# Analysis & Results: the TRAP-BATH split

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# Contents



## 0.1. Introduction

Formant measurements for the below analysis were taken from the normalised FAVE (Rosenfelder et al., 2014) output, which is taken at one third duration (see chapter 5), and normalised using the Lobanov method. The syllable information used was produced using the transcriptions from MFA/FAVE and the syllabifyr package (Fruehwald, 2020).

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 'predictor*Sum*'. Continuous predictors were scaled to a z-score using the scale() function (R Core Team, 2021). Duration is measured by FAVE in seconds, but was converted to milliseconds (x1000) for readability and log10 transformed to remove positive skew (Winter, 2019).

The origins of the BATH lexical set are described as lengthening and backing, and it is generally considered to be merged with the PALM (and START) sets in southern varieties of English (see chapter 3). Therefore, two approaches to modelling were taken. First, within each corpus group models included TRAP, BATH, and PALM (start words were coded as PALM since there is no difference in non-rhotic speakers) lexical sets to ascertain the pattern of BATH in relation to the other two sets of words. This analysis included F1 (to check for vowel height difference), F2 (to understand the reported difference in frontness), and duration. For vowels of the same quality **?** say that a difference of 50msec is needed to form a change in vowel category. However, since BATH moving from TRAP to PALM is also a change in vowel quality, a smaller difference in duration may contribute to a change in category. The second part of the analysis will take the BATH words alone and look at the effects on their realisation by both speakers group and morpho-phonological environment. Since the BATH set is backed on phonological environment (pre-fricative, and occasionally pre-nasal), following manner was not included in the models to avoid collinearity.

It is found in the analysis below that the TRAP-BATH is as expected in the CoRP-SE speakers, being found in F2 and duration, with a small effect of F1. The DECTE speakers also behave as expected, with no significant difference between TRAP and BATH. The CoRP-NE speakers are found to broadly pattern with the DECTE speakers, with some variation observed.

## 0.2. The Split

### 0.2.1. The Split in CoRP-SE speakers

The TRAP-BATH split as seen in the South East speakers is confirmed as the vowel in BATH words patterning with PALM rather than TRAP. This is seen in an F1 difference between TRAP and BATH/PALM of -98Hz and an F2 difference of -363Hz. There was also a duration difference of 28msec found. The BATH (and PALM) words have vowels that are higher, further back, and longer than the vowels in TRAP words. There was also some interaction between speakers sex and lexical set in the F1 dimension, full analysis of the split is found below.

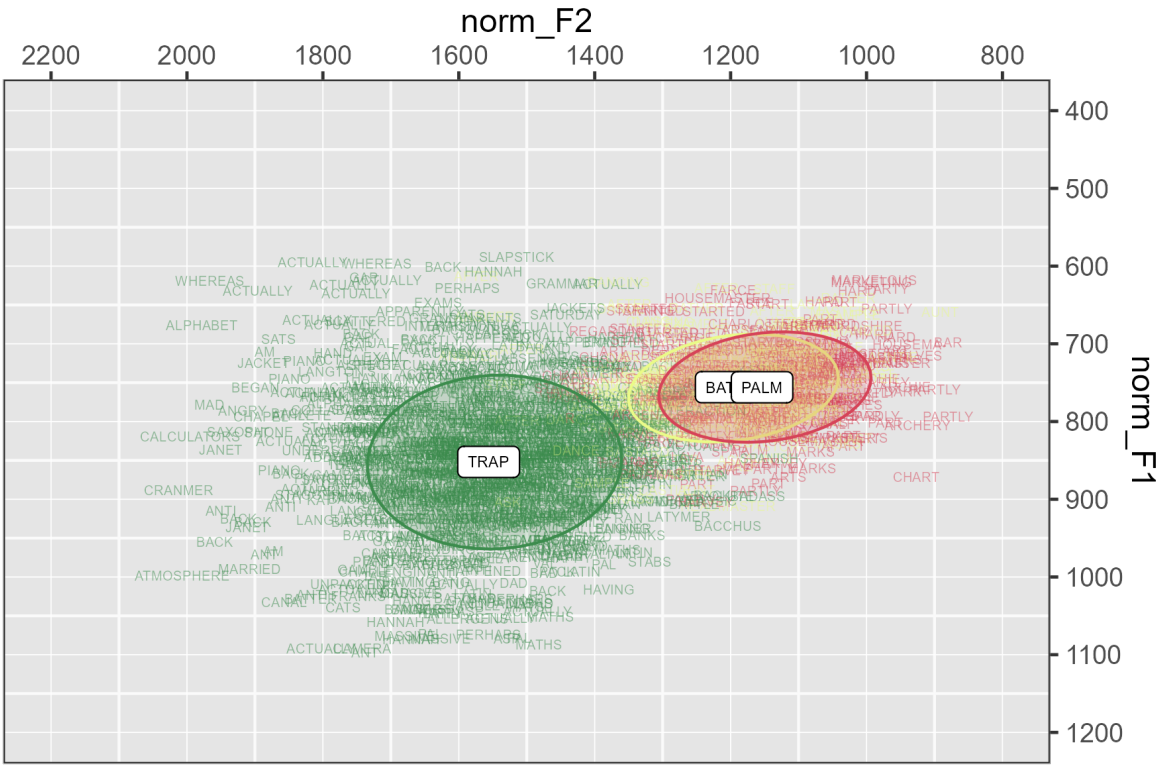


Figure 0.1.: Vowel Space plot of TRAP,BATH and PALM in the CoRP-SE speakers

### F1 of the CoRP-SE speakers

The best fit model of F1 of TRAP, BATH, and PALM in the CoRP-SE speakers is shown in table 0.1, which includes an interaction effect of lexical set and speaker sex. The calculation of the interaction (from intercept values) can be seen in table 0.2 (note, the cells in grey are marked to show that none of the effects that distinguish the PALM values from the BATH values had a t-value greater than 1.4 so could be considered negligible). This demonstrates that BATH patterns with PALM and the TRAP-BATH split in the South East speakers has an overall higher vowel in TRAP than in BATH (see figure 0.2). A mean F1 difference of +98Hz (calculated between BATH and TRAP, excluding the PALM effect). This is larger in female speakers (+117Hz) due to a lower BATH and higher TRAP, and lower in the male speakers (+79Hz) due to a higher BATH and lower TRAP. Overall the mean F1 for vowels in BATH words is 740Hz, for PALM words 755Hz, and for TRAP words 857Hz.

| fixedeffect | estimate | tvalue |
|---|---|---|
| (Intercept) | 739.50 | 61.88 |
| lexSetPALM | 15.90 | 1.40 |
| lexSetTRAP | 117.49 | 12.25 |
| sexMale | 13.94 | 0.81 |
| ageGroupSum1 | -0.60 | -0.09 |
| freq.zipf_z | 0.44 | 0.14 |
| styleminimalpair | 42.22 | 2.04 |
| stylewordlist | 32.41 | 3.38 |
| has_codaSum1 | 2.42 | 0.71 |
| lexSetPALM:sexMale | -9.63 | -0.61 |
| lexSetTRAP:sexMale | -38.95 | -2.93 |

Table 0.1.: Linear Mixed Effects Model of F1 of TRAP,BATH, and PALM in CoRP-SE speakers

| | BATH | PALM | TRAP | TRAP-BATH difference |
|---|---|---|---|---|
| Female | 764.37 | 780.27 | 881.86 | 117.49 |
| Male | 778.31 | 784.58 | 856.85 | 78.54 |
| Mean | 771.34 | 782.43 | 869.36 | 98.02 |

Table 0.2.: Interactions effects of lexical set and speaker sex on F1 of TRAP, BATH, and PALM in CoRP-SE speakers (calculated from interactions in table 0.1)

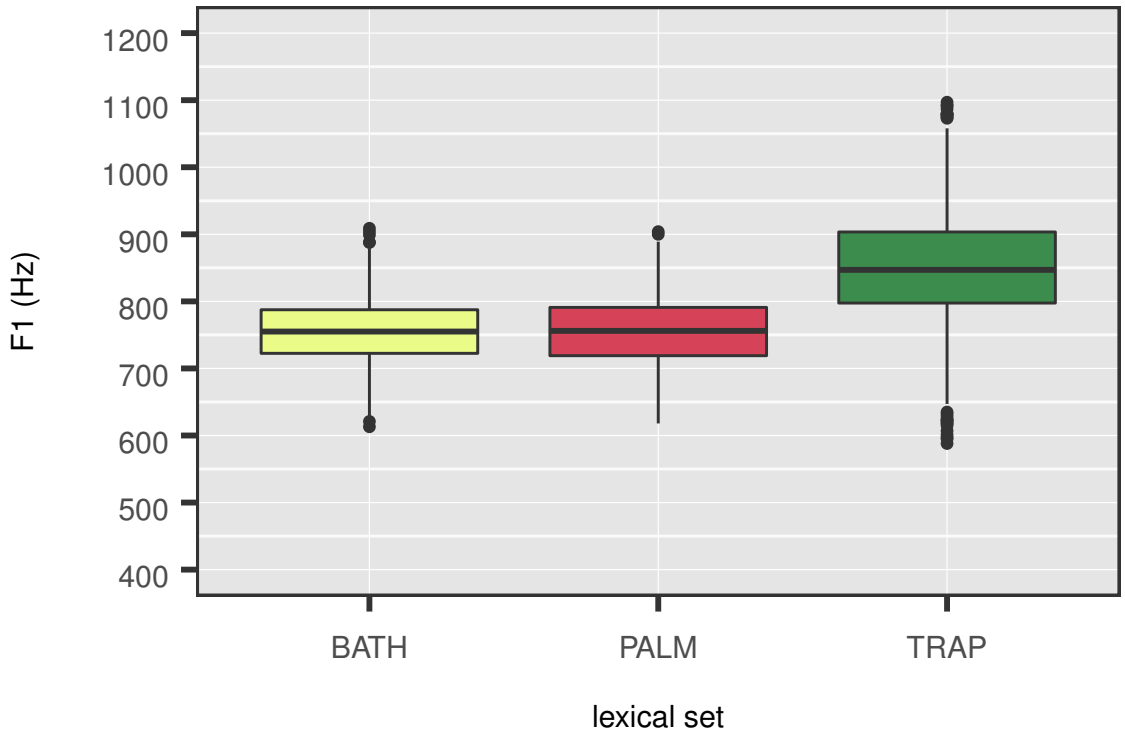


Figure 0.2.: F1 of BATH, PALM, and TRAP in CoRP-SE speakers

### F2 of the CoRP-SE speakers

The best fit model for the F2 of TRAP, BATH, and PALM, can be seen in table 0.3. Similar to the model of F1 there is a difference between BATH and TRAP (+363Hz, t=18.97) but little to none between BATH and PALM (-39Hz, t = -1.81), again supporting what is stated in the literature that BATH patterns with PALM in the South East; this difference is shown in figure 0.3. The mean F2 for vowels in the BATH lexical set is 1215Hz, for PALM 1175Hz, and for TRAP 1578Hz; there is no other significant variation.

| fixedeffect | estimate | tvalue |
|---|---|---|
| (Intercept) | 1214.63 | 46.57 |
| lexSetPALM | -39.41 | -1.81 |
| lexSetTRAP | 363.19 | 18.97 |
| sexSum1 | 1.80 | 0.13 |
| ageGroupSum1 | 25.92 | 1.85 |
| freq.zipf_z | 3.80 | 0.59 |
| styleSum1 | -25.27 | -1.59 |
| styleSum2 | 23.53 | 0.90 |
| has_codaSum1 | -1.73 | -0.25 |
| time_z | -6.25 | -1.46 |

