The adoption of sound change : synchronic and diachronic processing of regional variation in Dutch
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Regional variation in on-going sound change: the case of the Dutch diphthongs

This chapter has been submitted.

Abstract

This chapter discusses the regional variation in four on-going sound changes in the Dutch vowels /eː,øː,oː,ɛi,œy/ that are conditioned by a following coda /l/. The synchronic diatopic diffusion of these changes is charted using the Dutch teacher corpus, a comprehensive dataset containing word-list data from four regions in the Netherlands and four in Flanders. Comparisons are made of the five vowels preceding nonapproximant consonants and preceding coda /l/. To avoid manually segmenting the oftentimes highly gradient vowel–/l/ boundary, GAMMs are used to model whole formant trajectories. Comparisons are then made of trajectories and of peaks of trajectories. The results are used to classify the nature of the four sound changes in terms of phonetic and lexical abruptness/graduality, and show that the changes are intertwined in such a way that they can only be considered as separate facets of a single, currently on-going, vowel shift.

2.1   Introduction

When we want to study sound change, we are always too late: by the time a successful change can be identified, it has—by definition—already spread beyond the incipient stage, which makes it difficult to study the implementation of such a change (see e.g. Pinget 2015). However, if a change is regionally stratified, then this synchronic variation can be used as a proxy for the diachronic change, yielding a specific case of the apparent-time method to the study of sound change. The present chapter uses this approach to investigate an on-going vowel shift in Dutch that has been covered synchronically (Adank, van Hout, & Smits 2004, Adank, van Hout, & Van de Velde 2007) but has not yet been investigated from the perspective of diachronic change. The aim of the chapter is to make two points. First, the present chapter will show that recent innovations in statistical methods make it possible to analyze challenging phonetic data. Second, these approaches make it possible not only to characterize the changes in Dutch that are currently on-going, but also to retrospectively say something about the *nature* of these sound changes, specifically whether they were originally Neogrammarian, lexically diffuse, or something else.

Dutch is currently undergoing multiple interrelated changes in its vowel system. The vowels /eː,øː,oː/ are changing into upgliding diphthongs [ei,øy,ou] (change 1; van der Harst 2011, van der Harst, Van de Velde, & van Hout 2014, Van de Velde 1996, Zwaardemaker & Eijkman 1924), the vowels /ɛi,œy,ɔu/ are lowering towards [ai,ɒy,ɑu] (change 2; Blankestein 1994, Gerritsen & Jansen 1980, Gussenhoven & Broeders 1976, van Heuven, Van Bezooijen, & Edelman 2005, Jacobi 2009, Mees & Collins 1983, Stroop 1992, Stroop 1998, Van de Velde 1996, Voortman 1994), and both of these sets of vowels are realized as monophthongs when preceding coda /l/ (change 3; Berns & Jacobs 2012, Botma, Sebregts, & Smakman 2012, Voeten 2015), while coda /l/ itself is undergoing a process of vocalization and is causing retraction of the preceding vowel (change 4; Berns & Jacobs 2012, van Reenen & Jongkind 2000). These diachronic changes manifest synchronically as regional variation. Change 1 shows a clear split between the Dutch spoken in the Netherlands versus the Dutch spoken in Flanders (Adank, van Hout, & Smits 2004, Van de Velde 1996), and change 2 is restricted to the Randstad part of the Netherlands (Jacobi 2009, Stroop 1998). Preliminary research on change 3 shows that it is split between the Netherlands and Flanders in the same way as change 1 (Chapter 4). The sociogeographical status of change 4 is well-known, in that the change is restricted to the Netherlands, where coda /l/ is velarized. In Belgian Standard Dutch, coda /l/ is not velarized and change 4 has not taken place. However, there are a few Flemish dialects (mostly in West-Flanders and the west of East-Flanders; De Wulf, Goossens, & Taeldeman 2005:map 176) that have developed coda-/l/-vocalization independently, or have retained an ety-

Table 2.1: Modes of implementation of historical sound changes, after Bermúdez-
       Otero (2007).

	Lexical dimension	
Phonetic dimension	Abrupt	Gradual
Abrupt	Change in underlying forms (Janson 1983)	Lexical diffusion (Wang 1969)
Gradual	Neogrammarian change (Osthoff & Brugmann 1878)	Change by exemplars (Bybee 2002)

mological vocoid (in words like "geel", which in Proto-Germanic had a sec-
ond syllable following the /l/, as in the English cognate "yellow"; De Wulf,
Goossens, & Taeldeman 2005:map 175).

While the fact *that* these sound changes are on-going or have perhaps al-
ready completed in the language is well-known, *how* these sound changes are
implemented remains to be established. The present chapter makes use of the
same corpus as Adank, van Hout, & Smits (2004) and Adank, van Hout, &
Van de Velde (2007) to answer this question. The mode of implementation
of a historical sound change is generally classified along two axes: phonetic
abruptness versus graduality on the one hand, and lexical abruptness ver-
sus graduality on the other (Bermúdez-Otero 2007). Consequently, four pos-
sible types of change have been attested in the literature, which vary along
phonetic and lexical abruptness vs. graduality. These are changes in underly-
ing forms, Neogrammarian change, change via classic lexical diffusion, and
change by exemplars within an Exemplar-Theory framework. Table 2.1 pro-
vides an overview of how these modes of implementation map to the phonetic
and lexical dimensions. It is not yet known how the sound changes that are cur-
rently on-going in Dutch can be classified in these terms. However, this can be
measured from the synchronic data available in the corpus. Phonetic gradu-
ality versus abruptness can be inferred by looking at the differences between
the regions that have been included in the corpus. If the regional differences in
the realizations of the same vowel or vowel-/l/ sequence show a smooth trend,
then a change is phonetically gradual. If there are sharp categorical differences
between the regions, then the change is phonetically abrupt in the synchronic
grammar (although synchronic data cannot rule out the possibility that the
change was originally of a gradual nature, but has already completed). Simi-
larly, if realizations of the same vowel or vowel-/l/ sequence are very different
between the words containing them, there is evidence for lexical graduality.
This makes it possible to operationalize the main research question: what types
of changes are changes 1–4?

The phonetic data on the basis of which this question can be answered present methodological challenges. While changes 1 and 2 can be investigated with relative ease, changes 3 and 4 are more challenging to operationalize. Change 3 and 4 involve vowels followed by coda /l/. This is a challenging sequence to segment for a phonetician, because the transition between these two segments is phonetically highly gradient, and this problem gets worse if the coda /l/ is strongly vocalized (which is one of the sound changes to be investigated; van Reenen & Jongkind 2000). The acoustic-phonetic transition from a vowel to a coda /l/ is smooth and continuous rather than discrete, and hence these segments cannot be segmented reliably. One might even argue that in cases of such smooth transitions, the concept of a phonetic segmentation does not even make sense in the first place. It may not be surprising, then, that sociolinguistic studies on Dutch normally exclude vowels followed by liquids and glides, because a reliable way to analyze such vowels has up to now been lacking (see e.g. Van de Velde 1996, among many others). However, for the present chapter, ignoring coda /l/ is not an option, as it is an integral part of the research question. The present paper demonstrates a solution to this long-standing problem of analyzing vowel–approximant sequences by making use of generalized additive mixed models, henceforth "GAMMs". These models make it possible dispense with manual segmentation altogether and to instead analyze the entire time course of the vowel plus coda /l/ as-is. This makes it possible to compare hard-to-segment [Vɫ] sequences to unproblematic sequences of the same vowels followed by a nonapproximant consonant, dispensing with manual segmentation of the former but not the latter. The results in Section 2.3 will show that the GAMM-based approach to formant measurements provides new perspectives on the measurement of the four different types of sound change, for which the four changes currently on-going in Dutch are an excellent example. The results also highlight the advantages and limitations of a synchronic approach towards the analysis of diachronic sound change.

2.2   Method

2.2.1   Data and measurements

The regional variation in the on-going sound changes in Dutch is investigated using a large dataset called the "teacher corpus" (Adank 2003, van Hout et al. 1999), a corpus of 5,407 tokens of monosyllabic words sampled from four representative regions in the Netherlands and four in Flanders. The teacher corpus is particularly well-suited to investigating the regional variation in the realizations of the tense mid vowels and diphthongs, for at least three reasons.

