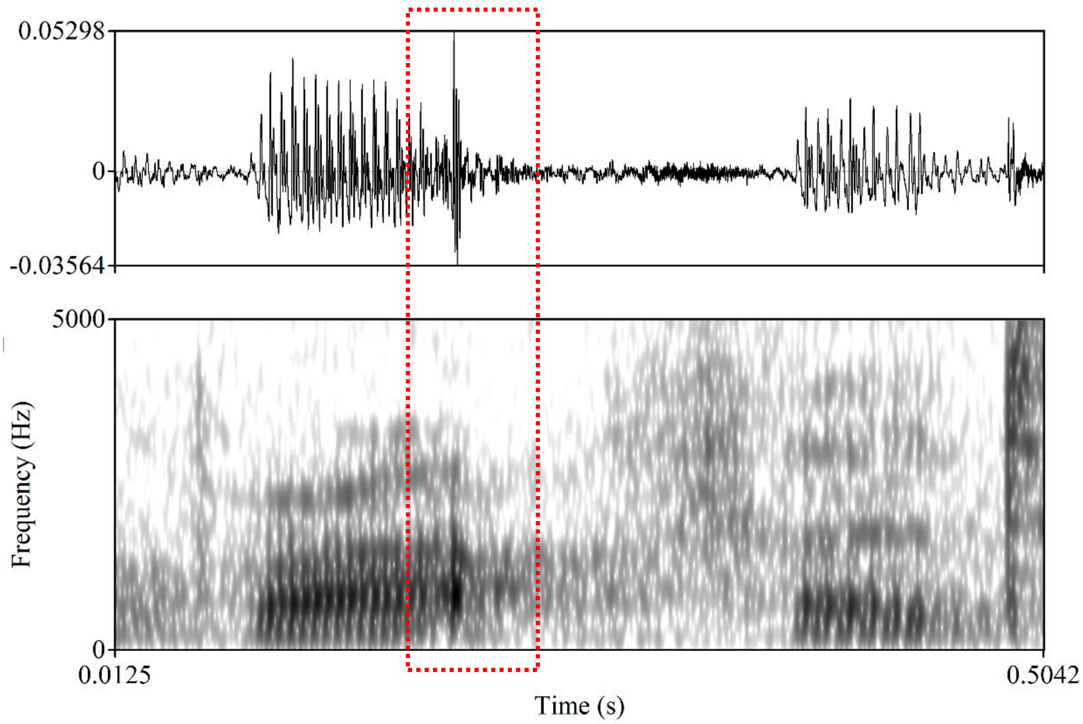


Figure 7: Oscillogram and spectrogram of speaker W16's realisation of *Bradford*.

The waveform shows an irregular pattern towards the end of the first vowel. This single glottal pulse manifests itself in spectrogram as a visible transient. A slightly different glottal realisation of *Bradford* was encountered in the pilot experiment, as visualised in Figure 8. This speaker shows a more extended period of creaky voice as evidenced by three irregularly spaced glottal pulses. In this experiment, then, glottal forms were very rare and when they occurred, they occurred in the most stereotypical example of Yorkshire Assimilation. At least for speaker Y03, a special status for *Bradford* is made more likely by the fact that the speaker, after being asked about its pronunciation immediately following the experiment, produced two alternate versions of *Bradford*: one which was quite similar to the recorded production and another which lacked glottalisation and included an alveolar stop at the end of the first syllable. There seems to be some awareness, then, of this place name's dialectal pronunciation[9].

[9] A similar role can perhaps be ascribed to the name of the West Yorkshire town of *Pudsey*, which is sometimes pronounced as Pu[ts]ey (Clive Upton, personal communication).

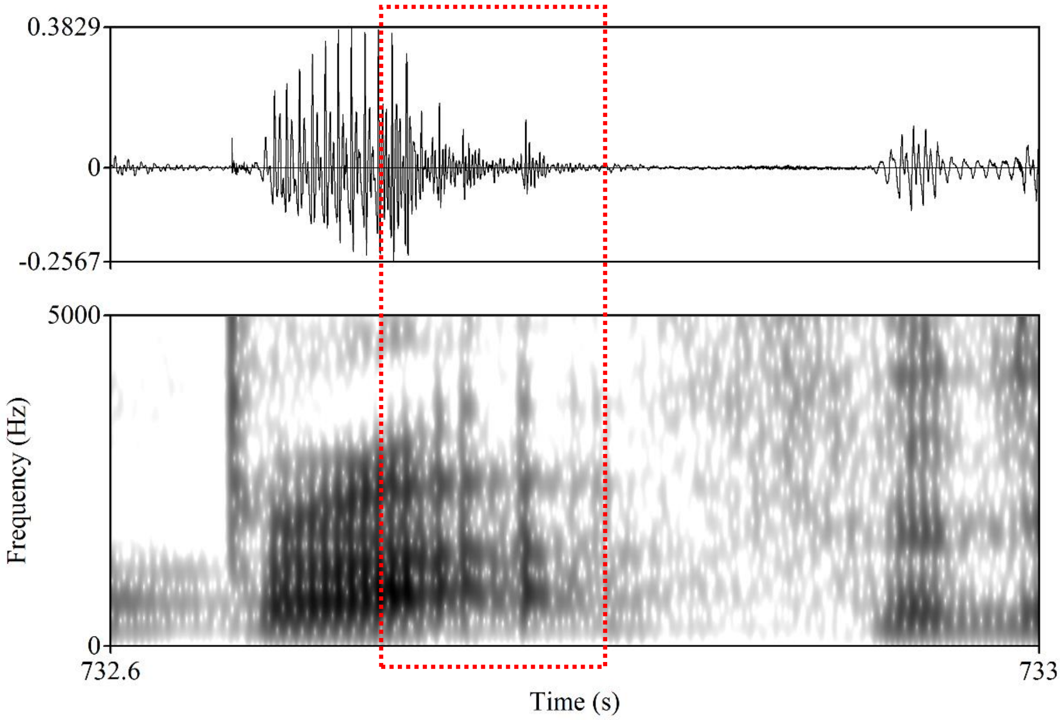


Figure 8: Oscillogram and spectrogram of speaker Y03's realisation of *Bradford*.

