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Loss of Historical Phonetic Contrast Across the Lifespan: Articulatory, Lexical, and Social Effects on Sound Change in Swabian[1]

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Abstract

This chapter explores the extent to which phonetic environment, lexical frequency, and social factors interact and incite or impede sound change over the lifespan of the individual. The corpus consists of sociolinguistic interviews with 20 panel speakers of Swabian, an Alemannic dialect spoken in southwestern Germany, from two different communities, Stuttgart and Schwäbisch Gmünd, first recorded in 1982 and again in 2017. We investigate the modern standard German diphthong [ai] which evolved from two different Middle High German (MHG) phonemes, /i:/ and /ei/. We use generalised additive mixed-effect models to investigate to what extent F1/F2 trajectories in the vowel space differ in lemmata originating from the two MHG phonemes based on the Total Euclidean Distance Squared (TEDS). In addition to voicing effects, we find that an interaction between community, lexical frequency, and indexicalities of Swabian identity affects the degree to which the two diphthongs are merging, or at least becoming more similar to one another, within the lifespan of one generation. By analysing intra-speaker trajectories, we show how sound change is governed by the intricate

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interplay between structural factors and individual speaker notions of language ideology, social meaning, and dialect identity.

1. Introduction

Since Labov's seminal work on sound change in Martha's Vineyard (Labov 1962) and New York City (Labov 1966), linguists have sought to understand the plethora of factors underpinning and inciting sound change (Weinreich, Labov, and Herzog (1968).[2] Sociolinguistic explorations of small speech communities (e.g., Labov 1962; Wolfram and Schilling-Estes 1996) and psycholinguistic studies of large language corpora (e.g., Baayen 1996; Wieling et al. 2016) have become the norm in investigations of linguistic change. However, less research has been conducted by combining psycholinguistic analytical methods and sociolinguistic variationist approaches in examining small, ethnographically rich panel datasets. This chapter targets this gap by analysing the intra- and extra-linguistic factors affecting an ongoing sound change in Swabian, an Alemannic dialect spoken in southwestern Germany, throughout the lifespan of 20 speakers recorded in two different communities, Stuttgart and Schwäbisch Gmünd, first in 1982 and again in 2017.

The target variable for the current investigation is the modern standard German diphthong [ai], which evolved from the merger of two different Middle High German (MHG) phonemes, /iː/ and /ei/ (Schwarz 2015:51,161) – a change that did not occur in the high German dialect of Swabian. The typical Swabian phonetic realisation of lemmata originating from the MHG phoneme /iː/ is [əi]; for example, the word *Zeit* (MHG /ziːt/) 'time' is

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pronounced [tsait] in standard German and [tsəit] in Swabian. The typical Swabian phonetic realisation of lemmata stemming from the MHG /ei/ is [ɔi]; for example, the word *klein* (MHG [klein]) ‘small’ is realised as [klain] in standard German and as [glɔi] in Swabian. In contemporary Swabian, standard German [klain] also varies with a more centralised, vernacular realisation [gləi], which is the object of this study. The aim of this investigation is to explore the variation in lemmata stemming from these two MHG phonemes to determine whether the historical phonetic distinction is collapsing in modern Swabian, as has happened in modern standard German, such that [ai] and [əi] are becoming more similar to one another within the lifespan of one generation.

The /ai/ diphthong is an ideal variable for analysis in Swabian because: (1) it occurs with relatively high frequency in our corpus, (2) it is well-researched from a dialectology perspective, and, (3) it is a prototypical and non-salient feature of the Swabian dialect (Russ 1990; Schwarz 2015). In analysing the /ai/ diphthongs based on the *Sprachatlas des deutschen Reichs* 'The Linguistic Atlas of Germany' (Wenker & Wrede 1895) and the *Südwestdeutscher Sprachatlas* ‘Linguistic Atlas of Southwest Germany’ (Steger et al. 1989), Schwarz (2015:488) found statistically significant differences between lemmata based on their MHG origin. To our knowledge, no longitudinal sociolinguistic or psycholinguistic study has been conducted on the /ai/ diphthong in Swabian.

2. Research Background

Starting with his seminal work in the 1960s, Labov introduced Sir Charles Lyell's (1833) UNIFORMITARIAN PRINCIPLE into sociolinguistics, claiming that "the forces operating to produce linguistic change today are the same kind and order of magnitude as those which operated in the past" (Labov 1972:275). According to this “apparent-time” approach, individuals, post-adolescence, do not substantially change their speech patterns throughout their lifespan (Labov 1994). However, this premise has proven to be problematic in many situations, leading researchers to ask questions such as: Do all individuals change in the same ways, at the same rates, and at the same points across their lifespan? And, do the grammars of individuals change along with the grammars of the communities of which they are a part? (see e.g., Rickford and Price 2013; Sankoff and Wagner 2006).

Sociolinguistic studies have repeatedly found that both internal linguistic and external social factors influence the nature and direction of language change (Labov 1994; Labov 2001). Confounding these environmental influences are lexical frequency effects, a linguistic force that has received little attention in sociolinguistic variationist research, even less in longitudinal panel studies, and none to our knowledge in Swabian. Indeed, there is considerable controversy regarding the nature and impact of lexical frequency on linguistic processes and sound change. Bybee (2002) claims that frequently used words or phrases undergo 'special reduction', yielding differing results based on lexical word class and showing that synchronic change occurs first in more frequently used words and then progresses to the less frequent ones (Bybee 2017:273-275). Aylett and Turk (2006) further suggest that high-frequency words are usually found in contexts in which they are more predictable and therefore provide less information than low-frequency words, which, as a consequence, makes them more likely candidates for reduction. Other research has shown that once a sound change is in progress, it spreads faster through low-frequency words due to analogical processes, hence it is the high-frequency words that show more resilience to change (Hay et al. 2015). Tomaschek et al. (2018) maintain that since high-frequency words "get more practice," they are produced with better proficiency and hence are more resistant to change. Better proficiency, therefore, reduces variability, which is generally accepted to be a precursor to sound change (Weinreich et al. 1968). Based on a listener-oriented exemplar model, Todd, Pierrehumbert, and Hay (2019) propose that frequency effects interact with the discriminability of the phone. Their research shows that when a sound change increases the similarity to other phones, then change occurs in high-frequency words first; conversely, when a sound change reduces the similarity to other phones, change occurs first in low-frequency words.