Table 0.3.: Linear Mixed Effects Model of F2 of TRAP,BATH, and PALM in CoRP-SE speakers

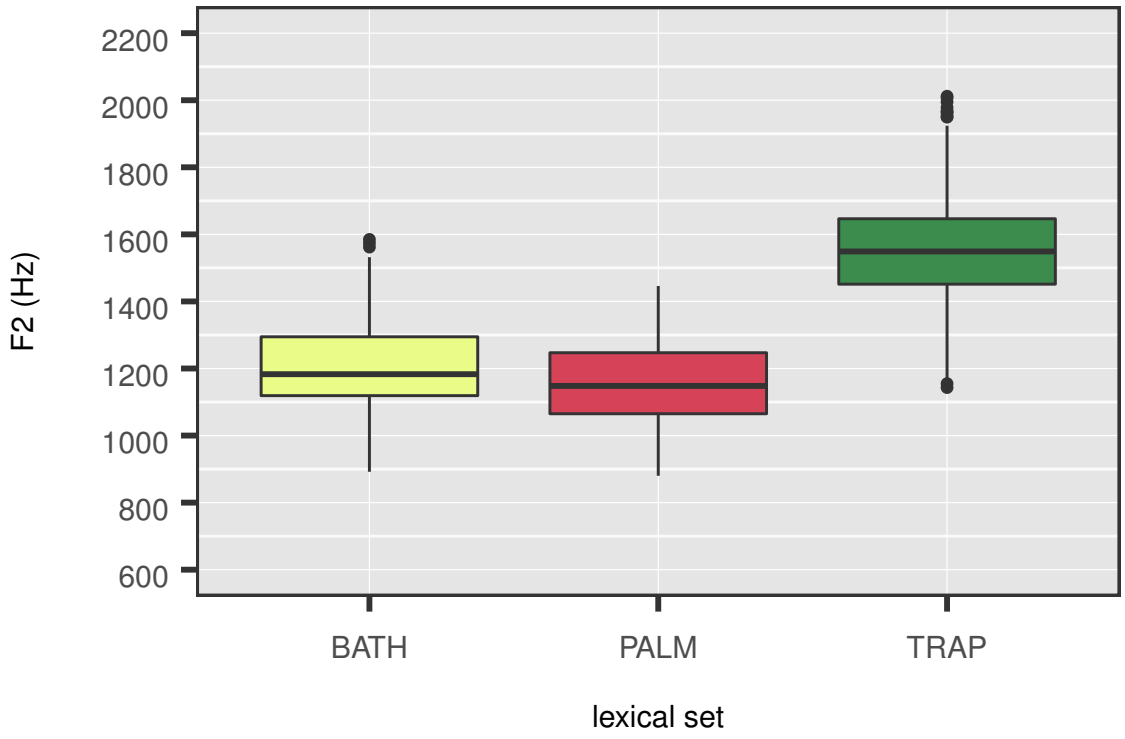


Figure 0.3.: F2 of BATH, PALM, and TRAP in CoRP-SE speakers

**Duration of the CoRP-SE speakers**

The model for duration of the TRAP, BATH, and PALM vowels is shown in table 0.4. The best fit model included an interaction between lexical set and presence of coda, as shown in table 0.5. The mean duration of the vowel in the BATH words is 123msec. However, the only significant effect seen is that of TRAP, which is 28msec shorter than PALM and BATH. This shows that BATH words are broadly the same length as PALM words and different to TRAP words, demonstrating that the TRAP-BATH split is also found in duration.

| fixedeffect | estimate | tvalue |
|---|---|---|
| (Intercept) | 2.09 | 30.02 |
| lexSetPALM | 0.06 | 0.78 |
| lexSetTRAP | -0.12 | -2.08 |
| has_codaTRUE | 0.03 | 0.44 |
| sexSum1 | 0.02 | 2.48 |
| ageGroupSum1 | 0.00 | 0.33 |
| freq.zipf_z | -0.00 | -0.03 |
| styleSum1 | -0.05 | -1.19 |
| styleSum2 | -0.04 | -0.47 |
| time_z | 0.04 | 1.93 |
| folVcSum1 | 0.01 | 0.82 |
| lexSetPALM:has_codaTRUE | -0.01 | -0.15 |
| lexSetTRAP:has_codaTRUE | 0.05 | 0.74 |
| styleSum1:time_z | -0.03 | -1.36 |
| styleSum2:time_z | 0.02 | 0.52 |

Table 0.4.: Linear Mixed Effects Model of log10(duration) of TRAP,BATH, and PALM in CoRP-SE speakers

| | BATH | PALM | TRAP | TRAP-BATH diff | PALM-BATH diff | TRAP-PALM diff |
|---|---|---|---|---|---|---|
| no coda | 123.0269 | 141.2538 | 95.49926 | -27.53 | 18.23 | -45.75 |
| coda | 131.8257 | 147.9108 | 114.8154 | -17.01 | 16.09 | -33.10 |
| average | 127.4263 | 144.5823 | 105.1573 | -22.27 | 17.16 | -39.42 |

Table 0.5.: Interaction effects of lexical set and presence of coda on duration of TRAP, BATH, and PALM in CoRP-SE speakers (converted to msec)

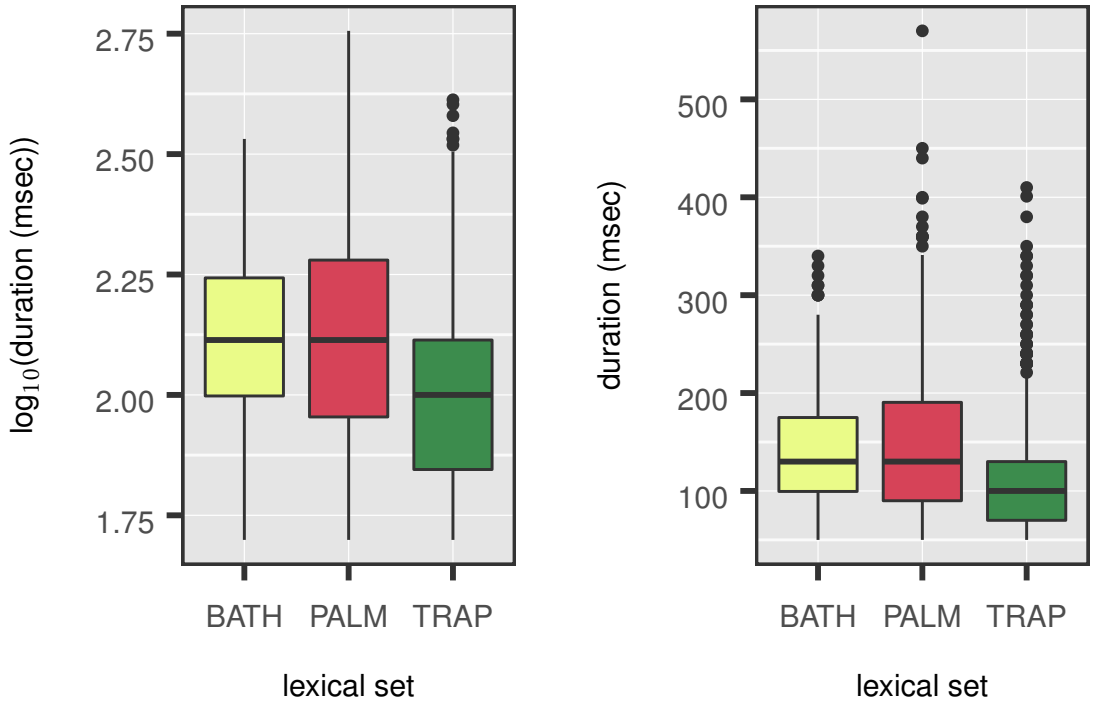


Figure 0.4.: Duration of BATH, PALM, and TRAP in CoRP-SE speakers

### 0.2.2. The Split in DECTE speakers

In models of F1, F2, and duration, the DECTE speakers do not show significant differences between TRAP and BATH words. There are some details in variation which are outlined in the sections below. The difference between TRAP and PALM is 70Hz in F1 and 205Hz in F2. These speakers show a more spread out PALM distribution than the CoRP-SE speakers (standard deviation: CoRP-SE = 117, DECTE = 198) but they show no difference between TRAP and BATH; there is no evidence of a TRAP-BATH split.

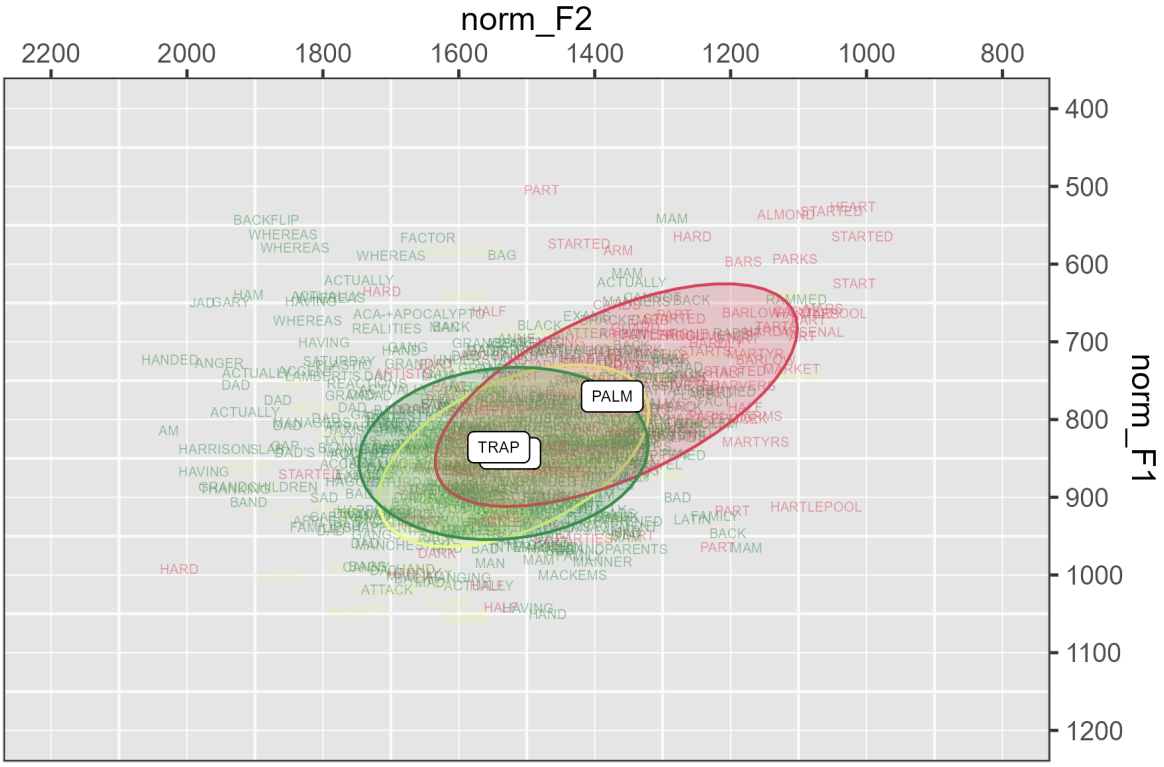


Figure 0.5.: Vowel Space plot of TRAP,BATH and PALM in the DECTE speakers

#### F1 of the DECTE speakers

Table 0.6 shows the best fit model for F1 of the TRAP, BATH, and PALM words in the DECTE speakers. The mean F2 of the vowel in the BATH words is shown to be 842Hz, 70Hz higher (lower in the mouth) than the PALM words, which have a mean of 771 Hz, and almost identical to the TRAP words (mean = 841Hz). As would be expected from speakers in the North of England, the DECTE speakers are not showing an evidence of a TRAP-BATH split in F1.

