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Variation in STRUT and BATH in the Stratford-upon-Avon area

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Jednocześnie przyjmuję do wiadomości, że gdyby powyższe oświadczenie okazało się nieprawdziwe, decyzja o wydaniu mi dyplomu zostanie cofnięta.

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(miejscowość, data) (czytelny podpis)

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ED	Euclidean distance
ME	Middle English
OF	older females
OM	older males
OS	older speakers
RP	Received Pronunciation
S	the *S*-centroid
SED	*Survey of English Dialects*
SD	standard deviation
YF	younger females
YM	younger males
YS	younger speakers

Introduction

This thesis investigates the variation in the phonetic properties of the STRUT and BATH vowels in the accent of the Stratford-upon-Avon area in the south-eastern West Midlands of England.[1] The variables have been chosen because of their status as two arguably most salient pronunciation features that distinguish northern and southern accents of British English. Previous descriptions of the West Midlands varieties show the Stratford-upon-Avon area lying in the transitional zone between the linguistic North and the linguistic South. These accounts, however, are based on relatively old data from the investigation of traditional rural accents.

This thesis aims at establishing whether the previous descriptions still apply to the modern accent of the Stratford-upon-Avon area. A study in apparent time is conducted to examine the variation in the realisation of STRUT and BATH across age and sex. The research questions ask whether there are any differences in the pronunciation of the vowels between younger and older speakers. Does the variation allow to fully include the Stratford-upon-Avon area on either side of the North-South border, changing its reportedly unequivocal status?

The thesis is structured as follows. Chapter 1 provides the necessary information about the area and variables under study, as well as states the research questions and expected results. Chapter 2 describes the methodology employed in the collection and analysis of data. Chapter 3 presents and analyses the results of the study. Finally, the conclusions section summarises the findings and tries to answer the research questions posed in the first chapter.

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[1] This paper uses Wells' vowel keywords for standard lexical sets so that STRUT refers to lexical sets containing the /ʌ/ vowel and BATH to lexical sets containing the /ɑː/ vowel (Wells 1982: xviii-xix).

Chapter 1: Background

1.1. Summary

This chapter provides the background information about the area and linguistic variables studied, as well as states the aims and expectations of the study. The chapter begins with the classification of regional varieties of British English into northern and southern in section 1.2. We also discuss the status of the West Midlands area as belonging to the linguistic North and the status of the Stratford-upon-Avon area as a transitional belt between the two zones. Section 1.3 provides a brief diachronic overview of the FOOT– STRUT split and BATH broadening. We observe that the lack of uniformity in the development of STRUT and BATH from a wide array of sources is caused by an incomplete lexical diffusion. Section 1.4 provides an overview of previous accounts of the phonetic properties of STRUT and BATH in Received Pronunciation and the accents of the West Midlands, including the Stratford-upon-Avon area. The chapter ends with section 1.5 that poses the research questions and describes the expected results.

1.2. The area under study

1.2.1. The West Midlands as a part of the linguistic North

The regional varieties of British English are generally divided into northern and southern (Wells 1982: 349). But the linguistic North starts lower than the geographical North. There are two salient pronunciation features that mark the North-South divide in regional accents. First, speakers in the North pronounce such words as *cup* with the FOOT vowel as [kʊp], while speakers in the South, as a result of the FOOT–STRUT split, pronounce it with the STRUT vowel as [kʌp]. Second, Northern speakers pronounce such words as *glass* with a vowel similar to TRAP[2] as [glæs], in contrast to southern speakers who, as a result of BATH broadening, use a fully back and long BATH vowel and pronounce such words as [glɑːs] (Wells 1982: 349-356). Therefore, the border between the linguistic North and South runs parallel to the isoglosses for the two aforementioned features in broad regional varieties (Wells 1982: 349). Another classification aligns the border with the line running from the River Severn to the Wash (Wells 1982: 350).

Even though the West Midlands lie in the centre of the country, the region is classified as the linguistic North. Similarly to the aforementioned difference between the geographical and the linguistic North, the linguistic West Midlands area does not encompass the entire geographical West Midlands region. Wells (1982: 350, 364) restricts the area to the county of West Midlands. Clark (2008: 145, 150) defines the area as centred at Wolverhampton, Birmingham, Walsall, West Bromwich and Coventry and notes that, being "just on the Northern side of the main North-South dialect isoglosses, has features typical of both northern and southern British English accents".

1.2.2. The Stratford-upon-Avon area as a transition between the North and South

The Stratford-upon-Avon area lies in south-western Warwickshire. The county of Warwickshire is located in the eastern part of the West Midlands region and borders on

[2] Similar but not identical because in some regions the northern BATH may be either short or long (Wells 1982: 354).

“Staffordshire to the north-west; Leicestershire to the north-east; Northamptonshire to the east; Oxfordshire and Gloucestershire to the south-east and south-west; and by Worcestershire and the West Midlands metropolitan county to the west” (Warwickshire County Council 2012).

This paper focuses on the town of Stratford-upon-Avon and four neighbouring settlements located within an 11 km radius of the town: two villages and two hamlets. The two villages are Newbold-on-Stour (11 km south-east of Stratford-upon-Avon) and Wilmcote (6.8 km north-west of Stratford-upon-Avon). The two hamlets are Crimscote (11 km south-east of Stratford-upon-Avon) and Wimpstone (7 km south of Stratford-upon-Avon).

Previous descriptions of Warwickshire – as well as the positions of the FOOT–STRUT split and BATH broadening isoglosses mentioned above – are based mostly on *Survey of English Dialects* (Orton and Barry [1969] 1998). *SED* data in Warwickshire was collected between the November and December of 1956. *SED* fieldworkers visited 7 places in Warwickshire (Orton and Barry 1998: 36-38). None of the surveyed locations, however, are those under study here. Nevertheless, three of them are located relatively close: Aston Cantlow (10.5 km north-west of Stratford-upon-Avon, 3 informants), Lighthorne (19 km east of Stratford-upon-Avon, 5 informants), Shipston-on-Stour (17.8 km south-east of Stratford-upon-Avon, 2 informants). Still, *SED* data presents two problems. First, the data is relatively old – it was collected over half a century ago. Second, *SED* sample is not particularly representative, as the survey investigated only the speech of old males in rural settings (Orton [1962] 1998: 15).

The position of the Stratford-upon-Avon area on the accentual map of England is ambiguous. As we established in section 1.2.1, the North starts with the West Midlands and Warwickshire is generally not treated as a part of this region (Wells 1982: 350). One notable exception here is Orton and Barry (1998), who include the data on Warwickshire in the volume of *SED* devoted to the West Midlands. Regarding the two southern pronunciation features, on the one hand, the area may belong to the South because most people report that the BATH broadening isogloss runs slightly above it (Wells 1982: 355; Trudgill 2004: 26; Upton and Widdowson 2006: 18). On the other hand, it may belong to the North because the isogloss for the FOOT–STRUT split passes below the area (Wakelin [1977] 1991: 87; Upton and Widdowson 2006: 26). The latter isogloss, however, seems to be slowly moving southwards, as Trudgill (2004: 38) reports that already in the southern part of Warwickshire *but* rhymes with *butt*. Figure 1 below, adapted from Chambers and Trudgill (1998: 107), shows the location of the Stratford-upon-Avon and one possibility of where the two isoglosses could run.

Figure 1. Stratford-upon-Avon and the FOOT–STRUT and BATH broadening isoglosses.

Prior to the investigation of the possible realisational variants of STRUT and BATH in the West Midlands and the Stratford-upon-Avon area, it is necessary to describe the processes that resulted in the creation of the two variables. The following section describes the development and sources of the two vowels.

1.3. The two southern innovations

1.3.1. The FOOT–STRUT split

As Wells (1982: 196-197) notes, most accents of English on the British Isles and beyond have six short vowels and use two different vowels in such words as *put* and *putt* (the FOOT and STRUT vowel, respectively). However, originally words from those two lexical sets were pronounced with only one vowel – the FOOT vowel. The STRUT vowel was added as the sixth short vowel to the five-part short vowel system of Middle English as a result of a phonemic split (Wells 1982: 351).

A phonemic split is a division of an existing phoneme that creates a new phonemic contrast (Labov 1994: 331). The FOOT–STRUT split was a phonemic split of FOOT into FOOT and STRUT. The split took place some time around 1650 (Wells 1982: 197), perhaps even as early as around 1550 (Radford et al. 2009: 65). It may be supposed that Londoners first started using an unrounded vowel similar to [ɤ] which then lowered to [ʌ] in the 1800s (Cruttenden 2008: 115, Radford et al. 2009: 54).

The innovation spread out of London, but did not reach the far North. Because, for reasons unknown, the split did not take place there, broad northern accents still have a five-part short vowel system and use the FOOT vowel for words that have the STRUT vowel in the South (Wells 1982: 351).

1.3.2. BATH broadening

BATH is just one of the three lexical sets that use /ɑː/ in RP, the other two being PALM and START (Wells 1982: 133-134). Accents of English are either flat-BATH or broad-BATH, depending on which vowel they use in the BATH lexical set. Flat-BATH accents use a vowel similar to TRAP, so that *castle* and *hassle* are pronounced with the same vowel, as /kæsəl/ and /hæsəl/ respectively. Broad-BATH accents will distinguish between a BATH vowel in /kɑːsəl/ and a TRAP vowel in /hæsəl/ (Wells 1982: 134).

The BATH words are the result of the TRAP–BATH split, a phonemic split that took place around the 17th century (Upton and Widdowson 2006: 19). Starting at [æ~a], the vowel first lengthened to [æː~aː] around the second half of the 17th century (Upton and Widdowson 2006: 19). By the mid-18th century, when the standard accent used [aː] in the PALM words and [aːr] in the START words, BATH still used [æː] (Wells 1982: 232). Around the 18th century, the BATH vowel broadened, i.e. lowered and retracted to [ɑː] (Upton and Widdowson 2006: 19). By the 20th century all three lexical sets used [ɑː] (Wells 1982: 232).

Similarly to the FOOT–STRUT split, BATH broadening was somehow inhibited and the change did not involve all the words similar to BATH (Wells 1982: 232). Such situations may be described as failures of lexical diffusion:

> The sound change was evidently subject to gradual lexical diffusion through the vocabulary items which met the structural description of the sound change in question; but this lexical diffusion was then arrested before all the relevant items had undergone change (Wells 1982: 100-101).