The objective of the current study is to explore to what extent the two MHG phonemes, /iː/ and /ei/, are undergoing change in Swabian within the lifespan of the individual speaker, explicitly losing their historical phonetic contrast and merging or becoming more similar to each other. Investigating the loss of phonetic contrast across the lifespan of individual speakers allows us to explore evidence for the principle that speakers can and do change their grammars post-adolescence, and that such structural changes are not restricted to generational change (Sankoff & Wagner 2006; Buchstaller 2015)

Given that the two MHG diphthongs have merged in standard German and considering the effects of dialect levelling occurring across Germany (Auer 2011; Schwarz 2019), we expect to see a greater loss of phonetic contrast in the later recordings from our panel speakers than in the earlier ones, indicating that speakers do change their grammars across their lifespan (HYPOTHESIS 1). In addition, given that metropolitan areas are more likely to promote innovations than smaller communities (Trudgill 1986; Nerbonne & Heeringa 2007), we expect to observe a greater loss of phonetic contrast for speakers who live in the large urban centre of Stuttgart rather than in the mid-sized, semi-rural town of Schwäbisch Gmünd (HYPOTHESIS 2). Based on studies of dialect identity, local orientation, and interlocutor accommodation (Auer & Hinskens 2005; Dodsworth 2017), we expect to find a greater loss of phonetic distinction between these diphthongs with speakers who have a low orientation toward Swabian (HYPOTHESIS 3).

In light of the prior studies on the /ai/ diphthong (Labov 1962; Schwarz 2015), we expect to observe the effects of the phonetic environment on diphthong production and change. Given that consonant voicing has been observed to have strong effects on the acoustic characteristics of vowels (Kluender et al. 1988) affecting its perceptual characteristics (Denes 1955), we focus primarily on voicing in this study and expect to find a greater loss of contrast in environments with following voiceless consonants as opposed to voiced ones (HYPOTHESIS 4). Finally, given the contradictory effects reported in the literature on word frequency and sound change (Hay et al. 2015; Wedel et al. 2013; Bybee 2002; Bybee 2017), we investigate whether the loss of phonetic contrast is stronger in words of high or of low frequency. As the current study focuses on a sound change that increases the similarity between two phones (Todd et al. 2019), we expect to find a greater loss of distinction in high-frequency words (HYPOTHESIS 5). In sum, in looking at the interaction effects across all of these different factors, we postulate that we will see a greater loss of phonetic contrast in later recordings (2017), in an urban setting (Stuttgart), in speakers with low orientation, in following voiceless environments, and with higher frequency words.

3. Data and Methodology

We first describe the data and the methodology employed in our investigation, providing a description of the corpus, the dependent and independent variables, and the statistical models used to analyse the data.

3.1. The Panel Corpus

Twenty native speakers of Swabian were recorded in the communities of Stuttgart and Schwäbisch Gmünd in 1982 and again in 2017. Stuttgart is a big urban metropolis with close to 630,000 inhabitants, and Schwäbisch Gmünd is a typical mid-sized, semi-rural German town of around 60,000 inhabitants. The comparison of these two localities thus provides the opportunity to investigate sound change from both an urban and a semi-rural perspective. The data were collected following a Labovian-style, semi-structured sociolinguistic interview (Labov 1984) covering topics about the speakers' childhood, hobbies, friends and family, knowledge of Swabian customs and icons, and participation in local cultural activities. Interviews were conducted in speakers' home, typically over coffee and cake, with the goal of creating a casual interview situation. Interviewers in 1982 and 2017 were matched for social characteristics (e.g., age, gender, education) to create an interview situation as similar as possible for the two recording periods.

3.2. Speakers

The speakers comprise three women and four men from Stuttgart and six women and seven men from Schwäbisch Gmünd. The majority are of similar socioeconomic status (middle class) and in the same age group (18-25 years old in 1982 and 53-60 years old in 2017). Four speakers were in their early 50's in 1982 and hence in their late 80's in 2017. In 1982, the 20 interviews comprised 17.9 hours (1075 minutes), 18,430 words (tokens), and 3,158 types (unique words). In 2017, the 20 transcripts total 24.2 hours (1451 minutes), 21,553 tokens, and 3,877 types. The number of tokens per speaker or word was not capped; hence, the dataset is not balanced for phonological context or word type.

3.3. Transcriptions

Transcriptions were completed in ELAN (Wittenburg et al. 2006) by native German speakers, students at the University of Tübingen, and extracted into PRAAT 4.0 (Boersma & Weenink 2015), with signals digitised at a sampling rate of 4.4 kHz and a low pass filter at 2.2 kHz. The audio files were aligned with the orthographic transcription using the Hidden-Markov-Model based Forced Aligner (Rapp 1995), and the segment boundaries of each item of interest were manually corrected. Word types with [ai] at the onset were excluded, as onset positions in German are frequently articulated with creaky voice, an allophone of glottal stops rendering the extraction of vowel formants impossible (Pompino-Marschall & Żygis 2010). Since our aim is to evaluate the loss of phonetic distinction between [ai] and [əi] in contemporary Swabian, tokens of [ɔi] were also excluded.

3.3. Formant Frequencies

The dataset was built in PRAAT by automatically extracting the first and second formants for the [ai] diphthongs every 2.5 milliseconds with the upper bound frequency set at 5500 Hz for the female speakers and 5000 Hz for the male speakers. Given the size of the dataset, no manual correction was applied. To reduce the effect of formant differences resulting from the physiological differences between speakers, we z-scaled the first and second formant for each speaker (Lobanov 1971). Tokens with F1 larger than 1500 Hz and F2 larger than 3000 Hz, and diphthongs longer than 400 milliseconds were excluded. Table 1 shows the resulting number of types (i.e., unique words) and tokens (i.e., instances of a word type) of the [ai] diphthong in the Swabian panel corpus for each diphthong and recording year. The number of types by speaker varies between 143 (Theo) and 714 (Helmut), based on the length of the interview, with a mean of 423 types per speaker.

MHG Diphthong	1982			2017		
	Types	Tokens	DataPts	Types	Tokens	DataPts
/iː/	357	1984	77,422	468	2189	107,184
/ei/	391	3056	112,656	442	3525	151,417
TOTAL	748	5040	190,078	910	5714	258,601

Table 1. Swabian [ai] diphthong corpus based on MHG origin. 'Types' represent unique words in the transcript; 'Tokens' count the number of instances of the same word type; 'Datapts' represent the number of F1/F2 frequency measurements.

3.4. Swabian Orientation

Swabian identity, i.e., speakers' affinity toward Swabia and the Swabian language, was assessed through a Swabian Orientation Index (SOI), developed based on speakers' answers to 16 questions in the interview covering four themes: (1) their allegiance to Swabia and self-identification as being Swabian; (2) their knowledge of Swabian culture and icons; (3) their attitudes toward the Swabian dialect; and (4) and their self-reported usage of Swabian or standard German with family, friends, relatives, teachers, colleagues, and others. Each question was rated on a five-point scale (from 1 for the lowest to 5 for the highest orientation), and the results were averaged to arrive at an individual index for each speaker for each year (see Beaman 2018).[3] Because SOI values were unequally distributed across the subsets and to reduce the complexity of the analysis, factorial predictors were created for the ranked SOI values, and high and low values were determined by a median split.

