Analysis & Results: the FOOT-STRUT split

School: English Literature, Language and Linguistics

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Contents

0.1. Introduction

This chapter will consider the FOOT-STRUT split in all three speakers groups (CoRP-SE, DECTE, and CoRP-NE, henceforth referred to as corpora), first, in section 0.2 by modelling FOOT and STRUT together in each corpus (in both F1 and F2 dimensions), then in section 0.3 by modelling the STRUT vowel alone in all three corpora together.

As summarised in chapter 5 the FOOT and STRUT vowels were measured once, at one third of the duration (Rosenfelder et al., 2014). Data cleaning methods are also explained in chapter 5. In order to prevent over fitting of models the linguistic predictors were plotted with F1 and F2, and only included if variation was seen between the levels of the predictor. Models were compared using CAIC, including using the stepCAIC() function from the cAIC4 package (Saefken and Ruegamer, 2018) to determine the model with the best fit. Unless involved in an interaction, categorical predictors were sum coded (suing contr.sum() from the stats package R Core Team 2021) in order to understand the intercept as a mean in real terms rather than at a combination of single levels of the predictors Winter (2019), those that were sum-coded are marked in the model tables as 'predic-

tor*Sum*'. Continuous predictors were scaled to a z-score using the scale() function (R Core Team, 2021).

0.2. The Split

0.2.1. CoRP-SE speakers

There is no reference in the literature (see chapter 3) that the split in the South East is affected by social class and so the CoRP-SE speakers are assumed to have the prototypical southern FOOT-STRUT split. Analysis of their vowels shows that the split is found mostly in height (F1: +199Hz) and very slightly in frontness (F2: -86Hz). As discussed below and in section 0.2.1, the frontness is a difference in mean but there is full overlap between the ranges. From figure 0.1 (a plot of F1 against F2, ellipses drawn at 0.67 of the standard deviation) it can be seen that there is overlap of individual tokens but the mean position of the STRUT words is lower in the vowel space than the FOOT words. They are also on average further back but the range falls within a subsection of the total F2 range of the FOOT words, which are more spread out. Full analysis of the F1 and F2 difference is in sections 0.2.1 and 0.2.1.

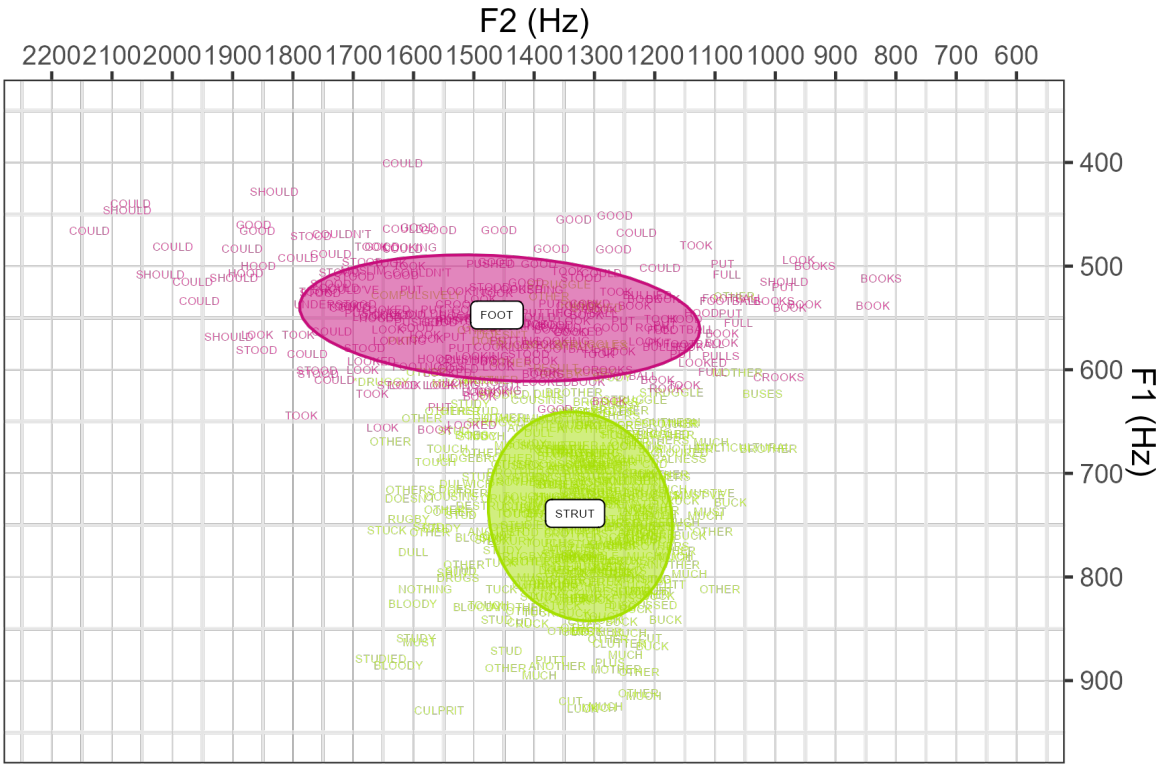

Figure 0.1.: Vowel Space plot of FOOT and STRUT in the CoRP-SE speakers

F1

The best fit model of the normalised F1 of the FOOT and STRUT words is shown in table 0.1; the model also includes random intercepts for speaker and word. The model intercept is 536Hz, which is the mean F1 of the FOOT words. The effect size of lexical Set is +199Hz (t=17.28). Therefore, the mean F1 for the vowels in the STRUT words is 735Hz. There is an effect of speaker sex (t=3.77) but the effect size is only 21Hz, which is not large in the context of the lexical set variation. This model demonstrates that the vowels of the two lexical sets are distinct in height in CoRP-SE speakers, with the mean of the STRUT lexical set lower in the mouth than the mean of the FOOT lexical set, by 199Hz. The difference is visualised in figure 0.2 (based on raw data, not the model predictions), where the distinction between the vowel measurements in the two lexical sets can be seen clearly, with no overlap between the interquartile ranges.

fixedeffect	estimate	tvalue
(Intercept)	536.37	35.36
lexSetSTRUT	199.08	17.28
sexSum1	20.57	3.77
ageGroupSum1	3.82	0.71
folManSum1	12.17	0.76
folManSum2	0.15	0.02
folManSum3	-20.85	-1.56
preSeg_smallSum1	19.32	1.50
preSeg_smallSum2	11.43	1.32
preSeg_smallSum3	-12.04	-0.96
preSeg_smallSum4	-19.77	-0.95
freq.zipf_z	0.61	0.11
styleSum1	-16.14	-2.18
styleSum2	7.27	0.79
time_z	1.55	0.43