1.3.3. The FOOT–STRUT split and BATH broadening as examples of lexical diffusion

Typically, a phonemic split is caused by a change in the phonetic environment of a vowel. One example of such a phonemic split would be the development of [iə] as an allophone of /iː/ before /r/ in RP (Wells 1982: 100). The two allophones [iː] and [iə] would have remained in complementary distribution if the loss of the preconsonantal and word-final /r/ had not happened. Because of the loss, people could no longer distinguish between such word pairs as *bead* [biːd] and *beard* [biəd] solely on the basis of the word-final [r] and had to pay more attention to the quality of the vowel.[3]

The two splits the effects of which are discussed here were not ordinary phonemic splits caused by a change in the phonetic environment of FOOT or BATH. Instead, they were caused by incomplete lexical diffusion and are therefore examples of a less common type of split – lexical split (Labov 1994: 333-334, 347). One characteristic feature of a lexical split is that, superficially, the change progresses regularly but there are unexplained exceptions to it. In present-day English the occurrence of /ʌ/ in STRUT and /ɑː/ in BATH is not at all random and at first glance may look as it is a result of complex phonetic conditioning. However, one cannot predict the incidence sole-

[3] Although this is just a simplification for the sake of clarity, for more details see Wells (1982: 213-215).

ly on the basis of phonetic environment because there are many exceptions to the conditions. The following section outlines the main sources of the STRUT and BATH lexical sets with examples of unexplained exceptions.

1.3.3.1. The sources of STRUT

There are many sources of the STRUT words. As it is beyond the scope of this thesis to retrace every source, only a brief outline of the two main sources will be provided here (see also Wells 1982: 196-199; Cruttenden 2008: 116).

The STRUT vowel is sometimes called 'short U' because most words containing the vowel can be traced back to the Middle English (ME) /u/, as in RP *cut* /kʌt/ or *dull* /dʌl/ (Wells 1982: 132; 197). At first, it may look as if the FOOT vowel did not change when following a labial consonant, e.g. *put* /pʊt/ or *full* /fʊl/ (Wells 1982: 197). Even if one finds what seems to be a regularity, for example that /ʊ/ was not retained following a labial and preceding a /g/ or /dʒ/, as in *bug* /bʌg/ or *fudge* /fʌdʒ/, there is a counterexample to that, e.g. *sugar* /ʃʊgə/ (Labov 1993: 347). Moreover, there are words starting with labials that did undergo the change, e.g. *fun* /fʌn/ or *mud* /mʌd/ (Wells 1982: 197).

Another source of the STRUT words is the shortened ME /o:/, as in *flood* /flʌd/ or *blood* /blʌd/ (Wells 1982: 132). This extends the range of possible exceptions even further, as FOOT did not change preceding apicals and /k/, as in *wood* /wʊd/ or *book* /bʊk/ (Labov 1993: 347).

1.3.3.2. The sources of BATH

The BATH words show signs of semi-regular occurrence in certain phonetic environments similar to STRUT. But again, the lexical set displays many irregularities too.

In RP, the BATH vowel occurs before word-final /s/ or /θ/, as in *path* /pɑ:θ/ or *class* /klɑ:s/ but not in *math* /mæθ/ or *lass* /læs/ (Wells 1982: 232). It is used when preceding a sequence of a nasal and a voiceless obstruent in words of French origin, e.g. *dance* /dɑ:ns/ but not in *romance* /rəʊˈmæns/ (Labov 1993: 334).

Again, even if one would like to narrow it down to just one very precise phonetic context, e.g. preceding the /mpl/ cluster, as in *example* /ɪgˈzɑːmpl/, no rule could be devised anyway, since there will always be exceptions to it with such irregular developments as, e.g. *ample* /æmpl/ (Labov 1994: 334).

1.4. The variables under study

1.4.1. STRUT

1.4.1.1. STRUT in Received Pronunciation

Before we investigate the possible regional realisational variants of STRUT, it is necessary to briefly describe its standard pronunciation in the reference accent of British English – Received Pronunciation, or RP.[4]

The IPA symbol traditionally used for STRUT is that of the half-open back unrounded vowel ʌ. However, STRUT has a markedly different phonetic realisation, an effect of changes that took place in the 20th century. At the beginning of the century, Jones (1909, as cited in Fabricius 2007: 296-297) described STRUT as a half-open back vowel, which was at the same height as NURSE and schwa and more back than the two. A couple of decades later, Wells (1982:131) described it already as "half-open or slightly opener, centralized-back or central."

Apparently, the STRUT vowel was steadily fronting until in the second half of the 20th century the degree of advancement stopped at [ɐ~a] due to rapid TRAP lowering (Cruttenden 2008: 115, Wells 1982: 291-292). Most recent accounts suggest backing and raising of STRUT in RP (Fabricius 2007: 310; Upton and Widdowson 2006: 27).

[4] There is little agreement regarding the name of the reference accent of British English. For the sake of clarity, I shall follow Wells (1982: 117) and use this label.

1.4.1.2. STRUT in the West Midlands

The West Midlands accents of British English are traditionally described as lacking the FOOT-STRUT phonemic contrast, and having [ʊ] in both the FOOT and STRUT words (Clark 2008: 156).

This is, however, only partially true, as it refers just to basilects, i.e. the least prestigious or standard varieties. Wells (1982: 351-352) notes that the area exhibits some degree of sociolinguistic variation and local RP-like accents of the area, including the West Midlands accent, use two distinct vowels in FOOT and STRUT. There is a considerable lack of agreement, however, as to the exact phonetic properties of STRUT (Clark 2008: 157). The descriptions range from [ɤ], through [ə] to [ʌ] (Wells 1982: 352; Collins and Mees 2003: 150; Clark 2008: 157).[5]

Regarding the Stratford-upon-Avon area, there is little previous quantitative empirical research on STRUT. In most *SED*-based sources, the FOOT–STRUT isogloss runs just below the area, which means that the speakers of this accent should not recognise the FOOT–STRUT opposition (Wakelin 1991: 87; Upton and Widdowson 2006: 26). But as seen above, the descriptions of the West Midlands accents in general suggest [ɤ~ə] (Wells 1982: 352; Clark 2008: 156-157) or even [ʌ] (Trudgill 2004: 38).

1.4.2. BATH

1.4.2.1. BATH in Received Pronunciation

As Wells (1982: 133) notes, in RP "BATH words belong phonetically with (…) PALM and START", that is all three lexical sets use an open back [ɑː]. Since the completion of BATH broadening, there have been no reports of any significant changes in the phonetic realisation of BATH in RP.

[5] Chambers and Trudgill (1998: 110) describe such STRUT realisation as fudged and the varieties that use it as fudged varieties.

1.4.2.2. BATH in the West Midlands

The southern broad BATH innovation is reportedly absent from the West Midlands varieties of British English, with BATH pronounced with a short vowel similar to RP TRAP [æ~a] (Wells 1982: 351). This is true, however, only for the northern part of the region, as in the southern West Midlands the realisation varies from [aː] (Upton and Widdowson 2006: 18) to [ɑː] (Clark 2008: 158).

Similarly to the FOOT–STRUT split, BATH broadening in the Stratford-upon-Avon area has been a rather neglected research topic. Again, a major source of information are works based on *SED* that show the BATH broadening isogloss running above the area, indicating a broad-BATH accent. While there is widespread agreement that the vowel is long, accounts vary as regards the degree of backness. Some indicate [aː] (Wakelin 1991: 86; Upton and Widdowson 2006: 18), whereas others [ɑː] (Hughes and Trudgill 1989: 31; Collins and Mees (2003: 144).

1.5. Research questions and expected results

This thesis is an empirical study of variation in the phonetic realisation of STRUT and BATH in the accent of the Stratford-upon-Avon area, a transitional belt between the northern and southern varieties of English. As we have seen, there is not much research on the accent of this variety and this is probably the first ever instrumental study of the STRUT and BATH vowels in this area. The study aims at answering two research questions regarding the accent and proving a hypothesis formulated on their basis.

First, what are the phonetic properties of STRUT and BATH? Since *SED* examined old speakers of broad rural accents 56 years ago, the isoglosses for the FOOT–STRUT and BATH broadening may not reflect the present-day situation. The modern accent of the Stratford-upon-Avon area should have the FOOT-STRUT opposition, with the STRUT vowel pronounced as [ɤ~ʌ]. As regards BATH, because this far South the vowel is reportedly long, this study focuses only on its quality. I expect little retraction, along the lines of [aː], but a quality overall distinct from TRAP.

Second, is there any variation in the quality of STRUT and BATH across age and sex? I expect some generational variation, with the more traditional fudged [ɤ] realisation in the older speakers and a southern-like [ʌ] in the younger speakers. If the younger generation uses a more southern STRUT realisation, it will also most likely use a more mainstream fully retracted [ɑː] for BATH. I do not make any assumptions about variation in males and females, as previous research includes no information on this.

If the expectations regarding these two questions are confirmed, it will also confirm the hypothesis put forward here that the Stratford-upon-Avon area is no longer on the border between the linguistic North and South, but lies on its southern side.

Chapter 2: Methods

2.1. Summary

This chapter presents the details of the fieldwork carried out in the Stratford-upon-Avon area and the methodology used in the investigation of the variables.[6] A brief account of how the field research was conducted is presented in section 2.2. The following section (2.3) describes the idea behind studying language variation in apparent time and provides basic demographic information about 16 informants studied. Section 2.4 provides information on the sociolinguistic interview that this study is based on: the recording equipment, the reading passage and wordlist used to elicit speech from the respondents and the tokens selected for analysis. The chapter finishes with the description of the methods used in the acoustic analysis of the tokens and describe the techniques for the normalisation, presentation and quantification of the F1 and F2 values.

2.2. Fieldwork

The study analyses data obtained in January and February 2012 in the Stratford-upon-Avon area. The fieldwork was conducted in the town of Stratford-upon-Avon and four neighbouring villages and hamlets located within an 11 km radius of the town: Newbold-on-Stour, Crimscote, Wimpstone and Wilmcote. Nine days of recordings yielded

[6] I would like to thank dr Jarosław Weckwerth for helpful comments on my fieldwork and expert practical advice on instrumental analysis.

370 minutes of recordings from 22 informants, out of which 16 were chosen for the present study (see section 2.3.2.1).

Before the fieldwork began, I established contact with two informants online. New informants were then recruited on-site using snowball sampling. The firsts two informants put me in contact with informants who in most cases agreed for an interview. The respondents did not receive remuneration for their participation.

2.3. Sample

This study is conducted within the apparent-time framework. Before we examine the demographic characteristics of the sample under study, it is necessary to take a closer look at the main assumptions behind the method, as it determined the structure of the sample.

2.3.1. Apparent-time study

Language variation and change may be studied by variationist sociolinguistics in two ways: in real time or in apparent time (Stockwell 2007: 15). A real-time study involves the comparison of data collected in the same speech community at different points in time. Even though that is the preferable method for investigating change, it has its drawbacks. A panel study, that is, a longitudinal observation of one group of speakers is costly and time-consuming, and therefore rarely used (Labov 1994: 44). A trend study, which compares current findings with a previous study of a supposedly similar representative sample of the community under study, may present methodological problems (Labov 1994: 44). There may be differences between the two studies that will render the comparison unreliable, for example different aims or data collection procedures. Therefore, the traditional diachronic method of observing linguistic variation and change remains virtually inaccessible for most researchers.