Assessing 'dialect identity' is not without its methodological challenges. Trudgill (1986, 2008) argues that, rather than identity, speakers choice of linguistic variants stems from contact

[3] Principal components analysis (PCA) was conducted on subscales of the Swabian Orientation Index (SOI) (Swabian allegiance, Swabian culture, Swabian language attitudes, and Swabian language usage), which showed all to be significant predictors of the variation between Swabian and standard German.

with speakers of different varieties, and this contact results in processes of “quasi-automatic accommodation in face-to-face interaction” (Trudgill 2008:241). Yet, no single factor can account for the myriad of influences in the sociolinguistic situation (Nagy et al. 2013; Hall-Lew & Yaeger-Dror 2014). Notions of local identity (Labov 2001; Eckert 1989), interlocutor accommodation (Auer & Hinskens 2005; Bell 1984; Trudgill 1986; Giles et al. 1991), social networks (Milroy 1987), and ethnic orientation (Hoffman & Walker 2010; Sharma 2011), along with traditional social and demographic characteristics, interact in ways that allow speakers to convey varying social identities through language. The questions in the Swabian Orientation Index (SOI) were selected to represent the wealth of cultural practices, loyalty, pride, discrimination, social interaction, and interlocutor accommodation that best reflect a speaker’s dialect identity.

3.5. Statistical Modelling

To account for the non-linear spatio-temporal behaviour of formants, we used Generalized Additive Mixed Models (GAMMs) (package *mgcv*, Version 1.8-23) (Wood 2011) for R Project, Version 3.0.2 (R Core Team 2014). GAMMs model nonlinear functional relations between a response variable and one or more covariates by means of “smooths” on the basis of thin plate regression splines. Because of their multi-dimensional appearance, GAMMs provide an effective method for visualising complex relationships between covariates and response variables.[4] Non-linear interactions between numeric variables are fitted by means of “tensor product smooths”.[5]

We used the following set of predictors to fit F1/F2 frequencies:

- recording year (1982 versus 2017);
- speech community (Stuttgart versus Schwäbisch Gmünd);
- word frequency (numeric), calculated from the Swabian corpus;
- diphthong origin (MHG /i:/ versus MHG /ei/), based on DWDS[6];
- Swabian Orientation Index (SOI) (as defined above);
- articulatory environment, i.e., voicing of the following consonant (voiced, voiceless); since actual vowel duration varies considerably between instances, *time* in the diphthong was normalised between 0 and 1 to support GAMM modelling.

GAMMs provide two pieces of evidence to test a hypothesis. Statistical validity of an effect in a GAMM analysis is derived from (1) model comparisons between a more complex and a less complex model and (2) significant non-linear effects ($\alpha = 0.001$), i.e., whether the F1 or F2 values show a curved behaviour across *time* in a given condition. Only when the addition of an effect significantly improves the model fit, and only when the effect is significantly non-linear, is it considered valid.

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[4] For a detailed description of Generalized Additive Models and their application to non-linear data, see Tomaschek et al. (2018); in particular, see Wieling et al. (2016) who used GAMMs to investigate articulatory differences between Dutch dialects. For an introduction to spline smooths, see (Baayen et al. 2017).

[5] Time-dependent data usually results in autocorrelation (AR) of the residuals (i.e., the correlation between the residual at timepoint T and timepoint T+1). To account for this, we included an AR(1) parameter in each model. Due to lack of space, all model summaries, along with all analyses, can be inspected in the Supplementary Material, downloadable from (URL to be released upon publication).

[6] Etymological origins were derived from *DWDS – Digitales Wörterbuch der deutschen Sprache, Berlin-brandenburgische Akademie der Wissenschaften*.

We fitted three different models in this study: (1) individual speaker differences between the two diphthongs across the lifespan, (2) effects of manner of articulation on the change in diphthong production across the years, and (3) group differences between the two diphthongs based on community, Swabian orientation, lexical frequency, and articulatory environment i.e., following voiced/voiceless consonant. To ensure homoscedasticity and the normal distribution of residuals, data points with residuals larger than 2.5 standard deviations from the mean were excluded, and each model was refit. We first review an example analysis to demonstrate how we developed the models to test our hypotheses. In the subsequent Analysis and Results section, we report on the specifics of each model and discuss our findings.

3.6. Example Analysis

Using Stuttgart 1982 by way of example, Figure 1 demonstrates how we used GAMMs to analyse the F1 and F2 formant trajectories in determining the difference between the MHG /i:/ and MHG /ei/ diphthongs. This approach was followed for all subsequent models. The top panel of Figure 1 shows the predicted trajectories for both years and both diphthongs in each community (plotted with data obtained from the *get_predictions()* function from the *itsadug* package, Version 2.3, van Rij et al. 2017). The predicted trajectories were obtained from two models, each fitting F1/F2 values with a smooth for *time* interacting with a multi-level predictor for community by year by diphthong. Inverted F1 values are plotted on the y-axis indicating vowel height, and inverted F2 values are plotted on the x-axis representing fronting or backing (the left of the figure denotes the front of the mouth). The black dot indicates the onset of the diphthong, and curly brackets show the anchor vowels, {i} and {a}. Solid lines designate diphthongs stemming from MHG /i:/ origin and dashed lines those with MHG /ei/ origin. Lighter grey lines represent speakers in 1982 and thicker black lines speakers in 2017.

