VOWEL FORMANTS AND ANGLE MEASUREMENTS IN DIACHRONIC SOCIOPHONETIC STUDIES: *FOOT*-FRONTING IN RP

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ABSTRACT

This paper examines vowel formant data from a corpus of recordings of male speakers of RP born during the course of the twentieth century. It compares average formant positions in the F1/F2 plane for the short vowel FOOT in juxtaposition with LOT (for this Keyword notation see Wells [12]). The relative positions of the two vowels are represented by a single numerical value, which is the calculated angle from LOT to FOOT relative to the vertical. Changing angle values between the early and the later part of the twentieth century reflect a diachronic process of FOOT-fronting and unrounding which is well documented in varieties of British English, such as Torgersen and Kerswill [10], including RP, as in Hawkins and Midgley [6]. The paper also demonstrates the versatility of an angle calculation method (Fabricius [3]), used in combination with F1/F2 plots, in producing replicable quantified measures which demonstrate changing vowel juxtapositions in real time.

Keywords: vowels, RP, formants, sociophonetics.

1. INTRODUCTION

Diachronic change in Received Pronunciation or RP, previously considered to be the elite accent of British English, is an area of sociophonetics that presents several interesting challenges to researchers. Since the sociolinguistic status of the accent within Britain has changed in the past few generations, issues such as the delimitation of the accent variety, its changing phonetic characteristics and its relevance to applied areas such as foreign language teaching are now regularly debated.

The position of this paper is that speakers of RP can be identified empirically, using social and linguistic criteria, and thus that change over time in the phonetics of the accent can be meaningfully revealed and investigated, (see Wells [12] and Hannisdal [4]). The present study contributes to that enterprise partly by using a previously gathered corpus of several published and unpublished sources of RP data (see further below), and partly by applying a newly-developed methodology to illustrate and measure a diachronic change within the short vowel sub-system of RP. Fabricius [3] investigated the TRAP and STRUT juxtaposition, and found a change identified there as the *TRAP/STRUT rotation*, such that while TRAP lowered and backed during the 20th century, STRUT rose and fronted.

The present paper turns its attention to two other short vowels in the subsystem: LOT and FOOT. While LOT has been remarkably stable within RP over the past century (Hawkins and Midgley [6], FOOT has undergone a process of fronting and unrounding, in line with Labov's [8] Pattern 3 predictions of universal directions in vowel chain shifts: that close back vowels move towards the front of the mouth over time, as pointed out by Torgersen and Kerswill [10].

Moreover, the angle calculation method to be presented below is combined with a normalization procedure with certain advantages for sociophonetic studies over algorithms such as conversion to the Bark scale, as in Zwicker [14]; for discussion see Watt and Fabricius [11].

Thus, the present investigation of changing vowel positions over time is carried out using a combination of phonetic and sociolinguistic methods. The mathematical comparison of formant values on one dimension (F1 or F2 alone), which is common in phonetic work, is combined with the usual sociolinguistic strategy comparing vowel positions visually on two dimensions at once. The combination of the angle calculation method described here with S-centroid normalization has potential forensic applications, since it enables comparison of data from several different recording situations (laboratory elicitations, interview speech, radio recordings).

2. THE DATA CORPUS

The data corpus assembled for the present paper consists of instrumental acoustic measurements of vowel formants F1 and F2 on the six short vowels of RP (KIT, DRESS, TRAP, STRUT, LOT, FOOT) from the following sources:

Source A: Radio broadcasts by two male RP speakers from the MARSEC corpus (Roach, Knowles, Varadi and Arnfield [10]) as analysed in Deterding [1].

Source B: Elicited citation forms spoken by a homogenous set of twenty-five male RP speakers born before 1945 as average values for the 25 speakers in the corpus (Wells [12])

Source C: Elicited citation forms spoken by twenty male RP speakers in four age groups – representing individual values (Hawkins and Midgley [6])

Source D: Broadcast speech from Queen Elizabeth II's Christmas broadcasts over three decades, 1950s, 1960s and 1980s (Harrington *et al* [5])

Source E: Sociolinguistic interview speech from four male speakers of modern RP recorded in Cambridge, UK in 1997 and 1998 (data documented in Fabricius [2])

3. METHODS OF ANALYSIS

3.1. Conversion of Data

The published formant data was available in Hertz in the case of sources A, B and C. Published formant data was available in Bark in source D. The latter was converted to Hertz using a conversion table based on Zwicker [14].