Instead, modern sociolinguistics relies more on studies in apparent time. An apparent-time study compares data obtained at only one point in time but from speakers belonging to different age groups. This method operates under the assumption that if two or more groups display similar social and stylistic characteristics, any linguistic differences between the groups are evidence of a real-time diachronic change (Labov 2006: 200). In other words, "[b]y comparing the speech of those born in 1920 with that of those born in 1970, (…) we are comparing the language acquired by children at two distinct points in the history of the language" (Radford et al. 2009: 66). The biggest advantage of this method over a real-time study is that it is synchronic – it does not require long-term arrangements.

2.3.2. Demographic characteristics of the sample

2.3.2.1. Number, age and sex

Out of the 22 available informants, 16 that matched the age requirements of either of the two age groups were chosen for the present study. Although such a small number of speakers is not sufficient for a very detailed description, the results are still likely to be representative of the area (Labov et al. 2006: 3). The respondents were grouped according to two social variables: age and sex. The four groups, or cohorts, were coded as follows: younger males (YM), younger females (YF), older males (OM) and older females (OF). Each group comprised four informants. They were numbered from the youngest to the oldest, e.g. YF1 was the youngest and YF4 the oldest informant in the younger females group.

The younger males ranged in age from 23 to 27 years (mean: 25.25, standard deviation, or SD,: 2.1). Similarly, the younger females ranged in age from 23 to 27 years (mean: 25.25, SD: 1.7). The older males ranged in age from 40 to 57 years (mean: 46.75, SD: 7.3). The older females ranged in age from 38 to 60 years (mean: 49.5, SD: 12.2). Individual informants' age is provided in Appendix A, p. 49. Detailed demographic data is provided in Appendix B, p. 49.

2.4. Interviews

The material for analysis was obtained through a standard sociolinguistic data-gathering procedure: the sociolinguistic interview. On average, an interview lasted for about 30 minutes and consisted of three parts. Each part aimed at eliciting a separate speech style: conversational, reading and wordlist style. First, the informants were asked demographic questions and then talked about pleasant experiences, e.g. recounted childhood memories, which should elicit casual conversational style (Feagin 2004: 30-31). Second, they read out aloud a reading passage (provided in Appendix C, p. 50). Third, they read out aloud a wordlist (target tokens provided in Appendix D, p. 51).

The respondents were recorded at their respective homes and in one case, in a parked car. The settings were generally quiet, although some degree of background noise, such as traffic outside, is unavoidable in a field study. The quality of the recordings was generally very good.

In the majority of cases, I interviewed two respondents at a time in an attempt to lessen the observer's paradox, that is the degree of self-monitoring of speech (Stockwell 2007: 3). On the one hand, as Wells (1982: 38) noted, "there is probably no substitute for being a native of the locality under investigation" and an outsider to a group is always going to remain an outsider. On the other hand, informing the participants that they will be recorded already helps in minimising the observer's paradox (Stockwell 2002: 3). The participants were reassured that whatever they said would be entirely acceptable.

2.4.1. Recording equipment and settings

The recordings were made on a Marantz PMD-660 portable solid-state recorder, using a DPA miniature omnidirectional XLR microphone.[7] The interviews were recorded in 16 bit mono, PCM-44.1K.

[7] Both were kindly made available to me by the Center for Speech and Language Processing AMU.

2.4.2. Tokens

Although the interview structure included both conversational and reading styles, only the reading passage and wordlist tokens are analysed because the conversational part of the interviews did not yield enough tokens in the desired phonetic context for all the informants. Although samples of natural speech would probably reveal a more realistic picture, controlled speech allows for a more reliable comparison of tokens across speakers because each subject's data includes tokens in the same phonetic context (Thomas 2011: 138-139).

The reading passage and wordlist tokens are analysed together, for two reasons. First, reading passage and wordlist styles are both formal styles. Second, style comparison is mostly helpful when social class is variable. Because this study does not focus on the differences between the speakers in terms of class membership, no style comparison needs to be attempted (Feagin 2004: 31). The study examines a total of 320 tokens: 16 BATH tokens in right phonetic context dental, 16 PALM tokens in right phonetic context bilabial, as well as 32 FOOT and 64 STRUT, START, TRAP and FLEECE tokens in right phonetic context alveolar. The FLEECE tokens were collected for the purpose of normalisation (see section 2.5.2.2 below).

2.5. Instrumental vowel analysis

Instrumental analysis involves the comparison of acoustic parameters of a vowel. In contrast to purely impressionistic auditory analysis, such measurements are more objective and quantifiable. The parameters that are usually investigated in vowels are quantity (duration) and quality (height, frontness-backness and lip rounding) (Thomas 2011: 138).

This study focuses solely on quality and the parameters measured and reported in the present study are F1 and F2. The former corresponds to the height of the vowel, while the latter corresponds to the degree of its frontness or backness.

2.5.1. F1 and F2 measurements

The procedure started with the annotation of data in speech analysis software *Praat* (Boersma and Weenink 2012). There are many approaches to vowel measurements. The differences involve the place of measurement and the number of measurements taken (Thomas 2011: 150). For this kind of study, the most effective method seems to be a single measurement at vowel midpoint. Such method ensures that the comparison of tokens is reliable and facilitates plotting, as there will be only one point measurement to compare across speakers or groups.

Techniques for determining vowel onset, or beginning, and offset, or end, vary as well. As there is no single proven method, it is best to choose one and be consistent. I decided to follow the guidelines laid down in Thomas 2011 (139-142). Vowel onset was marked at a point where F2 started to show, while vowel offset was marked at a point where F2 disappeared. In most cases, the latter was more or less aligned with the cessation of voicing. Values for each token were hand-verified and retaken manually whenever automatic measurements proved to be erratic.

Formant frequencies were extracted using the "Analyze from TextGrid…" command in *Akustyk for Praat* (Plichta 2004), a plugin for *Praat*. The settings were left at default (analysis width: 0.025, time step: 0.010).

2.5.2. Normalisation

2.5.2.1. The purpose of normalisation

Because this study compares the speech of speakers of different age and sex, it is necessary to normalise the results. Normalisation is a procedure that eliminates physiological differences and guarantees a direct comparison of vowel formant frequencies across age and sex (Watt and Fabricius 2002: 159-160).

As Thomas (2011: 160) notes, "because formants are resonances of various cavities within the vocal tract, they differ depending on the overall length of a speaker's vocal tract." The speech of mature females is generally characterised by higher F1 and F2 values than the speech of mature males (Watt and Fabricius 2002: 161). Whereas humans are naturally able to grasp the crucial contrasts between vowels pronounced by speakers of different age or sex, a comparison of non-normalised formant values produces meaningless results (Thomas 2011: 160). The aim of normalising data obtained through instrumental analysis is to even out the formant frequency ranges of all speakers (Watt and Fabricius 2002: 161). Normalisation guarantees that the differences in the normalised data are sociolinguistic rather than physiological. Moreover, it also facilitates the visual comparison of vowel plots, as the vowel envelopes for female speakers are not stretched in the F1 and F2 planes due to higher F1 and F2 range (Watt and Fabricius 2002: 161).

There are many different approaches to vowel normalisation and only a brief overview will be given here (see also Thomas 2011: 162-170). Normalisation methods are generally grouped into vowel-intrinsic and vowel-extrinsic. A vowel-intrinsic technique normalises each vowel of a given speaker separately, while a vowel-extrinsic technique also takes into consideration other vowels of that speaker (usually all vowels, although this depends on the method). While both methods have their advantages and disadvantages, when comparing speakers of the same accent, vowel-extrinsic method perform slightly better (Thomas 2011: 162-170).

2.5.2.2. The *S*-centroid normalisation

This study relies on the vowel-extrinsic modified Watt and Fabricius method, also known as the *S*-centroid normalisation. Introduced in Watt and Fabricius (2002) and slightly adjusted in Fabricius et al. (2009), the method normalises formant frequencies by dividing their values by the value of the *S*-centroid, the centre of gravity of speakers' vowel space (Watt and Fabricius 2002: 161-164).

The vowel space centre of gravity, also known as the centroid or *S*, is calculated by "taking the grand mean of the mean F1 and F2 frequencies for points at the apices of a triangular plane which are assumed to represent F1 and F2 maxima and minima for the speaker in question" (Watt and Fabricius 2002: 161-162). These maxima and minima are calculated from three point vowels that are located at the furthermost points of this somewhat idealised vowel triangle: the high front, bottom and high back corners, which Watt and Fabricius mark as *i*, *a* and *u*, respectively. Even though all three point vowels are used for the calculation of *S*, only two vowels are actually measured: *i* and *a*. For British English accents, these are FLEECE and TRAP, respectively. The values of *u* are derived on the basis of FLEECE and TRAP. Therefore, the high back vowel is marked as *u'*. The F1 and F2 values of *i* are calculated from the mean F1 and F2 values of FLEECE. The F1 value of FLEECE is also equalled with both the F1 and F2 values of *u*. The F1 value of *a* is calculated from the mean F1 value of the speakers' TRAP. The F2 value of *a* is calculated as the midpoint between the F2 values of *i* and *u*. Figure 2 below (after Watt and Fabricius 2002: 164) presents a visualisation of the three point vowels' position on the vowel triangle.

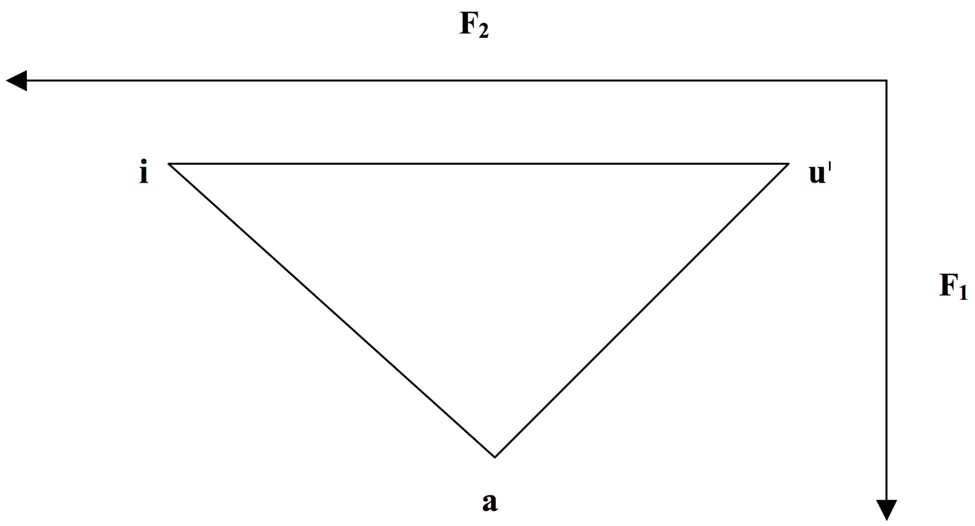

Figure 2. The three point vowels used for calculating *S*.

