HIGH VOWELS IN SOUTHERN BRITISH ENGLISH: /u/-FRONTING DOES NOT RESULT IN MERGER

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ABSTRACT

This study reports on the acoustic properties of the front vowel /i/ and the fronted back vowel /u/ in Standard Southern British English (SSBE). These two vowels are realized with very similar (and for some tokens overlapping) values of F2, so that F2 does not seem to be a reliable acoustic cue for the distinction between the two vowels. To test further possible cues to the English front-back contrast, we analyzed the steady-state formants and diphthongization for F1, F2 and F3, and duration and F0. We found that /u/ and /i/ are clearly distinguishable by their direction and degree of diphthongization of F2 and, to a lesser extent, by diphthongization of F3, but also by their steady-state F1, F2 and F3.

Keywords: vowels, SSBE, acoustic cues, diphthongization, /u/-fronting, near merger

1. INTRODUCTION

A shift of the once back vowel /u/ to the front region of the vowel space has recently taken place in Standard Southern British English (SSBE) and has been well documented in the literature [1, 5, 7].

Findings of a number of acoustic studies show that in the younger generation, the vowel /u/ is very much fronted, irrespective of consonantal context, so that its distribution along the F2 dimension comes to overlap with that of the front vowel /i/ [5, 6, 10]. The extreme closeness of these two vowels along the F2 axis suggests that F2 may no longer be an acoustic cue that is strong enough to reliably distinguish SSBE /i/ from /u/, and that a merger of the two tense high vowels is taking place. However, young SSBE listeners are apparently still able to differentiate between minimal pairs such as ‘geese’ and ‘goose’ or ‘needle’ and ‘noodle’. The present study examines other acoustic cues that might enable the listeners to differentiate the two vowels.

One of the acoustic correlates that could distinguish front /i/ from fronted /u/ is the amount and/or the direction of formant movement. The literature reports diphthong-like realizations of /i/ and /u/ for a number of Southern British English regional varieties. The vowel /i/ is commonly realized as an upgliding diphthong [ɪi] in Norwich, as either [ɪiˑ] or [ɪi] in Sheffield, and as [əi] in London. The vowel /u/ is a central diphthong [ʉ̹ʉ] in Norwich, in Sheffield it is realized as [ʊuː] or [ᶷuː], and it can be realized as [ʊʉ] in Derby (see [14] for Norwich and London, [13] for Sheffield, and [2] for Derby). For SSBE, it was shown that the realization of the vowel /u/, although quite variable across speakers, is diphthongal [12].

In other varieties of English, formant contours also are an important cue to vowel quality in monophthongs. American English vowels can be distinguished more reliably if formant contour is taken into account [8]; and for Australian English it has been shown that formant contour differences help to separate those vowels whose F1 and F2 values are very similar, i.e. members of tense-lax vowel pairs such as /i/ and /ɪ/, or /a/ and /ʌ/ [15].

Given this importance of formant contour as an (additional) distinguishing cue for some of the monophthongal contrasts, it is likely that speakers of SSBE – where the steady-state formant values of /u/ come very close to, or overlap with those of /i/ – are using the information about formant contour to separate these two vowel phonemes perceptually.

To the best of our knowledge, the literature does not report on the systematic use of any acoustic cues other than F2, that could be used to distinguish between the tense high vowels /i/ and /u/ in SSBE.

In this paper, we present a detailed acoustic analysis of English /i/ and /u/, as produced by nine SSBE speakers in three different contexts (velar, alveolar, labial). We analyze vowel duration, F0, and for the first three formants the steady state and the amount and direction of diphthongization to see whether these cues distinguish the high front and back tense vowels of SSBE.

2. METHOD

2.1. Participants

The participants were 9 monolingual speakers of SSBE (2 females). Table 1 lists each participant's year of birth and the county where they were born and/or spent the largest part of their lives.

Table 1: Speakers' birth years and counties of origin.

speaker	born	county
M1	1989	Suffolk
M2	1988	West Sussex
M3	1992	Somerset
M4	1982	West Sussex
M5	1987	Wiltshire
M6	1989	Bristol
M7	1984	Hampshire
F1	1987	Surrey
F2	1988	Essex

2.2. Recorded material

We recorded English non-words of the form C_1VC_2ing. The V was one of the vowels /i, ɪ, u, ʊ, æ, a, eɪ/, and C_1 was one of the set /k, t, f/ and was matched in place of articulation with C_2, which was one of the set /g, d, p/. The combination of the 7 vowels with the 3 consonantal contexts yielded 20 non-words (and 1 taboo word which was excluded from the analysis). There were 6 repetitions of each word. Words with the vowels /æ, a, ɪ, ʊ, eɪ/ served as fillers and are not analyzed in the present study. The lax high vowels /ɪ/-/ʊ/ could not be included in the analysis, as four of the participants produced some or all of the /ʊ/-tokens with /ʌ/ or /u/, which left us with too few data points.