3.2. Formant measurement

Measurement of F1 and F2 values from source E was carried out on digitized interview recordings using SIL Speech Analyzer. Tokens of the vowels KIT, DRESS, TRAP, STRUT, LOT, and FOOT were identified in phrasal-accented lexical or content words. The relevant segments were identified from simultaneous inspection of four displays (raw waveform, spectrum, spectrogram and a F2 versus F1 plot). Formant values calculated by the program's LPC algorithm, using a window of 20ms and a bandwidth of 300Hz, were read off the spectrum display at a point which was judged as indicating the main tendency of the vowel without consonantal interference, following a procedure described by Harrington *et al* [5]. These measuring conventions are also commonly used in sociophonetic investigations such as Labov [8]).

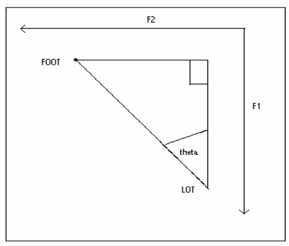
3.3. Normalization procedure

The normalization method used here is the S-centroid procedure presented and discussed in detail in Watt and Fabricius [11]. The procedure calculates a 'centre of gravity' (Koopmans-van Beinum [7]) for each speaker based on the grand mean of three points defining the extremes of the speaker's vowel space. The reader is referred to Watt and Fabricius [11] for more detail. In the present paper, the data points represent averages for each short vowel category, but the procedure can also be used to normalise individual data points.

3.4. Angle calculation

Having obtained S-normalised values for each keyword set, it is then possible to calculate the value of an angle between any two points, using one of them as the 'anchor'. The following figure illustrates the angle between STRUT and LOT relative to the vertical.

Figure 1: Illustration of the angle calculation principle applied to the juxtaposition of LOT and FOOT.



LOT was chosen as a suitable anchor point for the angle here, since it is a relatively stable mid back vowel over the period being examined, and by using LOT the fronting of FOOT vis-à-vis LOT is documented. The angle calculation in degrees is obtained by the formula

(1) $\tan \Theta = ((F2\ FOOT - F2\ LOT)/(F1LOT - F1\ FOOT))$

where Θ is the value of the angle relative to vertical. The tan Θ value was then used to derive the value of the angle in radians, using MS Excel's ATAN (= arctan) function. Excel's DEGREE function converts the angle from radians to degrees.

3.5. Euclidean distance calculation

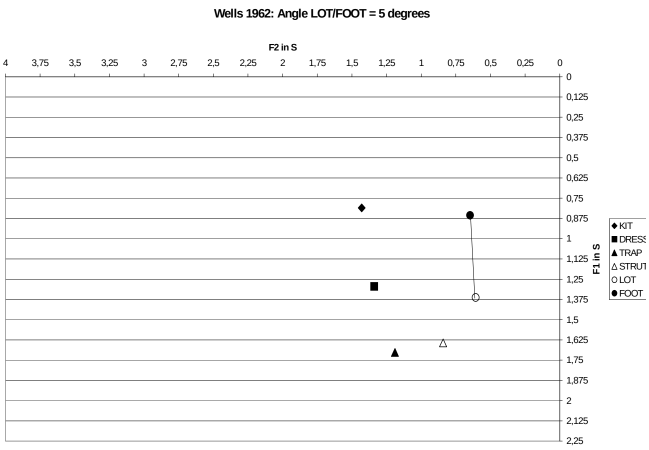
An additional check on the reliability of the angle calculation can be obtained by determining the Euclidean distance between two points, in this case LOT and STRUT for each speaker. This is calculated using the following formula:

(2) DISTANCE = $\sqrt{}$ (F1 LOT – F1 FOOT)^2 + (F2 FOOT–F2 LOT)^2

If the Euclidean distance was calculated as less than 0.1, the angle result was disregarded for the purposes of the discussion (but is included in the results for completeness). The values in question are italicized in the table in section 4.

Figure 2 shows an example of the angle relationship on an F2/F1 formant chart, here using the data from Wells [12], normalised according to the S-centroid procedure. The angle result, 5 degrees, represents an average value for 25 male speakers of RP, all born before 1945.