The *S*-centroid of the vowel triangle is then calculated and used for normalisation of data. The formant frequencies are divided by the value of *S*, and therefore not expressed in Hertz. Therefore, the normalised F1 and F2 values will be referred to as F1/*S* and F2/*S.* The dataset examined in the present study was normalised using *NORM: The vowel normalization and plotting suite* (Thomas and Kendall 2007).

I chose the modified Watt and Fabricius method for three reasons. First, in this kind of studies vowel-extrinsic methods outperform vowel-intrinsic techniques. Second, unlike other vowel-extrinsic method, the Watt and Fabricius method requires that only two vowels be measured (FLEECE and TRAP). Third, expressing normalised formant frequencies as proportions of *S* will be useful in the next step of data analysis – the presentation and quantification of vowel planar locations.

2.5.3. Methods for presenting and quantifying vowel planar locations

2.5.3.1. Plotting

The results of instrumental analysis are often presented on vowel charts, making the visual comparison of the data more accessible. The charts are a traditional way of visualising vowels' F1 and F2 values. The X-axis represents F1 (the degree of frontness), while the Y-axis represents F2 (height). Even though plots are a step forward from impressionistic analysis, the latter still has to go hand-in-hand with visual inspection of the data in order to spot errors in instrumental analysis (Watt et al. 2011: 117).

2.5.3.2. Vowel angles anchored on the *S*-centroid

While vowel plots provide a good general view of the position of vowels in the vowel space, vowel planar locations can only be compared visually. But since the *S*-centroid used for data normalisation is common to all speakers, it may serve as a point of reference for measuring the position of vowels may. Calculating vowel angles relative to *S* allows for a quantification and objective comparison of variable vowel planar locations.

Following Fabricius and Watt (2010), "[a]ngles are positive above horizontal line, and run counterclockwise from 0° to 180°; negative and clockwise below it (0 to -180°)", as in Figure 3 below (after Watt and Fabricius. 2011: 2104).

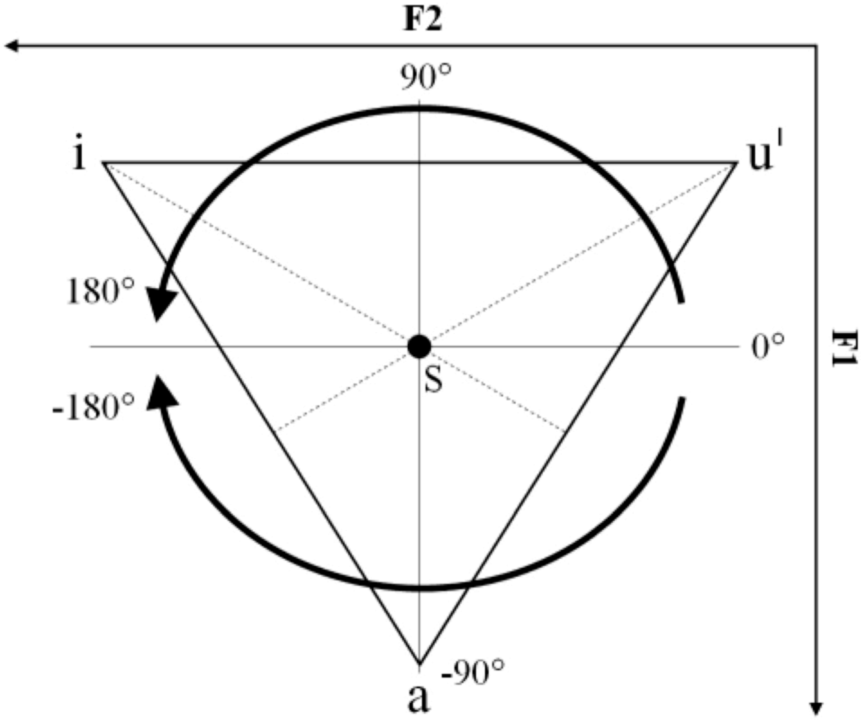

Figure 3. The *S*-centroid as an anchor for calculating planar locations of vowels.

The angle values were calculated in R (R Development Core Team 2011) using a script created by Johnson (2011) provided in Appendix G, p. 53.

2.5.4. Euclidean distances from the *S*-centroid

In addition to angle measurements described above, this study also analyses the Euclidean distance of a given vowel from *S*. This allows for an even more fine-grained analysis of vocalic variation, as we may compare the exact distance of a vowel from *S*. This provides confirmation as to whether the change in angle to *S* is significant.

The use of this method here is tentative. The method was introduced in Fabricius (2007) to quantify changes in angle of one vowel in relation to another vowel, not to *S*. I know of now previous works that would use this method for calculating angles to *S*, other than suggestions in Watt and Fabricius (2011). The Euclidean distance values were calculated in R using the aforementioned script by Johnson (2011).

Chapter 3: Results and discussion

3.1. Summary

This chapter presents and analyses the results of the study. We start with the instructions on how to read the results in section 3.2. The following section (3.3) provides an overview of the results which are then presented and discussed in turn in sections 3.4-3.5.

3.2. Presentation of results

Three types of results are analysed: mean F1/*S* and F2/*S*, angle relative to *S* and Euclidean distance from *S*. The results are visualised on vowel plots and radar charts.

Mean F1/*S* and F2/*S* values are shown on the vowel plots. The plots are a traditional way of visualising the relative position of vowels in the F1-F2 space. The X-axis represents F1 (vowel frontness-backness) and the Y-axis represents F2 (vowel height). Due to the normalisation procedure, the F1 and F2 values are not expressed in Hertz but as F1/*S* and F2/*S* (Hertz divided by *S*). The ellipses around the vowels show the real distribution of individual tokens (2 SDs).

Angle values relative to *S* are presented on radar charts when both age and sex are compared, or in tables for comparisons of age only. While the vowel plots provide an overview of the position of vowels in the vowel space, angle values show the movement of vowels relative to *S* across groups or individual speakers. Since *S* is the centre of the vowel space common to all speakers, these measurements allow for an objective quantification of any vowel movements. Following Fabricius and Watt (2010), “[a]ngles are positive above horizontal line, and run counterclockwise from 0° to 180°; negative and clockwise below it (0 to -180°)”.

The angle measurements are supplemented with tables with Euclidean distance values. These show the exact distance of a vowel from *S* and help in establishing whether a considerable change in angle to *S* was accompanied by an equally considerable movement in that direction.

At some points instrumental analysis is supplemented by my comments on the quality of the vowel, based on a thorough impressionistic analysis of the data.

3.3. Overview of results

To provide the reader with an overview of the speakers’ vowel spaces, this section presents combined results for younger and older speakers. All the results for the STRUT realisation per individual speakers are provided in Appendix E, p. 51. All the individual speakers’ results for BATH are provided in Appendix F, p. 52. Figure 4 below shows mean F1/*S* and F2/*S* of STRUT and FOOT in older and younger speakers with 2SD confidence ellipses. Figure 5 below shows mean F1/*S* and F2/*S* of BATH as well as FOOT, START, PALM and TRAP in older speakers and younger speakers with 2SD confidence ellipses.

This section presents only the two plots of the variables under study. Comments on the realisations of STRUT are provided in Section 3.4 below, while section 3.5 below presents the analysis of the realisations of BATH.

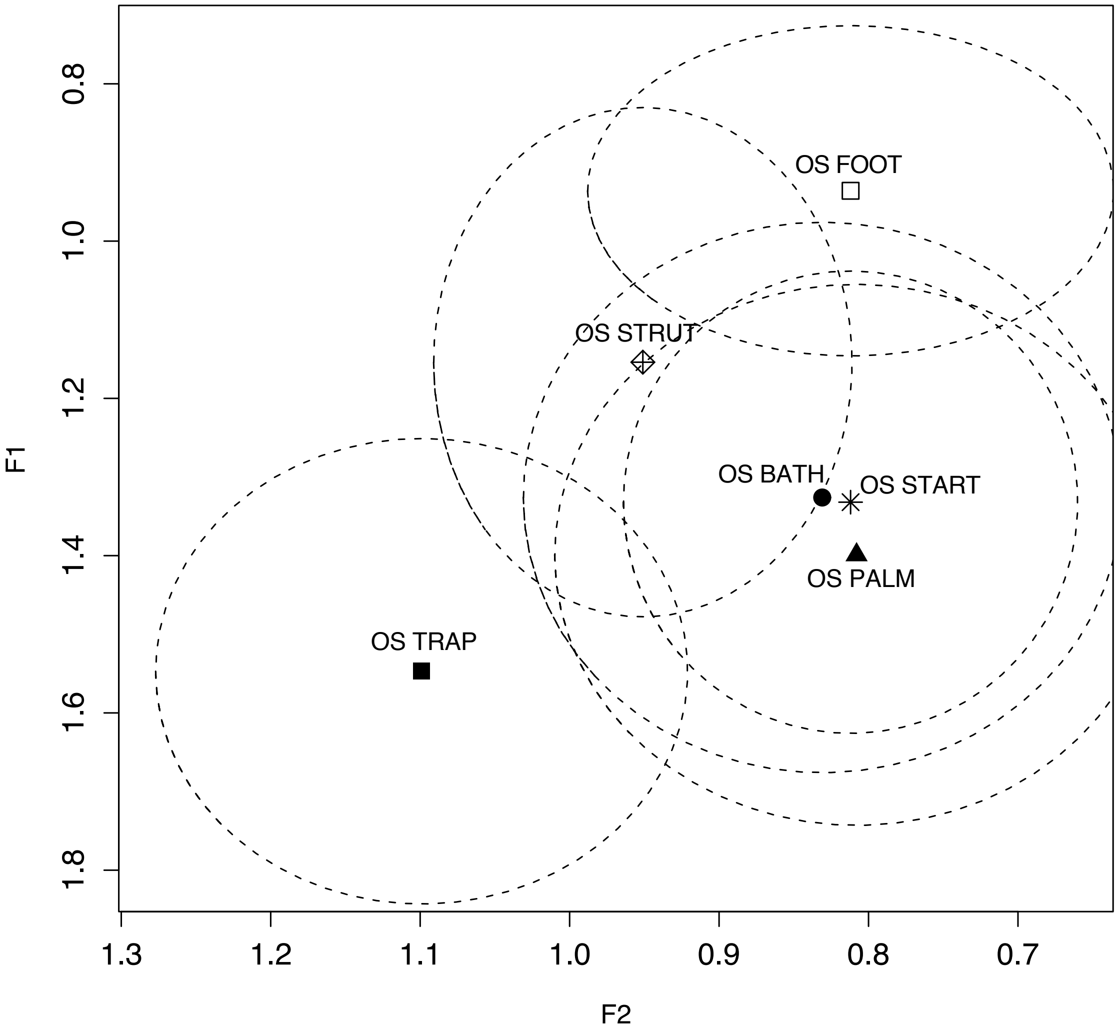

Figure 4. Mean F1/*S* and F2/*S* of STRUT, FOOT, BATH, START, PALM, and TRAP in OS.