The first reason is that it is phonologically comprehensive, in that it contains all the vowels of interest for the research into the particular sound changes, and it specifically distinguishes between coda-/l/ and non-coda-/l/ contexts within these vowels. The second reason is that it is excellently regionally stratified: the corpus consists of four regions in the Netherlands and four regions in Flanders, logically ranging from more central (prestigious) to more peripheral (non-prestigious). Lastly, the corpus is well-suited for studying on-going change in particular because it makes an effort to disentangle regional variation in implementation from *dialectal* variation. The ingenious approach is due to Van de Velde & van Hout (2003): the data in the corpus were collected from *teachers of Dutch*, who serve a role-model function to their students. This makes them representative for their region's interpretation of the standard language (see Delarue 2013, Grondelaers & van Hout 2012, Van Istendael 2008). For more details on the way the data were collected, and an in-depth treatment of the sociolinguistic issues involved, the reader is referred to Van de Velde & van Hout (2003) and Patti Adank's (2003) PhD dissertation. Part of the data presented in this chapter were also analyzed in Sander van der Harst's (2011) PhD dissertation, albeit with different aims and using different methods.

The corpus consists of samples of Dutch taken from four different regions in both the Netherlands and Flanders. For both countries, one "central" region was sampled (NL: Netherlands-Randstad, henceforth "NR"; FL: Flemish-Brabant, "FB"), one intermediate region (NL: the south of Gelderland, henceforth "NM" for "Netherlands-Middle"; FL: East-Flanders, "FE"), and two peripheral regions (NL: Groningen and Dutch Limburg, henceforth "NN" and "NS" for "Netherlands-North" and "Netherlands-South"; FL: Flemish Limburg and West-Flanders, respectively "FL" and "FW"); for details, see Adank (2003). A map of the regions is shown in Figure 2.1, which was created using the DynaSAND website (Barbiers et al. 2006). The corpus is further subcategorized for gender and age, and then has five speakers per cell, yielding a total of 8 (regions) × 2 (genders) × 2 (age groups: young vs. old) × 5 (speakers per cell) = 160 speakers in total. For the age groups, an age between 22 and 40 years was considered "young", whereas an age between 40 and 65 was considered "old".

The data that are relevant to the investigation in this chapter are those containing the vowels /eː,øː,oː,ɛi,œy,ɔu/, followed either by a nonapproximant consonant or by coda /l/. This yields the words "fee" /feː/, "beuk" /bøːk/, "boog" /boːx/, "boten" /boːtən/, "do" /doː/, "pook" /poːk/, "dij" /dɛi/, "meid" /mɛit/, "duin" /dœyn/, "luis" /lœys/, "tuin" /tœyn/, and "saus" /sɔus/ in the non-/l/ condition and the words "keel" /keːl/, "veel" /veːl/, "beul" /bøːl/, "geul" /ɣoːl/, "school" /sxoːl/, "zool" /zoːɫ/, "geil" /ɣɛil/, "heil" /ɦɛil/, "ruil" /rœyl/, and "uil" /œyl/ in the /l/ condition. Using Praat (Boersma & Weenink 2016), each of these words was sampled on F1 and F2 in 10-ms steps, using the
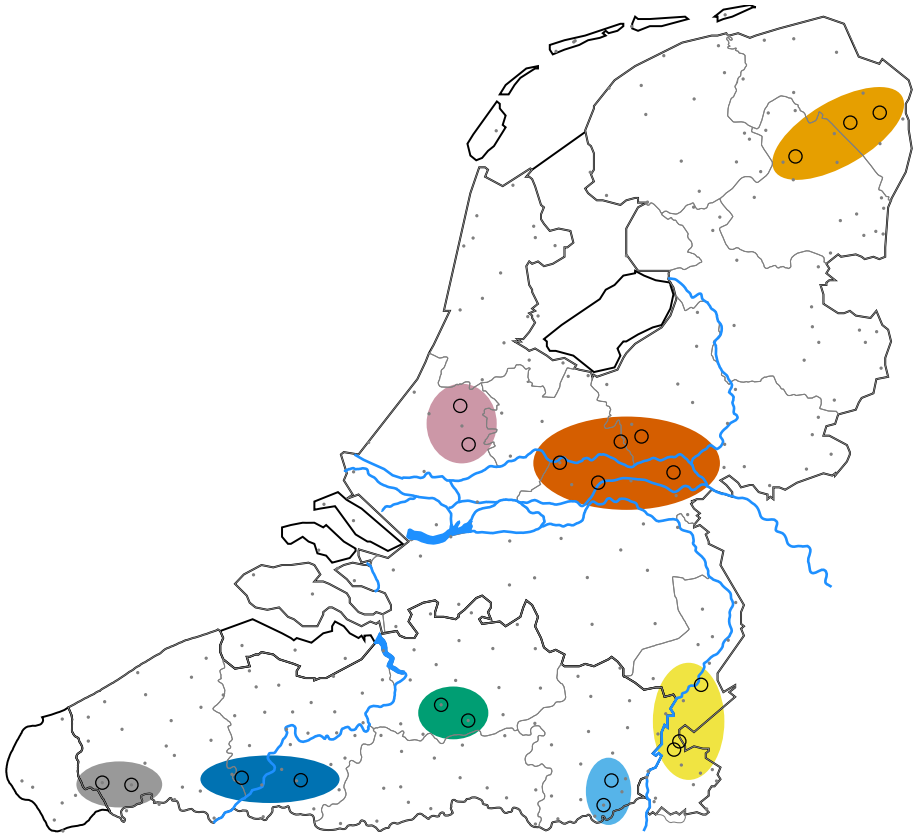
Figure 2.1: Overview of the different cities and towns from which data were sampled. Dots indicate major cities and towns according to Barbiers et al. (2006). Open circles indicate the cities and towns which were sampled for the teacher-corpus data. The overlaid colored circles indicate the corresponding regions, which are summarized in the following table (based on van der Harst 2011:55):

Region	Color	Cities/Towns
Netherlands-Randstad		Alphen aan den Rijn, Gouda
Netherlands-Middle		Tiel, Veenendaal, Ede, Culemborg, Elst
Netherlands-North		Assen, Veendam, Windschoten
Netherlands-South		Sittard, Geleen, Roermond
Flemish Brabant		Lier, Heist-op-den-Berg
Flemish Limburg		Ieper, Poperinge
Flanders-East		Oudenaarde, Zottegem
Flanders-West		Tongeren, Bilzen

same formant settings as in van der Harst (2011). Sampling started at the on-set of the vowel (which was segmented manually) and continued to the 10-ms point (rounded down) at either the end of the vowel (for the non-/l/ words) or the end of the vowel+/l/ (for the coda-/l/ words). This resulted in vary-ing numbers of 10-ms point samples, depending on the duration of the vowel, per token. The different token durations were normalized by converting the sample timestamps to percentages of vowel realization, such that each vowel token's duration ranged from 0% to 100% with a duration-dependent number of samples in between. Formant-measurement errors were excluded from the data by removing all samples falling outside the 100–1,000-Hz band for F1, and the 500–3,000-Hz band for F2.[1]

2.2.2   Data analysis

The resulting F1 and F2 trajectories were modeled by running separate GAMMs for each ⟨formant,vowel⟩ pair using function `bam` from R (R Core Team 2020) package `mgcv` (Wood 2017). Models were built up on the principle of parsi-mony (Bates et al. 2015a), based on visual inspection of the individual tokens and directly incorporating terms hypothesized to contribute to differences be-tween them, until no remaining structure was visible in the by-token resid-uals.[2] This led to the inclusion of fixed effects for the predictors "Gender" (coded as male or female, sum-coded such that female $= 1$ and male $= -1$), "Region" (the eight regions in the corpus, sum-coded such that Netherlands-Randstad $= -1$ and the others are 1), "Following segment" (treatment-coded as /l/ or non-/l/, such that /l/ $= 1$ and non-/l/ $= 0$), and "Region $\times$ Follow-ing segment". In addition, random intercepts and slopes by following segment were added by participants. Smooths, defined as thin-plate regression splines with 30 basis functions, were added for the predictor "Time" by following seg-ment; these terms model the nonlinear evolution of the dependent variable over time, for the non-/l/ and /l/ contexts separately. Finally, by-participants random smooths for "Time" by following segment were added to the model, configured in the same way as the regular smooths just described; penalties on the null space and on the first basis function of the thin-plate regression spline were added appropriately. Models were fitted to scaled-*t* errors includ-ing an order-1 autoregressive process with $\rho = .5$. The F1 model for the /ɔu/ vowel was fitted without effects for following segment, as this vowel was only

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[1]All data were also checked manually by the author for outliers or "suspicious" formant val-ues, but it was difficult to come up with a single, consistent, non-arbitrary set of criteria that was obviously correct for all cases. For this reason, it was decided to use only this formant-band-based criterion and to not use these additional manual corrections. The scaled-*t* error distribution makes the models robust against any remaining outlying observations; such outliers will be smoothed out without exerting undue influence on the regression estimates.