Given the discrepancy in the number of glottals reported in the present research and in the descriptions of previous researchers, it might be interesting to revisit those descriptions that were accompanied by audio recordings. The three examples of Yorkshire Assimilation in the recordings accompanying the Survey of English Dialects were all transcribed as having some sort of glottalisation, be it full glottal replacement or glottal reinforcement. Firstly, consider the realisation of *Bradfield*, transcribed as [bræʔfiːld], in Figure 9.

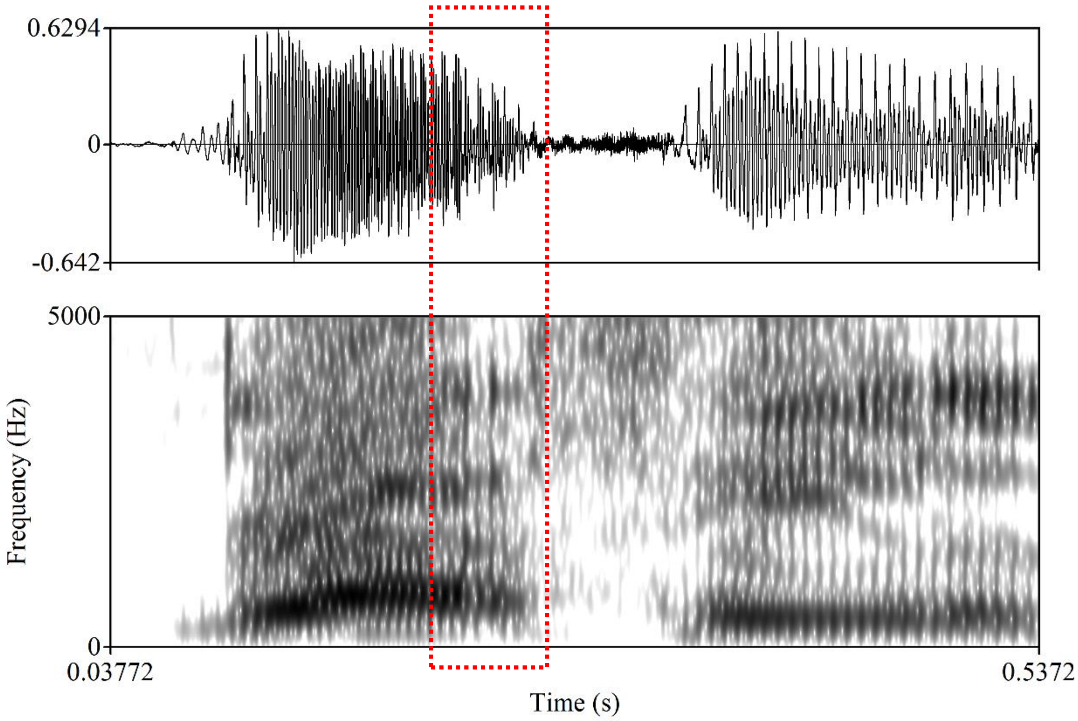


Figure 9: Oscillogram and spectrogram of an SED recording of *Bradfield*.

This production shows clear signs of glottalisation and with at least two visible irregular glottal pulses it resembles the production in Figure 8. As *Bradfield* is another place name—and one which is only slightly different from *Bradford*—this finding does not provide much evidence for a general phonological process. However, the realisation of *old shirt* in Figure 10, transcribed as [ɔːlʔ ʃət], also shows some signs of glottalisation.