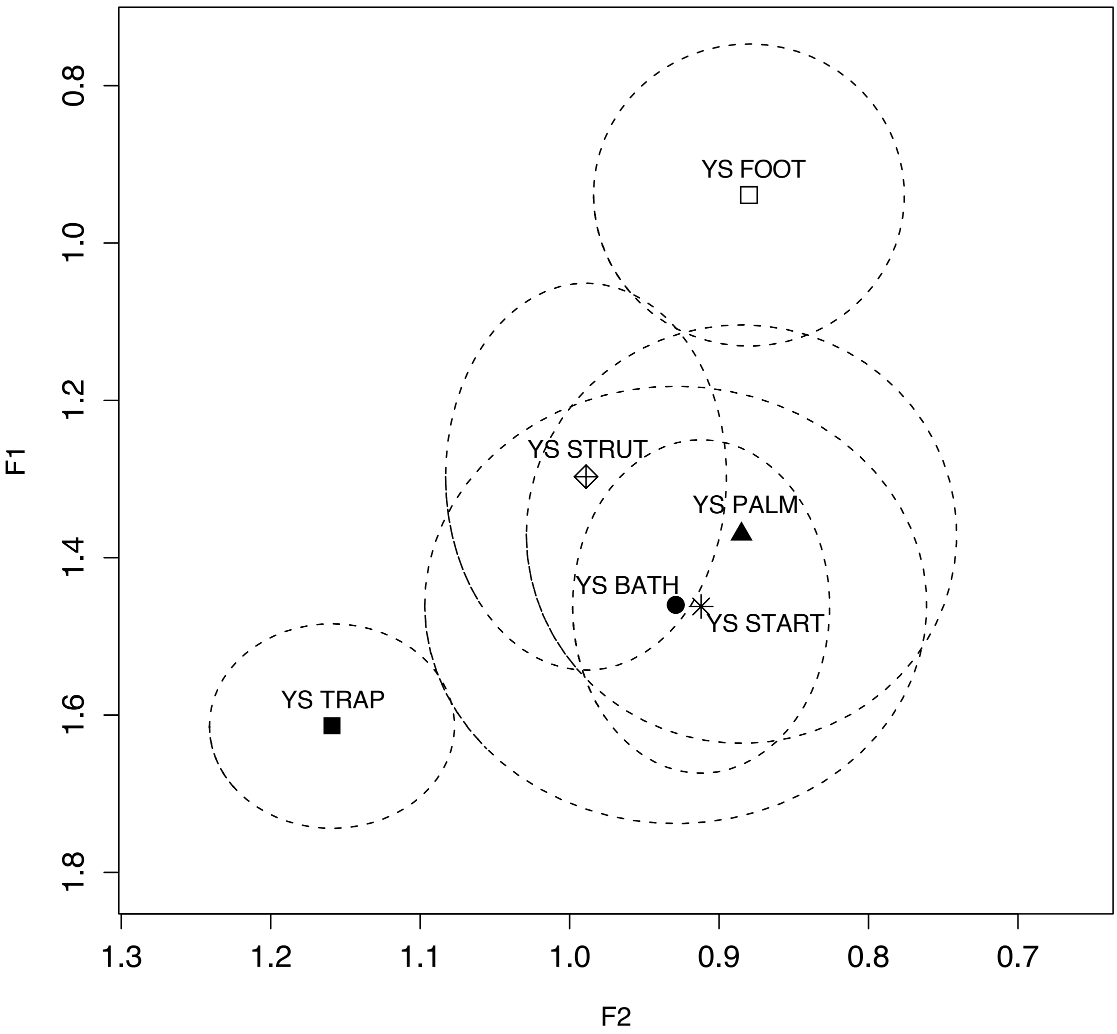

Figure 5. Mean F1/*S* and F2/*S* of STRUT, FOOT, BATH, START, PALM, and TRAP in YS.

3.4. Results for STRUT

3.4.1. Age comparison

The younger speakers are compared against the older speakers. Figure 6 shows mean F1/*S* and F2/*S* of STRUT and FOOT in younger and older speakers with 2SD confidence ellipses. Table 1 shows mean angles to *S* and Euclidean distances from *S* of STRUT for the two age groups.

The STRUT of the older speakers is similar to [ɤ]. Among the younger speakers it is slightly a centralised, or perhaps centralised and raised, [ʌ]. Therefore, the results show a lowering and fronting of STRUT in the younger speakers. F1/*S* in younger speakers is 1.2975, much more than in older speakers (1.1545). The lowering of STRUT is even more noticeable when compared to the position of FOOT, which is almost identical in both groups. F2/*S* in younger speakers is 0.9885, as compared to 0.9515 in older speakers, which makes the fronting less marked, although still noticeable. The confidence ellipses show a considerable overlap of STRUT and FOOT in the older speakers. In contrast, younger speakers display almost no such overlap and the two vowels occupy separate, albeit contiguous, vowel spaces.

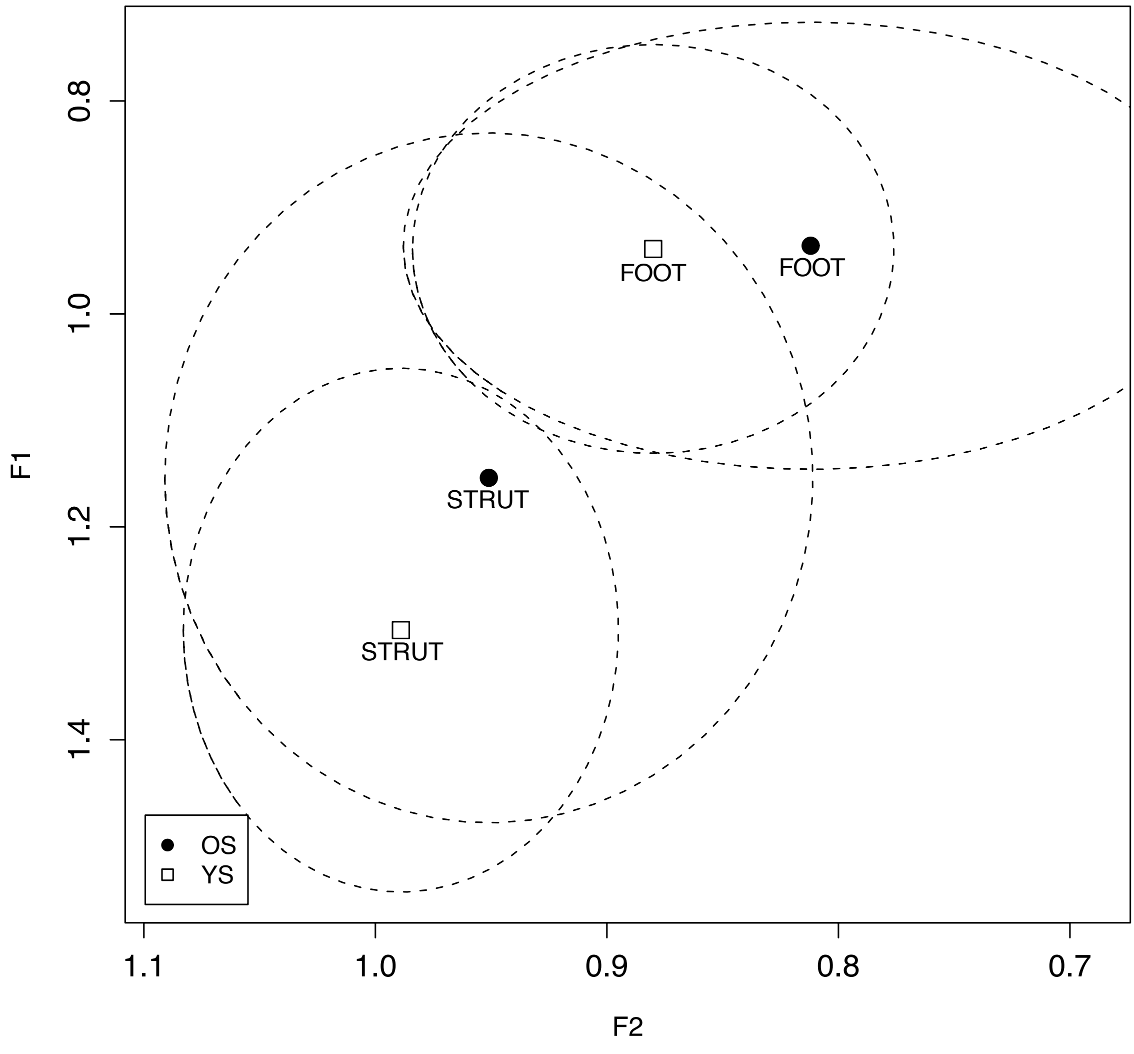

Figure 6. Mean F1/*S* and F2/*S* of STRUT and FOOT in OS and YS.

The mean angle of STRUT to *S* is -88 degrees for the younger speakers and -75 degrees for the older speakers. The difference in the angle of STRUT between the two age groups is 13 degrees. The STRUT of the younger speakers is positioned at 0.299 from *S*, which is 0.136 further than the STRUT of the older speakers at 0.163.

Table 1. Mean angles to *S* in degrees and Euclidean distances from *S* of STRUT in OS and YS.

	Angle to *S*	Euclidean distance from *S*
OS mean	-75	0.163
YS mean	-88	0.299
Difference (YS mean – OS mean)	13	0.136

3.4.2. Age and sex comparison

Older males are compared against older females, younger males and younger females. Additionally, the latter two groups are compared to older speakers in general. Figure 7 shows mean F1/*S* and F2/*S* of STRUT and FOOT in older males, older females, younger males and younger females with 2SD confidence ellipses. Table 2 shows mean angles to *S* and Euclidean distances from *S* of STRUT for each group. Figure 8 visualises the variability in angles relative to *S* across the cohorts.

The results demonstrate that younger males have the most fronted STRUT realisation, although there is little variability regarding the frontness of the vowel across age and sex overall (min. F2/*S* is 0.921 in older females, max. F2/*S* is 1.020 in younger males). The realisation of STRUT in younger females and younger males is almost identical regarding height (F1/*S* at 1.301 and 1.294, respectively). Older males prove to have the closest STRUT (F1/*S* at 1.103). Older females are in-between (F1/*S* at 1.206).