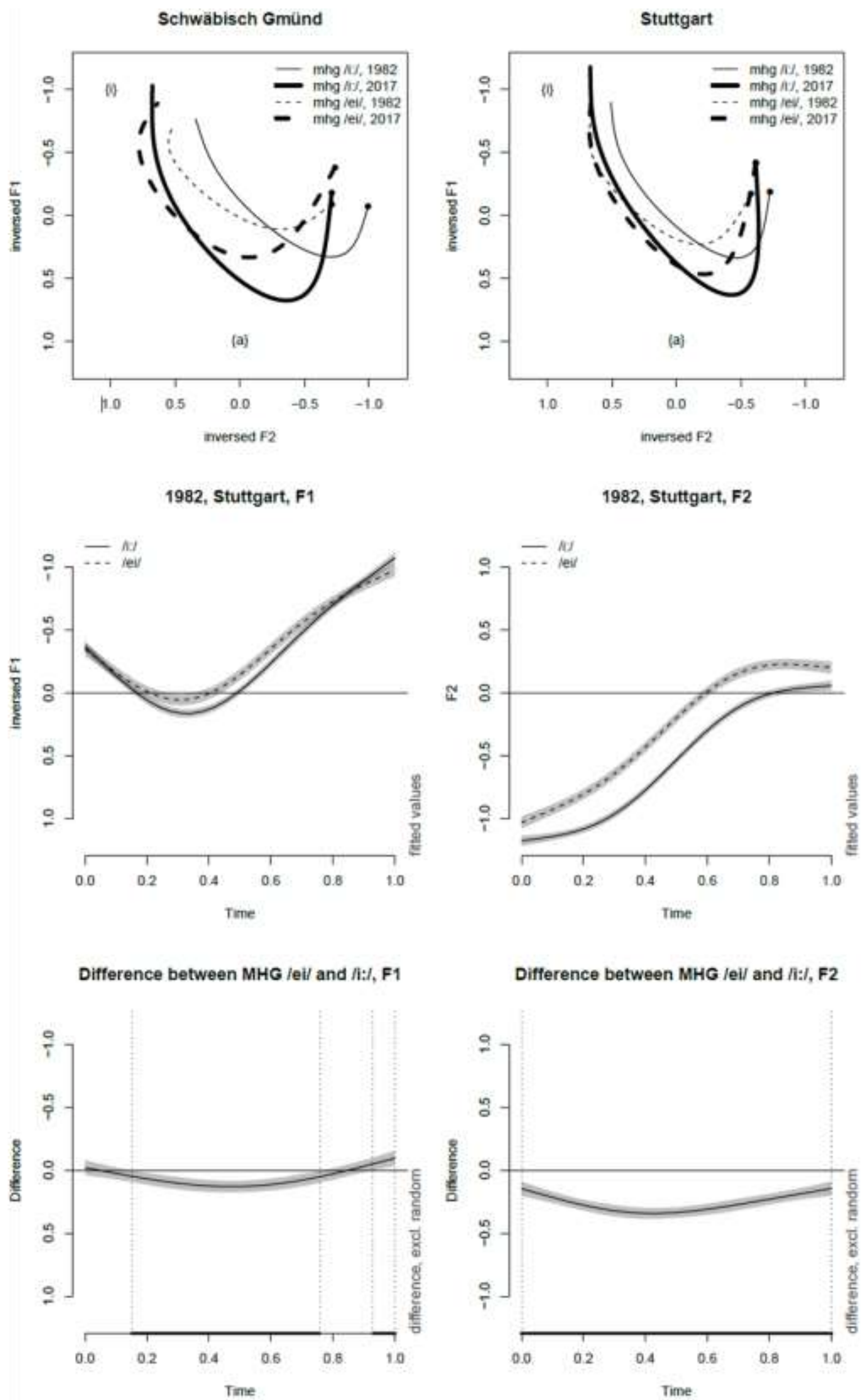

Figure 1. Example GAMM analysis. Top panel: predicted diphthong trajectories by community, year, and MHG origin. Middle panel: smooth of F1 and F2 across *time* for the diphthongs; Lower panel: estimated difference between the F1/F2 trajectories.

The middle and bottom panels of Figure 1 continue our example using Stuttgart 1982 to illustrate how we calculated the difference between the two diphthongs. The middle panels show the smooth of F1 and F2 across *time* for the two diphthongs. Lemmata originating from the MHG /i:/ phoneme (solid line) show a larger excursion than those stemming from MHG /ei/ (dashed line). The bottom panels depict the estimated difference between the F1/F2 trajectories for the two diphthongs across *time* (i.e., vowel length) on the y-axis (calculated with the *plot_diff()* function from the *itsadug* package). Using a confidence interval of two standard deviations ($\alpha < 0.05$), the two trajectories for F1 are significantly different between the time intervals 0.2 and 0.7 and the time intervals 0.9 and 1.0, as highlighted by the dark line on the x-axis. For F2, MHG /ei/ has significantly higher values than MHG /i:/ across the entire time interval.

To determine to what extent the two diphthongs have become more or less similar in 2017 compared with 1982, we developed the measure "Total Euclidean Distance Squared" (TEDS) to operationalise how sharply the two trajectories differ. As opposed to other methods that use simple Euclidean distance or Pillai scores to calculate differences on the basis of means (Nycz & Hall-Lew 2014), TEDS allows us to measure the distance between the two diphthongs across *time* in spite of their non-linear behaviour. TEDS is defined by the following formula:

$$TEDS = \sum_{i=1}^{n} (\sqrt{\Delta_{F1}^2 + \Delta_{F2}^2})^2$$

where Δ_{F1} and Δ_{F2} denote the vectors of the point-wise differences between the F1/F2 trajectories of the two diphthongs (as illustrated in the bottom panels of Figure 1) and where n denotes the length of the vectors (i.e., number of data points) in the F1/F2 trajectory. Note that the square root term defines the Euclidean distance for each predicted data point, which more strongly penalises large distances between the trajectories than small ones. By definition, any TEDS greater than zero represents a significant difference between the F1/F2 trajectories of the two diphthongs.[7]

In our example model, the TEDS for the Stuttgart speakers in 1982 was 9.6; by 2017, it has shrunk to 4.1, signalling that the two diphthongs have indeed become more similar over the 35-year time-span. In comparison, the TEDS for the Schwäbisch Gmünd speakers in 1982 was 23.1, shrinking to 15.0 in 2017, also showing a loss of phonetic contrast. The overall smaller TEDS in Stuttgart suggests that this sound change is further advanced in Stuttgart than in Schwäbisch Gmünd. Following this methodological framework, we now turn to a full analysis of the change in the Swabian [ai] diphthongs over the 35 years.

4. Analysis and Results

Our analysis of the change in the realisation of the [ai] diphthong comprises two aspects: individual change across speakers' lifespans and group change based on community, Swabian orientation, lexical frequency, and following phonetic environment, i.e., voicing.

4.1. Lifespan Change

There is ample research that shows individuals, for a variety of reasons, do not always follow community trends. Sankoff (2018) points out that people have options: "some people … maintain early-acquired patterns, others participate in the change, and still others reject it in favor of the conservative norms of previous generations." In panel literature, these three

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[7] TEDS was calculated in the Lobanov-normalized vowel space to serve as a heuristic: zero represents complete identity between the two trajectories, whereas increasing values represent increasing differences.

scenarios have become known, respectively, as SPEAKER STABILITY, speakers resisting the community change, LIFESPAN CHANGE, speakers moving in the direction of the overall community change, , and, RETROGRADE CHANGE, speakers moving in the opposite direction of the community change (Sankoff 2019).

To investigate individual speaker change across the lifespan, we separated the data by community (Schwäbisch Gmünd, Stuttgart) and fit the F1 and F2 formant values with a smooth for *time* in each subset, interacting with speaker and diphthong.[8]