| fixedeffect | estimate | tvalue |
|---|---|---|
| (Intercept) | 841.89 | 65.90 |
| lexSetPALM | -70.43 | -4.26 |
| lexSetTRAP | -0.90 | -0.07 |
| sexMale | -45.42 | -2.39 |
| ageGroupSum1 | 23.54 | 6.07 |
| freq.zipf_z | 8.10 | 1.69 |
| has_codaSum1 | 2.41 | 0.48 |
| time_z | -4.42 | -0.85 |
| lexSetPALM:sexMale | -9.28 | -0.35 |
| lexSetTRAP:sexMale | -1.91 | -0.09 |

Table 0.6.: Linear Mixed Effects Model of F1 of TRAP,BATH, and PALM in DECTE-NE speakers

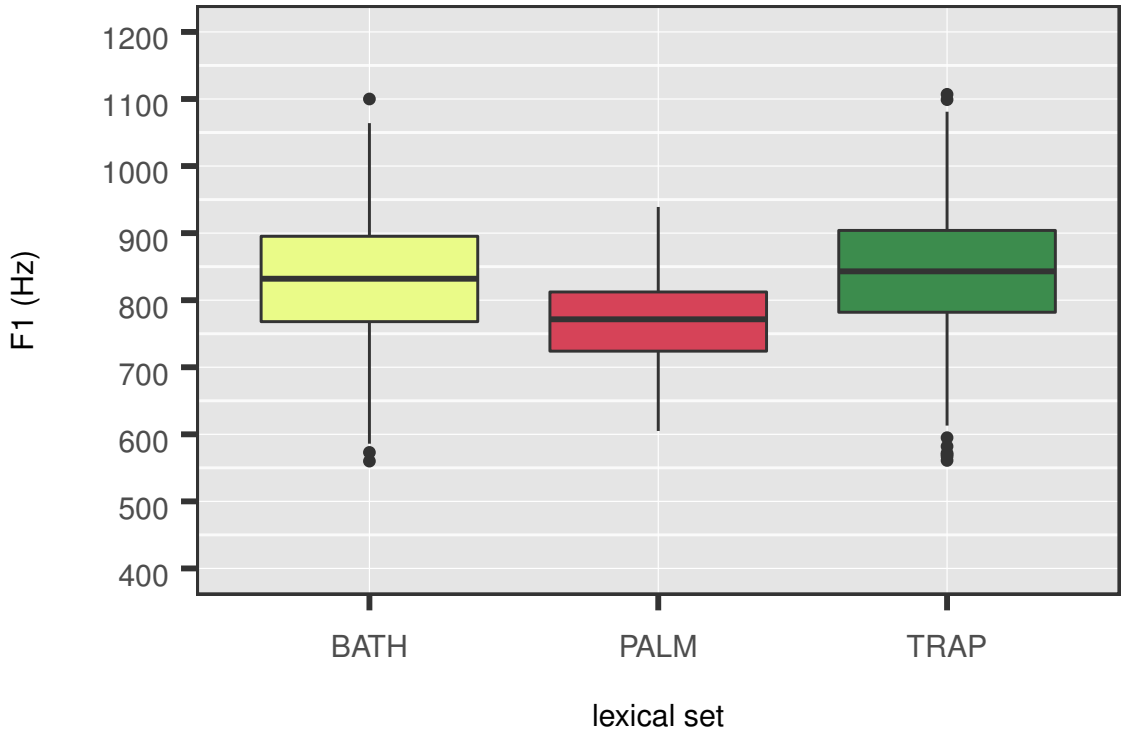


Figure 0.6.: F1 of TRAP, BATH and PALM in DECTE speakers

### F2 of the DECTE speakers

The best fit model for the F2 of the TRAP, BATH, and PALM words is shown in table 0.7. The vowels in the BATH words have a mean of 1505Hz and in PALM words, 1324 Hz (difference of 181Hz), showing that BATH is further forward in the vowel space. This is supported by the negligible difference between BATH and the TRAP words, which have a mean of 1530 Hz. The difference between PALM and TRAP/BATH is also smaller than in CoRP-SE speakers (CoRP-SE = 400Hz difference). This seems to be caused by a PALM vowel that is further forwards (mean = 1324Hz) than in CoRP-SE speakers (mean = 1175); TRAP is in a similar place (CoRP-SE = 1578Hz, DECTE = 1530Hz) in both groups.

| fixedeffect | estimate | tvalue |
|---|---|---|
| (Intercept) | 1504.91 | 37.87 |
| lexSetPALM | -180.69 | -6.42 |
| lexSetTRAP | 24.61 | 1.06 |
| sexSum1 | 36.40 | 1.12 |
| ageGroupSum1 | -17.55 | -0.53 |
| freq.zipf_z | 0.74 | 0.08 |
| has_codaSum1 | -5.21 | -0.57 |
| time_z | -18.10 | -1.99 |

Table 0.7.: Linear Mixed Effects Model of F2 of TRAP,BATH, and PALM in DECTE-NE speakers

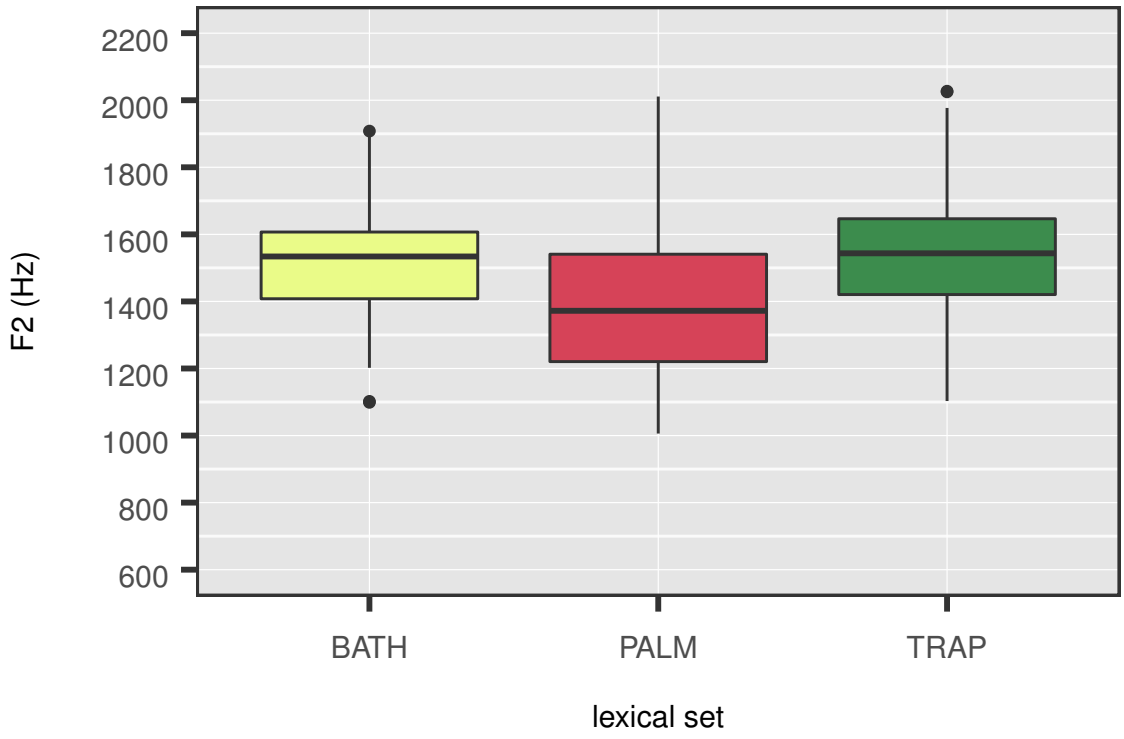


Figure 0.7.: F2 of TRAP, BATH and PALM in DECTE speakers

**Duration of the DECTE speakers**

The best fit model of duration in the DECTE speakers can be seen in table 0.8 and the interaction calculation (converted to msec) is shown in table 0.9. The model shows that the mean vowel length in the BATH words is 94msec. Those with a coda are approximately the same length as the TRAP words with codas (-4Hz difference), though in the words without codas the difference is larger (-22msec) due to shorter TRAP vowels in open syllables . There is a difference between TRAP and PALM (-20msec), however, all of these values are closer to the value for the TRAP words in the CoRP-SE speakers than to the PALM and BATH values in the CoRP-SE speakers demonstrating that not only do the DECTE speakers not show a TRAP-BATH split in duration, they also generally do not have a long PALM vowel. This supports the conclusion drawn from the variation found in F2 that the PALM vowel is not consistently the same in DECTE speakers as in the CoRP-SE speakers.

| fixedeffect | estimate | tvalue |
|---|---|---|
| (Intercept) | 1.99 | 33.16 |
| lexSetPALM | -0.04 | -0.40 |
| lexSetTRAP | -0.11 | -1.86 |
| has_codaTRUE | -0.03 | -0.46 |
| sexSum1 | 0.00 | 0.06 |
| ageGroupSum1 | -0.01 | -0.87 |
| freq.zipf_z | -0.00 | -0.21 |
| time_z | -0.00 | -0.16 |
| folVcSum1 | 0.01 | 0.44 |
| lexSetPALM:has_codaTRUE | 0.14 | 1.26 |
| lexSetTRAP:has_codaTRUE | 0.09 | 1.33 |

Table 0.8.: Linear Mixed Effects Model of duration of TRAP,BATH, and PALM in DECTE-NE speakers

| | BATH | PALM | TRAP | TRAP-BATH diff | PALM-BATH diff | TRAP-PALM diff |
|---|---|---|---|---|---|---|
| no coda | 97.72372 | 89.12509 | 75.85776 | -21.87 | -8.60 | -13.27 |
| coda | 91.20108 | 114.8154 | 87.09636 | -4.10 | 23.61 | -27.72 |
| mean | 94.4624 | 101.9702 | 81.47706 | -12.99 | 7.51 | -20.49 |

Table 0.9.: Interaction effects of lexical set and presence of coda on TRAP, BATH, and PALM in DECTE speakers