The results suggest a tendency among the older speakers towards a fudged realisation of the STRUT vowel, along the lines of a somewhat fronted [ɤ]. This is visible in the comparison of STRUT and FOOT distributions. While in both groups FOOT has a very similar realisation (F1/*S* at 0.935 and 0.937, F2/*S* at 0.864 and 0.759, respectively), older males show a partial overlap in the distribution of STRUT and FOOT, while in females the two vowels occupy separate parts of the vowel space. Nevertheless, the STRUT of the older females shows a wider range of realisations in terms of height.

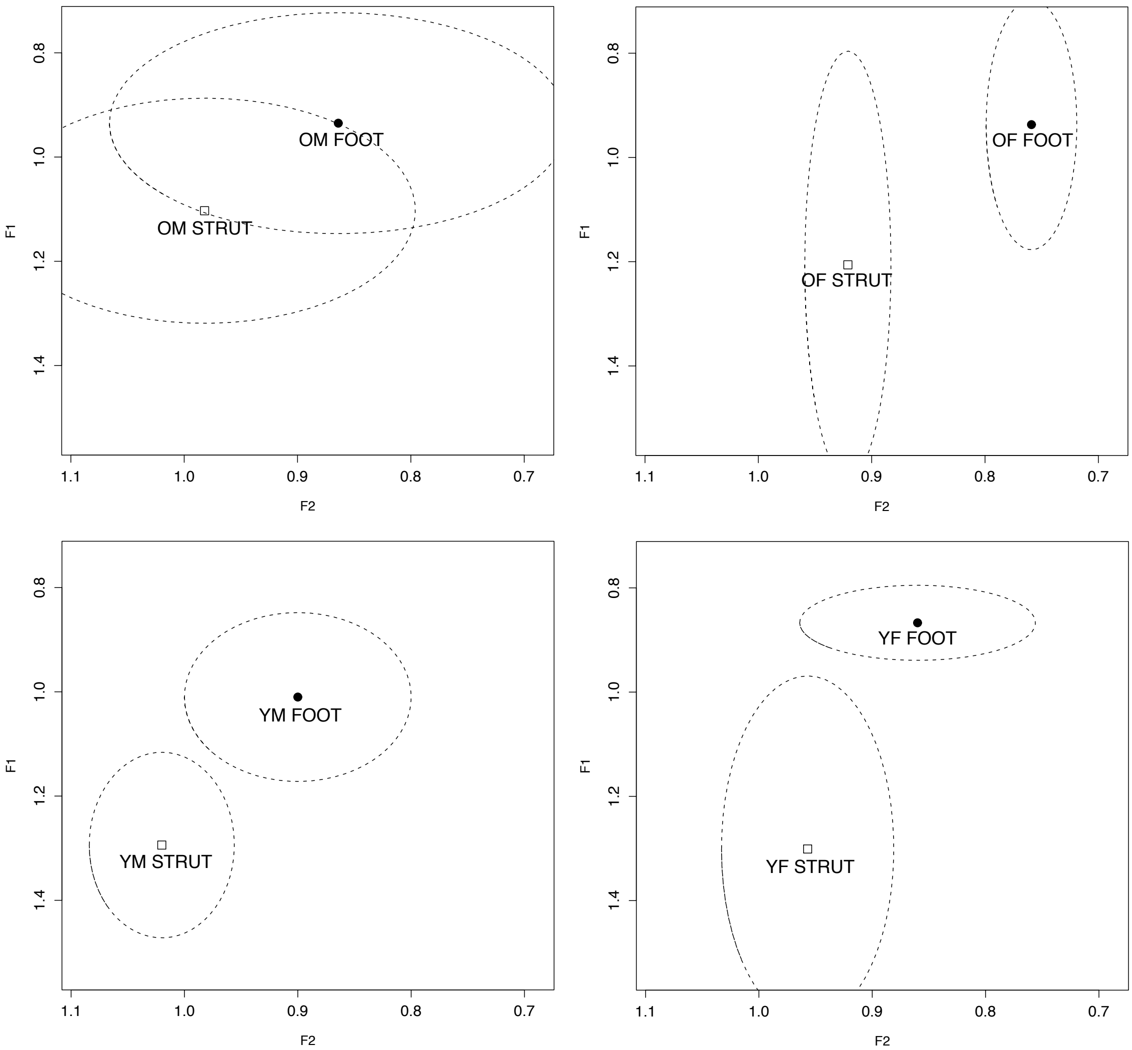

Figure 7. Mean F1/*S* and F2/*S* of STRUT and FOOT in OM, OF, YM and YF.

When compared to the older speakers in general, the generational change in STRUT is more pronounced in the younger males. At an angle to *S* of -94 degrees and distance from *S* of 0.295, the difference between the older speakers (-75 degrees, 0.163) is calculated at 19 degrees and 0.132. In the younger females, the difference in angle is smaller (7 degrees), although the vowel moved a bit further away from *S* (0.141, being now at 0.304).

Table 2. Mean angles to S in degrees and Euclidean distances from *S* of STRUT in OM, OF, YM and YF.

	Angle to *S*	Euclidean distance from *S*
OM mean	-80	0.105
OF mean	-69	0.221
YM mean	-94	0.295
YF mean	-82	0.304

Figure 8 below shows the variation in the angles of STRUT to *S*. Young males and females fairly consistently display an [ʌ]-like STRUT quality. Apart from Younger Female 4, there is little variation among the younger generation. The older speakers show much more inconsistency, though this may be due to a larger spread in the older informants' age.

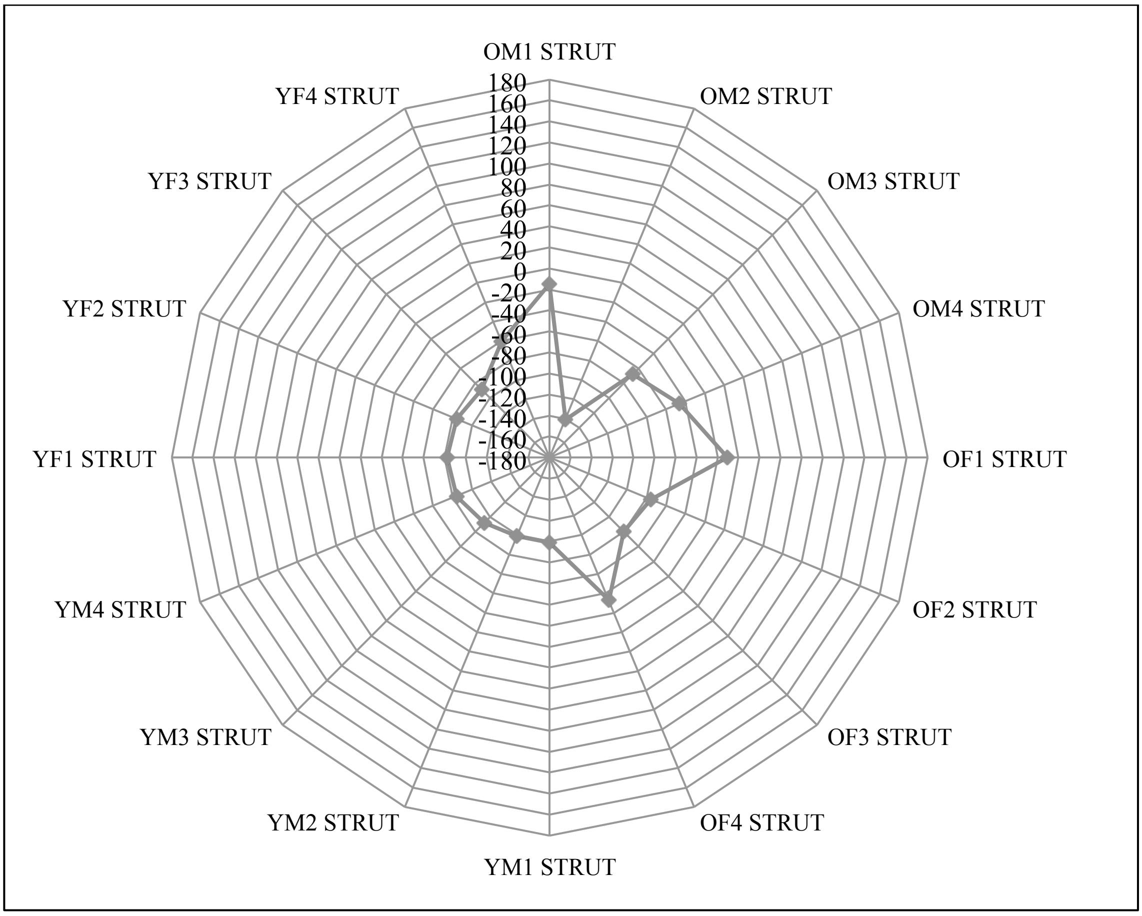

Figure 8. STRUT angles to *S* in OM, OF, YM and YF.

3.5. Results for BATH

3.5.1. Age comparison

The younger speakers are compared against the older speakers. Figure 9 shows mean F1/*S* and F2/*S* of BATH, START, PALM and TRAP in younger and older speakers with 2SD confidence ellipses. Table 3 shows mean angles to *S* and Euclidean distances from *S* of BATH for the two age groups.

For all speaker groups, BATH has a similar, broad START-like quality, with little variation across age or sex. Although in the young speakers the vowels of BATH and START are fronted and lowered when compared to the older speakers, the results show no significant fronting of BATH relative to START. In both the older and the younger generation a very slight fronting of BATH relative to START may be observed (F2/*S* of BATH at 0.831 and 0.929 and of START at 0.812 and 0.913, respectively). Moreover, the two vowels are almost at the same height.

The confidence ellipses show a relatively small overlap of BATH, START, PALM and TRAP in the older speakers. As it was the case with STRUT, the younger speakers display almost no such overlap – their TRAP vowel has a fronter and opener quality.