Table 0.1.: Linear Mixed Effects Model of F1 of FOOT and STRUT in the South East

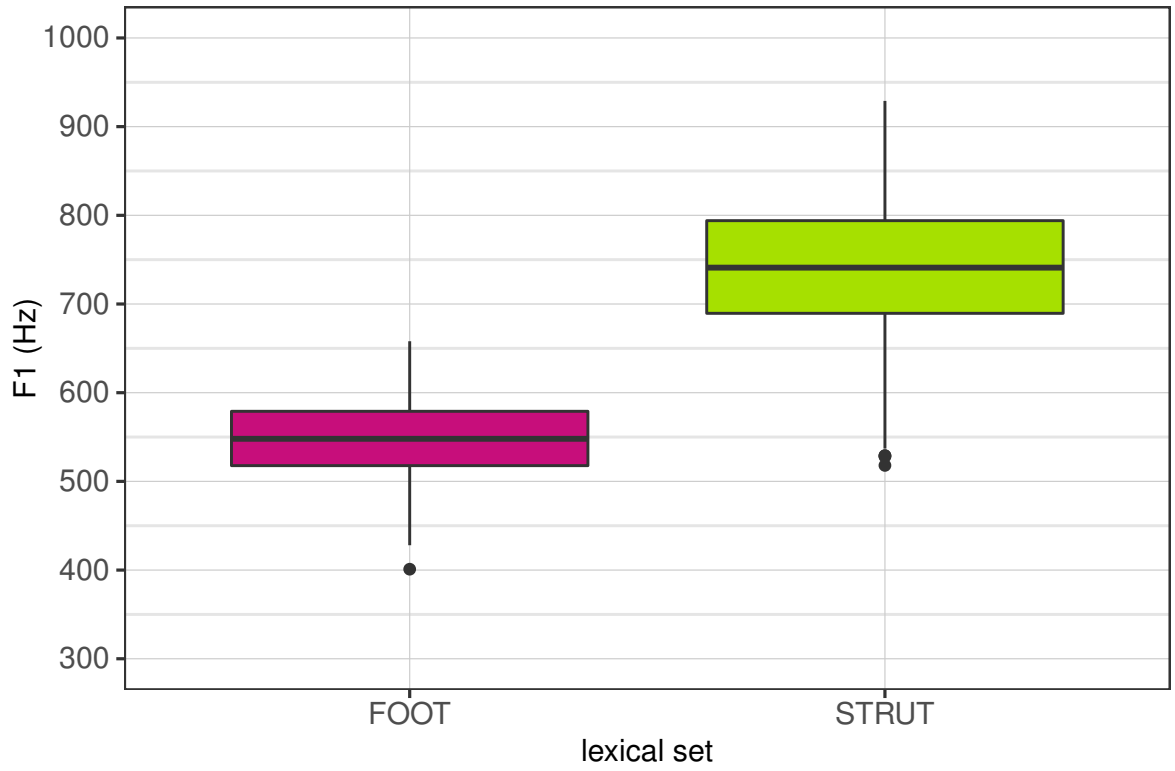

Figure 0.2.: F1 of FOOT and STRUT in CoRP-SE speakers

F2

Modelling F2 (see table .1) showed an intercept of 1383Hz, the mean of the FOOT() lexical set, and while there is a lot less variation according to lexical set than seen in F1, there is a difference of -86Hz (t =-2.58) implying that the mean of the STRUT vowel is slightly further back than the mean of the FOOT vowel in south-eastern speakers, this can be seen in figure 0.3. This difference is not large and it can be seen in figure 0.3 that the inter-quartile range is almost completely overlapping; the STRUT words sit almost completely within the range of the FOOT words. There is also a small but significant effect of style.

fixedeffect	estimate	tvalue
(Intercept)	1386.41	29.16
lexSetSTRUT	-85.98	-2.58
sexSum1	-13.82	-0.56
ageGroupSum1	-20.93	-0.84
folManSum1	10.77	0.23
folManSum2	-1.30	-0.05
folManSum3	-52.11	-1.37
preSeg_smallSum1	-26.20	-0.69
preSeg_smallSum2	-15.12	-0.60
preSeg_smallSum3	-62.95	-1.74
preSeg_smallSum4	107.84	1.81
freq.zipf_z	-2.61	-0.17
styleSum1	62.19	3.24
styleSum2	-43.60	-1.88
time_z	15.37	1.67

Table 0.2.: Linear Mixed Effects Model of F2 of FOOT and STRUT in the South East

A further model was run including STRUT, THOUGHT, and schwa, to check the frontness of the STRUT vowel of in comparison to other vowels at a similar height in the English vowel space. The model summary can be found in appendix .1.1; it shows that the STRUT vowel in these speakers is significantly further forward than the THOUGHT vowel (-399Hz, t=-13.50) and also significantly further back than the schwa (305Hz, t=8.16), placing it between the two in the vowel space, but closer to schwa (see figure 0.4). ‘