Figure 2: Plot showing angle relationship between LOT and Foot; data from Wells [9], normalized in accordance with Watt and Fabricius [8]



4. RESULTS

Table 1 shows the complete data set for the present paper, arranged chronologically from the oldest to the youngest speaker.

5. DISCUSSION

It is important to note the point at which a shift occurs from low to high values of the angle from LOT to FOOT relative to vertical. A low angle value indicates that LOT is positioned approximately under FOOT, such that both vowels

Table 1: Angle Data from the diachronic corpus

Birth year	Angle LOT to FOOT	Euc.dist.	Source
1909	1	0,525	A, male h
1926	27	0,158	D, 1950s
1926	13	0,340	D, 1960s
1926	10	0,376	D, 1980s
1927	36	0,285	A, male c
1928-1936	25	0,322	C, Sp.1-1
1928-1936	5	0,275	C, Sp.1-2
1928-1936	-2	0,226	C, Sp.1-3
1928-1936	17	0,585	C, Sp.1-4
1928-1936	22	0,334	C, Sp.1-5
before 1945	5	0,508	B
1946-1951	6	0,553	C, Sp.2-1
1946-1951	6	0,314	C, Sp.2-2
1946-1951	1	0,420	C, Sp.2-3
1946-1951	27	0,212	C, Sp.2-4
1946-1951	35	0,306	C, Sp.2-5
1956	*78*	*0,068*	E
1961-1966	-3	0,391	C, Sp.3-1
1961-1966	-1	0,289	C, Sp.3-2
1961-1966	13	0,426	C, Sp.3-3
1961-1966	*56*	*0,072*	C, Sp.3-4
1961-1966	61	0,214	C, Sp.3-5
1966	73	0,148	E
1973	57	0,244	E
1976-1981	69	0,202	C, Sp.4-1
1976-1981	64	0,126	C, Sp.4-2
1976-1981	68	0,104	C, Sp.4-3
1976-1981	58	0,162	C, Sp.4-4
1976-1981	62	0,127	C, Sp.4-5
1980	65	0,191	E

are in the back vowel area (where LOT subsequently remains for younger speakers). The first group to show what Hawkins and Midgley [6] term 'break group distribution' is the group born in the period 1961-1966. Of the four results which can be considered reliable (the separation between LOT and FOOT being too small at 0.072 in the case of Speaker 3-4), three have very small angles, at (-3, -1 and 13 degrees, indicating that FOOT in these cases is immediately above LOT or even very slightly behind it), while Speaker 5 has the most fronted FOOT value of this cohort with the angle at 61 degrees. In this group then, we see variability arising. The fronted position of FOOT vis-à-vis LOT is then shown consistently for all speakers in the younger cohorts, both in laboratory speech (source C) and interview speech (source E), since all show angles in the range 57 to 73 degrees.

Speakers born during the 1970s consistently have the fronted FOOT quality, which dates the establishment of this fronting movement quite specifically to the 1970s and possibly the early 1980s, when these speakers reached adolescence.

It is also notable that the earlier age cohorts do in many cases show a variable pattern, varying as they do between, firstly, very small positive and even very small negative angles (between +10 and –3) in some cases, secondly, angles that are somewhat higher, in the range 10-17, and finally angles that are higher again, in the range of 22-36 degrees. It is however difficult to group these results convincingly, as the data seem more to show a continuous gradual variation between low angles, signifying fully backed FOOT values, and several intermediate positions indicating some fronting, before the definitive shift to a consistently fronted FOOT quality is found in the 1970s cohort.

In Fabricius [3], an investigation of TRAP and STRUT in the present corpus found evidence that the realignment of TRAP and STRUT which has taken place in the course of the twentieth century began with TRAP lowering early in the century. STRUT raising seems to have begun slightly earlier than FOOT fronting, although the 1961-1966 cohort in that case also shows considerable variability.

6. CONCLUSION

These comparisons demonstrate that differences in the relative placements of two vowels over time can be meaningfully and reliably expressed simultaneously on both the F1 and F2 dimensions. The methodology of this paper unites F1 and F2 shifts into a single polar representation, capturing the two-dimensionality of the vowel space in a single quantified relative position. This aids understanding of the progress of changes in vowel configurations over time. With careful comparisons in real time, it is possible to accurately date vocalic shifts in speech corpora, and thus, by implication in speech communities, both absolutely and relative to each other.

7. REFERENCES

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