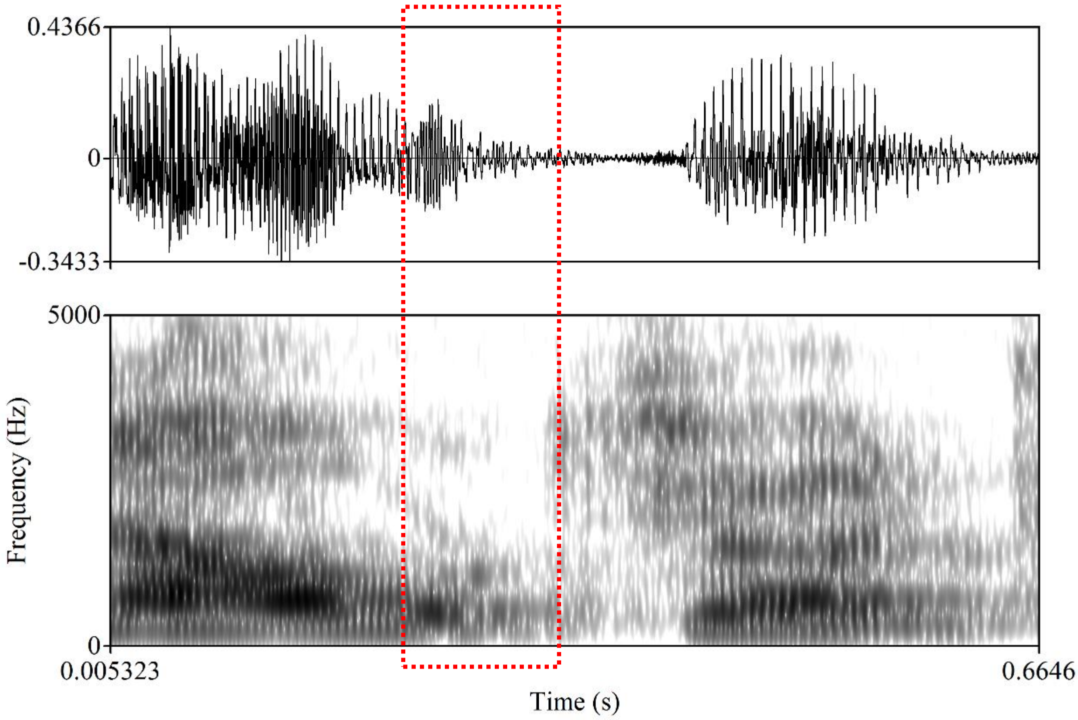


Figure 10: Oscillogram and spectrogram of an SED recording of *old shirt*.

Although it is hard to tell due to the quality of these old recordings, it does seem that there are some irregular glottal pulses towards the end of *old*. Additionally, there is no clear audible or visible alveolar stop burst, although its detection is made more difficult by the homorganic fricative that directly follows. Note that apart from *Bradford* the only other form for which Wells transcribes a glottal stop is *old people*. This could be indicative of a lexical effect involving *old*.

Finally, the transcription [peːʔt fɒ] for an SED recording of *paid for* indicates that the final alveolar is glottally reinforced. However, inspection of the waveform and spectrogram in Figure 11 reveals no glottal stops or irregular glottal action. There is some residual voicing during the closure for the alveolar stop but if anything this should count towards the obstruent not having assimilated. Perhaps the fact that the final stop was not released with much alveolar friction was misinterpreted by the transcriber as being the result of glottalisation. In both the pilot experiment in York and the final experiment in Windhill, it was often the case that final stops remained unreleased. The resulting spectrograms, see Figure 12 for example, look very similar to that of the supposedly glottalised realisation of *paid for*. It is possible that misinterpretations such as these have resulted in glottal forms being overrepresented in descriptions of Yorkshire Assimilation.

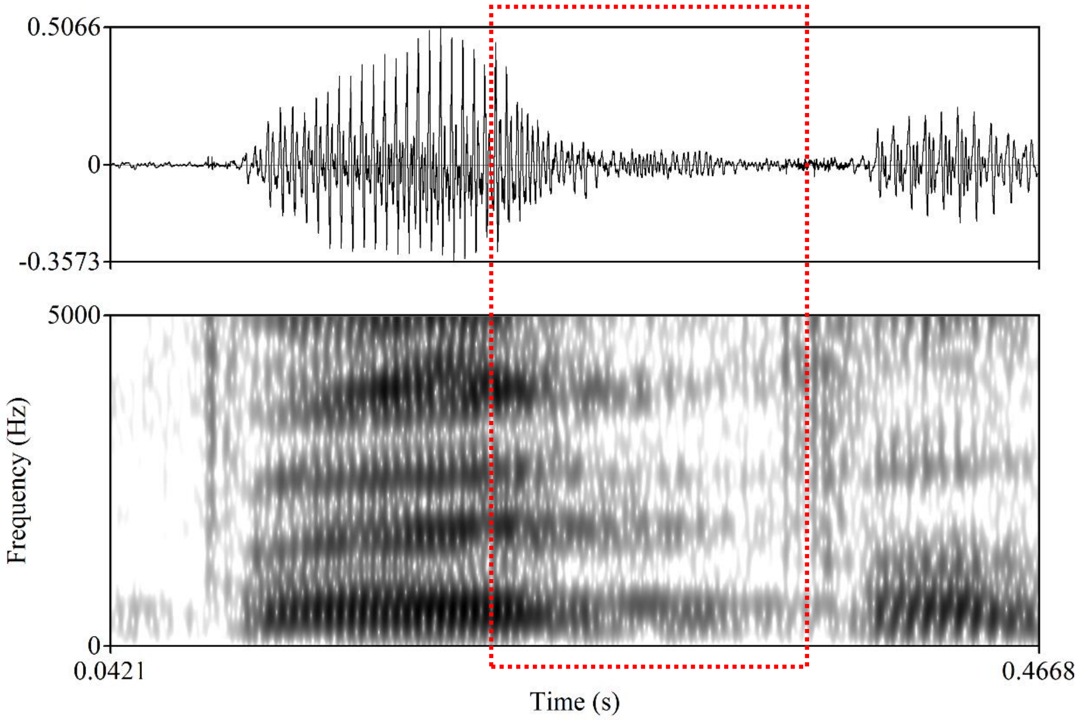


Figure 11: Oscillogram and spectrogram of an SED recording of *paid for*.