[2]I thank Harald Baayen for introducing me to the procedure.

present in one word: "saus". No F2 model was fitted for this vowel, as there are no coda-/l/ words available for this vowel, and the only change involving F2 is change 4, which only concerns coda /l/.

Regional variation due to the four on-going sound changes was established by comparing the fitted trajectories between the Netherlands-Randstad region with those in the other regions. The Randstad is chosen as the reference region because this is the region where all four changes are considered to be the most advanced (van der Harst 2011, Stroop 1998). For changes 1, 2, and 4, regional diffusion was assessed by predicting the fitted models' linear-predictor matrices onto a time grid of 101 points, corresponding to 0–100% realization. With eight regions, two following-consonant types, and two genders, this resulted in $101 \times 8 \times 2 \times 2 = 3,232$ linear predictions for each model. These were averaged over the two genders, and the linear predictions for the Randstad region were subtracted from them. The resulting linear differences were finally multiplied by the model's linear coefficients to obtain difference curves. Accompanying 95% Bayesian credible intervals were calculated using the approach in Wood (2017:293–294). Differences along a formant's time course are considered significant if their credible interval excludes zero.

Investigating the regional diffusion of change 3, the blocking of diphthongization before coda /l/, requires comparing the difference in diphthongization between vowels before non-/l/ and before coda /l/. In order to characterize the difference between these different types of trajectories, change 3 looks at the difference in formant *ranges*. Starting from the predicted trajectories provided by the GAMMs, for each vowel and region a trough was found by taking the highest F1 (corresponding to the lowest position of the tongue) within the first 50% realization, and a peak was found by taking the lowest F1 (corresponding to the highest position of the tongue) within the final 50% realization. The range of diphthongization is defined as the range between the trough and the peak, such that a negative range indicates upgliding diphthongization, whereas a range of zero or a small positive range indicates absence of this upglide (see Equation 2.1). Of interest is the *difference* in trough-to-peak ranges between the non-/l/ condition and the /l/ condition (henceforth "ΔTTP", see Equation 2.2). This difference is defined such that negative values indicate that there is more diphthongization in the non-/l/ condition than in the /l/ condition, whereas positive values indicate the reverse. Regional differences were established by subtracting the ΔTTP for the Randstad from that for the other regions ("ΔNR"; see Equation 2.3). Credible intervals for the ΔTTP and ΔNR measures were computed by performing the same steps as for the ΔTTP and ΔNR themselves on the corresponding linear-predictor matrices, and then again following the procedure outlined in Wood (2017:293–294).

$$\text{TTP} \; = \; \text{F1}_{\text{peak}} - \text{F1}_{\text{trough}} \tag{2.1}$$

$$\Delta\text{TTP} \; = \; \text{TTP}_{\text{non-}/l/} - \text{TTP}_{/l/} \tag{2.2}$$

$$\Delta\text{NR} \; = \; \Delta\text{TTP}_{\text{region}} - \Delta\text{TTP}_{\text{Netherlands-Randstad}} \tag{2.3}$$

The degree of lexical diffusion of the four sound changes is quantified by the between-words variability in each result to be discussed. To calculate a statistic representing this lexical variability, the same GAMMs (without effects for following segment and with the number of basis functions reduced to 10 for computational efficiency) were run for each word separately. For each peak value along the difference trajectory (changes 1, 2, 4) and ΔNR (change 3), the sum of squared differences of this result from the by-words individual estimates was computed and divided by the original result's variance (Equation 2.4). The resulting ratio is a chi-square random variable with $n-1$ degrees of freedom, where n is the number of words.

$$\chi^2{}_{n-1} \; = \; \frac{\sum_{i=1}^{n}\left(x_{\text{full model}} - x_{\text{by-words model }i}\right)^2}{\text{Var}(x_{\text{full model}})} \tag{2.4}$$

Section 2.3 discusses the results of the analyses. The data and R code with which these have been produced are available at https://figshare.com/s/48e 0afc5dc7b10d24726 as the files `data.csv` and `analysis.R`, respectively.