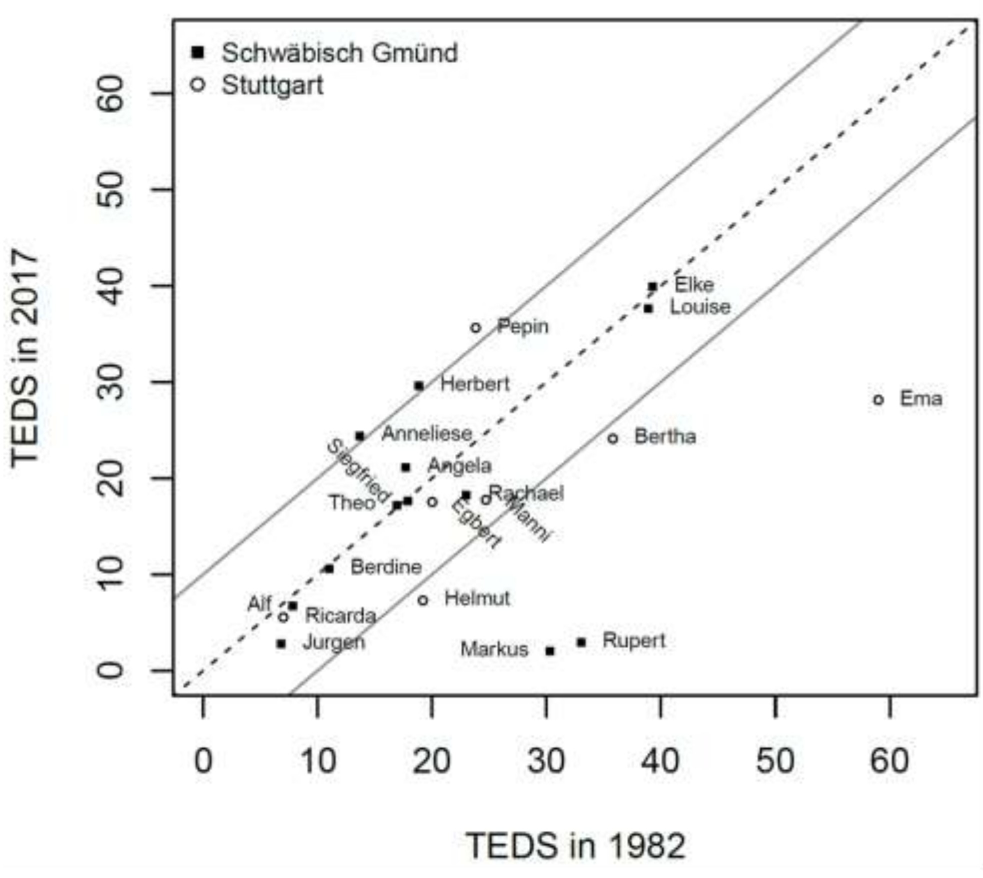

Figure 2. Total Euclidian Distance Squared (TEDS) between the F1/F2 trajectories of MHG /i:/ and /ei/ diphthongs for individual panel speakers in 1982 (x-axis) and in 2017 (y-axis). The dashed diagonal line shows equal TEDSs in 1982 and 2017, and the solid grey diagonal lines delineates TEDS greater than 10 and less than -10.

[8] All models contain random intercepts for word and speaker gender. Unless otherwise mentioned, all model terms were significantly non-linear (alpha = 0.0001).

Figure 2 plots the TEDS for each speaker: 1982 values are shown on the x-axis and 2017 values on the y-axis. Solid squares represent speakers from Schwäbisch Gmünd, and open circles mark speakers from Stuttgart. Recall that all distances greater than zero are significant. The dashed diagonal line represents equal TEDSs in 1982 and 2017, and the solid grey diagonals delineate TEDSs greater than 10 and less than -10.[9] The lower or higher a speaker is in relation to the diagonal, the lessor or greater is the change in their diphthongs across the years. For example, Elke and Louise on the dotted diagonal show little change in their diphthong realisations across the two recording periods: both show TEDS values close to 40 in both years. On the other hand, Markus, Rupert and Ema show the greatest loss of contrast between their diphthongs since their TEDS points appear well below the diagonal, signaling smaller distances between their diphthongs in 2017 than in 1982. Conversely, Pepin, Herbert, and Anneliese show retrograde change (or perhaps hypercorrection) since they show greater distances between their diphthongs in 2017 than in 1982. Overall, most speakers fall either on or below the dotted diagonal, indicating a smaller distance between the two diphthongs in 2017 than in 1982 and providing support for our first hypothesis that the two diphthongs are collapsing and losing their phonetic contrast across the lifespans of these individuals.

[9] We chose 10 as a somewhat arbitrary cut-off to differentiate speakers who show the greatest distances.

Community	Speaker	TEDS 1982	TEDS 2017	TEDS diff	SOI 1982	SOI 2017	SOI diff	
Stuttgart	Ema	59.0	28.1	-30.9	4.2	4.2	0.0	
Sch.Gmünd	Rupert	33.0	2.9	-30.1	4.0	2.6	-1.4	
Sch.Gmünd	Markus	30.3	2.0	-28.3	4.3	2.8	-1.5	Lifespan Change
Stuttgart	Helmut	19.2	7.3	-11.9	3.3	2.0	-1.3	
Stuttgart	Bertha	35.8	24.1	-11.7	3.6	3.3	-0.3	
Stuttgart	Manni	24.7	17.7	-7.0	3.7	2.8	-0.9	
Sch.Gmünd	Rachael	23.0	18.2	-4.8	4.4	4.3	-0.1	
Sch.Gmünd	Jurgen	6.8	2.8	-4.0	3.8	3.3	-0.5	
Stuttgart	Egbert	20.0	17.5	-2.5	4.0	3.6	-0.4	
Stuttgart	Ricarda	7.0	5.5	-1.5	3.5	2.1	-1.4	
Sch.Gmünd	Louise	38.9	37.6	-1.3	4.3	4.0	-0.3	Speaker Stability
Sch.Gmünd	Alf	7.8	6.7	-1.1	4.5	4.2	-0.3	
Sch.Gmünd	Berdine	11.0	10.6	-0.4	3.9	3.3	-0.6	
Sch.Gmünd	Siegfried	17.9	17.6	-0.3	4.2	4.8	0.6	
Sch.Gmünd	Theo	16.9	17.2	0.3	4.0	3.7	-0.3	
Sch.Gmünd	Elke	39.3	39.9	0.6	4.2	4.3	0.1	
Sch.Gmünd	Angela	17.7	21.1	3.4	4.5	4.2	-0.3	
Sch.Gmünd	Anneliese	13.7	24.4	10.7	3.5	3.6	0.1	
Sch.Gmünd	Herbert	18.8	29.6	10.8	4.2	4.2	0.0	Retrograde Change
Stuttgart	Pepin	23.8	35.6	11.8	3.4	3.8	0.4	

Table 2. Individual speakers' Total Euclidian Distance Squared (TEDS) between the F1/F2 trajectories in MHG /i:/ and /ei/ diphthong production, along with Swabian Orientation Index (SOI) scores, for the two recording years (1982 and 2017). Speakers sorted by TEDS difference between the years, revealing three typical speaker lifespan patterns: lifespan change (TEDS differences < -10; speaker stability (TEDS differences between -10 and 10); retrograde change (TEDS differences >10).