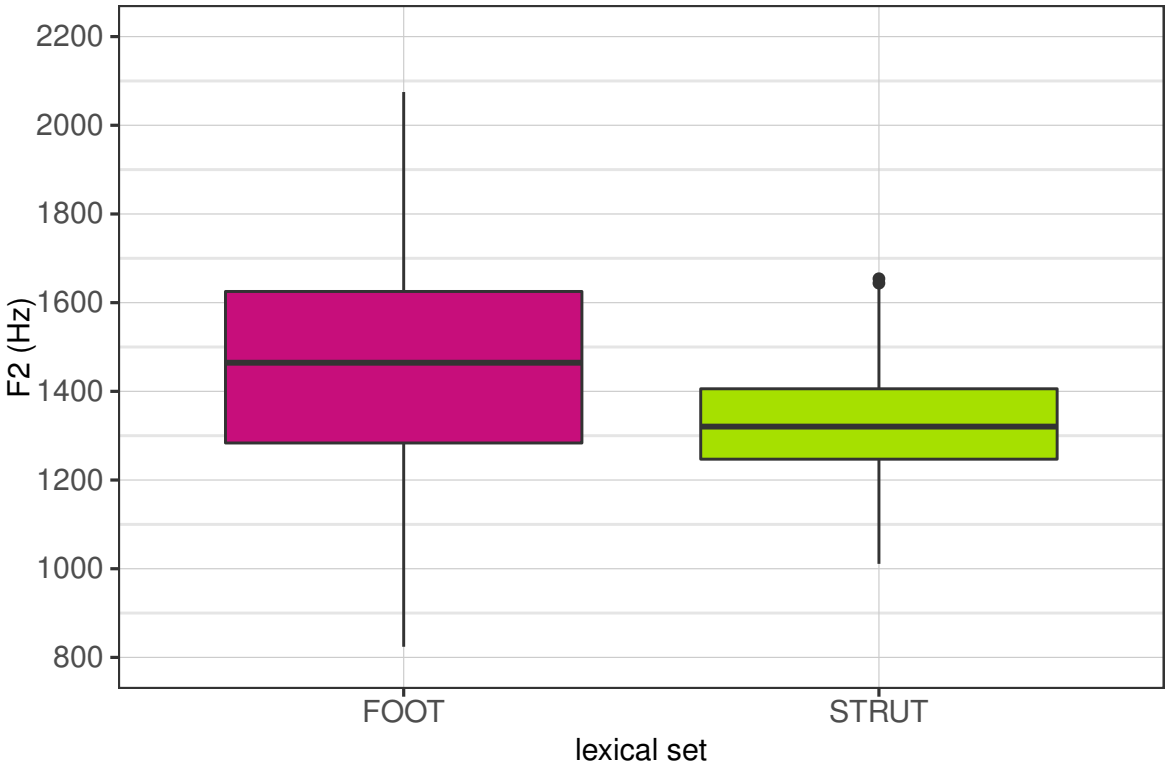

Figure 0.3.: F2 of FOOT and STRUT in CoRP-SE speakers

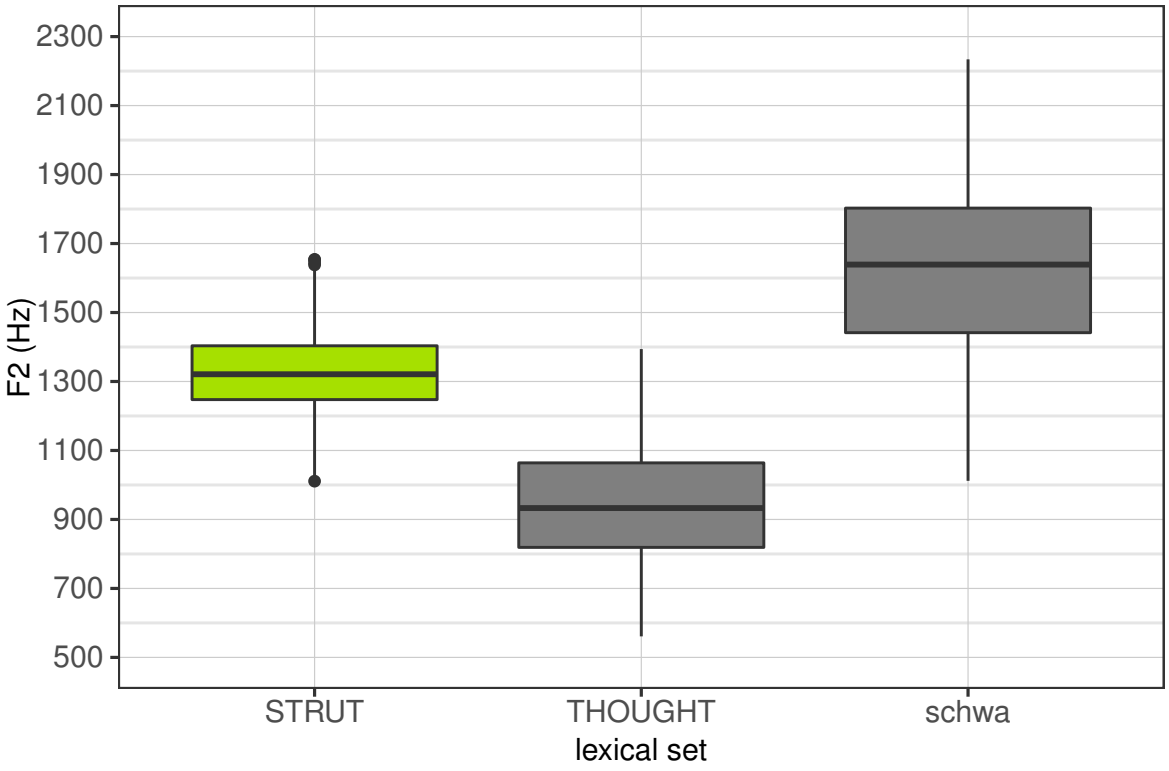

Figure 0.4.: F2 of STRUT, THOUGHT, and schwa in CoRP-SE speakers

0.2.2. DECTE speakers

Overall, the DECTE speakers do not show a split in height, as measured by F1 and while they show some F2 differences between FOOT and STRUT in the old age group (+147Hz) the pattern is clearly different to that found in the CoRP-SE speakers and it can be concluded that according to this sample, the majority of state-educated speakers in the North East do not show a FOOT-STRUT split. Further analysis of the F1 and F2 dimensions is continued below.

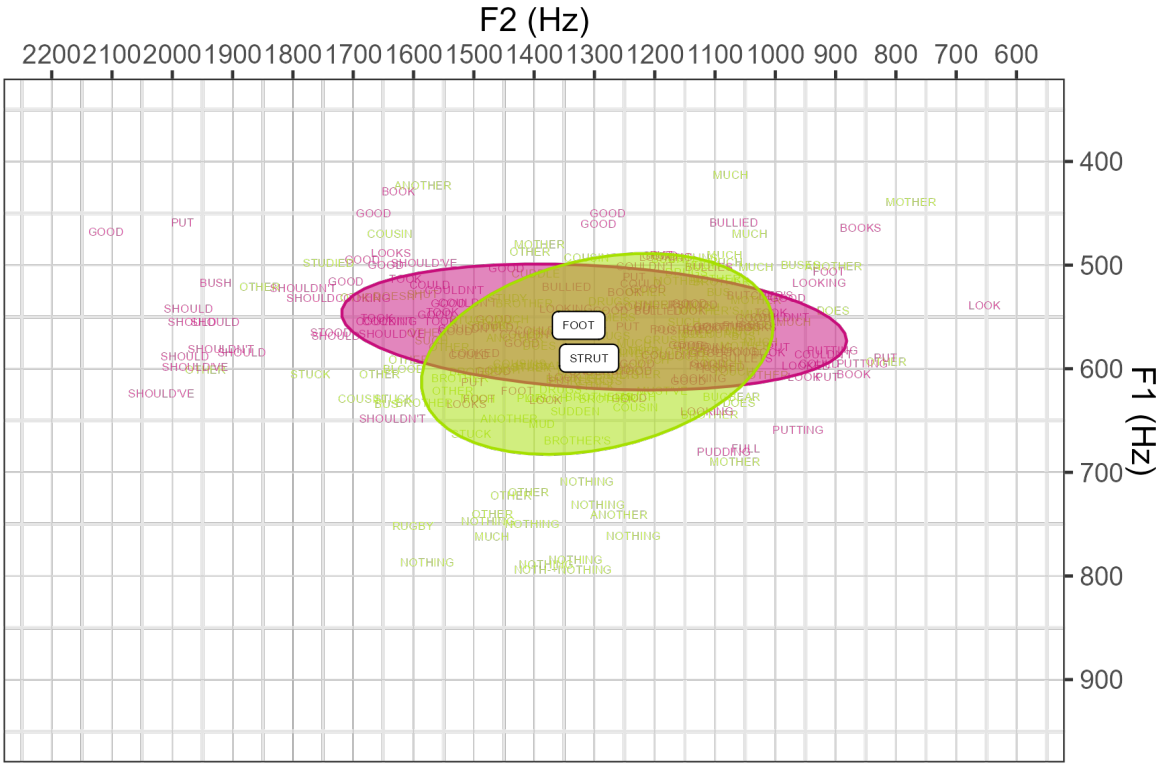

Figure 0.5.: Vowel Space plot of FOOT and STRUT in the DECTE speakers

F1

Modelling F1 of the FOOT and STRUT words in the DECTE speakers gives an intercept of 572Hz (table 0.3), which is the mean of the FOOT words, and no significant effect of lexical set (seen in figure 0.6). However, when looking at individual speakers, as shown in figure 0.7, it does appear that some speakers have a small difference. Since the best fit model did not include random effect for speaker it is not possible to investigate this further.