2.3   Results

The results for the four sound changes are discussed in order, based on the relevant statistics extracted from the fitted GAMMs. One of the models—the F1 model for the /ɔu/ vowel—did not converge successfully. This vowel was therefore excluded from the results. For reference, Figures 2.2–2.4 provide a general overview of the data for the F1 followed by a nonapproximant consonant, the F1 followed by coda /l/, and the F2 followed by coda /l/, respectively. These figures were obtained by predicting from the model in the same way as described in Section 2.2.2, without subsequently calculating any differences between conditions. As such, they are equivalent to smoothed versions of the raw data, for the average participant and the average word. In Figure 2.2, the full vowel trajectories are shown for the vowels followed by a nonapproximant consonant. This consonant itself is not included, but the vowels' trajectories to and from the consonants are clearly visible. This underscores the observations by van der Harst (2011) on the same data that the influence of coarticulation is minimal no earlier than 25% realization and no later than 75% realization. Figures 2.3 and 2.4 show the vowels followed by coda /l/, which is *included* in the depicted trajectories, as it could not be reliably segmented. Thus, in these plots, the ends of the depicted trajectories coincide with the ends of the words.
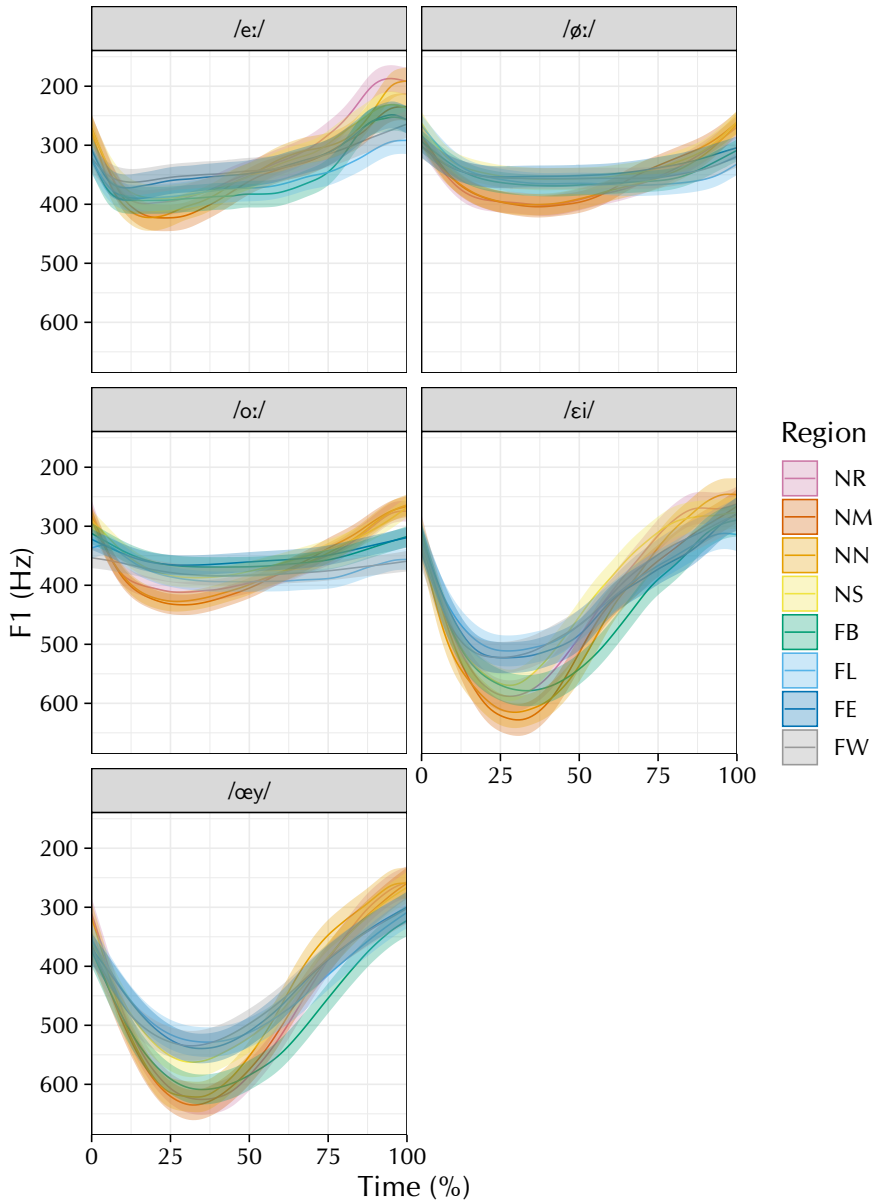
Figure 2.2: Overview of the vowel trajectories as smoothed curves, for the F1 data (closed/open dimension) when followed by a nonapproximant consonant. The following consonant itself is not included. The ribbons around the curves indicate the 95% CI.
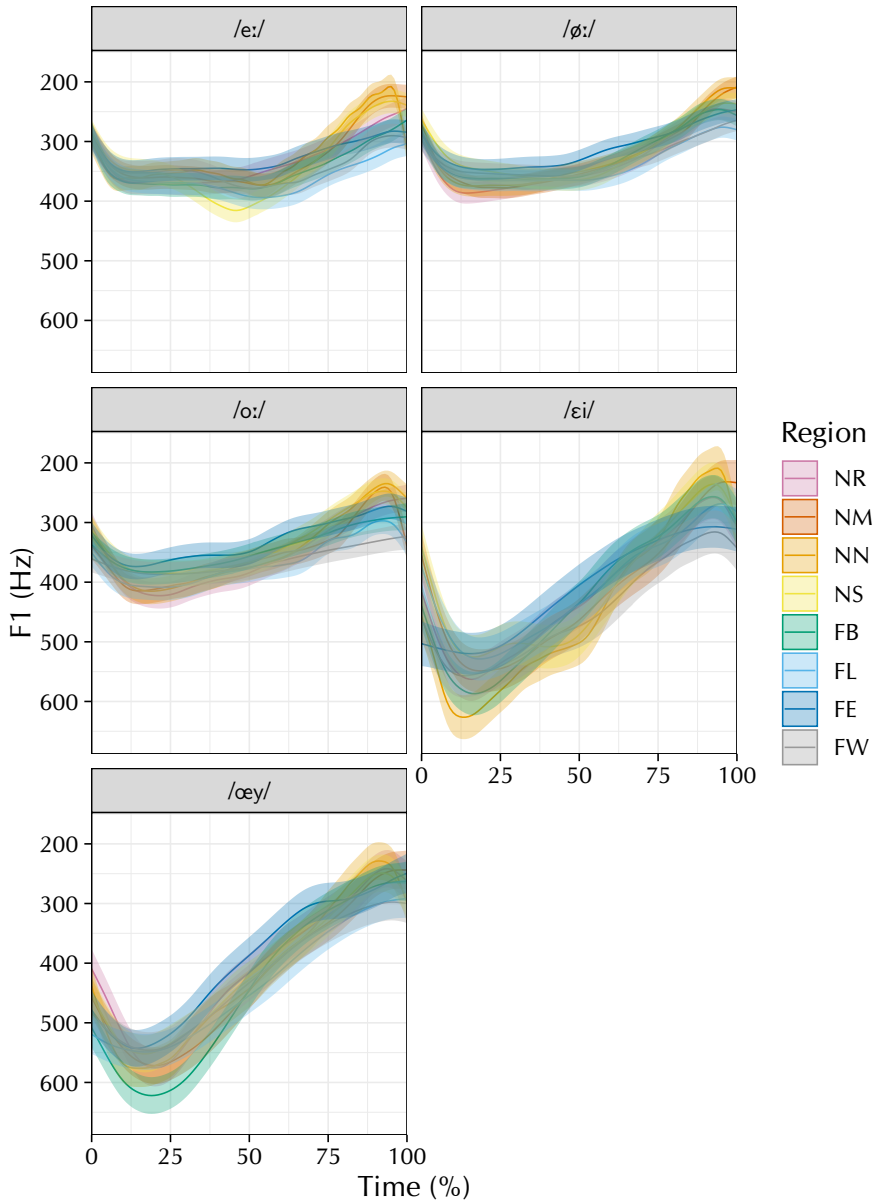
Figure 2.3: Overview of the vowel trajectories as smoothed curves, for the F1 data (closed/open dimension) when followed by coda /l/. The curves include the coda /l/ in its entirety. The ribbons around the curves indicate the 95% CI.
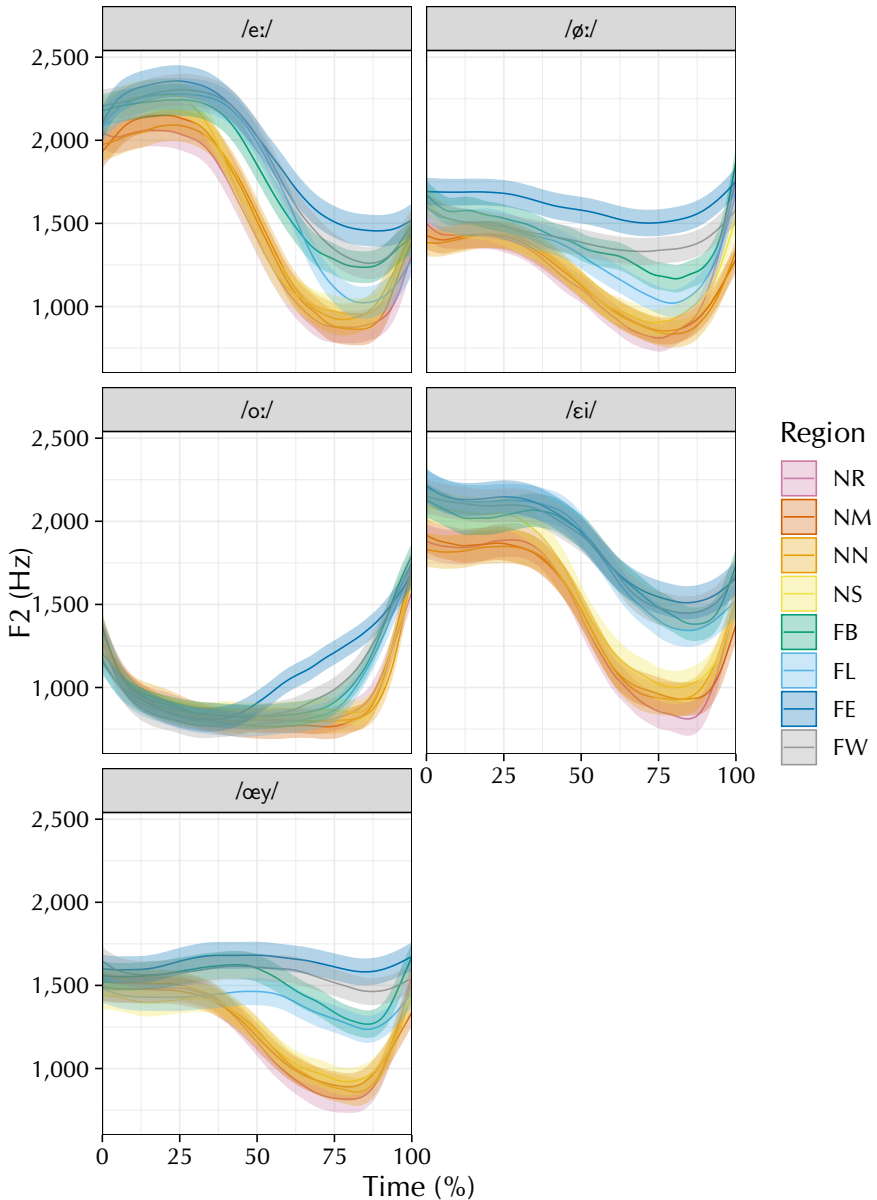
Figure 2.4: Overview of the vowel trajectories as smoothed curves, for the F2 data (front/back dimension) when followed by coda /l/. The curves include the coda /l/ in its entirety. The ribbons around the curves indicate the 95% CI.

2.3.1   Change 1: diphthongization of /eː,øː,oː/

Figure 2.5 shows the difference smooths of the five vowels when not followed by /l/, compared to the Netherlands-Randstad region. As the focus for change 1 is the diphthongization of /eː,øː,oː/, the dependent variable in this plot is the F1. In this figure as well as Figure 2.6, significance of the differences is indicated by the presence of a ribbon around the smooth; the width of the ribbon spans precisely the 95% CI. The peak points of the significant differences are listed in Table 2.2. Because change 1 is about upgliding diphthongization, which only affects the latter half of the vowel, only differences beyond the vowel midpoint (>50% realization) are considered relevant for interpretation. Significant differences that are found *only* in the final 10% of the smooth are excluded, as this part of the signal is strongly influenced by coarticulation (van der Harst 2011), making these differences unreliable.