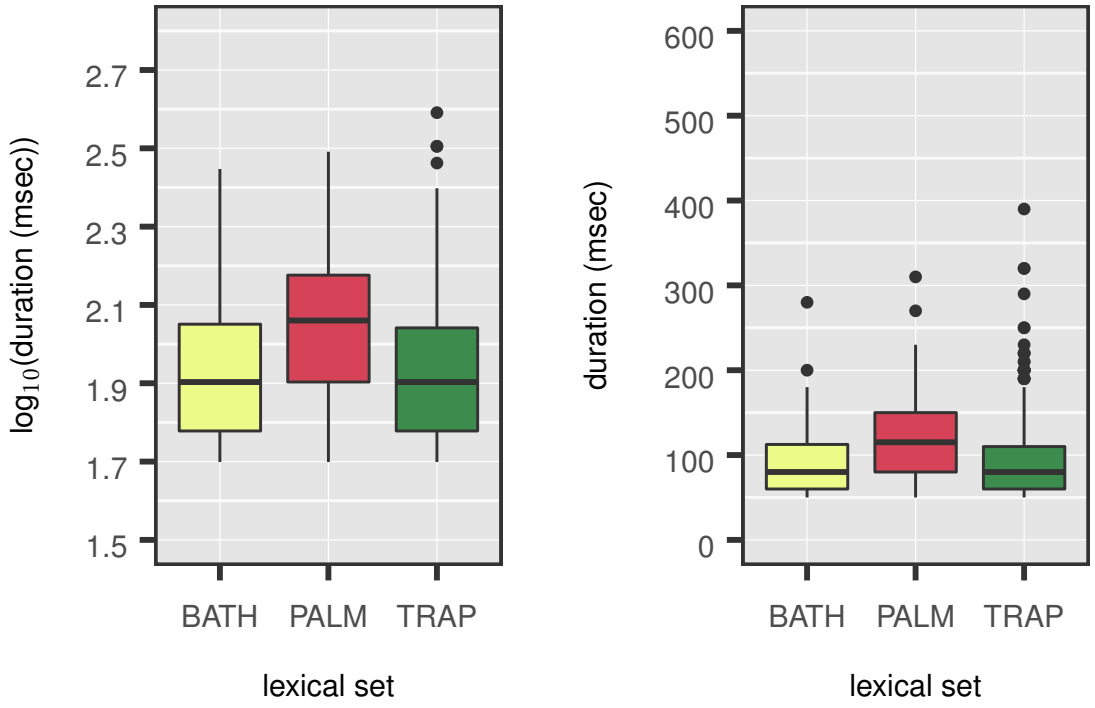


Figure 0.8.: Duration of TRAP, BATH and PALM in DECTE speakers

### 0.2.3. The Split in CoRP-NE speakers

The CoRP-NE speakers show little to no difference in F1 or F2 that could be evidence for a TRAP-BATH split (though F2 is a little more complex, details below). The difference between TRAP and PALM in F1 is 86Hz and in F2 is 329Hz.

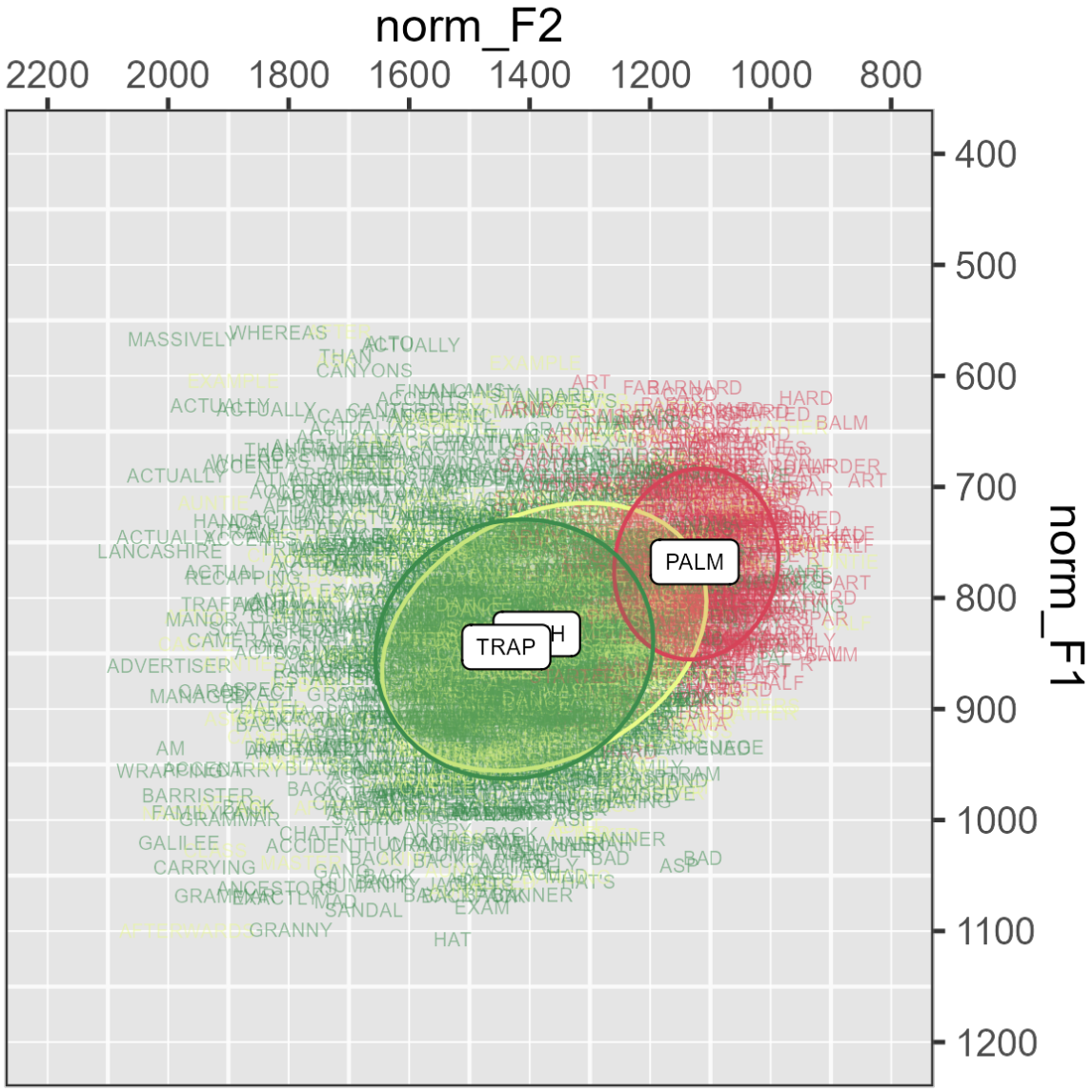


Figure 0.9.: Vowel Space plot of TRAP,BATH and PALM in the CoRP-NE speakers

### F1 of the CoRP-NE speakers

Table 0.10 shows the best fit model for the CoRP-NE speakers. There is a three way interaction between lexical set, speaker sex, and speaker age group, which is summarised in full in table 0.11. However, many of the interaction terms, while they improve the fit of the model (according to cAIC), do not have a t value greater than 2.00; table 0.12 shows the interactions excluding these terms. It can be seen in table 0.12 that the height difference between TRAP and PALM is larger for the Old Female speakers than for any other speakers. This is caused by a lower TRAP vowel in that speaker group. All speakers have a BATH vowel 53Hz lower than the PALM vowel, for most speakers this is a similar position to TRAP, except for the Old Female speakers for whom it sits between the heights of TRAP and PALM.

Overall it can be concluded from this analysis that the CoRP-Ne speakers do not show a significant TRAP-BATH in acoustic vowel height.

| fixedeffect | estimate | tvalue |
|---|---|---|
| (Intercept) | 814.30 | 43.81 |
| lexSetPALM | -52.55 | -2.88 |
| lexSetTRAP | 78.88 | 4.97 |
| sexMale | 10.88 | 0.40 |
| ageGroupYoung | 45.78 | 2.41 |
| freq.zipf_z | 1.58 | 0.53 |
| styleSum1 | -16.23 | -2.16 |
| styleSum2 | -4.94 | -0.39 |
| has_codaSum1 | 1.69 | 0.52 |
| time_z | 1.50 | 0.64 |
| lexSetPALM:sexMale | 15.55 | 0.55 |
| lexSetTRAP:sexMale | -55.72 | -2.34 |
| lexSetPALM:ageGroupYoung | -9.22 | -0.48 |
| lexSetTRAP:ageGroupYoung | -74.15 | -4.47 |
| sexMale:ageGroupYoung | -33.80 | -1.10 |
| lexSetPALM:sexMale:ageGroupYoung | -30.44 | -0.98 |
| lexSetTRAP:sexMale:ageGroupYoung | 59.93 | 2.25 |

Table 0.10.: Linear Mixed Effects Model of F1 of TRAP,BATH, and PALM in CoRP-NE speakers

| | BATH | PALM | TRAP | TRAP-BATH diff | PALM-BATH diff | TRAP-PALM diff |
|---|---|---|---|---|---|---|
| Old Female | 814.30 | 761.75 | 893.18 | 78.88 | -52.55 | 131.43 |
| Old Male | 825.18 | 788.18 | 848.34 | 23.16 | -37.00 | 60.16 |
| Young Female | 860.08 | 798.31 | 864.81 | 4.73 | -61.77 | 66.50 |
| Young Male | 837.16 | 760.50 | 846.10 | 8.94 | -76.66 | 85.60 |
| Mean | 834.18 | 777.19 | 863.11 | 28.93 | -57.00 | 85.92 |

Table 0.11.: Interaction effects of lexical set, speaker sex and speaker age group on F1 of TRAP, BATH, and PALM in CoRP-NE speakers (calculated from interactions in table 0.10)

| | BATH | PALM | TRAP | TRAP-BATH diff | PALM-BATH diff | TRAP-PALM diff |
|---|---|---|---|---|---|---|
| Old Female | 814.30 | 761.75 | 893.18 | 78.88 | -52.55 | 131.43 |
| Old Male | 814.30 | 761.75 | 837.46 | 23.16 | -52.55 | 75.71 |
| Young Female | 814.30 | 761.75 | 819.03 | 4.73 | -52.55 | 57.28 |
| Young Male | 814.30 | 761.75 | 823.24 | 8.94 | -52.55 | 61.49 |
| Mean | 814.30 | 761.75 | 843.23 | 28.93 | -52.55 | 81.48 |

Table 0.12.: Interaction effects of lexical set, speaker sex and speaker age group on F1 of TRAP, BATH, and PALM in CoRP-NE speakers (not including terms with t<2.00)

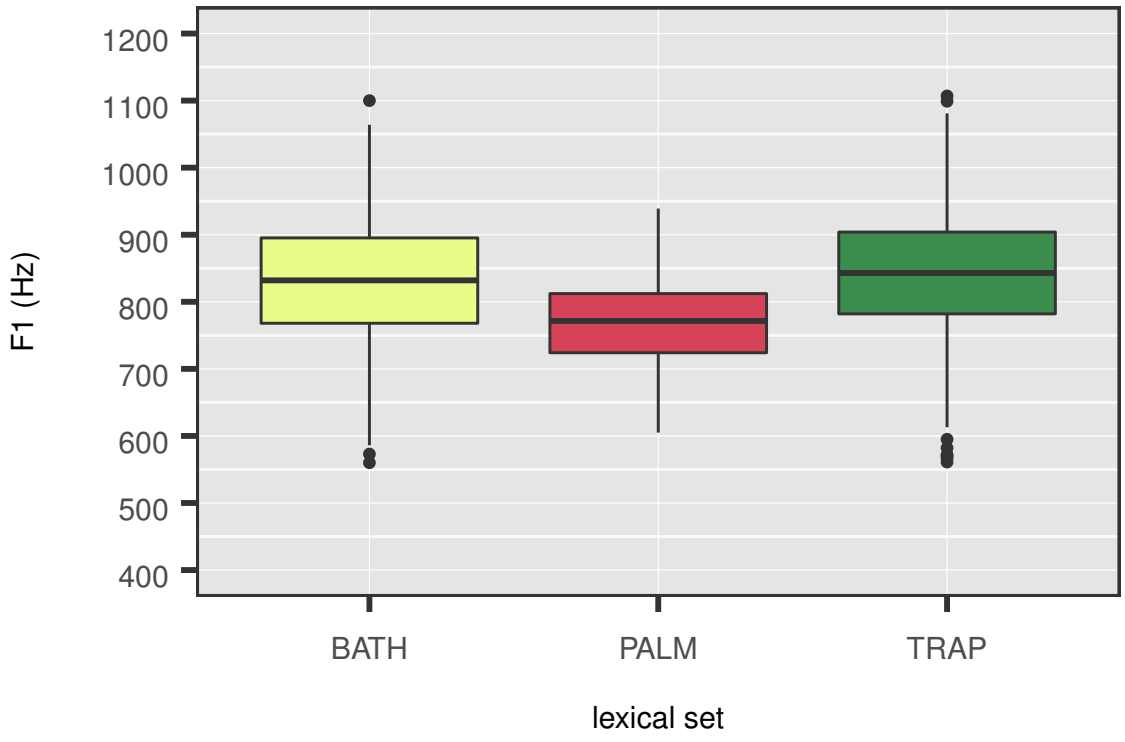


Figure 0.10.: F1 of TRAP, BATH and PALM in CoRP-NE speakers

### F2 of the CoRP-NE speakers

Table 0.13 shows the best fit model for F2 of the CoRP-NE speakers; the model included a three way interaction between lexical set, speaker sex, and speaker age group, the results of which are shown in table 0.14, and in table 0.15 with terms with t<2.00 removed.