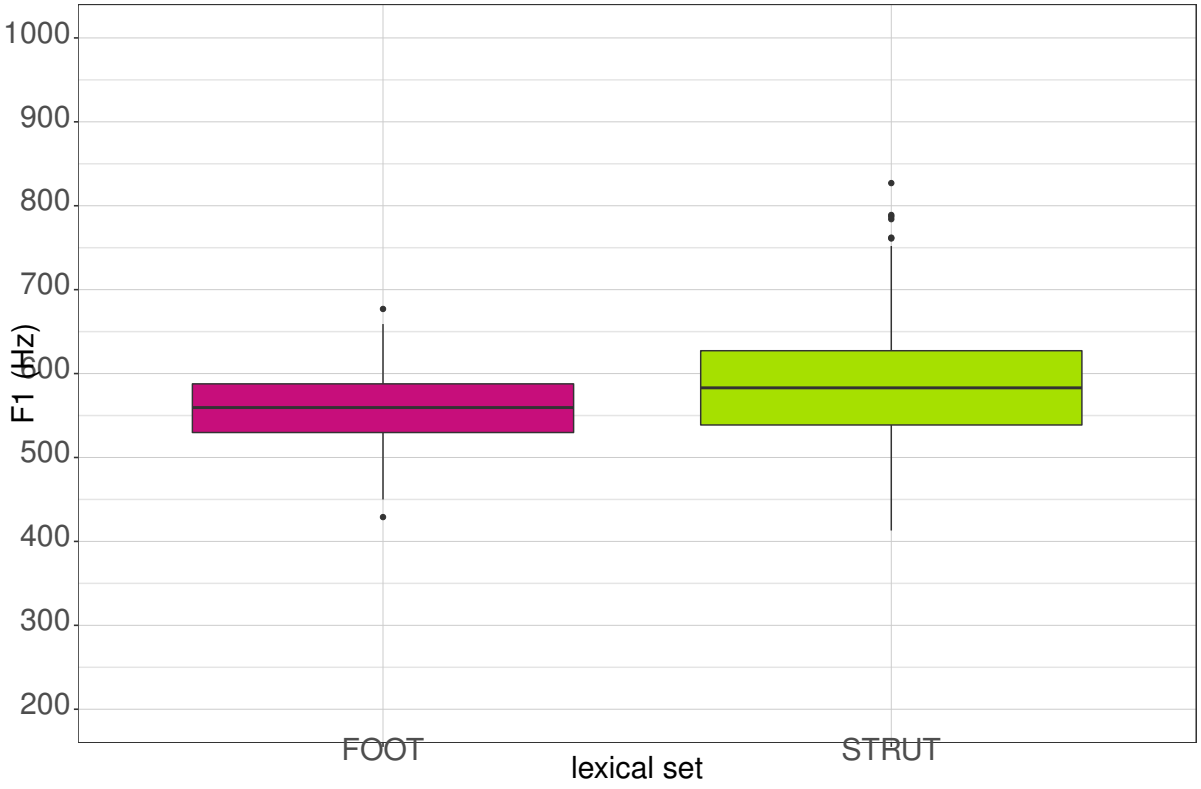

Figure 0.6.: F1 of FOOT and STRUT in DECTE speakers

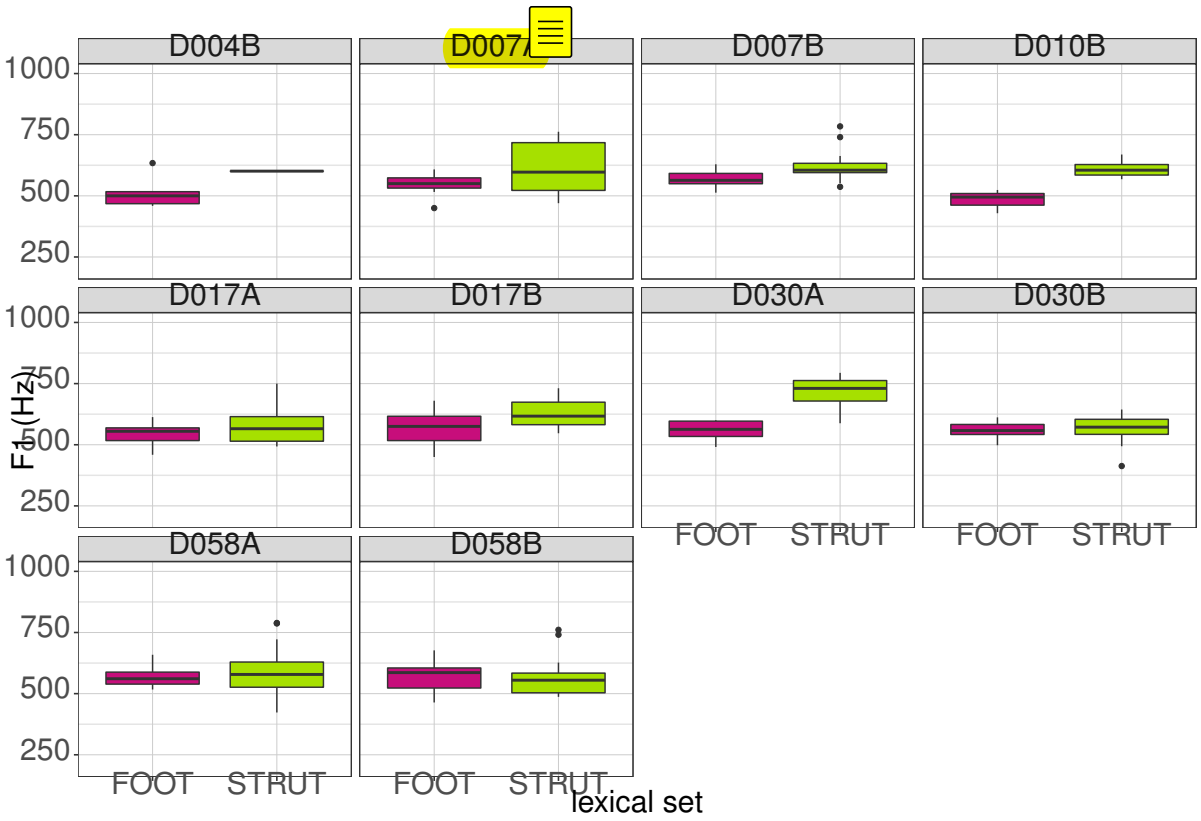

Figure 0.7.: F1 of FOOT and STRUT in DECTE speakers, by speaker

fixedeffect	estimate	tvalue
(Intercept)	571.28	27.70
lexSetSTRUT	27.12	1.47
sexSum1	3.53	0.72
ageGroupSum1	-8.55	-1.70
folManSum1	-19.81	-0.86
folManSum2	5.81	0.41
folManSum3	14.90	0.69
preSeg_smallSum1	24.82	1.14
preSeg_smallSum2	-4.07	-0.30
preSeg_smallSum3	1.52	0.07
preSeg_smallSum4	-19.53	-0.65
freq.zipf_z	7.14	0.75
time_z	11.41	1.84

Table 0.3.: Linear Mixed Effects Model of F1 of FOOT and STRUT in DECTE speakers

F2

The best fit model of F2 of the FOOT and STRUT words in the DECTE speakers (table 0.4) includes an interaction of lexical set and age group. The intercept (mean of FOOT words in old speakers) is 1232Hz, the mean of FOOT words in young speakers is 1638Hz. The split in the old age group is +147Hz whereas in the young age group it is -26Hz. It is possible that the split in the younger speakers is affected by the fronting of FOOT due to the Tyneside phenomenon of FOOT merging with GOOSE, which seems to be more prevalent in the younger speakers in this age group (figure 0.8).