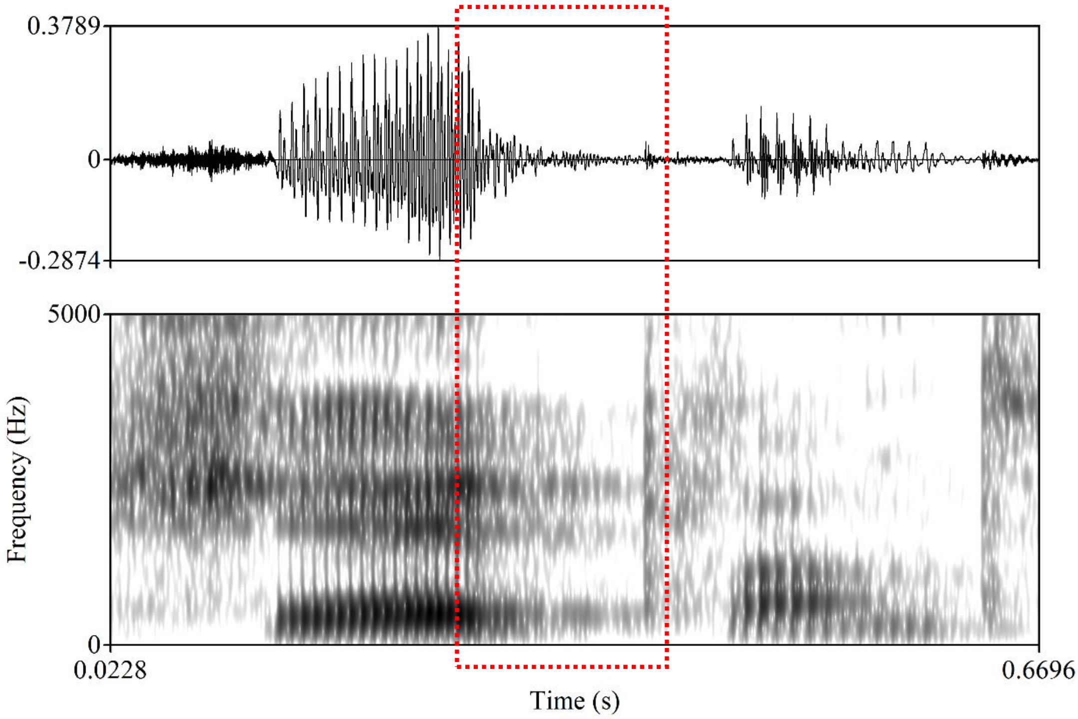


Figure 12: Oscillogram and spectrogram of speaker W18’s realisation of *shade plant*.

5. Discussion

5.1 Interpretation of Results

In the Theoretical Framework of this thesis, two key questions about the characteristics of Yorkshire Assimilation were posed. The first of these was whether the process could be purely phonetic or if some phonological aspect needs to be assumed as well. It was argued that segmental duration of a final obstruent and the vowel preceding it are reliable cues for the relevant voicing distinction and that these cues could not be influenced by a purely phonetic process. Consequently, if any assimilation of these cues were found in West Yorkshire English, it could be concluded that the assimilation process must be at least partly phonological. Furthermore, it was posited that if glottal forms occurred, this would also count as evidence for a phonological alternation, because these too could not be explained using exclusively phonetic principles. Glottal forms were not found in the regular stimuli and, as a result, they cannot be used to determine the nature of Yorkshire Assimilation. However, the results show that 10 out of the 14 participants that were considered (i.e. 71%) showed some form of assimilation of segmental duration. It can therefore be argued that Yorkshire Assimilation does have a phonological quality.

Secondly, the question was raised whether the assimilation was categorical or gradient. Three hypotheses were put forward which outlined the possibilities regarding this issue. They have been reproduced in (15).

(15) H_0: Given a population of speakers displaying some form of Yorkshire Assimilation, this process is categorical for all of them.

H_1: Given a population of speakers displaying some form of Yorkshire Assimilation, this process is gradient for all of them.

H_2: Given a population of speakers displaying some form of Yorkshire Assimilation, this process is both categorical and gradient.

These hypotheses can be related to the results by determining whether assimilation of V/C ratio was complete, incomplete or both. If every single participant showed complete assimilation, it would be categorical for all of them (H_0). Conversely, if all participants showed incomplete assimilation, it would be gradient for all of them (H_1). Another option would be that some participants showed complete assimilation and others showed incomplete assimilation. In this case, the process would be both categorical and gradient (H_2). Finally, this second alternative hypothesis would also be supported if individual participants showed both complete and incomplete assimilation.

It is clear from the results that the null hypothesis cannot be maintained, as only one participant showed some indication of complete assimilation. Instead, the data seem to support the first alternative hypothesis: 9 out of the 10 people who assimilated did so incompletely. However, there was one participant who left some items unassimilated and completely assimilated the remaining items. This result calls to mind the findings by Ellis and Hardcastle (2002) that were discussed earlier. In the present study, this speaker's apparently bimodal behaviour could unfortunately not be confirmed in a statistically robust way. Furthermore, it needs to be taken into account that apart from V/C ratio other parameters that were not analysed in the current investigation also play a role in cueing the voicing distinction under consideration. Consequently, even if further research shows that some speakers completely assimilate some items, it may well be that other cues would still render those assimilations gradient. Until further research has been conducted, then, it would be safest to hold that the first alternative hypothesis receives strong support from the current experimental results and that Yorkshire Assimilation is gradient. Although there are signs that it is categorical for some speakers, this remains to be confirmed.