Before considering the split in frontness in these speakers it is important to note that the mean PALM value for the CoRP-NE speakers is 1119Hz, which is similar to the mean PALM vowel in CoRP-SE speakers (1175Hz) and further back than the mean PALM vowel of the DECTE speaker (1324Hz). This means that the vowels at the bottom of the vowel space are further apart in both CoRP groups of speakers than in the DECTE speakers.

Within the interaction effects taken into account (using table 0.15) it can be seen that the main variation within this speaker group is seen in the Old Male group (only one speaker), who has a TRAP vowel that is further forwards than the other speakers. Despite this, the TRAP-BATH difference is usually 60-80Hz (and approximately 190Hz for that one speakers), and the PALM-BATH difference is 215Hz demonstrating that these speakers have a BATH vowel that is far closer to TRAP than to PALM. The difference of 60-80Hz could be caused by individual BATH words being realised with a PALM vowel rather than a shift of the entire lexical set. Further analysis of the BATH vowel alone can be seen in section 0.3 below.

| fixedeffect | estimate | tvalue |
|---|---|---|
| (Intercept) | 1334.28 | 29.30 |
| lexSetPALM | -214.93 | -5.86 |
| lexSetTRAP | 80.85 | 2.52 |
| sexMale | 5.92 | 0.08 |
| ageGroupYoung | 45.92 | 0.92 |
| has_codaSum1 | 5.25 | 0.73 |
| freq.zipf_z | -1.75 | -0.26 |
| time_z | -2.45 | -0.58 |
| lexSetPALM:sexMale | 24.34 | 0.46 |
| lexSetTRAP:sexMale | 106.53 | 2.36 |
| lexSetPALM:ageGroupYoung | -28.76 | -0.79 |
| lexSetTRAP:ageGroupYoung | -26.68 | -0.84 |
| sexMale:ageGroupYoung | 39.27 | 0.46 |
| lexSetPALM:sexMale:ageGroupYoung | -89.44 | -1.52 |
| lexSetTRAP:sexMale:ageGroupYoung | -124.64 | -2.48 |

Table 0.13.: Linear Mixed Effects Model of F2 of TRAP,BATH, and PALM in CoRP-NE speakers

| | BATH | PALM | TRAP | TRAP-BATH diff | PALM-BATH diff |
|---|---|---|---|---|---|
| Old Female | 1334.28 | 1119.35 | 1415.13 | 80.85 | -214.93 |
| Old Male | 1343.20 | 1152.61 | 1530.58 | 187.38 | -190.59 |
| Young Female | 1380.20 | 1136.51 | 1434.37 | 54.17 | -243.69 |
| Young Male | 1428.39 | 1119.60 | 1464.45 | 36.06 | -308.79 |
| Mean | 1371.52 | 1132.02 | 1461.13 | 89.61 | -239.50 |

Table 0.14.: Interaction effects of lexical set, speaker sex and speaker age group on F2 of TRAP, BATH, and PALM in CoRP-NE speakers (calculated from interactions in table 0.13)

| | BATH | PALM | TRAP | TB diff | PB diff | TP diff |
|---|---|---|---|---|---|---|
| Old Female | 1334.28 | 1119.35 | 1415.13 | 80.85 | -214.93 | 295.78 |
| Old Male | 1334.28 | 1119.35 | 1521.66 | 187.38 | -214.93 | 402.31 |
| Young Female | 1334.28 | 1119.35 | 1415.13 | 80.85 | -214.93 | 295.78 |
| Young Male | 1334.28 | 1119.35 | 1397.02 | 62.74 | -214.93 | 277.67 |
| Mean | 1334.28 | 1119.35 | 1437.24 | 102.96 | -214.93 | 317.89 |

Table 0.15.: Interaction effects of lexical set, speaker sex and speaker age group on F2 of TRAP, BATH, and PALM in CoRP-NE speakers (not including terms with t<2.00)

### Duration of the CoRP-NE speakers

Table 0.13 shows the best fit model for duration in the CoRP-NE speakers. An interaction effect is seen between lexical set and presence of a coda. This interaction is summarised in table 0.17. TRAP and PALM are on average 62 msec apart, and the PALM length is closer to the length found in the CoRP-SE speakers, implying that CoRP-NE speaker do not have the shorter PALM vowel found in the DECTE speakers. There is a TRAP-BATHdifference present in the words with a coda (-20msec) but none in words without a coda. The difference is less than the difference between TRAP-PALM, and while the mean duration of the BATH (136msec) words is longer than the TRAP words (126msec) it is not as long as the PALM words (189msec). In a form similar to the F2 results above, the duration of the BATH values could be interpreted as a target that is slightly further back than TRAP, or as some individual BATH words having a PALM target and so pulling the mean duration higher.

| fixedeffect | estimate | tvalue |
|---|---|---|
| (Intercept) | 2.14 | 35.52 |
| lexSetPALM | 0.16 | 1.49 |
| lexSetTRAP | -0.07 | -1.25 |
| has_codaTRUE | -0.01 | -0.22 |
| sexSum1 | 0.02 | 1.68 |
| ageGroupSum1 | 0.00 | 0.28 |
| freq.zipf_z | 0.01 | 1.27 |
| styleSum1 | -0.11 | -5.35 |
| styleSum2 | 0.06 | 1.74 |
| time_z | 0.00 | 0.38 |
| folVcSum1 | -0.01 | -0.85 |
| lexSetPALM:has_codaTRUE | -0.04 | -0.34 |
| lexSetTRAP:has_codaTRUE | 0.07 | 1.14 |

Table 0.16.: Linear Mixed Effects Model of duration of TRAP,BATH, and PALM in CoRP-NE speakers

| | BATH | PALM | TRAP | TRAP-BATH diff | PALM-BATH diff | TRAP-PALM diff |
|---|---|---|---|---|---|---|
| no coda | 138.0384 | 199.5262 | 117.4898 | -20.55 | 61.49 | -82.04 |
| coda | 134.8963 | 177.8279 | 134.8963 | 0.00 | 42.93 | -42.93 |
| mean | 136.4674 | 188.6771 | 126.193 | -10.27 | 52.21 | -62.48 |

Table 0.17.: Interaction effects of lexical set and presence of coda on duration of TRAP, BATH, and PALM in CoRP-NE speakers.

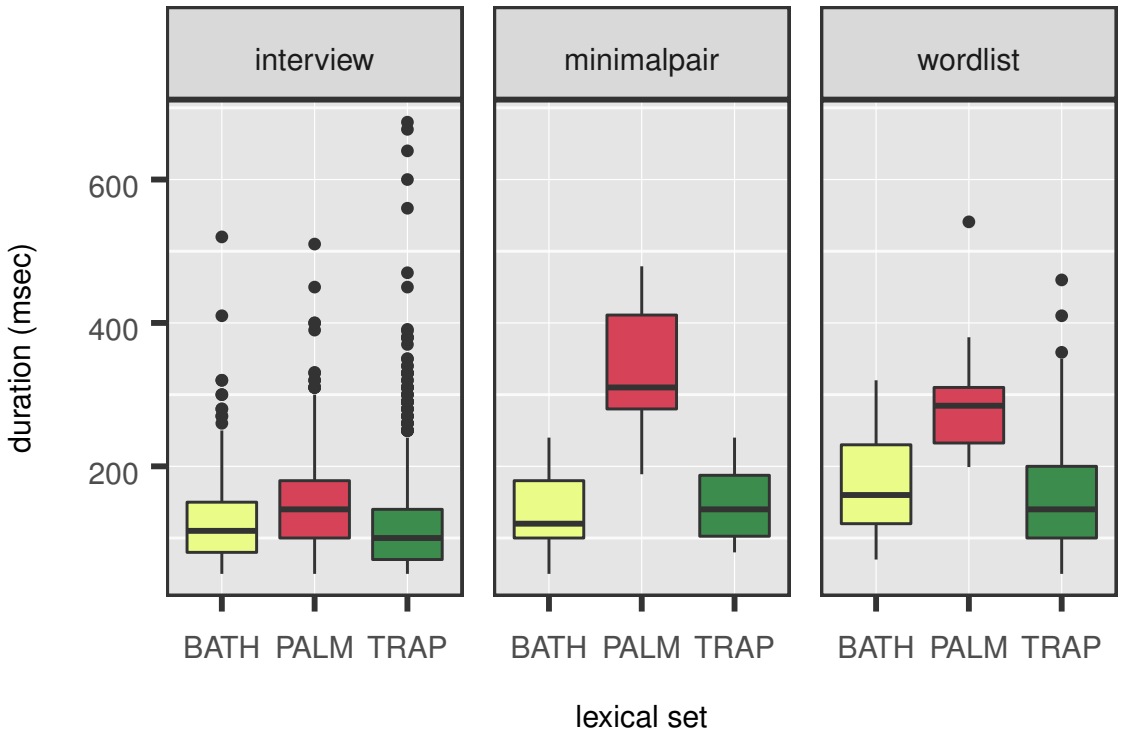


Figure 0.11.: Duration of TRAP, BATH and PALM in CoRP-NE speakers

### 0.2.4. Conclusions on the nature of the TRAP-BATH split in all three speaker groups

As attested in the literature, the analysis above has confirmed that the major feature of the TRAP-BATH split is a distinction in vowel frontness, as shown by an F2 difference, and duration. The TRAP-BATH split is the BATH words being found in a PALM-like position as opposed to a TRAP-like position (this is a change, as outlined in chapter 2, but as a phonemic split is stable in the South of England). It was was found that The CoRP-SE speakers have the following difference between TRAP and BATH:

- F1: +98Hz (BATH higher)
- F2: +363Hz (BATH less front)
- duration: -28msec (BATH longer)

There are two points of variation that impact analysis of the split but may not be required characteristics of it. First, in the CoRP-SE speakers, who have a clear TRAP-BATH split in F2 and duration, there is the potential for variation in the height of TRAP. In this speaker group an F1 difference is found between TRAP and BATH/PALM, which may be an indicator of the split but is not focussed on as a primary characteristic. Figure 0.1 shows that the F1 variation in TRAP is larger than in either of BATH or PALM. Secondly, in the DECTE speakers PALM is further forward than than in the CoRP-SE speakers, if the CoRP-NE speakers showed a similar position it would impact analysis of the split as a movement from a TRAP-like position to a PALM-like position.