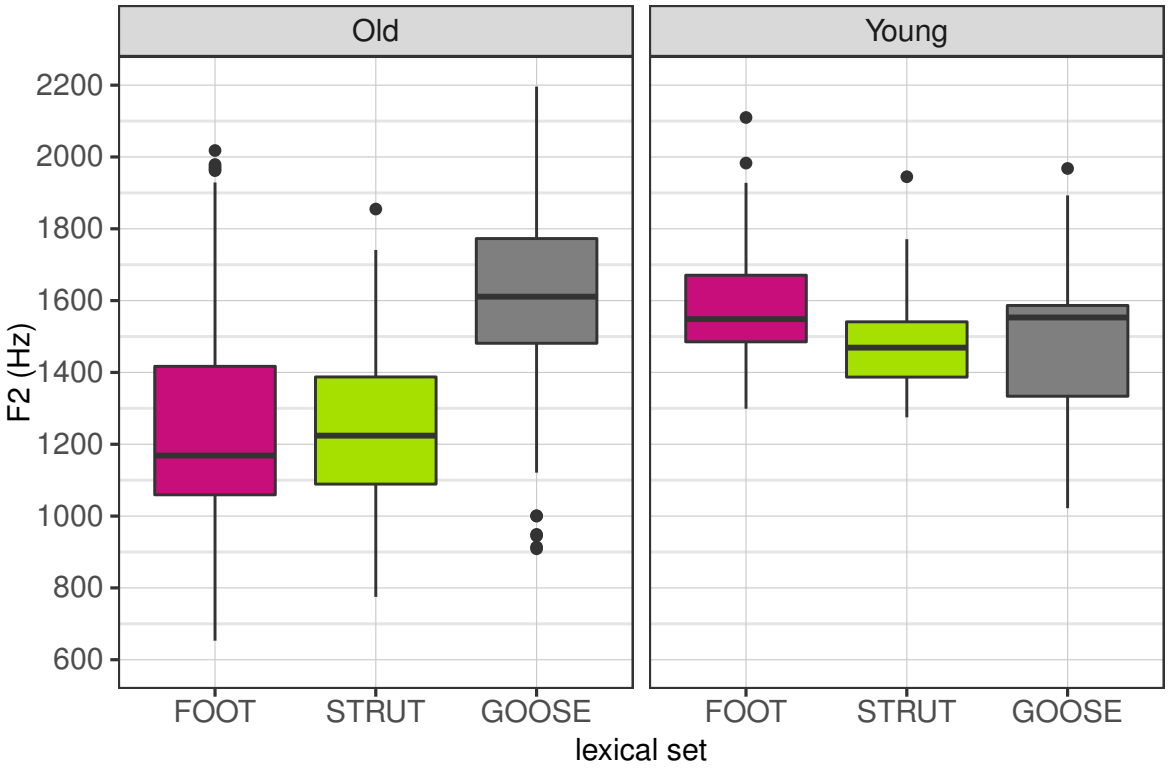

Figure 0.8.: F2 of FOOT, STRUT, and GOOSE in DECTE speakers, by age group

fixedeffect	estimate	tvalue
(Intercept)	1232.05	19.07
lexSetSTRUT	146.67	2.67
ageGroupYoung	405.58	6.41
sexSum1	-48.29	-1.80
folManSum1	-73.52	-1.13
folManSum2	-12.44	-0.31
folManSum3	11.04	0.18
preSeg_smallSum1	-150.48	-2.42
preSeg_smallSum2	-139.84	-3.60
preSeg_smallSum3	-148.60	-2.36
preSeg_smallSum4	458.85	5.36
freq.zipf_z	25.87	0.95
time_z	-37.39	-1.96
lexSetSTRUT:ageGroupYoung	-172.85	-2.88

Table 0.4.: Linear Mixed Effects Model of F2 of FOOT and STRUT in DECTE speakers

0.2.3. CoRP-NE speakers

CoRP-NE speakers show some evidence of a FOOT-STRUT split, particularly in F1 (on average 110Hz, higher in female speakers) but little evidence of an F2 split except in one speaker. Further analysis of the F1 and F2 differences can be seen below, but from the vowel space plot in figure it can be seen that the STRUT words are lower than the FOOT words (with some overlap) but have similar frontness.

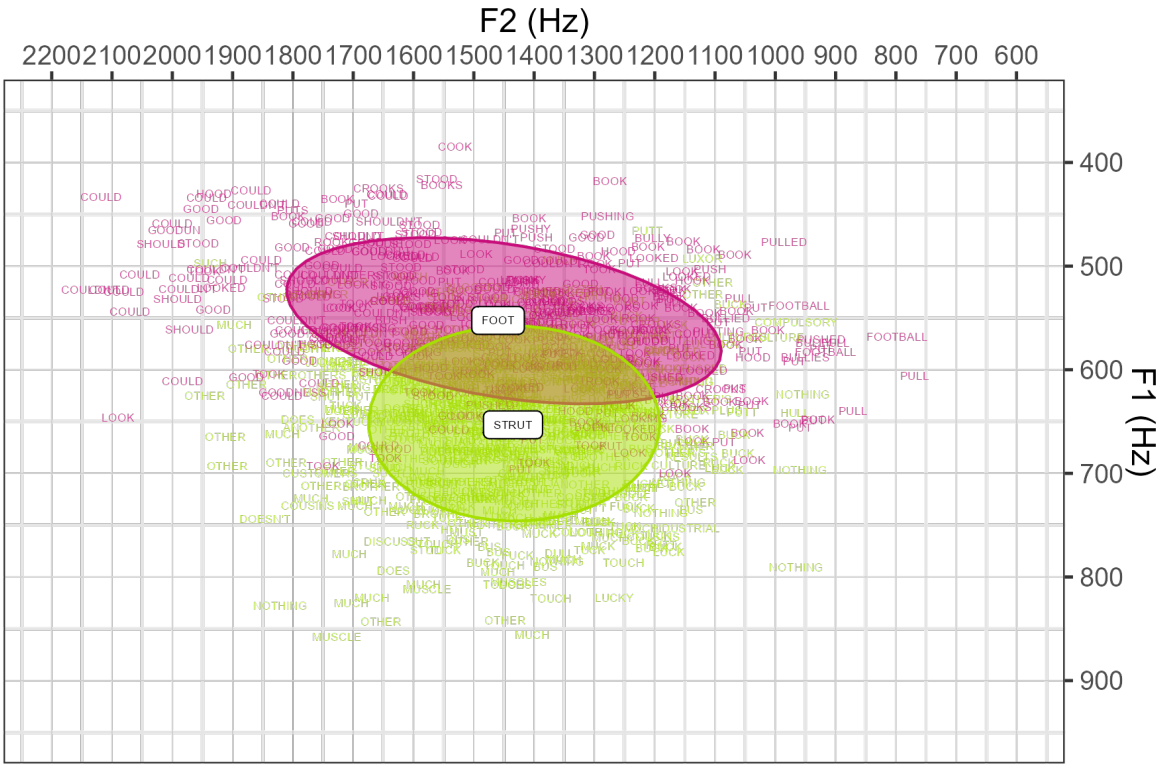

Figure 0.9.: Vowel Space plot of FOOT and STRUT, in the CoRP-NE speakers

F1

The best fit model for F1 of the CoRP-NE speakers can be seen in table 0.5 and shows a FOOT-STRUT split in F1 that interacts with both speaker sex and age group. The mean value of FOOT is 541.53 and the mean value of STRUT is 651Hz, showing an average split of 110Hz. However, this split is overall higher for female speakers (mean=142Hz) compared to male speakers (mean=78Hz) (64 Hz difference), there is also a slightly larger split in older speakers. Overall the size of split is ranked: old female, young female, old male, young male.