5.2 Theoretical Implications

The main theoretical relevance of the findings presented above is that they provide evidence against the notion that *phonological* and *gradient* are mutually exclusive qualities. This assumption is often made in order to provide a clear distinction between phonetics and phonology (Ernestus, 2011, p. 2116), but experimental findings have suggested that the distinction between gradience and categoricality cannot always be equated with the distinction between phonetics and phonology (Pierrehumbert et al., 2000, p. 287). Previously investigated instances of gradient voicing assimilation (e.g. Kuzla et al., 2007; Jansen, 2007), though problematic for generative phonology if they are treated as phonological processes, could be reinterpreted as phonetic processes. As a result they do not challenge a distinction based on categoricality and gradience. Jansen's (2007) study of voicing assimilation in Standard Southern British English is especially valuable in light of the current findings. He interprets the gradient assimilation that was found as a result of "the coarticulation of […] gestures" (2007, p. 290). Jansen is able to give this interpretation precisely because some cues, namely vowel and obstruent duration, did not assimilate. As Jansen explains, an account of assimilation based on the purely physical interaction of subsequent articulations would not result in assimilation of such cues (2007, p. 289). However, the present study did find assimilation of durational cues and, as such, cannot be analysed using a framework inspired by phonetics. Moreover, because of its apparently gradient nature, it cannot be analysed using traditional generative frameworks, which are based on categorical contrasts. The case of Yorkshire Assimilation, then, perfectly illustrates the problems with two prominent approaches to phonological and phonetic knowledge. Generative approaches posit a distinction between phonology and phonetics that is too restrictive, and, by not making a distinction at all, an approach such as Articulatory Phonology is only suited for processes that are phonetically "natural" (Ladefoged, 1990, p. 404). A wholly different kind of model, then, is necessary to account for the type of productions that are characteristic of Yorkshire Assimilation. This thesis will not attempt to specify such a framework other than requiring it to allow phonological alternations that are also gradient.

6. Conclusion

At the outset of this thesis, it was argued that very little empirical evidence for Yorkshire Assimilation was available and that, consequently, not much could be said about its characteristics. In order to provide insight into this linguistic phenomenon, the present study acoustically and statistically analysed Yorkshire Assimilation as it manifested itself in the speech of 14 West Yorkshire speakers. The results showed that vowel-consonant duration ratio, a consistent cue to the voicing distinction in English, incompletely assimilated for most speakers. As this quality is unnatural from a phonetic account, it can be concluded that Yorkshire Assimilation is both phonological and gradient. Although these findings are in line with previous classifications of this process as different from more general phonetic devoicing processes in English (e.g. Wells, 1982; cf. Jansen, 2007), they contradict the earlier claims that Yorkshire Assimilation is categorical (e.g. Wells, 1982). In addition, previous accounts claimed that this alternation could also result in glottal stops (Wells, 1982, p. 367). However, acoustic analysis in the present investigation showed that glottal stops were very rare and limited to a single lexical item.

Although the current investigation has made some steps towards the classification of Yorkshire Assimilation, a detailed definition of its identity remains to be given. For instance, this thesis did not thoroughly investigate whether the manner of articulation of an obstruent in assimilation context plays a role in the degree of assimilation. Similarly, possible effects of place of articulation on assimilation were not considered, as the stimuli only contained items with alveolar C1s. Furthermore, a complete investigation of Yorkshire Assimilation would take every cue for the voicing distinction into account. Such research would be particularly interesting in the case of Yorkshire Assimilation, because it could determine whether coarticulatory forms of assimilation (as discussed in Jansen, 2007) are a factor in the alternation as well. Ideally, such an account would incorporate perception experiments to shed some light on the relative importance of the respective cues. It should also be noted, of course, that the speech elicited in the current production experiments is far from natural and that, ideally, corpora of natural speech should be used.

Another limitation of the present research is that it does not provide an explanation for Yorkshire Assimilation. That is to say, it does not answer the following question: Why do speakers from West Yorkshire assimilate, whereas speakers from other parts of the UK do not? Both diachronic and sociolinguistic research would be required to provide an answer to that question and, given the findings regarding glottalisation, lexical effects would have to be considered as well. An excellent start to such an effort would be to investigate the recent history of Yorkshire Assimilation by comparing speech corpora which were compiled at different points in time but which include speech from a similar group of speakers. In regard to West Yorkshire dialect, the Houck (Houck, 1968) and Morley (Richards, 2008) corpora provide such a pair. Apart from working towards an explanation for Yorkshire Assimilation, a diachronic line of investigation might provide crucial insights on the interaction between phonology and phonetics, a topic that has been avoided by the current thesis.

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Appendix A: List of Stimuli

Test Items:

	Assimilation Context	Voiceless Context	Voiced Context	Sonorant Context
d#p				
Close	food#poisoning	boot#polish	food#bank	food#waste
	speed#painting	seat#pads	speed#boat	speed#limit
Close-mid	toad#pond	coat#pocket	code#breaker	code#word
	shade#plant	skate#park	spade#beard	spade#work
d#f				
Close	speed#freak	seat#frame	seed#vault	speed#walking
	food#fight	boot#faced	food#vendor	food#mixer
Close-mid	toad#fish	boat#fishing	toad#venom	code#name
	paid#for	state#funded	jade#vein	aid#worker
z#p				
Close	blues#pianist	goose#pimples	blues#band	blues#melody
	cheese#plate	peace#pipe	cheese#burger	cheese#wire
Close-mid	maize#plant	face#paint	maize#bread	phase#meter
	hose#pipe	dose#pump	nose#bone	nose#muscles
z#f				
Close	blues#fan	goose#fat	blues#violin	blues#music
	cheese#fingers	peace#fighter	cheese#vat	cheese#wedge
Close-mid	maize#field	space#flight	blaze#victim	maze#map
	nose#fracture	dose#feeder	nose#vein	nose#wipes
Short - d#p				
	bed#post	jet#pack	head#band	head#wear
	blood#pressure	nut#paste	blood#bath	mud#water
Short - d#f				
	mud#flap	nut#flower	blood#vow	flood#wave
	head#phones	jet#fighter	head#vein	head#massage