The non-words were presented in randomized order on a computer screen in English orthography (in bold face large font), together with English rhymes (small font). The rhymes were words of the same structure, which differed from the test words either only in C_1, or in C_1 and C_2. An example of what participants saw on the screen during a trial is given in (1).

(1)
feeding
rhymes with
teeding

The English rhymes were to ensure that participants produced the target vowel correctly. Table 2 lists the 6 trials that contained the vowels that we analyze in the present study.

Table 2: Target words analyzed in the present study and their English rhymes.

vowel	target word	English rhyme
/i/	teeding	feeding
	keeging	seeking
	feeping	sleeping
/u/	tooding	brooding
	kooging	goofing
	fooping	looping

2.3. Recording procedure

The recordings were made in a soundproof room using a Sennheiser HF condenser microphone MKH 105 with an 80 Hz HP filter and a TASCAM CD-RW 900 recorder. Participants were seated in front of a computer monitor and read the words that were presented on the screen.

The recording was preceded by a short practice in which participants read each rhyme and the non-existent word silently, and then read out loud the target word only. The practice contained all 20 words in random order. After the practice period, the recording began. If the experimenter judged a word mispronounced, the participant was asked to read the word again.

2.4. Acoustic analysis

The vowels were analyzed for duration, F0, F1, F2, and F3 with the methods reported in [3]. Formants, pitch, and duration were measured along linear scales (Hz and ms) and were then transformed into logarithmic units. Formants were analyzed at three points: at 25%, 50% and 75% of the vowel duration. The 50% value is referred to below as steady-state formant. The ratio (the difference between the logarithms) of the formant values at 75% and at 25% is our measure for formant change. Although this measure heavily reduces the data (e.g. formant change within the first and the second half of the vowel), it does capture both the size of the overall formant movement as well as its direction (a number smaller than 1 indicates a fall in formant value, and a number greater than 1 a rise; the bigger the absolute difference from 1 the bigger the formant change).

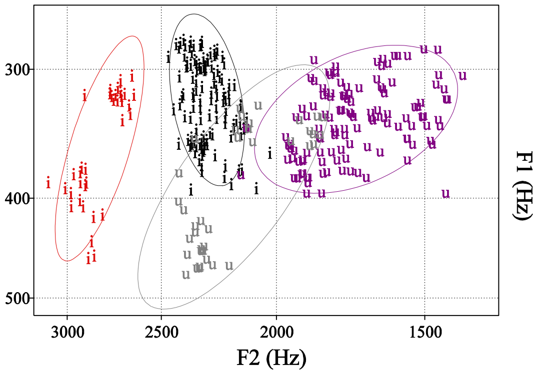
3. RESULTS & DISCUSSION

We submitted the data to a repeated-measures analysis of variance with vowel and consonant as the within-subject factors, and with 8 dependent variables: steady-state F1, F2, and F3, F1 change, F2 change, F3 change, vowel duration and F0.

3.1. Steady-state formants

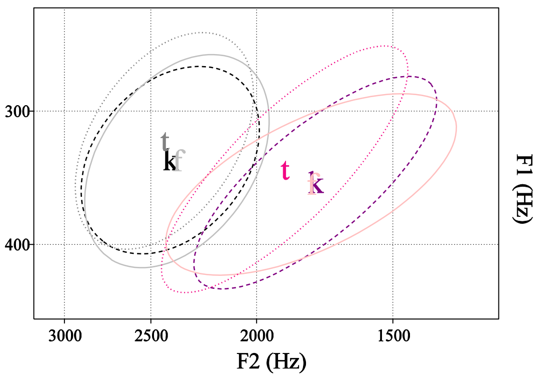
The analysis reveals a main effect of vowel category on all three steady-state formants in SSBE. The two vowels differ in F1 ($F[1,8] = 20.1$, $p = 0.002$), in F2 ($F[1,8] = 110.5$, $p = 6 \cdot 10^{-6}$), and in F3 ($F[1,8] = 172$, $p = 1 \cdot 10^{-6}$); /i/ has a higher F2 and F3 than /u/, and /u/ has a higher F1 than /i/. Figure 1 is a plot of the vowels' steady-state F1 and F2.