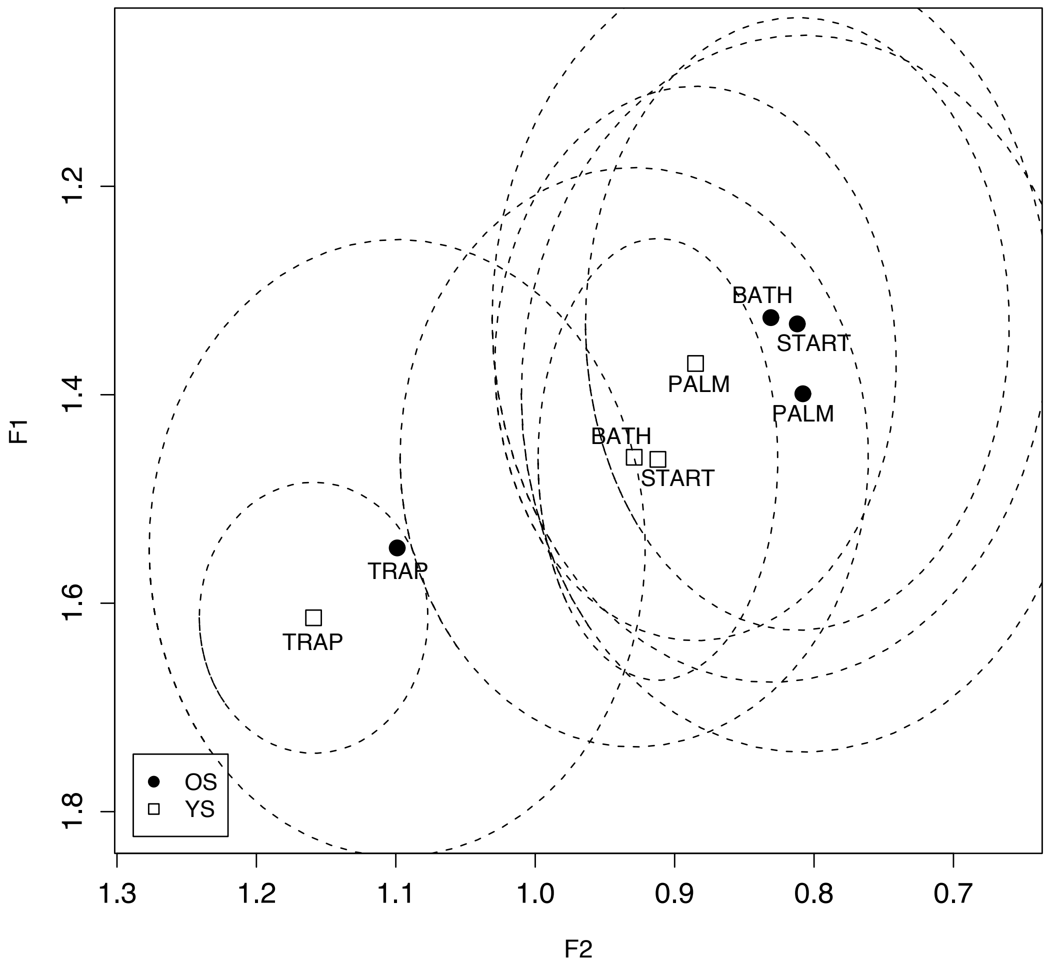

Figure 9. Mean F1/*S* and F2/*S* of BATH, START, PALM and TRAP in OS and YS.

The mean angle of BATH to *S* is -64 degrees for the younger speakers and -81 degrees for the older speakers. At 17 degrees, the difference in the angle of BATH between the two age groups is significant relative to *S* but of little importance relative to START.

Table 3. Mean angles to *S* in degrees and Euclidean distances from *S* of BATH in OS and YS.

	Angle to *S*	Euclidean distance from *S*
OS mean	-64	0.372
YS mean	-81	0.467
Difference (YS mean – OS mean)	17	0.095

3.5.2. Age and sex comparison

Older males are compared against older females, younger males and younger females. Figure 10 shows mean F1/*S* and F2/*S* of BATH, START, PALM and TRAP in older males, older females, younger males and younger females with 2SD confidence ellipses. Table 4 shows mean angles to *S* and Euclidean distances from *S* of BATH in each group. Figure 11 visualises the variation in angles relative to *S* across the two groups.

The results show that the younger males have the most fronted BATH realisation (at an angle of -86 and distance 0.459). The fronting in slight, however, and may be due to chance or other factors that were not taken into consideration in this study.

In younger males and females the distribution ellipses of BATH and START are similarly superimposed on one another, in both cases with a wide range of realisations for BATH. The convergence of the three open back vowel distributions is most visible in the younger males and older females. The males display a slight overlap of the TRAP and BATH vowel spaces

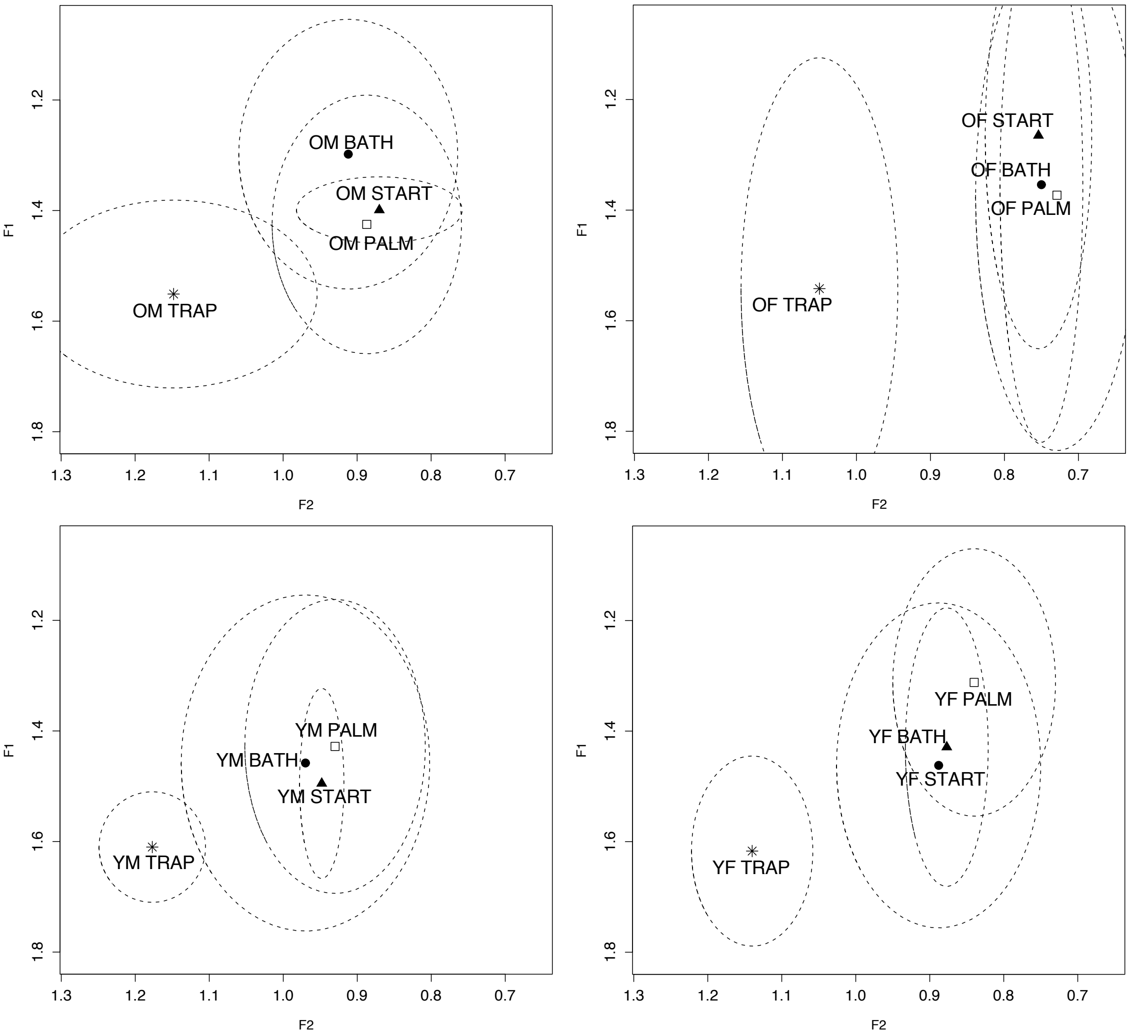

Figure 10. Mean F1/*S* and F2/*S* of BATH, START, PALM and TRAP in OM, OF, YM and YF.

When compared to the older speakers in general, the generational change in BATH is more pronounced in the younger males. At an angle to *S* of -86 degrees and distance from *S* of 0.459, the difference between the older speakers (-64 degrees, 0.372) is calculated at 22 degrees and the distance of 0.087. The difference in angle is smaller in the younger females (7 degrees), although the vowel moved slightly further away from *S* (0.103). As it has been shown above, however, angle measurements are of lesser significance here than in the case of STRUT since there is little difference in the frontness of BATH relative to START between the cohorts.

Table 4. Mean angles to S in degrees and Euclidean distances from *S* of BATH in OM, OF, YM and YF.

	Angle to *S*	Euclidean distance from *S*
OM mean	-74	0.311
OF mean	-55	0.433
YM mean	-86	0.459
YF mean	-76	0.475

Figure 11 below shows the differences in the angles of BATH to *S*. A small degree of variation is visible among the younger generation. This contrasts with a wider range of realisation in terms of height with no clear pattern among the older speakers, especially the females. However, as in the case of STRUT, this may be caused by a larger spread in age of the older informants.

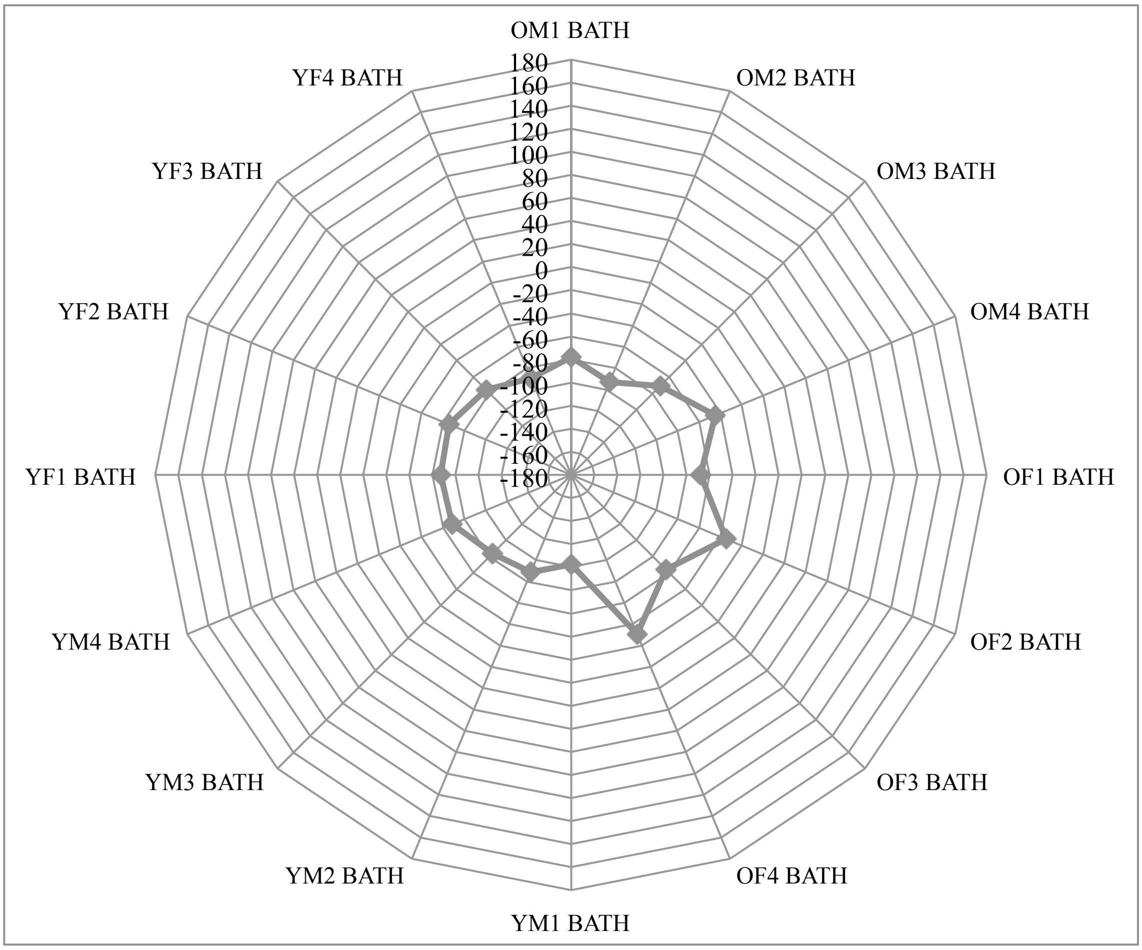

Figure 11. BATH angles to *S* in OM, OF, YM and YF.