Additional stimulus: Brad#ford

Fillers:

	I	OI	O	E	-
au#short					
coda	sound#mix	oyster#dish	mouth#wash	house#arrest	sound
no-coda	cow#milk	toy#pistol	flower#pot	flower#bed	plough
au#long					
coda	mouth#piece	noise#meter	house#owner	house#maid	house
no-coda	cow#thief	soy#beans	cow#bone	flower#shaped	cow
ai#short					
coda	price#list	oil#filter	time#slot	wine#belly	price
no-coda	eye#lid	toy#bridge	eye#drop	eye#lens	eye
ai#long					
coda	rhyme#scheme	foil#sheet	mile#stone	wine#maker	rhyme
no-coda	fly#wheel	soy#leaf	high#note	eye#shade	high

Appendix B: *Mix* Script

```
ItemFile C:\Users\Tim\Documents\final_items.txt

Property item_type 3
Property item_number 4
Property item_condition 5
Property obstruent_sequence 6
Property item_type_b 8

// Constraint 1: Start with a filler.

LineType actualitem 3 item
LineBan actualitem 1

// Constraint 2: 6 subsequent fillers at most.

Constraint item_type MaxRep 6

// Constraint 3: 5 subsequent actual items at most.

Constraint item_type_b MaxRep 5

// Constraint 4: 2 subsequent actual items from the same item set at most.

Constraint item_number MaxRep 2 ConditionalUpon item_type_b

// Constraint 5: 3 subsequent actual items with the same C1 at most

Property C1 6 Sub 1
Constraint C1 MaxRep 3 ConditionalUpon item_type_b

// Constraint 6: If subsequent items have the same obstruent sequence,
their condition cannot be the same.

Constraint item_condition MaxRep 1 ConditionalUpon obstruent_sequence

// Constraint 7: Actual items in which 1 word is the same must be at a
distance of 8 or greater.

Property first_three 1 Sub 1:3
Constraint first_three MinDist 9 ConditionalUpon item_type_b

Seed 25
OutputFile C:\Users\Tim\Documents\final_items_randomized_seed25.txt
```

Appendix C: *Unix* Shell Script

```
#!/bin/bash

printf "vowel_start\tvowel_end\tcons_start\tcons_end\tword\n" >
~/Documents/W15_dataset.txt

for FILE in $HOME/Documents/W15_text/W15*

do

cat $FILE | sed -e '1,18d' | sed '/intervals/ d' | sed '/text/ d' | tr -d
"(xmin|xmax) = " | sed -e '5,6d' | tr -d "\r" | tr "\n" "\t" >>
~/Documents/W15_dataset.txt

printf "$FILE" | sed 's/\/Users\/tim\/Documents\/W15_text\/W15_//' | sed
's/.TextGrid//' | tr "_" "#" >> ~/Documents/W15_dataset.txt

done
```