Figure 1: Steady-state F1 and F2 of all vowel tokens; the ellipses cover two standard deviations for the men (black and purple), and the women (red and grey).



The analysis gives a main effect of consonant on F1 ($F[2,16] = 10.4$, $p = 0.001$), and F2 ($F[2,16] = 9.7$, $p = 0.002$). Figure 2 plots mean F1 and F2 in each context (men and women together). Vowels have a higher F2 and a lower F1 in coronal than labial or dorsal context. There is a significant vowel-consonant interaction for F2 ($F[2,16] = 3.8$, $p = 0.045$); the consonant effect on F2 is larger for /u/ than for /i/.

Figure 2: Mean F1 and F2 of /i/ (shades of grey) and /u/ (shades of pink) in the three consonantal contexts, ellipses are two s.d., male and female values are plotted together. Solid lines: labial context, dashed lines: dorsal context, dotted lines: coronal context.



In sum, /i/ and /u/ are well separated both on the F2 and the F3 dimension. Both vowels are fronted (and slightly raised) in coronal context; this contextual effect is stronger for /u/.

3.2. Formant movement

For formant change, the analysis yields a significant main effect of vowel category on F2 change ($F[1,8] = 7.5$, $p = 0.026$), and on F3 change ($F[1,8] = 6.5$, $p = 0.034$). Inspection of the data reveals that the F2 change in /i/ is bigger than that in /u/ by an average factor of 1.058 (95% c.i.=1.009..1.108).

The F3 change in /i/ is bigger that that in /u/ by an average factor of 1.037 (95% c.i.=1.004..1.071). The average F2 change in /i/ is 1.030, and in /u/ it is 0.973, which means that the F2 contour of /i/ is rising, while the F2 contour of /u/ is falling.

The same direction of change is found in F3, it is 1.024 for /i/ and 0.988 for /u/. Figures 3 and 4 plot the formant changes in F1 against F2 and F1 against F3, respectively; they show that the direction of F2 and F3 change for /u/ is different from that for /i/.

Figure 3: F1 and F2 change from 25 to 75% of the vowel. Arrows represent median change per speaker per context. Overall change pooled over all speakers and contexts is shown as a line between symbols in circles (small circle: 25%, larger circle: 75%).

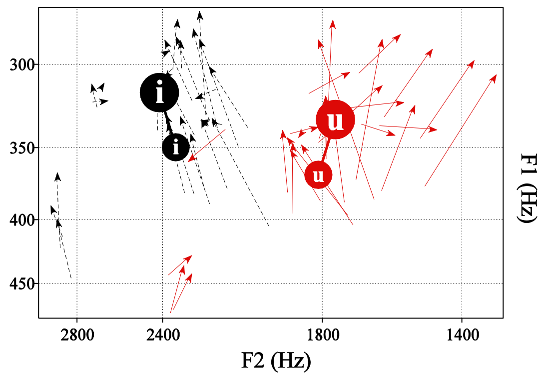
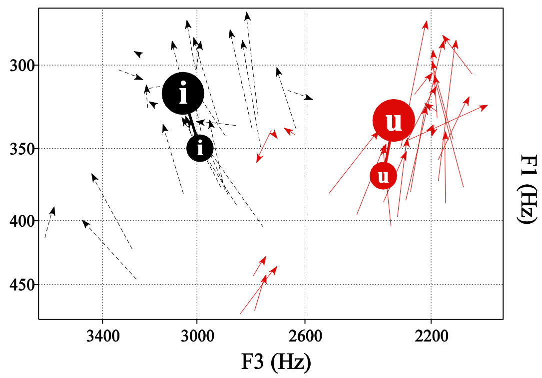


Figure 4: F1 and F3 change from 25 to 75% of the vowel. The figure is organized in the same way as Figure 3.



The analysis further shows a main effect of consonant on F1 change ($F[2,16] = 7.1$, $p = 0.006$) and on F3 change ($F[2,16] = 5.8$, $p = 0.013$); in the labial context the F1 change is smaller and the F3 change bigger than in the other contexts. The smaller F1 change is due to vowels being shortest in the labial context (see Sec. 3.4 below), and thus allowing for a relatively small formant change between the 25% and 75% portion of vowel duration. The greater F3 change in the labial context can be due to the low F3 locus of labials (about 2400 Hz for vowels in the front region of the vowel space [11]) which causes a greater formant change if the contour has to reach a relatively high steady-state F3 (which was here between 2600 Hz and 3600 Hz for all /i/'s, and above 2700 Hz for two speakers' /u/'s).