fixedeffect	estimate	tvalue
(Intercept)	516.30	27.03
lexSetSTRUT	172.92	14.45
sexMale	32.17	1.22
ageGroupYoung	36.03	1.88
folManSum1	-12.31	-1.08
folManSum2	11.62	1.59
folManSum3	-5.03	-0.52
preSeg_smallSum1	24.05	2.49
preSeg_smallSum2	12.59	1.82
preSeg_smallSum3	-22.43	-2.08
preSeg_smallSum4	-9.66	-0.56
freq.zipf_z	2.55	0.61
styleSum1	-12.35	-2.17
styleSum2	5.40	0.78
lexSetSTRUT:sexMale	-89.79	-5.32
lexSetSTRUT:ageGroupYoung	-61.66	-5.40
sexMale:ageGroupYoung	-36.95	-1.18
lexSetSTRUT:sexMale:ageGroupYoung	50.89	2.53

Table 0.5.: Linear Mixed Effects Model of F1 of FOOT and STRUT in the North East

	FOOT	STRUT	*size of split*
Old Female	516.3	689.22	*172.92*
Old Male	548.47	631.6	*83.13*
Young Female	553.07	664.33	*111.26*
Young Male	548.29	620.65	*72.36*
Mean	541.53	651.45	*109.92*

Table 0.6.: table showing interactions effects of speaker age group and sex on F1 of FOOT and STRUT in CoRP-NE speakers (calculated from interactions in table 0.5)

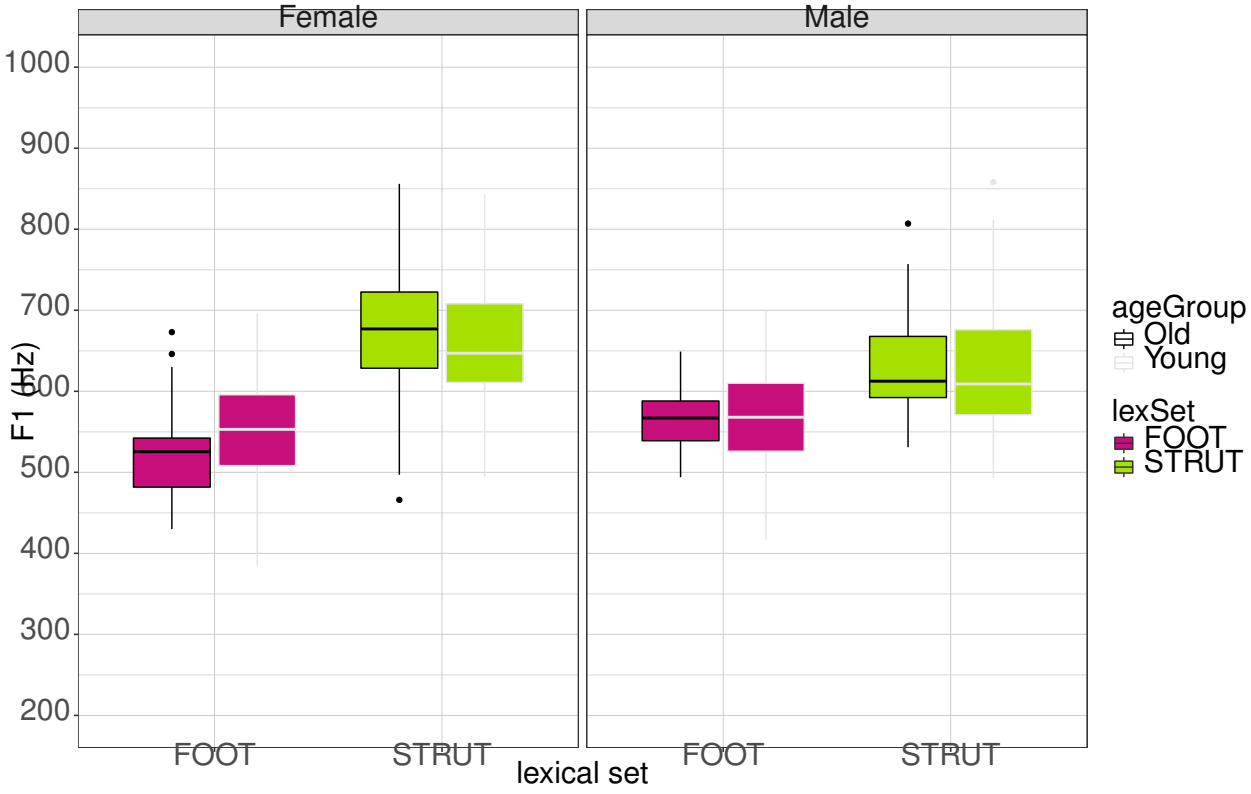

Figure 0.10.: F1 of FOOT and STRUT in CoRP-NE speakers

F2

The best fit model for F2 of the CoRP-NE speakers (see table 0.7) also includes a three way interaction between lexical set, sex, and age group (summarised in figure 0.8). The mean value of FOOT is 1339Hz and the mean value of STRUT is 1380Hz, showing very little distinction, when the interaction is considered the largest distinction that is seen is in the opposite direction to the CoRP-SE speakers showing a STRUT vowel that is slightly fronter than the FOOT vowel.

fixedeffect	estimate	tvalue
(Intercept)	1468.01	25.11
lexSetSTRUT	-27.34	-0.68
sexMale	-261.86	-3.42
ageGroupYoung	-77.10	-1.45
folManSum1	81.82	1.71
folManSum2	52.98	1.89
folManSum3	-209.68	-5.95
preSeg_smallSum1	-45.91	-1.21
preSeg_smallSum2	-28.81	-1.10
preSeg_smallSum3	-68.50	-1.71
preSeg_smallSum4	161.72	2.57
freq.zipf_z	28.41	1.74
styleSum1	56.67	3.08
styleSum2	-30.87	-1.52
time_z	-6.79	-0.83
lexSetSTRUT:sexMale	203.82	4.34
lexSetSTRUT:ageGroupYoung	52.55	1.67
sexMale:ageGroupYoung	162.76	1.84
lexSetSTRUT:sexMale:ageGroupYoung	-240.35	-4.31

Table 0.7.: Linear Mixed Effects Model of F2 of FOOT and STRUT in the North East

	FOOT	STRUT	*size of split*
Old Female	1468.01	1440.67	*-27.34*
Old Male	1206.15	1382.63	*176.48*
Young Female	1390.91	1416.12	*25.21*
Young Male	1291.81	1280.49	*-11.32*
Mean	1339.22	1379.98	*40.76*

Table 0.8.: table showing effects of speaker age group and sex on F2 of FOOT and STRUT in CoRP-NE speakers (calculated from table 0.7)

0.2.4. Conclusions on the nature of the FOOT-STRUT Split in all three speaker groups

In the CoRP-SE speakers the FOOT and STRUT vowel are distinguished in F1 (a difference of +110Hz) and F2 (-86Hz). The F1 difference is clearly meaningful but while the F2 difference is present and statistically significant it needs to be considered more carefully because it is only a small difference within the whole vowel space. Overall the FOOT-STRUTsplit can be described as mostly characterised by height and slightly by frontness. It was also found that the frontness of the STRUT vowel in the South East is between the schwa and THOUGHT vowels, but closer to schwa. If the CoRP-NE speakers are behaving like the CoRP-SE speakers, we would expect them to have a similar pattern in both F1 and possibly F2.

In the DECTE speakers we see what can be considered 'normal' North East FOOT-STRUT positions of FOOT and STRUT. The speakers show no significant difference between FOOT and STRUT in F1, and in F2 a small difference in mainly older speakers (+147Hz). It can be concluded that there is not a robust FOOT-STRUT split in the North East as found in the CoRP-SE speakers.