Appendix D: *R* Script

```
# Loads vowel and consonant measurements and a template file with which
they will be merged

W15_dataset = read.delim("~/R_files/YA/W15_dataset.txt")
format_final = read.delim("~/R_files/YA/format_final.txt")

options(scipen=999) # Prevents numbers being given in scientific notation

# Calculates segment durations from raw measurements and calculates the
Vowel-Consonant Duration Ratio (V/C ratio)

W15_dataset$vowel_length = W15_dataset$vowel_end-W15_dataset$vowel_start
W15_dataset$cons_length = W15_dataset$cons_end-W15_dataset$cons_start
W15_dataset$ratio = W15_dataset$vowel_length/W15_dataset$cons_length

# Cleans up the dataframe and merges the durations and ratio with the
template

format_final = format_final[format_final$vowel_type == "long" , c("word",
"stimulus_number", "item_number", "item_condition", "obstruent_sequence",
"vowel_type")]

lengths = W15_dataset[ , c("word", "vowel_length", "cons_length",
"ratio")]

W15_dataset_t.test = merge(format_final, lengths, by.x = "word", by.y =
"word")

W15_dataset_t.test =
W15_dataset_t.test[order(W15_dataset_t.test$stimulus_number), ]

# Makes Box and Whisker plots of V/C ratio for the different experimental
contexts

library(lattice)
par(mfrow = c(1,1))

bwplot(ratio ~ item_condition, data = W15_dataset_t.test, xlab =
"Consonant context", ylab = "Vowel-consonant duration ratio", main = "V/C
ratios for speaker W15")

# prep work for the upcoming for-loop

W15_long_assimilation =
W15_dataset_t.test[W15_dataset_t.test$item_condition == "assimilation" &
W15_dataset_t.test$vowel_type == "long", "ratio"]

W15_long_voiceless = W15_dataset_t.test[W15_dataset_t.test$item_condition
== "voiceless" & W15_dataset_t.test$vowel_type == "long", "ratio"]

W15_long_voiced = W15_dataset_t.test[W15_dataset_t.test$item_condition ==
"voiced" & W15_dataset_t.test$vowel_type == "long", "ratio"]

W15_long_sonorant = W15_dataset_t.test[W15_dataset_t.test$item_condition
== "sonorant" & W15_dataset_t.test$vowel_type == "long", "ratio"]

W15_ratios = list(W15_long_assimilation, W15_long_voiced,
W15_long_voiceless, W15_long_sonorant)

W15_nms = c("W15_long_assimilation", "W15_long_voiced",
"W15_long_voiceless", "W15_long_sonorant")
```

```
# gives histograms, QQ-plots and Shapiro-Wilk tests for the distributions
of the respective contexts

par(mfrow = c(2,4))
counter = 1
W15_norm_shapiro_p.value = rep(0, 4)
W15_norm_shapiro_statistic = rep(0, 4)

for (v in W15_ratios){
  hist(v, main = W15_nms[counter], xlab = "V/C ratio")
  qqnorm(v, main = W15_nms[counter])
  qqline(v)
  W15_norm_shapiro_p.value[counter] = shapiro.test(v)$p.value
  W15_norm_shapiro_statistic[counter] = shapiro.test(v)$statistic
  counter = counter + 1
}

W15_norm = data.frame(W15_nms, W15_norm_shapiro_statistic,
W15_norm_shapiro_p.value)

names(W15_norm) = c("Context", "Test statistic W", "Shapiro-Wilk p-value")
print(W15_norm)


# Performs one-sided paired t-tests comparing voiced-voiceless,
assimilation-voiced, assimilation-voiceless and voiced-sonorant
distributions respectively

W15_long_effects_p.value = rep(0, 4)

W15_long_effects_p.value[1] = t.test(W15_long_voiced, W15_long_voiceless,
paired=T, alternative="greater")$p.value

W15_long_effects_p.value[2] = t.test(W15_long_assimilation,
W15_long_voiced, paired=T, alternative="less")$p.value

W15_long_effects_p.value[3] = t.test(W15_long_assimilation,
W15_long_voiceless, paired=T, alternative="greater")$p.value

W15_long_effects_p.value[4] = t.test(W15_long_voiced, W15_long_sonorant,
paired=T, alternative="greater")$p.value

W15_long_effects_statistic = rep(0, 4)

W15_long_effects_statistic[1] = t.test(W15_long_voiced,
W15_long_voiceless, paired=T, alternative="greater")$statistic

W15_long_effects_statistic[2] = t.test(W15_long_assimilation,
W15_long_voiced, paired=T, alternative="less")$statistic

W15_long_effects_statistic[3] = t.test(W15_long_assimilation,
W15_long_voiceless, paired=T, alternative="greater")$statistic

W15_long_effects_statistic[4] = t.test(W15_long_voiced, W15_long_sonorant,
paired=T, alternative="greater")$statistic

W15_effects_nms = c("voicing effect: p < 0.05", "assim.: p < 0.05", "comp.
assim.: p > 0.05", "RVA: p < 0.05")

W15_effects = data.frame(W15_effects_nms, W15_long_effects_statistic,
W15_long_effects_p.value)

names(W15_effects) = c("Effects", "Test statistic t", "t-test p-values")
print(W15_effects)
```

Appendix E: Full Results

Speaker W01:

Context	Test statistic *W*	Shapiro-Wilk test *p*-values
Assimilation	0.8274711	0.10230137
Voiced	0.8384156	0.12647674
Voiceless	0.8620575	0.19633735
Sonorant	0.7847886	0.04270043

Tests for:	*t*-test samples	Test statistic *t*	*p*-values
V/C ratio as cue for voicing	Voiced – Voiceless	2.7142128	**0.02103211**
Yorkshire Assimilation	Assim. – Voiced	-2.5094119	**0.02693335**
Incomplete Yorksh. Assim.	Assim. – Voiceless	2.1669048	**0.04123233**
RVA in Voiced context	Voiced – Sonorant	-0.8104863	0.77275410

Speaker W03:

Context	Test statistic *W*	Shapiro-Wilk test *p*-values
Assimilation	0.9729775	0.91699542
Voiced	0.8622675	0.08114908
Voiceless	0.9658361	0.84978558
Sonorant	0.9827114	0.97801398

Tests for:	*t*-test samples	Test statistic *t*	*p*-values
V/C ratio as cue for voicing	Voiced – Voiceless	7.9811425	**0.00001127801**
Yorkshire Assimilation	Assim. – Voiced	-2.7222154	**0.01176117767**
Incomplete Yorksh. Assim.	Assim. – Voiceless	3.2673397	**0.00486198605**
RVA in Voiced context	Voiced – Sonorant	-0.0896155	0.53472230871

Speaker W04:

Context	Test statistic *W*	Shapiro-Wilk test *p*-values
Assimilation	0.9373250	0.5236494
Voiced	0.9757146	0.9381963
Voiceless	0.9568237	0.7491380
Sonorant	0.9436480	0.5942717

Tests for:	*t*-test samples	Test statistic *t*	*p*-values
V/C ratio as cue for voicing	Voiced – Voiceless	8.3093564	**0.00000816314**
Yorkshire Assimilation	Assim. – Voiced	-2.9101461	**0.00865356622**
Incomplete Yorksh. Assim.	Assim. – Voiceless	5.0299016	**0.00035473101**
RVA in Voiced context	Voiced – Sonorant	0.1670836	0.43549904785

Speaker W07:

Context	Test statistic *W*	Shapiro-Wilk test *p*-values
Assimilation	0.8878971	0.09130763
Voiced	0.9600522	0.75446697
Voiceless	0.8859642	0.08593264
Sonorant	0.9375877	0.42643382