Since the vowel-specific F2 change is context-independent (unlike the F3 change), we conclude that F2 diphthongization is a stable cue for the /i/-/u/ contrast in SSBE.

3.3. F0

The analysis does not reveal any effects of vowel on F0, but does yield a main effect of consonantal context ($F[2,16] = 6.3$, $p = 0.010$). F0 is higher in labial than in dorsal context by an average factor of 1.029, which is probably due to the fact that the labial in C_2-position was voiceless, while the non-labials in this position were voiced [9].

3.4. Duration

We find a main effect of consonant on vowel duration ($F[2,16] = 25.5$, $p = 1 \cdot 10^{-5}$); vowels are shorter in labial than in the other two contexts by 1.303. This is again due to the voicelessness of the labial C_2 [9]. The effect of vowel category on duration is almost significant ($F[1,8] = 5.1$, $p = 0.053$); the data suggest that /i/ is longer than /u/ by an average factor of 1.038 (c.i.=1.000..1.079).

4. CONCLUSIONS

Our results show that SSBE /u/ and /i/ can still be relatively well distinguished by their steady-state F2 and F3 values. Furthermore, there is an additional (context-independent) acoustic cue to this contrast: the F2 contour, which is falling for /u/ and rising for /i/. The F3 contour follows the same vowel-specific pattern, but is probably a less stable cue because it is sensitive to context, i.e. labialization. Duration seems a possible further cue, as /i/ tends to be longer than /u/, but this effect did not reach significance in the present study. The perceptual relevance of these acoustic cues remains to be tested in the future work. The present study showed that a merger of the high tense vowels in SSBE as result of /u/-fronting is not imminent.

5. REFERENCES

[1] Deterding, D. 1997. The formants of monophthong vowels in Standard Southern British English pronunciation. *JIPA* 27, 47-55.

[2] Docherty, G.J., Foulkes, P. 1999. Derby and Newcastle: instrumental phonetics and variationist studies. In Foulkes, P., Docherty, G. (eds.), *Urban Voices*. London: Arnold, 47-71.

[3] Escudero, P., Boersma P., Rauber, A., Bion, R. 2009. A cross-dialect acoustic description of vowels: Brazilian versus European Portuguese. *JASA* 126, 1379-1393.

[4] Ferragne, E., Pellegrino, F. 2010. Formant frequencies of vowels in 13 accents of the British Isles. *JIPA* 40, 1-34.

[5] Harrington, J., Kleber, F., Reubold, U. 2008. Compensation for coarticulation, /u/-fronting, and sound change in standard southern British: An acoustic and perceptual study. *JASA* 123, 2825-2835.

[6] Hawkins, S., Midgley, J. 2005. Formant frequencies of RP monophthongs in four age groups of speakers. *JIPA* 35, 184-199.

[7] Henton, C.G. 1983. Changes in the vowels of received pronunciation. *J. Phon*. 11, 353-371.

[8] Hillenbrand, J.M., Nearey, T.M. 1999. Identification of resynthesized /hVd/ utterances: Effects of formant contour. *JASA* 105, 3509-3523.

[9] House, A., Fairbanks, G. 1953. The influence of consonant environment upon the secondary acoustical characteristics of vowels. *JASA* 25, 105-113.

[10] de Jong, G., McDougall, K., Hudson, T., Nolan, F. 2007. The speaker discriminating power of sounds undergoing historical change: A formant-based study. *Proc. 17th ICPhS* Saarbrücken, 1813-1816.

[11] Kewley-Port, D. 1982. Measurement of formant transitions in naturally produced stop consonant-vowel syllables. *JASA* 72, 379-389.

[12] McDougall, K., Nolan, F. 2007. Discrimination of speakers using the formant dynamics of /u:/ in British English. *Proc. 17th ICPhS* Saarbrücken, 1825-1828.

[13] Stoddart, J., Upton, C., Widdowson, J.D.A. 1999. Sheffield dialect in the 1990s: revisiting the concept of NORMs. In Foulkes, P., Docherty, G. (eds.), *Urban Voices*. London: Arnold, 72-89.

[14] Trudgill, P. 1999. Norwich: endogenous and exogenous linguistic change. In Foulkes, P., Docherty, G. (eds.), *Urban Voices*. London: Arnold, 124-140.

[15] Watson, C.I., Harrington, J. 1999. Acoustic evidence for dynamic formant trajectories in Australian English vowels. *JASA* 106, 458-468.