Conclusions

This apparent-time acoustic study investigates the variation in the quality of the STRUT and BATH vowels in the accent of the Stratford-upon-Avon area. This under-researched area is a transitional zone between the linguistic North and South, as it reportedly lies between the isoglosses marking the occurrence of the two most characteristic features of southern accents – the FOOT–STRUT split and BATH broadening. Previous descriptions of the accent of this area report either the absence of the FOOT–STRUT contrast or, in the case of its presence, a wide range of STRUT realisations along the lines of [ɤ~ə~ʌ]. Regarding the BATH vowel, previous research shows [aː~ɑː].

As expected, the results of the study clearly show that the accent of the Stratford-upon-Avon area has the FOOT–STRUT opposition, with a generational variation in STRUT, realised as [ɤ] in the older generation, especially the older males, and as [ʌ̟~ʌ̟˔] in the younger generation. Expectedly, the results demonstrate the broadening of BATH. The degree of broadening, however, is larger the expected [aː] – the vowel is pronounced with as slightly more front START quality. The study shows that the younger speakers more or less consistently display the southern-like broad BATH quality, while there is some unexplained variability in the height of the vowel in the older females.

Overall, the results confirm the hypothesis put forward in section 1.5. Previous descriptions of the Stratford-upon-Avon as lying on the border between the linguistic North and South are no longer adequate. The area may now be classified as belonging to the linguistic South.

This is only a pilot study, a potential starting point of a longitudinal research that, accompanied by similar studies carried out in other locations in the West Midlands, could help establish where the isoglosses for the FOOT–STRUT split and BATH broadening run today, marking the new position of the border that divides the UK into the linguistic North from the linguistic South.

To investigate the at-times unclear generational pattern of variation, further research should examine one or more intermediate generations, and take into consideration other social variables, such as class or education. A thorough investigation of lexical effects is also needed – an unexpected finding of the study is that in both age groups PALM has a noticeably different realisation than START and BATH. Although some degree of variation in the frontness of the vowel has been reported (Clark 2008: 169), there have been no previous accounts of variation in height, which is another idea for future research.

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Appendices

Appendix A: Informants' age

	ID	Age	ID	Age
	Males		Females	
Older	OM1	40	OF1	38
	OM2	44	OF2	40
	OM3	46	OF3	60
	OM4	57	OF4	60
Mean		46.75		49.5
Younger				
	YM1	23	YF1	23
	YM2	24	YF2	25
	YM3	27	YF3	26
	YM4	27	YF4	27
Mean		25.25		25.25

Appendix B: Informants' geographical background

Speaker	Birthplace	Where lived until the age of 12	Currently lives
OM1	Ettington	Ettington	Newbold-on-Stour
OM2	Moreton-in-Marsh	Newbold-on-Stour	Newbold-on-Stour
OM3	Stratford-upon-Avon	Stratford-upon-Avon	Stratford-upon-Avon

OM4	Newbold-on-Stour	Newbold-on-Stour	Newbold-on-Stour
OF1	Stratford-upon-Avon	Newbold-on-Stour	Newbold-on-Stour
OF2	Birmingham	Newbold-on-Stour	Newbold-on-Stour
OF3	Stratford-upon-Avon	Stratford-upon-Avon	Stratford-upon-Avon
OF4	Shipston-on-Stour	Shipston-on-Stour	Crimscote
YM1	Redditch	Alcester	Stratford-upon-Avon
YM2	Wimpstone	Wimpstone	Wimpstone
YM3	Stratford-upon-Avon	Stratford-upon-Avon	Stratford-upon-Avon
YM4	Stratford-upon-Avon	Stratford-upon-Avon	Stratford-upon-Avon
YF1	Newbold-on-Stour	Newbold-on-Stour	Newbold-on-Stour
YF2	Newbold-on-Stour	Newbold-on-Stour	Newbold-on-Stour
YF3	Alderminster	Alderminster	Crimscote
YF4	Wilmcote	Wilmcote	Wilmcote

Appendix C: Reading passage

Comma gets a cure

Well, here's a story for you: Sarah Perry was a veterinary nurse who had been working daily at an old zoo in a deserted district of the territory, so she was very happy to start a new job at a superb private practice in North Square near the Duke Street Tower. That area was much nearer for her and more to her liking. Even so, on her first morning, she felt stressed. She ate a bowl of porridge, checked herself in the mirror and washed her face in a hurry. Then she put on a plain yellow dress and a fleece jacket, picked up her kit and headed for work.

When she got there, there was a woman with a goose waiting for her. The wom-an gave Sarah an official letter from the vet. The letter implied that the animal could be suffering from a rare form of foot and mouth disease, which was surprising, because normally you would only expect to see it in a dog or a goat. Sarah was sentimental, so this made her feel sorry for the beautiful bird.

Before long, that itchy goose began to strut around the office like a lunatic, which made an unsanitary mess. The goose's owner, Mary Harrison, kept calling, "Comma, Comma," which Sarah thought was an odd choice for a name. Comma was strong and huge, so it would take some force to trap her, but Sarah had a different idea. First she tried gently stroking the goose's lower back with her palm, then singing a tune to her. Finally, she administered ether. Her efforts were not futile. In no time, the goose began to tire, so Sarah was able to hold onto Comma and give her a relaxing bath.

Once Sarah had managed to bathe the goose, she wiped her off with a cloth and laid her on her right side. Then Sarah confirmed the vet's diagnosis. Almost immediately, she remembered an effective treatment that required her to measure out a lot of medicine. Sarah warned that this course of treatment might be expensive—either five or six times the cost of penicillin. I can't imagine paying so much, but Mrs. Harrison—a millionaire lawyer—thought it was a fair price for a cure.

Appendix D: Wordlist tokens

bard, bad, bawd, bead, bed, bid, bird, bod, booed, bud, woman, brother, monkey, nothing, company, animal, making, crisp, important, outline, second, remote, coffee, whisper, children, different, morning, order, himself, table

Appendix E: All results for STRUT

Mean F1/*S* and F2/*S*, angles to *S* in degrees and Euclidean distances from *S* of STRUT in individual speakers.

Speaker	F1/*S*	F2/*S*	Angle to *S*	Euclidean distance from *S*
OM1	1.007	0.973	-15	0.028
OM2	1.091	1.112	-141	0.144

OM3	1.257	0.895	-68	0.278
OM4	1.056	0.946	-46	0.078
OF1	1.015	0.919	-10	0.082
OF2	1.408	0.895	-76	0.421
OF3	1.357	0.94	-80	0.362
OF4	1.045	0.93	-33	0.083
YM1	1.247	1.038	-99	0.25
YM2	1.309	1.05	-99	0.313
YM3	1.411	1.015	-92	0.411
YM4	1.207	0.978	-84	0.208
YF1	1.154	0.979	-82	0.155
YF2	1.483	0.952	-84	0.485
YF3	1.4	0.992	-89	0.400
YF4	1.166	0.906	-60	0.191
OM mean	1.103	0.982	-80	0.105
OF mean	1.206	0.921	-69	0.221
OS mean	1.155	0.952	-75	0.163
YM mean	1.294	1.020	-94	0.295
YF mean	1.301	0.957	-82	0.304
YS mean	1.298	0.989	-88	0.299

OM = older male; OF = older female; YM = younger male; YF = younger female; OS = older speaker; YS = younger speaker

Appendix F: All results for BATH

Mean F1/*S* and F2/*S*, angles to *S* in degrees and Euclidean distances from *S* of BATH in individual speakers.

Speaker	F1/*S*	F2/*S*	Angle to *S*	Euclidean distance from *S*
OM1	1.446	0.907	-78	0.456
OM2	1.254	1.014	-93	0.254
OM3	1.335	0.884	-71	0.355
OM4	1.159	0.841	-45	0.225
OF1	1.651	0.736	-68	0.702
OF2	1.187	0.729	-35	0.329
OF3	1.427	0.792	-64	0.475
OF4	1.151	0.745	-31	0.296
YM1	1.348	1.075	-102	0.356
YM2	1.6	0.99	-89	0.600
YM3	1.578	0.936	-84	0.582
YM4	1.306	0.878	-68	0.329
YF1	1.357	0.847	-67	0.388
YF2	1.317	0.855	-65	0.349
YF3	1.558	0.857	-76	0.576
YF4	1.616	0.991	-89	0.616
OM mean	1.298	0.912	-74	0.311
OF mean	1.354	0.75	-55	0.433
OS mean	1.326	0.831	-64	0.372
YM mean	1.458	0.97	-86	0.459
YF mean	1.462	0.888	-76	0.475
YS mean	1.46	0.929	-81	0.467

OM = older male; OF = older female; YM = younger male; YF = younger female; OS = older speaker; YS = younger speaker

Appendix G: R algorithm for calculating planar locations (Johnson 2010)

```
polarize.r <- function(x,y,x0=0,y0=0){
	r <- vector()
	for (i in 1:length(x))
		r[i] <- sqrt((x[i]-x0)^2+(y[i]-y0)^2)
r}
polarize.t <- function(x,y,x0=0,y0=0){
	t <- vector()
	for (i in 1:length(x)){
		t[i] <- atan((y[i]-y0)/(x[i]-x0))*180/pi
		if (x[i]-x0<0) t[i] <- t[i]+180
		if (x[i]-x0<0 & y[i]-y0<0) t[i] <- t[i]-360}
t}
```