There is systematicity in the combinations of vowel and region that show significant differences from the Randstad. With the exception of the /øː/ vowel in Flanders-East, all Flemish regions realize all five vowels with significantly less upgliding diphthongization (higher target F1) than the Randstad region. This observation already covers 79% (19/24) of the significant differences that were found. A second major role is played by the vowel /eː/, which the three non-Randstad regions in the Netherlands also diphthongize less strongly than the Randstad region, although the differences are quantitatively smaller than those between the Randstad and the Flemish regions. Thirdly and finally, in the Netherlands-Middle region the vowel /ɛi/ diphthongizes significantly less than the Randstad, and in the Netherlands-North the vowel /œy/ diphthongizes significantly more than in the Randstad.

The χ^2 values in Table 2.2 measure the variability across words of the peak differences presented in the table, and hence provide an index of the degree of lexical diffusion detectable in these data. There is limited evidence for lexical diffusion of this sound change. This is partly due to a shortcoming of the corpus—for /eː/ and /øː/, only a single word was available in the non-/l/ condition ("fee" and "beuk", respectively)—but for the words that are available, the variation did not turn out very large. Significant evidence of lexical diffusion is found in the /oː/ vowel (in regions FB, FE, and FW) and for the /œy/ vowel (in regions NN and FE). Only the former result is geographically contiguous, spanning all Flemish regions minus Flemish Limburg.
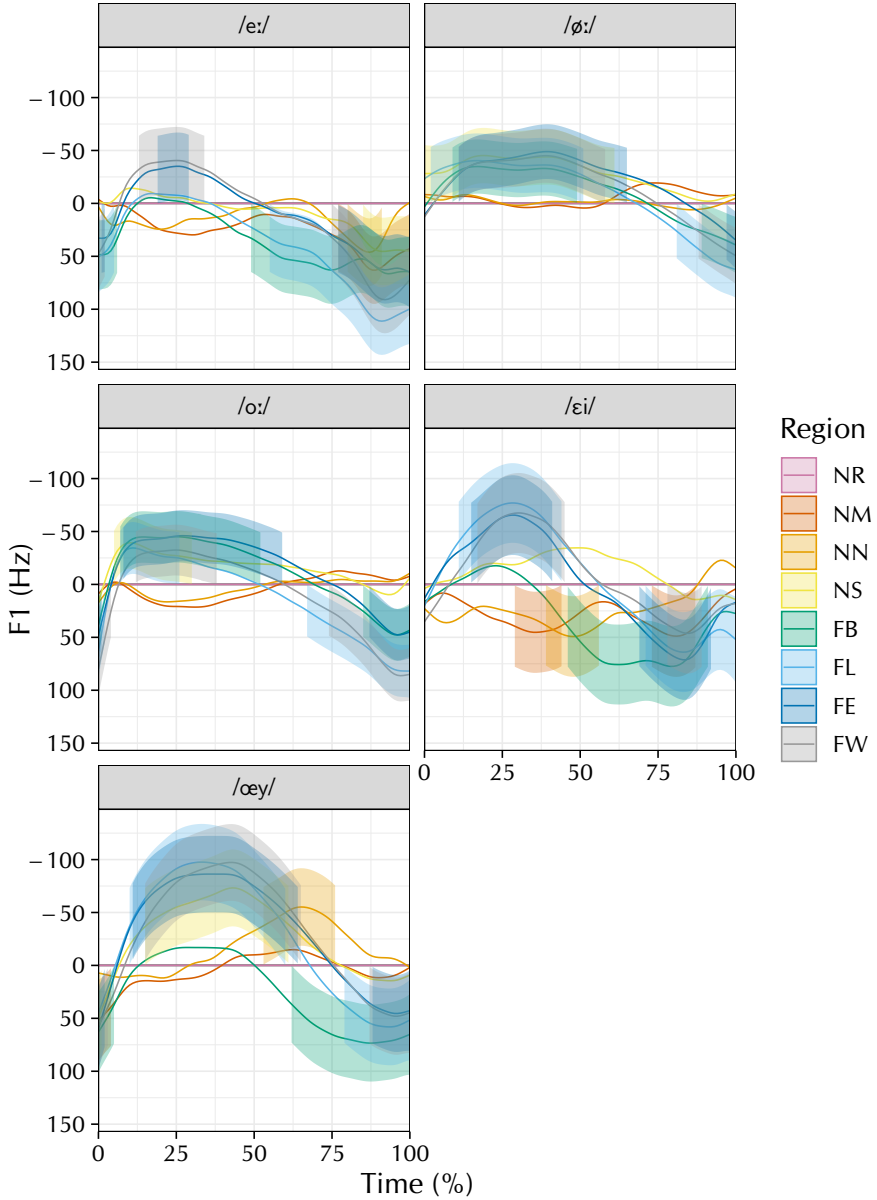
Figure 2.5: Differences in vowel diphthongization before nonapproximant consonants by the separate regions, relative to the Netherlands-Randstad
region.

Table 2.2: Regional differences in diphthongization before nonapproximant consonants. The "Timespan" column reflects the start and end point of the consecutive stretch of largest significant differences from the Randstad; the column labeled "95% CI" gives the 95% Bayesian credible interval of this largest difference. Only significant results are shown. The two right-hand columns are the lexical-diffusion measure; the χ^2 measures the amount by which individual words deviate from the peak difference in the middle column.

Vowel	Region	Timespan (%)	Peak diff. (Hz)	95% CI (Hz)	χ^2	p
/eː/	NM	77 – 100	63.09	31.21 – 94.97		
/eː/	NN	80 – 91	46.19	14.26 – 78.11		
/eː/	NS	85 – 100	45.38	13.53 – 77.24		
/eː/	FB	49 – 100	66.49	34.35 – 98.63		
/eː/	FL	55 – 100	111.26	79.35 – 143.17		
/eː/	FE	77 – 100	65.03	31.87 – 98.19		
/eː/	FW	75 – 100	90.97	59.18 – 122.77		
/øː/	FB	89 – 100	39.35	12.77 – 65.92		
/øː/	FL	81 – 100	62.51	35.92 – 89.10		
/øː/	FW	88 – 100	49.51	22.94 – 76.09		
/oː/	FB	85 – 100	47.69	23.17 – 72.20	11.19	.01
/oː/	FL	67 – 100	81.86	57.10 – 106.62	2.59	.46
/oː/	FE	87 – 100	47.68	23.29 – 72.06	50.94	<.001
/oː/	FW	74 – 100	86.24	61.86 – 110.62	22.73	<.001
/ɛi/	NM	73 – 87	48.89	10.39 – 87.40	3.49	.06
/ɛi/	FB	46 – 91	77.42	39.50 – 115.35	0.89	.35
/ɛi/	FL	71 – 100	64.02	26.26 – 101.79	2.62	.11
/ɛi/	FE	69 – 92	71.23	33.39 – 109.07	2.80	.09
/ɛi/	FW	78 – 89	46.24	8.26 – 84.22	1.02	.31
/œy/	NN	53 – 76	− 37.49	− 74.12 – − 0.86	14.07	<.001
/œy/	FB	62 – 100	73.40	37.06 – 109.73	3.06	.22
/œy/	FL	79 – 100	58.08	21.86 – 94.31	2.64	.27
/œy/	FE	88 – 100	45.43	9.03 – 81.83	6.37	.04
/œy/	FW	87 – 100	48.00	11.50 – 84.49	5.03	.08

2.3.2   Change 2: lowering of /ɛi,œy,ɔu/

Change 2, the lowering of /ɛi,œy,ɔu/ to [ai,ɒy,ɑu], concerns the same mod-
eled differences as change 1, so the relevant differences can also be observed in
Figure 2.5. Because change 2 is concerned with the nuclear vowels of the diph-
thongs, only differences *before* 50% realization are considered for interpretation.
Differences that remain confined to the first 10% are excluded. As before, the
differences are relative to the Netherlands-Randstad and are based only on the
non-/l/ data. The peaks of the significant differences from the Randstad are
listed in Table 2.3.