Tests for:	*t*-test samples	Test statistic *t*	*p*-values
V/C ratio as cue for voicing	Voiced – Voiceless	7.6422220	**0.000002993604**
Yorkshire Assimilation	Assim. – Voiced	-3.3236561	**0.003034479818**
Incomplete Yorksh. Assim.	Assim. – Voiceless	3.5753806	**0.001907249554**
RVA in Voiced context	Voiced – Sonorant	-0.5352191	0.698861969664

Speaker W08:

Context	Test statistic *W*	Shapiro-Wilk test *p*-values
Assimilation	0.9780490	0.9543401
Voiced	0.9270211	0.3815092
Voiceless	0.9716241	0.9024349
Sonorant	0.9062058	0.2197692

Tests for:	*t*-test samples	Test statistic *t*	*p*-values
V/C ratio as cue for voicing	Voiced – Voiceless	3.9637194	**0.001335164**
Yorkshire Assimilation	Assim. – Voiced	-0.7414680	0.237731178
Incomplete Yorksh. Assim.	Assim. – Voiceless	2.7350744	**0.010504810**
RVA in Voiced context	Voiced – Sonorant	0.2476116	0.404722447

Speaker W09:

Context	Test statistic *W*	Shapiro-Wilk test *p*-values
Assimilation	0.9492651	0.6598131
Voiced	0.9576449	0.7587207
Voiceless	0.9385196	0.5366611
Sonorant	0.9115081	0.2915119

Tests for:	*t*-test samples	Test statistic *t*	*p*-values
V/C ratio as cue for voicing	Voiced – Voiceless	9.217897	**0.000003508783**
Yorkshire Assimilation	Assim. – Voiced	-2.857795	**0.009424015469**
Incomplete Yorksh. Assim.	Assim. – Voiceless	5.344872	**0.000232739735**
RVA in Voiced context	Voiced – Sonorant	0.494078	0.316542594369

Speaker W14:

Context	Test statistic *W*	Shapiro-Wilk test *p*-values
Assimilation	0.9574659	0.8000132
Voiced	0.8602307	0.1899588
Voiceless	0.9223095	0.5221483
Sonorant	0.8841897	0.2888544

Tests for:	*t*-test samples	Test statistic *t*	*p*-values
V/C ratio as cue for voicing	Voiced – Voiceless	7.4681068	**0.0003397905058**
Yorkshire Assimilation	Assim. – Voiced	0.5521094	0.6976785324077
Incomplete Yorksh. Assim.	Assim. – Voiceless	30.2128408	**0.0000003725906**
RVA in Voiced context	Voiced – Sonorant	-0.1695712	0.5640027197551

Speaker W15:

Context	Test statistic *W*	Shapiro-Wilk test *p*-values
Assimilation	0.8976787	0.1043711
Voiced	0.9311220	0.3163780
Voiceless	0.9504107	0.5670993
Sonorant	0.8977074	0.1044711

Tests for:	*t*-test samples	Test statistic *t*	*p*-values
V/C ratio as cue for voicing	Voiced – Voiceless	10.849382	**0.00000003466077**
Yorkshire Assimilation	Assim. – Voiced	-4.129709	**0.00059267462421**
Incomplete Yorksh. Assim.	Assim. – Voiceless	2.689393	**0.00928280171651**
RVA in Voiced context	Voiced – Sonorant	0.343635	0.36830746313986

Speaker W16:

Context	Test statistic *W*	Shapiro-Wilk test *p*-values
Assimilation	0.9589787	0.7741668
Voiced	0.9371047	0.5212691
Voiceless	0.9436906	0.5947606
Sonorant	0.9623823	0.8126590

Tests for:	*t*-test samples	Test statistic *t*	*p*-values
V/C ratio as cue for voicing	Voiced – Voiceless	4.746964	**0.0005243214**
Yorkshire Assimilation	Assim. – Voiced	-1.654099	0.0662474022
Incomplete Yorksh. Assim.	Assim. – Voiceless	3.530638	**0.0032037631**
RVA in Voiced context	Voiced – Sonorant	-1.798502	0.9471795709

Speaker W17:

Context	Test statistic *W*	Shapiro-Wilk test *p*-values
Assimilation	0.9711933	0.8983125
Voiced	0.9255609	0.3677057
Voiceless	0.8896253	0.1375775
Sonorant	0.9445641	0.5755398

Tests for:	*t*-test samples	Test statistic *t*	*p*-values
V/C ratio as cue for voicing	Voiced – Voiceless	8.4349068	**0.000003692158**
Yorkshire Assimilation	Assim. – Voiced	-3.0842540	**0.005778286998**
Incomplete Yorksh. Assim.	Assim. – Voiceless	8.0028833	**0.000005868917**
RVA in Voiced context	Voiced – Sonorant	0.7002592	0.249866274294

Speaker W18:

Context	**Test statistic *W***	**Shapiro-Wilk test *p*-values**
Assimilation	0.9323232	0.26528915
Voiced	0.9103516	0.11789948
Voiceless	0.9380527	0.32584195
Sonorant	0.8885049	0.05275398

Tests for:	***t*-test samples**	**Test statistic *t***	***p*-values**
V/C ratio as cue for voicing	Voiced – Voiceless	7.291884	**0.000001322184**
Yorkshire Assimilation	Assim. – Voiced	-1.998203	**0.032079084335**
Incomplete Yorksh. Assim.	Assim. – Voiceless	3.706673	**0.001055026315**
RVA in Voiced context	Voiced – Sonorant	-2.702740	0.991815695371