In CoRP-NE speakers we some evidence of a split. They show an F1 difference of 110Hz (mean, male and female speakers behave differently) and some F2 difference in the opposite direction to CoRP-SE. This suggests that these speakers have a split, but it is not identical to the split found in the CoRP-SE speakers. It is not as large in height (F1 is 110Hz vs the 199Hz found in CoRP-SE speakers) and does not seem to exist in frontness.

By analysis of the FOOT and STRUT words in all three speaker groups it can be concluded that CoRP-NE speakers do not behave identically to either of the other speaker groups. However, conclusions can be drawn in answer to research question 1. The DECTE speakers (state educated in the North East) do not show any FOOT-STRUT split and CoRP-NE speakers clearly have at least some distinction between FOOT and STRUT so it can be concluded that they are not behaving consistently regionally. While the CoRP-NE speakers do not show as large a split as the CoRP-SE speakers, there is clearly a split present, demonstrating at least a tendency towards non-regional behaviour.

In order to further understand the nature of the difference between the split in different speaker groups the STRUT words were modelled separately, results of this are discussed in section 0.3.

0.3. STRUT VOWEL ONLY

0.3.1. F1

fixedeffect	estimate	tvalue
(Intercept)	671.04	43.85
relevel(corpus, "CoRP-NE")DECTE-NE	-79.47	-5.16
relevel(corpus, "CoRP-NE")CoRP-SE	93.87	6.42
sexMale	-47.85	-3.41
ageGroupSum1	3.91	0.76
folManSum1	-3.69	-0.25
folManSum2	12.89	1.48
folManSum3	-21.14	-1.79
preSeg_smallSum1	12.66	0.86
preSeg_smallSum2	15.56	1.72
preSeg_smallSum3	-17.46	-1.47
preSeg_smallSum4	-21.44	-0.93
freq.zipf_z	6.54	1.06
styleSum1	-20.18	-2.28
styleSum2	14.45	1.48
relevel(corpus, "CoRP-NE")DECTE-NE:sexMale	77.98	3.00
relevel(corpus, "CoRP-NE")CoRP-SE:sexMale	4.27	0.19

Table 0.9.: Linear Mixed Effects Model of F1 of STRUT

Modelling the STRUT vowel alone (see table 0.9) shows that the CoRP-NE speakers are significantly different in F1 from both the CoRP-SE and the DECTE speakers. The best fit model included an interaction between corpus and speaker sex, the results of which are shown in table 0.10. These results partially support those above but add an extra dimension. The mean F1 value for STRUT in CoRP-NE female speakers is between the CoRP-SE and DECTE values, but the male speakers show a vowel that is very similar to the DECTE speakers (visualised in figure 0.11). This implies that while female speakers are not behaving regionally, male speakers are.

	CoRP-SE	DECTE	CoRP-NE
Female	764.91	591.57	671.04
Male	721.78	621.7	623.19
Mean	*743.35*	*606.64*	*647.12*

Table 0.10.: table showing effects of corpus group and speaker sex on F1 of STRUT (calculated from table 0.9)

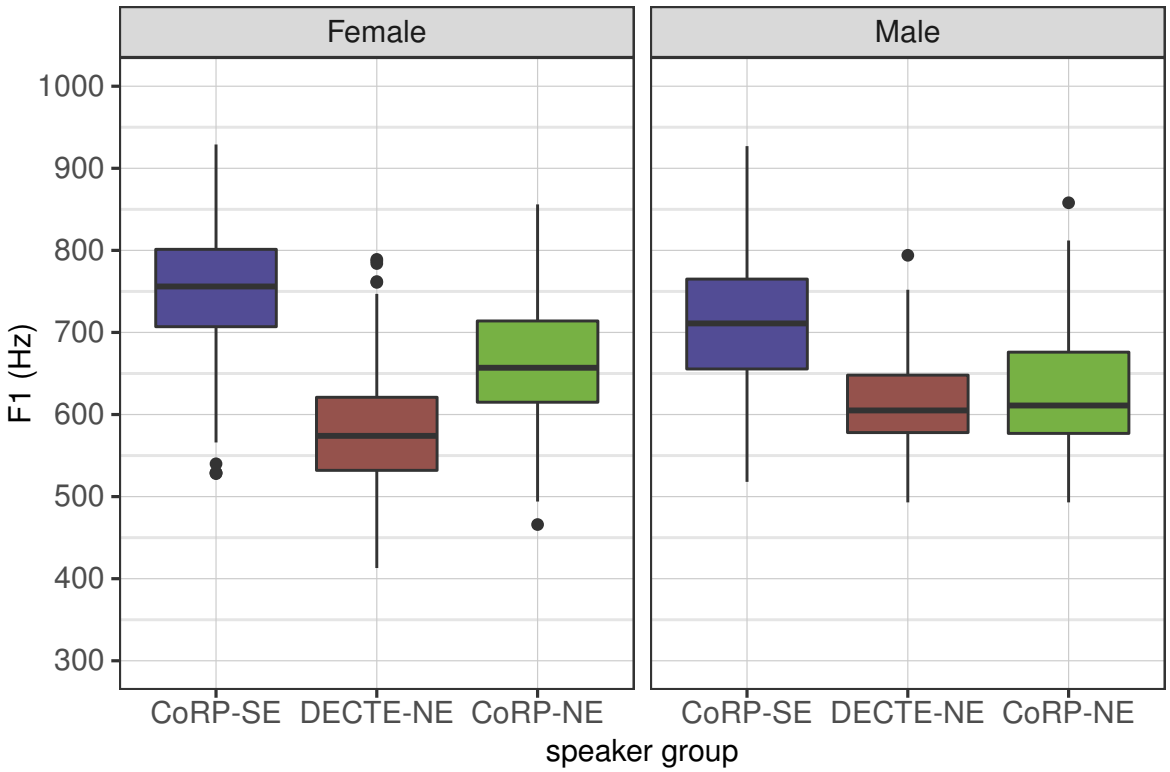

Figure 0.11.: F1 of STRUT in CoRP-SE, DECTE, and CoRP-NE speakers, by speaker sex

0.3.2. F2

Modelling F2 of the STRUT words alone again shows an interaction of corpus and speaker sex (0.11). In each corpus the male speakers have a less front vowel, and overall the CoRP-NE speakers have the most front vowel, in both male and female speakers. Even if the CoRP-SE vowel is taken as the prototypical STRUT vowel there is variation between male and female, with male speakers producing a less front vowel (82Hz difference). The DECTE speakers show a relatively similar frontness to the CoRP-SE speakers, however the CoRP-NE speakers behave differently, both male and female speakers produce a fronter STRUT vowel than either of DECTE or CoRP-SE speakers, though the female difference is larger (see tables 0.11 and 0.12).

fixedeffect	estimate	tvalue
(Intercept)	1476.10	31.13
relevel(corpus, "CoRP-NE")DECTE-NE	-149.03	-2.54
relevel(corpus, "CoRP-NE")CoRP-SE	-167.30	-2.77
sexMale	-122.73	-2.18
ageGroupSum1	-14.63	-0.73
folManSum1	59.85	1.64
folManSum2	27.27	1.30
folManSum3	-106.91	-3.83
preSeg_smallSum1	-58.13	-1.65
preSeg_smallSum2	-21.82	-1.01
preSeg_smallSum3	-52.51	-1.86
preSeg_smallSum4	132.08	2.43
freq.zipf_z	12.46	0.85
styleSum1	10.33	0.51
styleSum2	-11.97	-0.58
relevel(corpus, "CoRP-NE")DECTE-NE:sexMale	208.16	2.32
relevel(corpus, "CoRP-NE")CoRP-SE:sexMale	159.08	1.71