The significant differences are mostly confined to the Flemish regions,
which overall have higher starting points (lower F1s) than in the Randstad.
For the vowel /e:/, this is the case for the regions FE and FW, for the vowels
/ø:/ and /o:/, it is true of all four Flemish regions, and for the diphthongs /ɛi/
and /œy/, it holds for all Flemish regions but Flemish-Brabant. For the vowels
/ø:,o:,œy/, Netherlands-Limburg goes along with the Flemish regions, in hav-
ing higher F1s. Finally, for the /ɛi/ vowel, the regions Netherlands-Middle and
Netherlands-North have a significantly lower F1 than the Netherlands Rand-
stad.

The lexical-diffusion chi-squares in Table 2.3 again provide limited evi-
dence for lexical diffusion. These indicate the degree to which the peak dif-
ferences in Table 2.3 are variable between the different words in the corpus.
Significant χ^2s are found for the /o:/ (regions NS, FB, FL, and FW) and /ɛi/
vowels (regions NN and FE) and for /ɛi/ in Netherlands-North and Flanders-
East. The /o:/ vowel additionally shows marginal signs of lexical diffusion in
Flanders-East ($p = .06$), in which case this vowel forms a coherent group: all
of Flanders plus Netherlandic Limburg. Of the lexical-diffusion pattern found
in the /ɛi/ vowel, the same cannot be said.

Table 2.3: Regional differences in the lowering of /ɛi,œy,ɔu/. Only significant results are shown.

Vowel	Region	Timespan (%)	Peak diff. (Hz)	95% CI (Hz)	χ^2	p
/eː/	FE	19 – 29	− 35.05	− 66.97 − − 3.13		
/eː/	FW	13 – 34	− 40.52	− 72.26 − − 8.79		
/øː/	NS	0 – 61	− 45.22	− 71.35 − − 19.10		
/øː/	FB	9 – 49	− 34.84	− 60.47 − − 9.22		
/øː/	FL	2 – 51	− 40.42	− 66.14 − − 14.71		
/øː/	FE	11 – 65	− 48.90	− 74.78 − − 23.02		
/øː/	FW	11 – 58	− 45.07	− 70.64 − − 19.49		
/oː/	NS	5 – 30	− 39.13	− 63.54 − − 14.72	11.04	.01
/oː/	FB	7 – 52	− 44.99	− 69.30 − − 20.68	32.89	<.001
/oː/	FL	7 – 26	− 34.48	− 58.99 − − 9.98	9.38	.02
/oː/	FE	8 – 59	− 46.02	− 70.22 − − 21.83	7.55	.06
/oː/	FW	12 – 38	− 32.45	− 56.44 − − 8.46	17.37	<.001
/ɛi/	NM	29 – 44	39.01	0.69 − 77.33	3.30	.07
/ɛi/	NN	39 – 56	38.71	0.72 − 76.71	4.24	.04
/ɛi/	FL	11 – 44	− 76.94	− 114.58 − − 39.30	0.33	.57
/ɛi/	FE	15 – 41	− 65.47	− 103.16 − − 27.77	9.13	<.01
/ɛi/	FW	17 – 45	− 67.50	− 105.31 − − 29.68	1.28	.26
/œy/	NS	15 – 61	− 73.24	− 109.58 − − 36.91	3.87	.14
/œy/	FL	10 – 60	− 97.61	− 133.71 − − 61.51	1.01	.60
/œy/	FE	11 – 64	− 86.28	− 122.42 − − 50.14	0.76	.68
/œy/	FW	15 – 65	− 97.30	− 133.56 − − 61.04	3.15	.21

2.3.3   Change 3: blocking of diphthongization before /l/

Table 2.4 lists the ΔTTPs between the non-/l/ and the /l/ contexts, and their differences from the Netherlands-Randstad. The lexical-diffusion χ^2s concern the between-word variation in these ΔNR scores.

Similarly to the previous results, it is mostly the Flemish regions where ranges that are significantly different from the Randstad are found. For the /e:/ and /œy/ vowels, three of the four Flemish regions have significantly different ΔTTPs from the Netherlands-Randstad, and for /e:/ so does the Netherlands-South region. For the vowel /ø:/ all four of the Flemish regions differ significantly. For the /o:/ vowel, only one region differs significantly from the Randstad: Flemish Limburg; the same also holds for the vowel /ɛi/. The directions of the differences call for some discussion. The hypothesized change 3 was one whereby vowels followed by non-/l/ would be diphthongized more strongly than vowels followed by /l/, but the ΔTTPs in Table 2.4 largely go into the opposite direction (the only exception is the /e:/ vowel). The ΔNRs, by contrast, are exactly as expected: all regions that are significantly different from the Randstad have more positive trough-to-peak differences than the Randstad, indicating a less severe distinction between the non-/l/ and /l/ conditions. Section 2.4 will discuss possible explanations.

The lexical-diffusion χ^2s for the peak differences are large. This is because there is variation from the TTPs for the vowels preceding coda /l/ and also for the vowels preceding non-/l/. The fact that the *combinations* of these two sources of variation are what has to be considered means that the χ^2 values will be larger, but so will their degrees of freedom and hence their *p*-values. The fact that all of the relevant χ^2 values are significant thus suggests that these differences from the Netherlands-Randstad are quite variable between words, indicating that change 3 is lexically diffuse.

Table 2.4: Differences in the ranges of diphthongization before nonapproximant consonants versus before coda /l/, split out by vowel and region in order to answer RQ 3. Only regions significantly different from the Netherlands-Randstad are shown.

Vowel	Region	ΔTTP	95% CI	ΔNR	95% CI (Hz)	χ^2	p
/eː/	FB	− 26.61	− 60.69 − 7.48	59.31	10.63 − 107.99	33.96	<.001
/eː/	FL	− 10.84	− 45.13 − 23.44	75.07	26.25 − 123.90	47.30	<.001
/eː/	FW	− 10.82	− 44.78 − 23.14	75.09	26.50 − 123.69	40.83	<.001
/eː/	NS	23.67	− 8.68 − 56.02	109.59	62.10 − 157.07	76.38	<.001
/øː/	FB	56.67	31.55 − 81.78	47.73	10.94 − 84.52	49.31	<.001
/øː/	FE	50.52	22.29 − 78.75	41.59	2.61 − 80.57	24.40	<.001
/øː/	FL	56.44	31.28 − 81.60	47.51	10.69 − 84.33	8.71	<.01
/øː/	FW	55.85	31.50 − 80.19	46.91	10.65 − 83.18	3.90	.048
/oː/	FL	73.59	46.04 − 101.14	47.89	7.40 − 88.37	52.30	<.001
/ɛi/	FL	61.07	8.63 − 113.50	82.57	6.91 − 158.23	16.50	<.001
/œy/	FB	72.76	21.53 − 124.00	107.27	35.92 − 178.62	106.03	<.001
/œy/	FE	54.07	2.56 − 105.59	88.58	17.02 − 160.13	193.81	<.001
/œy/	FL	37.58	− 12.55 − 87.71	72.08	1.52 − 142.64	78.99	<.001

2.3.4   Change 4: vocalization and retracting effect of coda /l/

The fourth change concerns the second formant, rather than the first; Figure 2.6 shows the significant differences from the Netherlands-Randstad. As the coda /l/ was not separated from the vowel, it is included in this figure. Table 2.5 provides a summary of the significant differences relative to the Netherlands-Randstad that are visible. It can already be seen from Figure 2.6 that quite a few significant differences start at the very first few timepoints, which is consistent with coda /l/ having a retracting effect on the quality of the entire vowel.

Table 2.5 shows very clear results, which can be summarized as follows. All vowels in all Flemish regions exhibit significantly less retraction (i.e. higher F2) than the same vowels do in the Netherlands-Randstad. The Netherlands-North (for the vowels /e:/ and /o:/) and the Netherlands-South (for the vowels /ɛi/ and /œy/) also demonstrate some sporadic differences, but these are not very meaningful for interpretation, as they occupy relatively small stretches of signal and the 95% CIs only just exclude zero, neither of which is true for the massive differences from the Randstad region in the Flemish regions. These regions show large effects (median difference = 574 Hz) over, in many cases, nearly the complete vowel-/l/ trajectory.