Table 2 shows the summary values for each speaker, sorted by TEDS, quantitatively demonstrating the sound change continuum. For explanatory purposes, we have parsed the speakers into Sankoff's three lifespan trajectory types: lifespan CHANGE, STABILITY, RETROGRADE CHANGE. The five speakers at the top of the table exhibit the most extreme change between 1982 and 2017 (i.e., TEDS less than -10). These speakers are losing the phonetic contrast between the two diphthongs, moving in the direction of the community trend and levelling with the standard language (LIFESPAN CHANGE). Ema at 88 years old is one of the oldest speakers in the sample demonstrating that individuals can and do change their linguistic production, following the community trend, even in later life. She, along with Markus and Rupert from Schwäbisch Gmünd, show an almost complete collapse of the two diphthongs. Both Markus and Rupert travel and work extensively outside of their home town, Markus as a high-tech marketing executive based in Munich, and Rupert as a lecturing and consulting sociologist based in Tübingen. Their careers have broadened their social networks and dialect identities outside of their homeland, bringing them into more frequent contact with standard German speakers and constraining their Swabian identity. Rupert feels that speaking Swabian is a sign of lack of education, and Markus wants his children to learn standard German so they will have improved opportunities on the job market.

The speakers in the middle of Table 2 are those for whom the distinction between the two diphthongs has changed minimally or not at all (SPEAKER STABILITY) (i.e., TEDS between -10 and 10). Five are from Schwäbisch Gmünd, mother and daughter, Louise and Elke, and cousins, Berdine, Jurgen, and Alf. The stable group also includes two siblings from Stuttgart, Ricarda and Egbert, and Egbert's best friend, Manni. Except for Berdine, all speakers have lived and worked their entire lives in their Swabian communities. All have remained stable in their careers, seven of the twelve are elementary or middle school teachers. As a result, these speakers have experienced few dialect influences beyond Swabia that would stimulate change.

Finally, there are three speakers (at the bottom of Table 2 and above the upper solid grey diagonal in Figure 2) who are moving against the community trend and increasing the phonetic contrast between the two diphthongs, RETROGRADE CHANGE. Based on our ethnographic investigations of the speakers within their communities, we know that these speakers have lived and worked in Swabia (or southern Germany/Switzerland in the case of Anneliese) for their entire lives. Herbert and Pepin are both retired. Sociolinguistic theory hypothesises that speakers revert to more conservative dialect features later in life once they have retired and moved out of the linguistic market (Sankoff & Wagner 2006; Chambers 1997; Buchstaller et al. 2017). Our speaker's attitudes in later life support this interpretation. Anneliese remarks,

ich bin eigentlich gern eine Schwäbin.	*'I like being Swabian.'*
mir gefällt der Dialekt.	*'I like the dialect.'*
mir gefällt die Landschaft.	*'I like the countryside.'*
mir gefällt es im Schwabenländle.	*'I like it in little Swabia.'*[10]

Figure 3 depicts the individual diphthong trajectories for each speaker for the two diphthongs in both years, sorted from the smallest TEDS to the largest. The solid lines represent diphthongs with MHG /i:/ origin and dashed lines those with MHG /ei/ origin; light grey lines represent speakers in 1982 and thicker black lines speakers in 2017. The individual trajectories clearly illustrate the substantial distinction between the diphthongs for those at the top of the figure (e.g., Ema, Rupert, Markus, and Helmut) and the almost complete overlap between the diphthongs for those in the middle of the figure (e.g., Ricarda, Louise, Alf, and Berdine). This figure also illustrates retrograde change for those at the bottom (e.g., Anneliese, Herbert, and Pepin).

[10] *Schwabenländle* 'little Swabia', with the use of the Swabian diminutive affix, is a term of endearment.

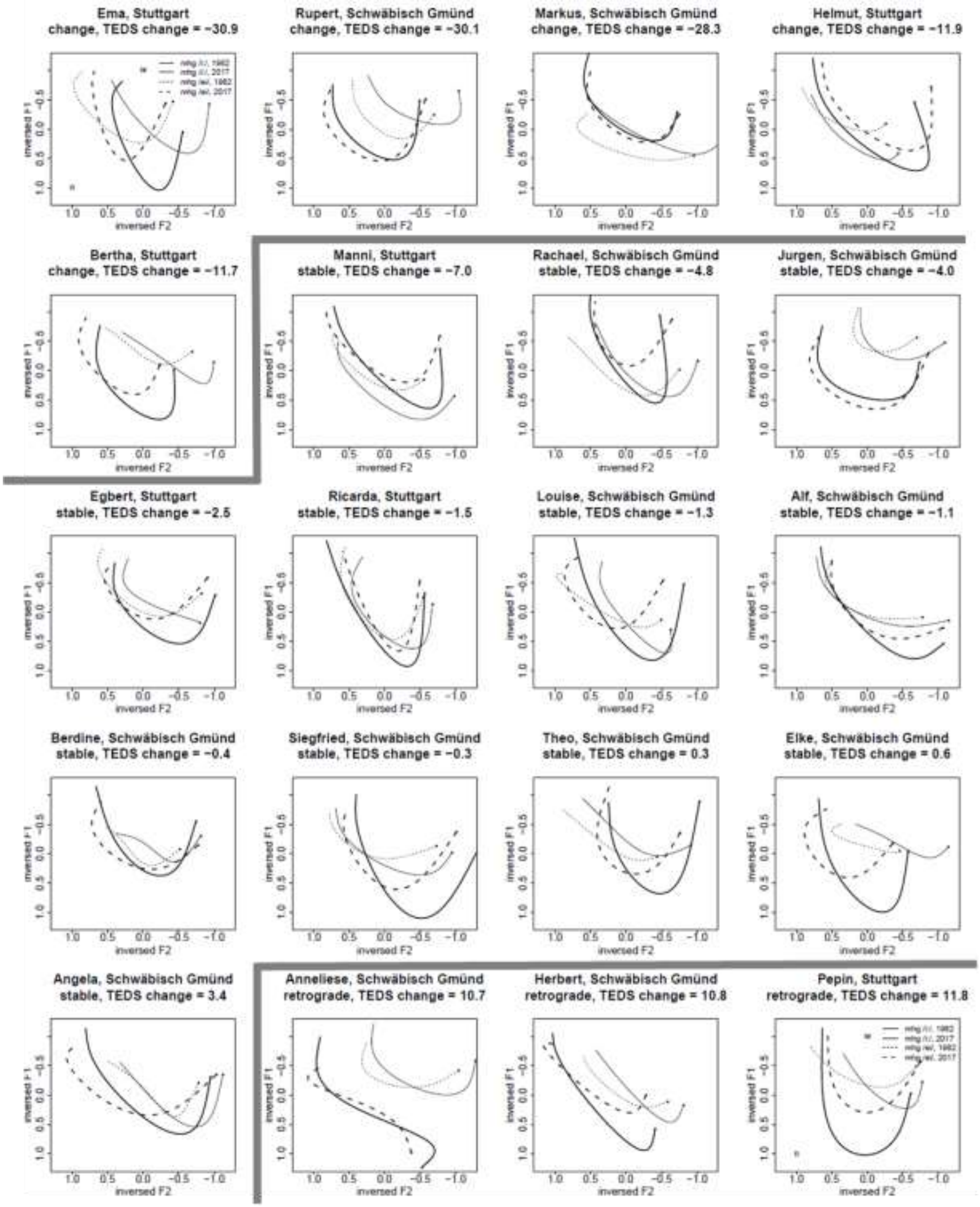

Figure 3. Individual speaker diphthong trajectories across the lifespan, sorted by Total Euclidian Distance Squared (TEDS) between the F1/F2 trajectories in MHG /i:/ and /ei/ diphthong production.