Table 0.11.: Linear Mixed Effects Model of F2 of STRUT

	CoRP-SE	DECTE	CoRP-NE
Female	1308.8	1327.07	1476.1
Male	1226.93	1263.47	1353.37
Mean	*1267.87*	*1295.27*	*1414.74*

Table 0.12.: table showing effects of corpus on F2 of STRUT (calculated from interaction effects in table 0.11)

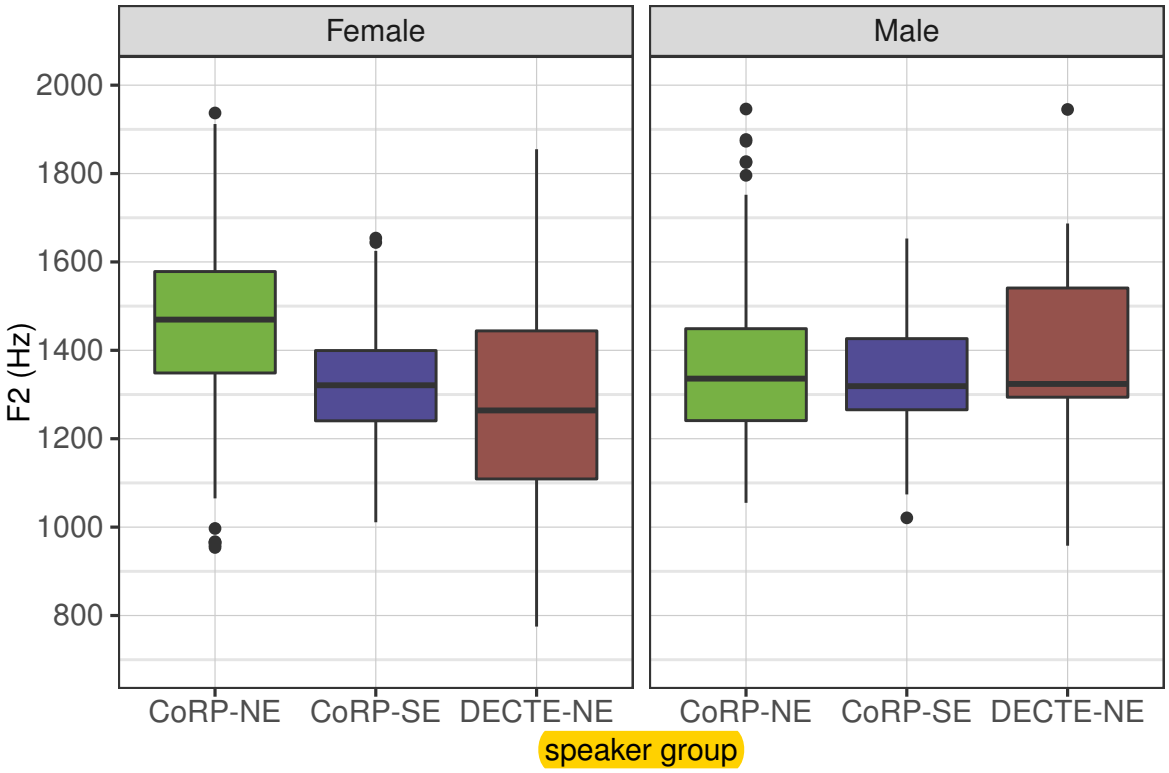
Female
Male
2000
1800
1600
1400
1200
1000
800
F2 (Hz)
CoRP-NE
CoRP-SE
DECTE-NE
CoRP-NE
CoRP-SE
DECTE-NE
speaker group

Figure 0.12.

0.4. Discussion & Conclusion

Modelling the behaviour of both FOOT and STRUT in section 0.2 showed that the FOOT-STRUT split is mostly characterised by a difference in height, though some evidence of a frontness difference is found. The CoRP-NE speakers were found to have some evidence of a FOOT-STRUT split, the difference between the two lexical sets was larger than in the DECTE speakers but smaller than in the CoRP-SE speakers. Further analysis of the STRUT vowel alone showed that this difference is mainly due to the female speakers. The majority of male speakers seem to maintain the local pattern found in the DECTE speakers. The F2 pattern is a little more complex and likely is less informative when it comes to behaviour of the FOOT-STRUT split. As stated above, there is only some evidence of a split in frontness in the CoRP-SE speakers, who only show a difference of -86Hz, which is not a large change in frontness. In the focussed analysis of STRUT alone it can be seen that the CoRP-NE speakers have a different F2 to both the DECTE and CoRP-SE speakers. This shows that their production of the vowel, particularly in the female speakers is diverging from both groups.

There are two factors that need to be considered in relation to the results described above. First, the differences between privately educated and state-educated speakers as a type of social class variation, since while it is not occupation based, it is a form of social stratification connected to income, education and other social opportunities (see chapter 3 for further discussion of this approach). It is a known effect that male and female speakers diverge in socially stratified accent variation (Labov, 2001), and this effect has been specifically attested in Newcastle (Watt, 1998). In general it has been seen that female speakers tend towards a standard and local variants are more often found in male speakers (for example the Tyneside centring diphthongs in GOAT and FACE are found in male working class speakers by Watt (1998)). The pattern we see in the CoRP-NE speakers where male speakers have a STRUT vowel that is similar to the DECTE speakers whereas female speakers have a STRUT vowel that is different to them and more similar to the CoRP-SE speakers, clearly reflects this tendency. Male speakers are producing a local variant (though local here is likely 'northern' rather than Tyneside specific) and female speakers are tending towards a non-local variant.

Secondly, while the CoRP-NE female speakers discussed above do seem to tend towards a southern-like STRUT vowel, they do not successfully reach the target. The F1 is lower than in the CoRP-SE speakers and the F2 is slightly higher. This difference may be the source of a the description occasionally given to STRUT realisations found in the north

as ‘schwa-like’ (Braber and Flynn, 2015; Jansen and Braber, 2020). It is possible that the speakers are creating a different target for the STRUT vowel but it is also possible that they are aiming for the target as realised by CoRP-SE and other southern speakers but not hitting it. Not being able to reach the target could be be due to later acquisition of the split (Evans and Iverson, 2007) , but this is difficult to determine with the data available. While information on parent’s education and region was collected, there are not enough speakers to draw meaningful conclusions. Another approach to understanding this would be to record people still at school (at various stages) to see when the FOOT-STRUT split appears in their speech.

Further discussion on the implications of the variation found here will be undertaken in chapter 9.

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.1. Extra models

.1.1. F2 of STRUT and THOUGHT in the CoRP-SE speakers

fixedeffect	estimate	tvalue
(Intercept)	1296.45	37.71
lexSetTHOUGHT	-399.00	-13.50
lexSetschwa	305.19	8.16
sexSum1	-12.72	-0.77
ageGroupSum1	-4.21	-0.26
folManSum1	37.03	0.98
folManSum2	17.13	0.86
folManSum3	-102.64	-5.05
preSeg_smallSum1	-55.23	-1.80
preSeg_smallSum2	-16.17	-0.92
preSeg_smallSum3	-69.59	-2.41
preSeg_smallSum4	68.11	1.52
freq.zipf_z	-1.90	-0.16
styleSum1	59.22	3.20
styleSum2	-47.13	-2.04

Table .1.: Linear Mixed Effects Model of F2 of STRUT, THOUGHT, and schwa in the South East