There is some evidence for lexical diffusion. This is particularly the case for the /o:/ vowel, which is lexically diffuse in all four of the Flemish regions. Lexical-diffusion results for the other vowels are a bit more haphazard. The /ø:/ vowel shows significant lexical diffusion in Flemish Brabant and Flanders-West, and the /œy/ vowel does so in Flanders-East.
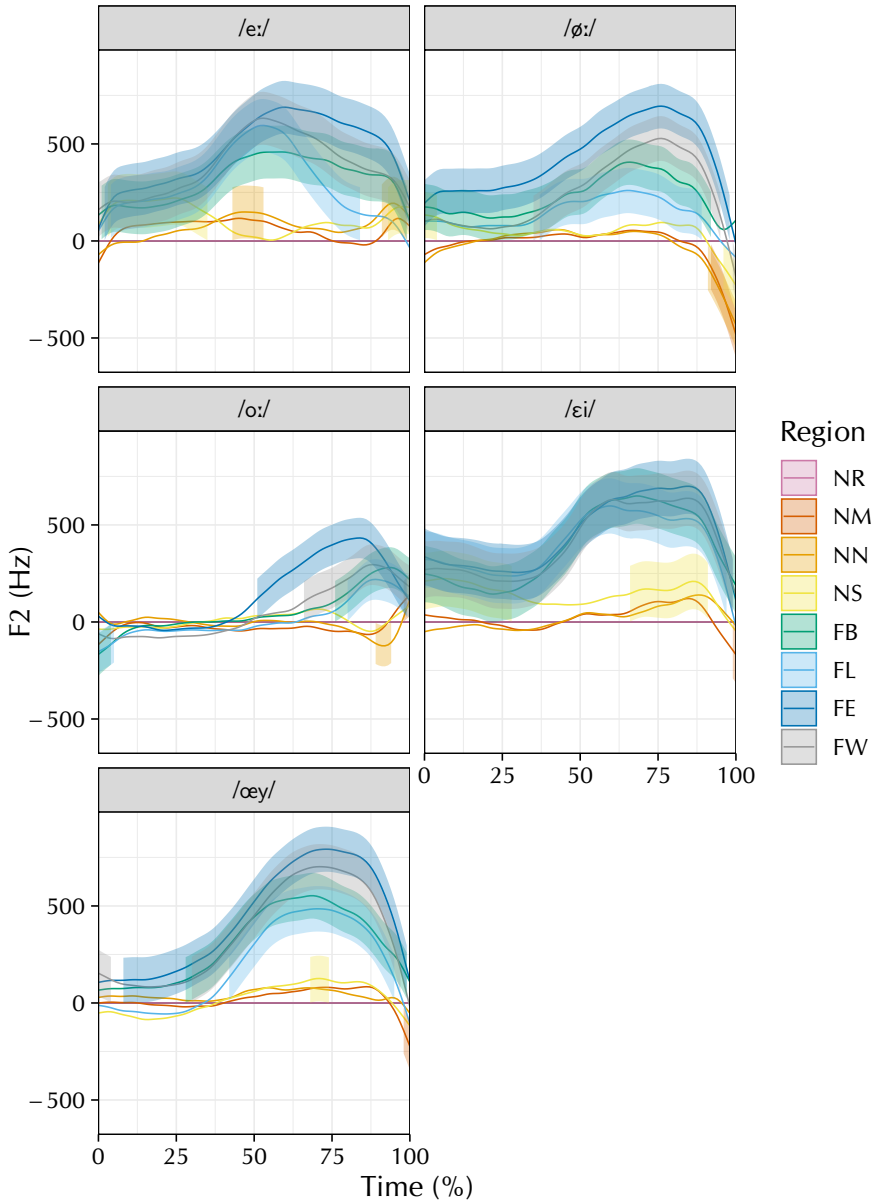
Figure 2.6: Differences from the Randstad in the retraction of vowels including a following coda /l/, averaged over gender.

Table 2.5: Regional differences in the retracting effect of coda /l/.

Vowel	Region	Timespan (%)	Peak diff. (Hz)	95% CI (Hz)	χ^2	p
/eː/	NN	43 – 53	145.88	9.43 – 282.33	1.97	.16
/eː/	FB	1 – 99	458.69	322.60 – 594.79	1.30	.25
/eː/	FL	4 – 84	595.26	458.75 – 731.77	2.49	.11
/eː/	FE	2 – 100	689.18	553.29 – 825.07	0.06	.81
/eː/	FW	0 – 100	632.59	496.38 – 768.79	0.29	.59
/øː/	FB	0 – 92	406.11	289.08 – 523.13	11.21	<.001
/øː/	FL	37 – 89	260.18	143.59 – 376.78	3.27	.07
/øː/	FE	0 – 98	694.84	579.86 – 809.82	0.44	.51
/øː/	FW	35 – 95	528.36	413.00 – 643.71	5.34	.02
/oː/	NN	89 – 94	– 110.78	– 216.65 – – 4.91	2.90	.09
/oː/	FB	76 – 100	262.49	157.64 – 367.35	9.29	<.01
/oː/	FL	80 – 100	219.23	114.69 – 323.76	12.40	<.001
/oː/	FE	51 – 99	432.83	328.59 – 537.07	25.19	<.001
/oː/	FW	66 – 100	295.56	190.87 – 400.25	5.59	.02
/ɛi/	NS	66 – 91	209.11	65.89 – 352.33	0.11	.74
/ɛi/	FB	0 – 100	649.40	506.24 – 792.56	1.59	.21
/ɛi/	FL	0 – 97	597.89	455.55 – 740.23	0.97	.33
/ɛi/	FE	0 – 99	699.22	557.11 – 841.33	2.95	.09
/ɛi/	FW	0 – 99	637.34	494.76 – 779.92	1.97	.16
/œy/	NS	68 – 74	126.21	8.48 – 243.95	3.53	.06
/œy/	FB	28 – 99	552.74	434.87 – 670.62	1.81	.18
/œy/	FL	42 – 95	485.18	367.96 – 602.41	0.08	.78
/œy/	FE	8 – 99	792.47	676.23 – 908.71	7.75	<.01
/œy/	FW	30 – 97	702.30	585.62 – 818.98	0.81	.37

2.4   Discussion

We have discussed four sound changes that are currently on-going in Dutch: (1) the diphthongization of /e:,ø:,o:/; (2) the lowering of /ɛi,œy,ɔu/; (3) the monophthongization of diphthongs before coda /l/; (4) the vocalization and retracting influence of coda /l/. The main tenet of the present chapter was that the present-day regional distribution of these sociolinguistic variables could inform us about the current status and the nature of these four sound changes. The results presented in Section 2.3 support this viewpoint.

Change 1, the diphthongization of /e:,ø:,o:/, was shown to be subject to significant regional variation. Nearly all Flemish regions were found to diphthongize the five vowels /e:,ø:,o:,ɛi,œy/ significantly less than the Netherlands-Randstad. The same is true of the more peripheral vowel–region combinations in the Netherlands. This paints the picture of an on-going sound change that originated in the Randstad and has partially spread towards the other regions in the Netherlands, while affecting very little of Flanders. The between-region effects are phonetically gradual: there are no regions which categorically do not diphthongize their vowels, but there are quantitative differences in the degrees to which they diphthongize. Little evidence was found for lexical diffusion. Thus, according to the data in this corpus, change 1 is phonetically gradual but lexically (mostly) abrupt. Referring back to the typology of sound change reviewed in Table 2.1, this means that this change can be qualified as Neogrammarian. Note that the data show that change 1 is not, in fact, restricted to /e:,ø:,o:/ but that /ɛi/ and /œy/ are also involved in the change, in exactly the same way as the tense mid vowels.

Change 2, the lowering of /ɛi,œy/, yielded similar results, mostly concerning the boundary between the Netherlands and Flanders: the Netherlands have undergone the change, but Flanders has not. To a lesser extent (viz. excluding the front vowels), Netherlands-Limburg turned out to be more conservative than the rest of the Netherlands, patterning more with Flanders on this change. This is consistent with change 2 being more recent than change 1, while both originated in the same area (Netherlands-Randstad; Jacobi 2009, Stroop 1998). As with change 1, only weak evidence was found for lexical diffusion while there is substantial intra-country phonetic variation, allowing change 2 to be qualified also as Neogrammarian, as far as the data permit. In addition, the data again reveal that change 2 is not only lowering the nuclei of /ɛi/ and /œy/, but also those of /e:,ø:,o:/.