4.2. Phonetic Change

We next look at the differences between the MHG /i:/ and /ei/ diphthong production depending on the manner and type of articulation. Given the robust effects of anticipatory coarticulation in the preceding environment, we elected to consider only the following environment in our analysis (Tomaschek et al. 2018; Hoole et al. 1993; Sziga 1992). We separated the data by community and fit the F1/F2 formant values with a smooth including a Time * Manner * Voicing * Year * MHG origin interaction. Figure 4 shows the TEDS for each community depending on the manner of articulation for the following consonant. Solid circles represent voiced consonants and open circles voiceless consonants. 1982 is shown on the x-axis and 2017 on the y-axis. The diagonal dashed line represents equal TEDS values in 1982 and 2017. The data reveal that speakers in Schwäbisch Gmünd (left panel) exhibit larger TEDSs in both years for diphthongs followed by plosives (both voiced and voiceless) than by other manners of articulation. The smallest TEDS in Schwäbisch Gmünd are in 1982 when the diphthong is articulated in an open syllable (TEDS = 24) followed by voiceless fricatives (TEDS = 45) and then voiced sonorants (TEDS = 56), which may be attributed to the co-articulatory aspects of the sonorant's vowel-like quality (Hickey 2004:12). We see a similar pattern in Stuttgart (right panel) in 1982 with open syllables (TEDS = 49) and voiced sonorants (TEDS = 19) showing smaller TEDSs than in 2017, with voiceless fricatives remaining about the same across the two periods (TEDS = 10). However, in contrast to Schwäbisch Gmünd, Stuttgart speakers appear to have become more sensitive to plosives in 2017: while they show significantly smaller TEDSs in 2017 in all environments, this effect is strongest for plosives (showing TEDSs from 120 (voiceless) and 47 (voiced) in 1982 to 24 and 5 in 2017, respectively,).

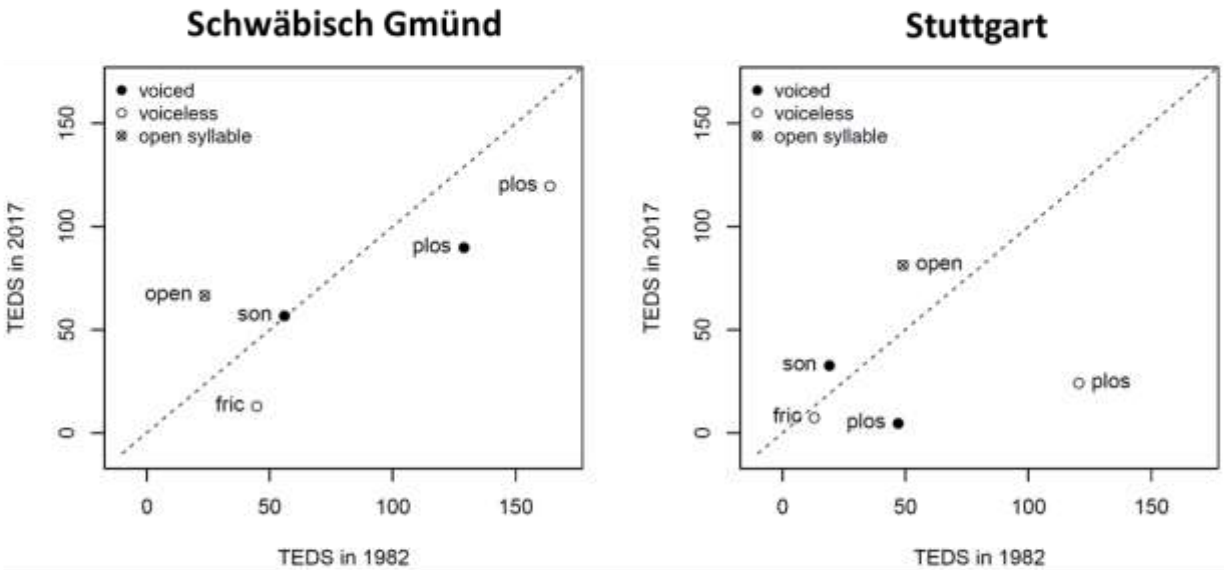

Figure 4. Total Euclidian Distance Squared (TEDS) between the F1/F2 trajectories in MHG /i:/ and /ei/ diphthong production for 1982 and 2017 based on manner and type of articulation in following environments: fric = fricatives; open = open syllables; plos = plosives; son = sonorants. The dashed diagonal line shows equal TEDSs in 1982 and 2017.

The TEDS reductions we see in 2017 suggest that our panel data captures a potential merger in progress by revealing a loss of phonetic contrast between the two MHG diphthongs across the two recording years (HYPOTHESIS 1), favoured by following plosives, then voiceless sonorants and fricatives. While the constraints for the two communities are essentially the same, the sound change appears to have progressed further for speakers in Stuttgart than for those in Schwäbisch Gmünd, supporting our hypothesis that the urban centre of Stuttgart is leading this change in progress (HYPOTHESIS 2).

4.3. Interaction Effects of Change in Progress

We now evaluate the interactional effects influencing change in the realisation of the MHG /i:/ and /ei/ diphthongs based on community, Swabian orientation, lexical frequency, and voicing of the following consonant. Due to limitations with the size of our database, we decided to move forward with a binary voiced/voiceless distinction as most representative of the phonetic environment.

For this model, we split the data by community and then fitted the F1/F2 formant values with a tensor containing a six-way interaction: Time * Frequency * Swabian Orientation * MHG origin * Year * Voicing. Model comparison using a $\chi 2$-test indicated that the inclusion of Voicing in the interaction provided a better model fit for F1 values but not for F2. Hence, F2 was fitted with a five-way interaction: Time * Frequency * Swabian Orientation * MHG origin * Year. All models contained random intercepts for speaker and word.[11] We calculated TEDS based on these models for each combination of factors: Community, Year, Swabian Orientation, Frequency, and Voicing. For Voicing, we predicted the trajectories for the 25th and 75th percentile of the frequency distribution. In total, we obtained 32 TEDS values (2 diphthongs * 2 SOI levels * 2 frequencies * 2 voicing/voiceless * 2 communities).