The DECTE speakers do not show a split, there is a statistically significant but not linguistically meaningful meaningful F1 difference of +1HZ and F2 difference of +24Hz, and a duration difference of +13msec.

The CoRP-NE speakers broadly pattern with the DECTE speakers, though with some important differences. They show an F1 difference of +28Hz, an F2 difference of 60-80Hz, and a duration difference of -20Hz (if the vowel is followed by a coda). However, this speaker group is not identical to the DECTE speakers. The PALM vowel is closer to the CoRP-SE speakers (possibly an effect of education but beyond the scope of this discussion), and there is some variation within the BATH vowel, as seen by a higher F2 and duration difference than in the DECTE speakers. This difference will be discussed in the analysis of the BATH vowel below.

## 0.3. BATH vowel alone

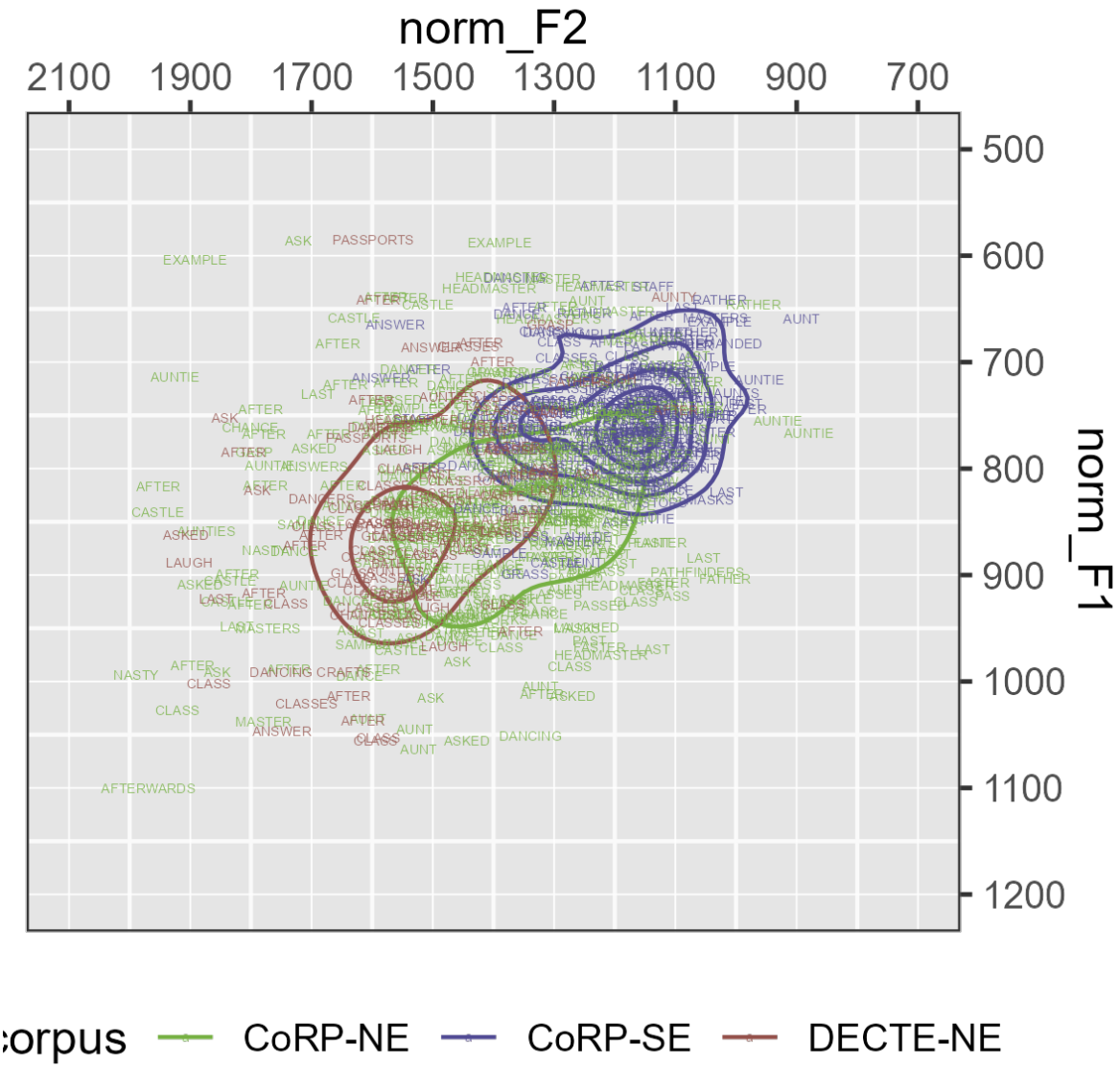


Figure 0.12.: BATH

### 0.3.1. F1

The best fit model of BATH in all speaker groups is shown in table 0.18. There is a three way interaction between sex, age group and corpus, shown in table 0.19. It can be seen that overall the CoRP-NE speakers have a BATH vowel at 828Hz, very similar to the height

of the DECTE speakers (837Hz), whereas the CoRP-SE speakers have a higher vowel, at 762Hz. While there is variation between male and female, and old and young, none of this variation reaches overlap between the lower vowels (CoRP-NE and DECTE), and the higher vowels (CoRP-SE). Despite height not acting as the primary indicator of historical BATH movement, these values align with the predicted TRAP and PALM positions in section 0.2 respectively. The difference further defends that in all north-eastern speakers (DECTE and CoRP) the BATH vowel has not moved and remains in the same place as TRAP whereas in the CoRP-SE speakers it has moved to the PALM position.

| fixedeffect | estimate | tvalue |
|---|---|---|
| (Intercept) | 815.06 | 38.48 |
| relevel(corpus, "CoRP-NE")DECTE-NE | 61.18 | 2.53 |
| relevel(corpus, "CoRP-NE")CoRP-SE | -68.19 | -2.82 |
| ageGroupYoung | 40.96 | 1.96 |
| sexMale | 2.08 | 0.07 |
| freq.zipf_z | 0.78 | 0.12 |
| styleSum1 | -23.64 | -2.19 |
| styleSum2 | 1.15 | 0.06 |
| has_codaSum1 | -12.15 | -1.69 |
| time_z | -4.63 | -1.05 |
| relevel(corpus, "CoRP-NE")DECTE-NE:ageGroupYoung | -78.54 | -2.30 |
| relevel(corpus, "CoRP-NE")CoRP-SE:ageGroupYoung | -21.00 | -0.70 |
| relevel(corpus, "CoRP-NE")DECTE-NE:sexMale | -40.70 | -1.05 |
| relevel(corpus, "CoRP-NE")CoRP-SE:sexMale | 19.85 | 0.52 |
| ageGroupYoung:sexMale | -25.99 | -0.78 |
| relevel(corpus, "CoRP-NE")DECTE-NE:ageGroupYoung:sexMale | -8.42 | -0.15 |
| relevel(corpus, "CoRP-NE")CoRP-SE:ageGroupYoung:sexMale | -7.77 | -0.15 |

Table 0.18.: Linear Mixed Effects Model of F1 of BATH

| | CoRP-NE | DECTE-NE | CoRP-SE | Mean |
|---|---|---|---|---|
| Old Female | 815.06 | 876.24 | 746.87 | 812.72 |
| Old Male | 817.14 | 837.62 | 768.80 | 807.85 |
| Young Female | 856.02 | 838.66 | 766.83 | 820.50 |
| Young Male | 832.11 | 791.62 | 755.00 | 792.91 |
| Mean | 830.08 | 836.04 | 759.38 | 808.50 |

Table 0.19.: F1 of BATH vowel for all three speaker groups

### 0.3.2. F2

Table 0.20 shows the best fit model for F2 of the vowel in BATH words in all three speaker groups. Modelling the BATH words alone shows that the CoRP-NE speakers have a vowel with F2 between the CoRP-SE speakers (-144Hz lower) and DECTE speakers (173Hz higher). From this model it is difficult to tell if this is truly a vowel with a mean in between or the effect of both positions existing with the set of tokens.

| fixedeffect | estimate | tvalue |
|---|---|---|
| (Intercept) | 1346.66 | 38.65 |
| relevel(corpus, "CoRP-NE")DECTE-NE | 173.11 | 3.62 |
| relevel(corpus, "CoRP-NE")CoRP-SE | -143.53 | -3.12 |
| sexMale | 40.09 | 0.92 |
| ageGroupSum1 | -5.17 | -0.32 |
| freq.zipf_z | 26.29 | 1.58 |
| has_codaSum1 | -24.64 | -1.27 |
| time_z | -5.45 | -0.72 |
| relevel(corpus, "CoRP-NE")DECTE-NE:sexMale | -148.92 | -2.07 |
| relevel(corpus, "CoRP-NE")CoRP-SE:sexMale | -50.06 | -0.69 |