Change 3, the blocking of diphthongs before coda /l/, is a rule change, rather than a change in the locations of the vowels in the articulatory space. This qualitative change has quantitative effects on the difference between a vowel followed by /l/ vs. by another consonant. The results suggest, to some degree, a split between the Netherlands and Flanders, although this split is not

perfect and does not hold for all vowels (the vowels /oː/ and /ɛi/ are largely excluded). Most of the Flemish regions were shown to have a significantly less negative difference between vowels in /l/ versus non-/l/ words than the Randstad region. These regions thus make a smaller distinction between these two contexts than the Randstad does. This is in line with the hypothesis that the blocking of diphthongization started out as a sound change in the Randstad area.

Concerning change 3, a final issue remains to be solved. While the differences from the Netherlands-Randstad region were all in the expected direction (ΔNR being positive, indicating less diphthongization in the non-Randstad regions), the range differences between /l/ and non-/l/ themselves were not. The mostly positive ΔTTPs in Table 2.4 suggest that there is *more* upgliding diphthongization before coda /l/, not less. The approach used to extract these scores compared the ranges of diphthongization between F1 peaks and troughs before /l/ vs. non-/l/. In the non-/l/ case, this is not problematic, but in the /l/ case, the F1 will naturally fall at the onset of the /l/, because this consonant requires alveolar occlusion and hence raising of the tongue blade. This will also lower the F1, and will cause it to fall more strongly than an upgliding diphthong, as the latter does not require the tongue tip to make full contact with the alveolar ridge. This contextualizes the findings regarding change 3, in that the positive ΔNRs measured are more likely to have arisen due to differences in the nuclei of the diphthongs (i.e. the first 50% of the trajectory) rather than due to differences in the target positions: the latter are the same for all the /l/ words, hence making these words' contributions to the ΔTTP measure relatively constant. The interpretation of the significant differences in the ΔNRs thus has to be that the Randstad observes a larger distinction in vowel quality between vowels followed by /l/ and vowels followed by non-/l/.

This is in line with change 2, the lowering of /ɛi,œy/. It was shown in Voeten (2015) that, even in the Randstad region of the Netherlands, the realizations of /eː,øː,oː,ɛi,œy/ before coda /l/ were as monophthongs [eː,øː,oː,ɛː,œː], omitting the lowering observed in change 2. It must then be the Netherlands-Randstad, in which area /ɛi,œy/ are lowered the most strongly, where change 3 results in a maximal difference between the /l/ vowel allophone and the non-/l/ vowel allophone. In regions where the lowering of /ɛi,œy/ is less advanced, this difference should be less salient. This is precisely what the results for change 3 show. The results for change 3 thus indicate that the lowering of diphthongs in change 2 is restricted to the non-/l/ condition, where vowels are realized as full upgliding diphthongs. It should also be observed that the degree of lexical diffusion is significant: all but one of the differences from the Randstad that were significant also achieved significant lexical-diffusion χ^2s. Change 3 is thus lexically gradual. Given that it is also phonetically gradual—as demonstrated by the significant inter-region variability—this change can therefore be

qualified as a change by exemplars.

Finally, change 4, the vocalization and retracting effect of coda /l/, is the largest of the four changes under investigation. The significant differences are large in magnitude, and in most cases span large sections of the signal, which is consistent with an across-the-board change in vowel quality. The results chiefly suggest a split between the Netherlands and Flanders, with all vowels in all Flemish regions being significantly different from the Randstad for very large stretches of signal. This agrees with observations by van Reenen & Jongkind (2000) that the Flemish varieties of Dutch use a clear coda [l] and the Netherlandic varieties realize a dark [ɫ]. The present results also extend them by showing that this difference is not confined to the realization of coda /l/ itself, but also affects the entire vowel preceding it. There is some evidence for lexical diffusion, although it is really only the /oː/ vowel that stands out in terms of significance, with all four of the Flemish regions obtaining a significant χ^2). In terms of the mode of implementation of change 4, the evidence is thus inconclusive, both in the phonetic dimension and in the lexical dimension. Phonetically, the categorical differences between the Netherlands and Flanders suggest that change 4 is abrupt, but this could also simply reflect a change that has already completed, and lexically, the evidence of lexical diffusion achieves significance only for the /oː/ vowel, but the relatively large χ^2 values do suggest a trend. Future research is necessary.

On the subject of lexical diffusion, the /oː/ vowel presents a noteworthy case. For changes 1, 2, and 4, the evidence for lexical diffusion was haphazard with the exception of this vowel. For some reason, in all of these three otherwise Neogrammarian changes, the /oː/ vowel shows significant between-words variation. This cannot be coincidental, and could be taken to imply that, technically speaking, none of these changes are *truly* Neogrammarian, as there is evidence of systematic lexical diffusion. This point is well-taken, and demonstrates how the categories in Table 2.1 represent only theoretical endpoints of a practical *continuum*. But why is it the vowel /oː/ that consistently shows this high degree of lexical variability between the words in the corpus? The relationship between /oː/ and /ɔu/ may provide an explanation. The lowering of /ɔu/ to /ɑu/ is phonologically complete (as can be seen by the fact that /pɑul/ "Paul" is monophthongized to [pɑːɫ] rather than *[pɔːɫ], at least in Netherlandic Dutch; Voeten 2015) and phonetically more advanced than the lowering of /ɛi,œy/ (Adank, van Hout, & Smits 2004). If the vowels /oː/ and /ɔu/ have become further apart in phonetic space, then this may provide more room for /oː/ to vary due to, for instance, coarticulation, compared to the other vowels under study, which would naturally lead to increased between-word variation. A way to investigate this possibility would be to compute differences between /oː/ and /ɔu/ realizations and to compare their stability across different words using, for instance, the χ^2 statistic. This approach would be analogous to that

taken in the investigation of change 3 in the present chapter. Unfortunately, as there was only a single word available for the /ɔu/ vowel in the present corpus and the associated model failed to converge, this must be left to future research using a different dataset or methodology.

A remark on the data used in the present chapter is that the number of words included in the corpus was relatively low. While the data collector (Adank 2003) had made a very deliberate effort to incorporate sociolinguistically and phonologically relevant factors into her design, and the dataset is unique in its thorough representation of the regional variation in Dutch sociophonetics, the number of words per cell in the design ranged from 1 to 5. This made it easy to construct the statistically principled χ^2 measures of lexical diffusion (which would not have been feasible with thousands of words), but generalization of the lexical-diffusion results must be approached with appropriate caution. Despite the clear results found in the present study, which show that the quantitative approach to sound change taken here is promising, the χ^2 measures would have achieved more power if the corpus had contained more words. As such, the lexical-diffusion statistics reported in the present paper represent only a lower bound, constrained by the limited amount of available data.

The results from this study provide new insights into the sociophonetic variation in the Dutch language area. Changes 1 and 2 turned out to be suspectly similar to one another in terms of their behaviors. In particular, change 1 turns out to actually not be restricted to the tense mid vowels /eː,øː,oː/ and change 2 turns out not to be restricted to the diphthongs /ɛi,œy,ɔu/. Instead, both changes demonstrate a more general split between the Netherlands and Flanders, where the latter has generally less open vowels and generally less diphthongization than the former. These observations are consistent with the idea that changes 1 and 2 are actually facets of a single, larger-scale, Neogrammarian change, that originated in the Netherlands and has subsequently not spread uniformly across the two countries. This is briefly touched upon by Jacobi (2009:87), although she does not explicitly posit this theory; the present results suggest that such an integrated account of change 1 and 2 as a single sound change is warranted by the data. The results additionally suggest that change 3 interacts with these two changes, which has been implied before (Voeten 2015), but has only now been shown explicitly. Finally, the results from change 4 highlight the limitations of a synchronic approach to diachronic variation: the observed differences themselves are crystal clear, but these data do not tell us if this is because the change itself is very abrupt, or because it has already completed. A true diachronic investigation would be needed to answer this question.

2.5   Conclusion

The goal of this study was to describe and explain the synchronic regional differences resulting from four diachronic changes in Dutch: the diphthongization of /eː,øː,oː/, the lowering of /ɛi,œy,ɔu/, the blocking of diphthongs before coda /l/, and the increasing vocalization and retraction of coda /l/. These issues were investigated by means of an analysis of the teacher corpus (Adank 2003). The results show that changes 1 and 2 are Neogrammarian, while change 3 was classified as change by exemplars. The evidence suggests that these three changes together constitute different facets of a single on-going vowel shift. Change 4, on the other hand, was of indeterminate status; this change demonstrated the limitations of the synchronic approach to diachronic variation, and is in need of future research. These results show that the approach adopted in the present chapter, when combined with the appropriate statistical tools, can lead to new insights that would not have been obtained with the same efficiency from a real-time diachronic study.

Acknowledgments