Table 0.20.: Linear Mixed Effects Model of F2 of BATH

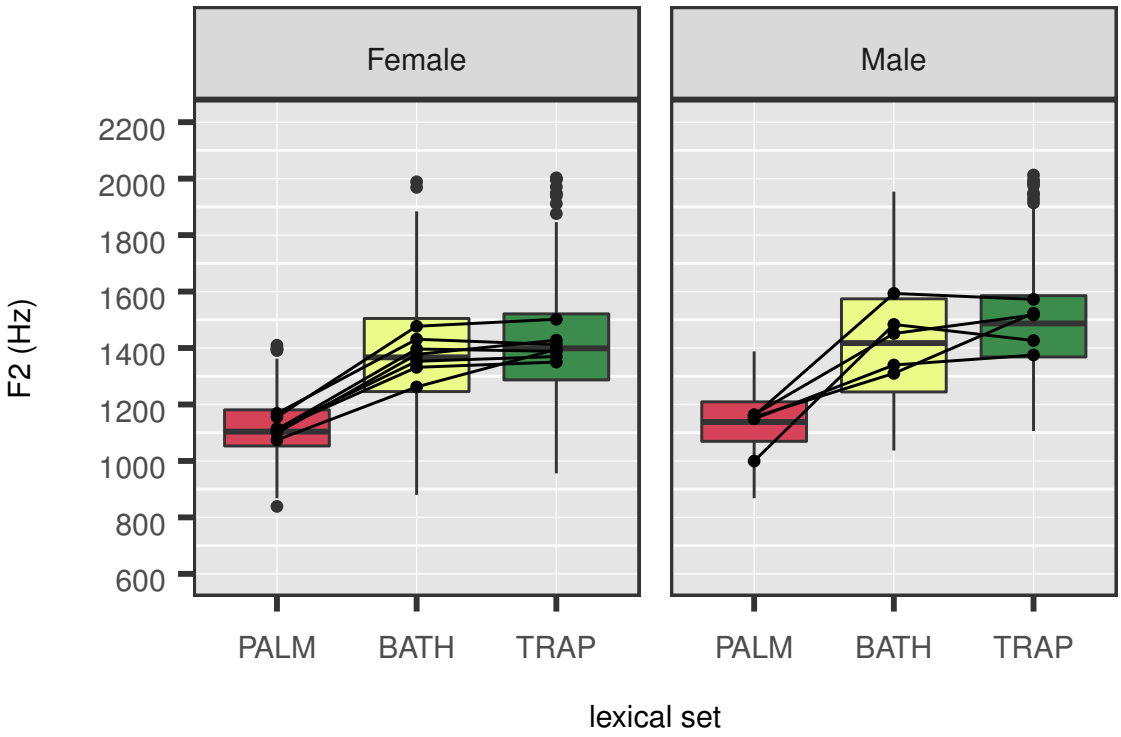


Figure 0.13.: BATH

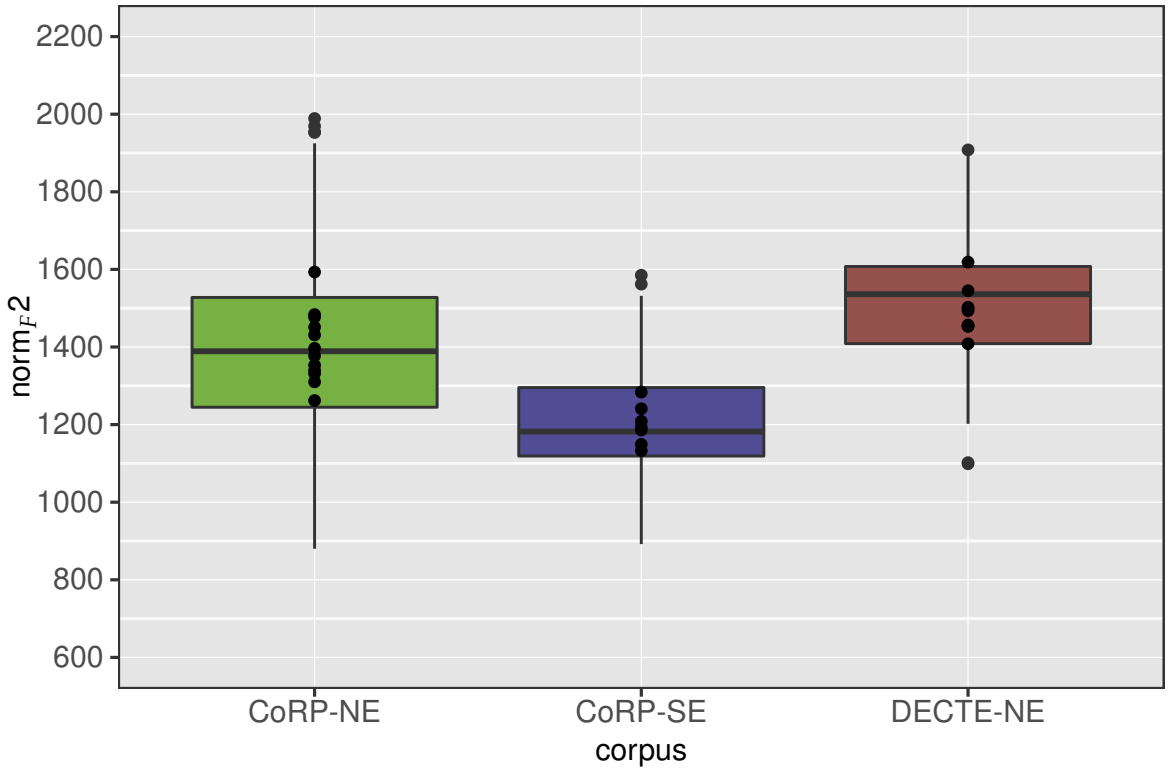


Figure 0.14.: BATH

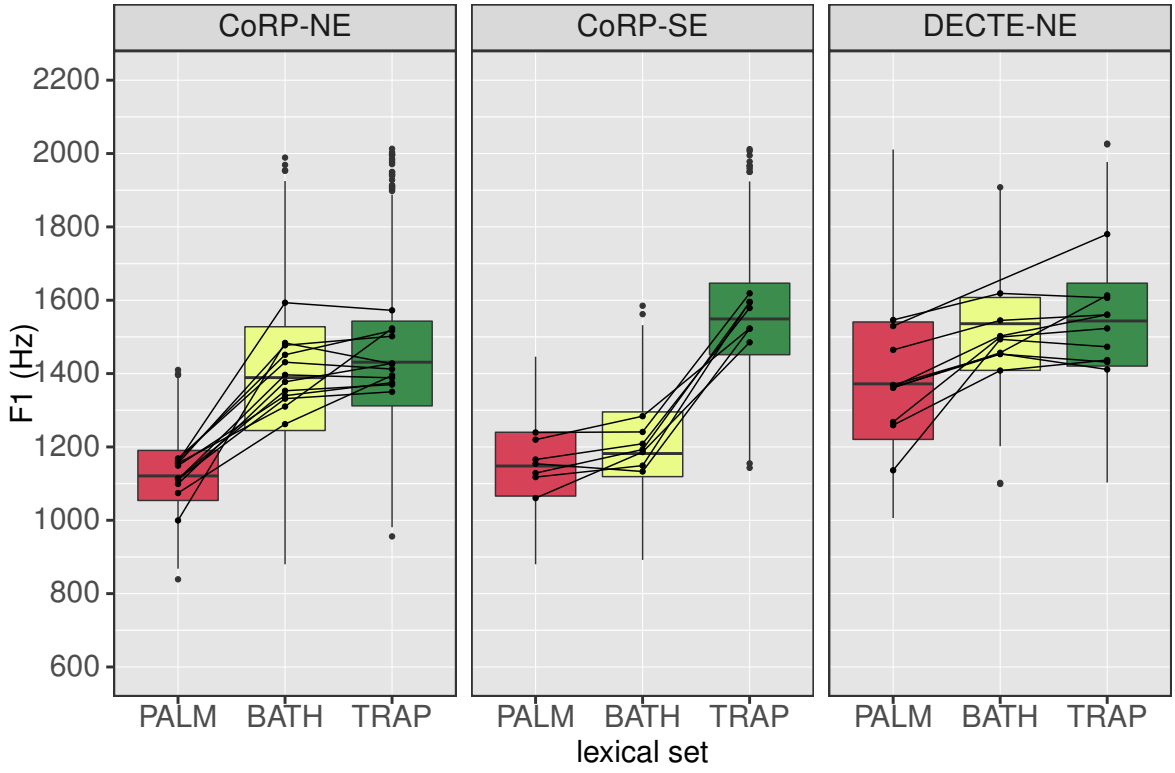


Figure 0.15.: BATH

### 0.3.3. Duration

Table 0.21 shows the best fit model for the duration of the BATH vowel, and the interaction effect is summarised in table 0.22. These show that the BATH vowel duration is not patterning in the same way as F2, instead we see that the CoRP-NE speakers have a similar (though not identical in value or coda interaction) duration to CoRP-SE speakers, whereas DECTE speakers have a shorter duration. These differences are not large but considering the history of the TRAP-BATH split, which began with a change in length, it is possible that this difference is reflective of the beginning a split in the CoRP-NE speaker group.

| fixedeffect | estimate | tvalue |
|---|---|---|
| (Intercept) | 2.15 | 38.53 |
| relevel(corpus, "CoRP-NE")DECTE-NE | -0.12 | -1.88 |
| relevel(corpus, "CoRP-NE")CoRP-SE | 0.00 | 0.01 |
| has_codaTRUE | -0.02 | -0.42 |
| sexSum1 | 0.03 | 2.13 |
| ageGroupSum1 | 0.01 | 0.43 |
| freq.zipf_z | 0.03 | 1.56 |
| styleSum1 | -0.12 | -3.99 |
| styleSum2 | 0.07 | 1.32 |
| time_z | -0.00 | -0.35 |
| folVcSum1 | -0.05 | -3.10 |
| relevel(corpus, "CoRP-NE")DECTE-NE:has_codaTRUE | 0.03 | 0.52 |
| relevel(corpus, "CoRP-NE")CoRP-SE:has_codaTRUE | 0.05 | 1.05 |

Table 0.21.: Linear Mixed Effects Model of log10(duration) of BATH, in all three speaker groups

| | CoRP-NE | CoRP-SE | DECTE |
|---|---|---|---|
| has_codaFALSE | 141.2538 | 141.2538 | 107.1519 |
| has_codaTRUE | 134.8963 | 151.3561 | 109.6478 |
| Mean | 138.075 | 146.3049 | 108.3999 |

Table 0.22.: Interaction effects on the duration of BATH in all three speaker groups (calculated from log10(duration) in table 0.21)

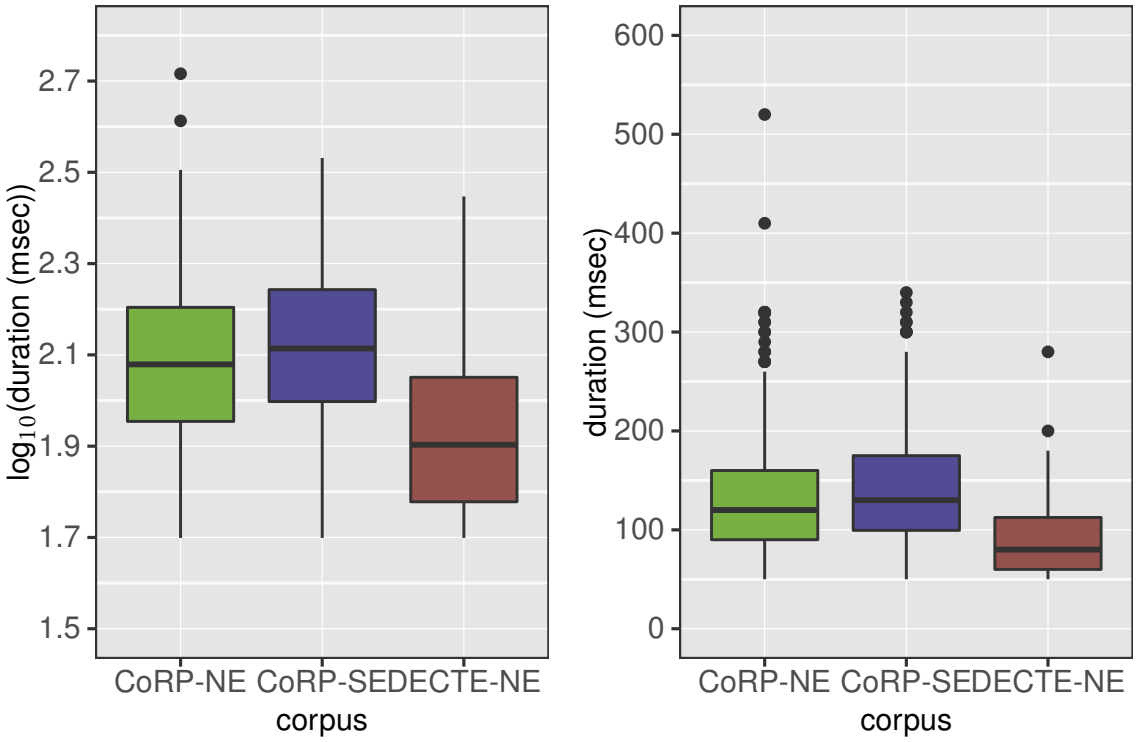


Figure 0.16.: BATH

## 0.4. Discussion and Conclusion

The parameters of the TRAP-BATH split in the CoRP-SE speakers are clearly canonical, supporting defining the TRAP-BATH split as found in F2 and duration (with some impact of F1). DECTE speakers clearly do not show a TRAP-BATH split, with no significant difference in F2 or duration between TRAP and BATH.

In analysis of F2 and duration of the BATH vowels that it is difficult to tell if the variation seen in the CoRP-NE speakers is the result of a different BATH target or individual speakers, or words behaving differently. At this point it is important to consider the linguistic status of the variables being considered, not just the modelled values. Two relevant points about the BATH vowel at this point are:

1. A BATH realisation between TRAP and PALM is not attested in the literature

2. The TRAP-BATH split is a move of a subset of the TRAP lexical set (words in pre-fricative and pre-nasal environment) from one existing target (a low front vowel) to another existing target (*long* low vowel back vowel, i.e. the PALM position). Speakers

are not creating a new vowel in their inventory so there is no reason for an intermediate vowel quality to appear.

Therefore, unlike what is seen in the STRUTvowel in chapter 5, it is unlikely that CoRP-NE speakers are creating a new split.

In addition to the model of F2 of BATH in section 0.3.2, it is possible to understand this data further by visualising the vowel positions and including individual speaker means. Figure 0.13 (reproduced below), split by speaker sex to aid in seeing individual speakers, not to show any particular pattern) shows the CoRP-NE speakers alone and looking at the speaker means and connections between them it can be seen that BATH consistently patterns with TRAP, there is no evidence of a TRAP-BATH split in this speakers.

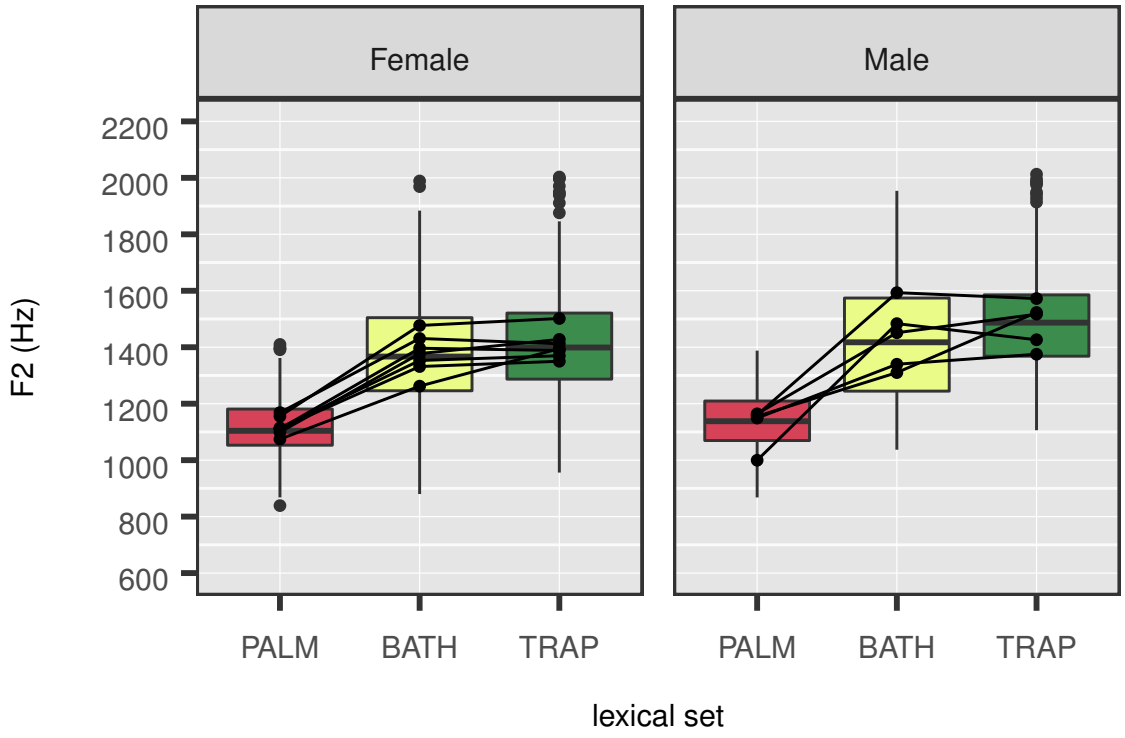


Figure 0.13

Considering figure 0.14 (reproduced below), it is clear why the model shows a BATH value for CoRP-NE that is in between those for CoRP-SE and DECTE. The CoRP-NE BATH vowels are wider in distribution than either of the other two speaker groups, with some overlap in both direction, implying that some speakers in CoRP-NE produce BATH words with a PALM-like realisation.

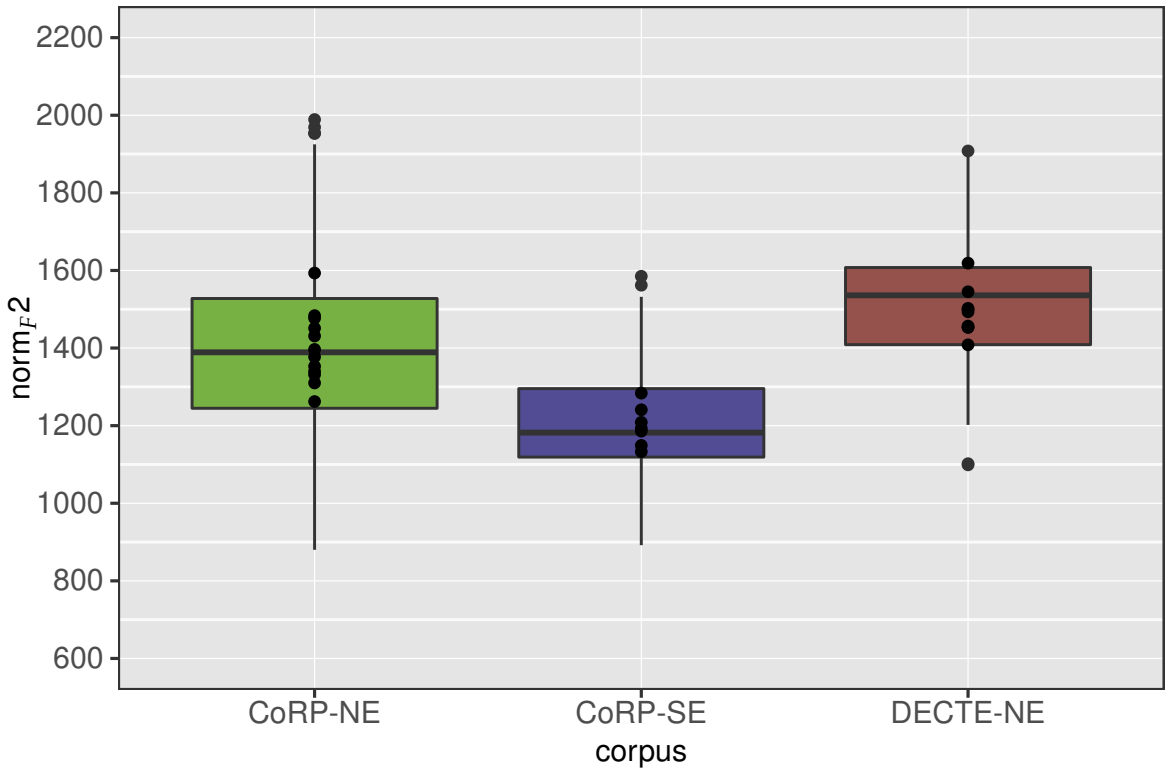


Figure 0.14

However, a figure that looks at all the data together provides a slightly different perspective. Figure 0.15 (also reproduced below) shows that within the CoRP-NE speaker group there exist BATH vowels that are in overlap with the CoRP-SE BATH and PALM position. For example see the lowest F2 value for BATH from CoRP-NE. However, if that speaker is taken as an example, they show a PALM vowel with a lower F2 again, demonstrating that their BATH is not produced in their PALM position.

It is possible that the spread of F2 values for CoRP-NE speakers is due to individual words. It is known that the TRAP-BATH split is not consistent within the pre-fricative context, even in southern speakers who maintain the split (see chapter 2), e.g. *gas* vs *grass*. In CoRP-NE speakers we may be seeing the effect of some ''BATH' words remaining in the TRAP position, but others moving to the PALM position. However, the data set is not large enough to be able to take reliable word means that can explain the pattern of this variation.

The variation in the CoRP-NE group is further seen in vowel duration where the mean of BATH in CoRP-NE is closer to CoRP-SE than DECTE suggesting that pre-fricative lengthening may be occurring in the CoRP-NE speakers, which historically was the precursor to the split in the South of England, and hence could be understood as the beginning of a split happening in this speech community.

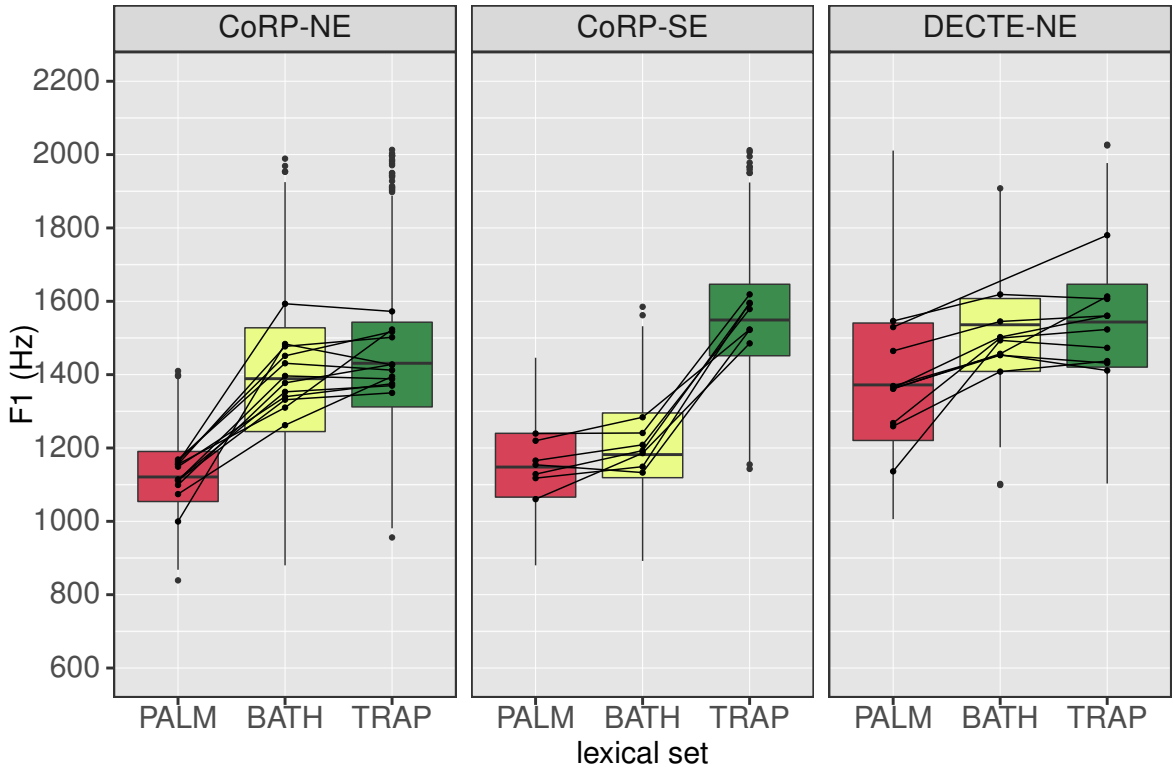


Figure 0.15

In conclusion, broadly CoRP-NE speakers behave in a regional manner with respect to the TRAP-BATH split. However, there are some indicators of variation due to the mixed input these speakers receive. There is indication of a PALM-like quality in some words, and also of a mean longer vowel length than found in DECTE.

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