Figure 5 illustrates the best-fit results from the modelling effort: TEDS is shown on the y-axis and frequency and voicing on the x-axis. Overall, the TEDS values were smaller in 2017 (solid circles and triangles) than in 1982 (open circles and triangles), confirming our first hypothesis regarding the loss of contrast between these diphthongs over the years. Speakers from Schwäbisch Gmünd (left panel) show larger TEDS than speakers from Stuttgart (right panel), confirming our second hypothesis that we would find a greater loss of contrast in an urban environment rather than in a mid-sized, semi-rural setting. As we expected, low SOI speakers (circles) produce smaller TEDS, exhibiting a greater loss of contrast, than high SOI

[11] Model comparisons and model summaries can be found in the Supplementary Materials, which can be downloaded from https://osf.io/nfqt3/.

speakers (triangles), confirming our third hypothesis that high orientation to Swabian would restrict innovation and promote retention of conservative dialect forms. The details of the change, however, depend heavily on the interaction between predictors.

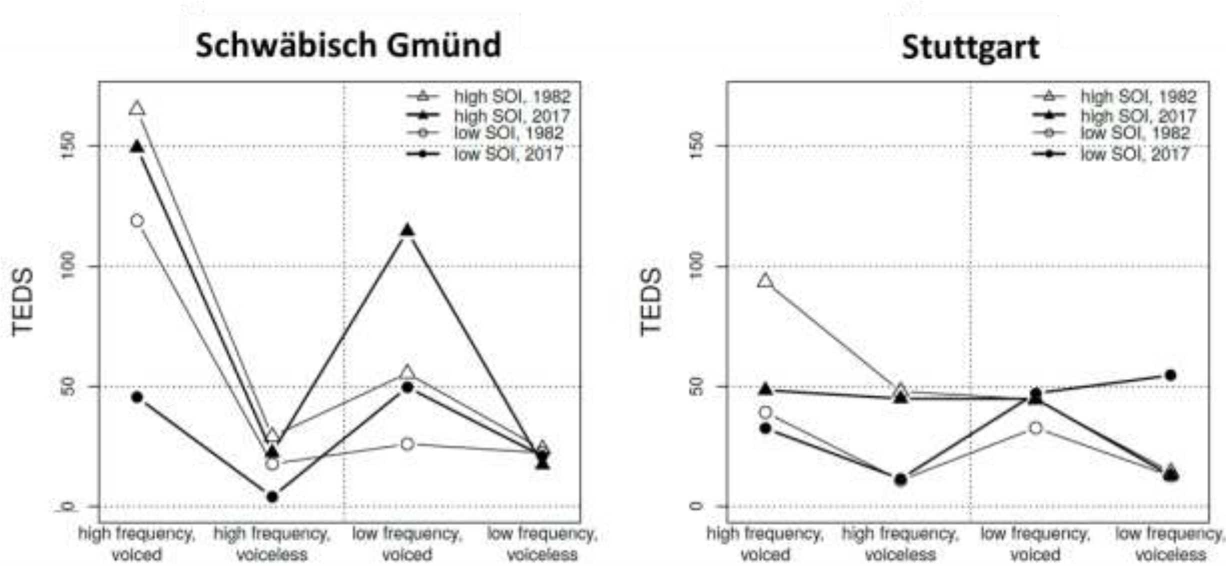

Figure 5. Total Euclidian Distance Squared (TEDS) between the F1/F2 trajectories in MHG /iː/ and /ei/ diphthong production by community, recording year, and voiced/voiceless consonants, word frequency, and Swabian orientation (SOI) (high/low SOI values determined based on a median split).

First we consider the effects of frequency and voicing. In Schwäbisch Gmünd, independent of year, SOI, and frequency, voiceless consonants show the lowest TEDS, hence the smallest distinction between the diphthongs. With high-frequency words, the TEDS are starkly reduced for all factors in voiceless environments, yet with low-frequency words, the voicing distinction is not as paramount, except with high SOI speakers in 2017 who show a considerable TEDS peak (discussed further below). These results confirm our fourth hypothesis that the acoustic characteristics of vowel production would be sensitive to voicing, and implicates voicing as the main predictor impelling the loss of phonetic contrast between these diphthongs, at least for these 20 speakers in the community of Schwäbisch Gmünd.

Because this sound change increases the similarity between the two phones, our fifth hypothesis predicted a greater loss of phonetic contrast in high-frequency over low-frequency words. While this holds for high-frequency words in voiceless environments, for low-frequency words, there is no difference between the predictors. However, this effect interacts with SOI, which shows lower TEDS and a greater loss of phonetic contrast for low SOI speakers. In high-frequency words, low SOI speakers show the smallest TEDS, while high SOI speakers show only minor TEDS reduction over the years. In contrast, with low-frequency words, both high and low SOI speakers increased their TEDS over the years, with high SOI speakers showing a spike from 1982 to 2017, signifying the potential effect of "hypercorrection" at play (Janda & Auger 1992). This interaction between frequency and SOI bring to light the powerful intersectional effect that socio-cognitive factors such as Swabian orientation, in combination with linguistic constraints such as frequency and voicing, have on sound change.

Turning to Stuttgart, the effects on the loss of contrast between the diphthongs are less pronounced. The TEDS have declined from 1982 to 2017 but only with high SOI speakers using high-frequency words in voiced environments. For the other environments, the effects are much smaller, which we surmise is because this sound change is already relatively advanced and may even be nearing completion in Stuttgart. Supporting this position, we see that high SOI speakers in 2017 produce TEDS similar to low SOI speakers in 1982. In all other predictor combinations, there is no major change in Stuttgart. We presume that, apart from the high-frequency words followed by voiced consonants uttered by high SOI speakers, the Stuttgart community had already begun to lose the diphthong contrast in 1982. Hence, we can conjecture that this change will continue its trajectory and progress to high-frequency words in voiced environments for the high SOI speakers as well in order to complete the change.

5. Discussion

Our analysis of 20 panel speakers unveils an intricate set of interacting factors affecting the loss of phonetic contrast between the two diphthongs of MHG origin in modern Swabian. Our findings indicate that "speakers' internal grammars are more labile than we would expect" (Buchstaller et al. 2017:26) and that the loss of phonetic contrast between the traditional Swabian diphthongs is well underway across the lifespan of our panel speakers. Given that the two diphthongs are less differentiated in Stuttgart than in Schwäbisch Gmünd, our findings support the Gravity (Trudgill 1986) and Cascade (Labov 2003) models which claim that change begins in big urban centres and spreads to smaller communities. Most revealing in our findings is how the community of Schwäbisch Gmünd in 2017 mirrors the community of Stuttgart in 1982, conceivably marking the origin and trajectory of the change. It appears that this change was already in progress in Stuttgart in 1982 and has begun to emerge in Schwäbisch Gmünd in 2017 with low SOI speakers. However, high SOI speakers in Schwäbisch Gmünd are resisting the change and continuing to maintain a resilient distinction between the two diphthongs.

So, what has prompted low SOI speakers to start adopting this innovation and why are high SOI speakers resisting it? We contend that this change is a reflection of the immense societal transformation that has occurred in Germany (indeed across western Europe) over the last 30 years. Rising levels of education (e.g., Ammon 2001; Schwarz 2019), ever-increasing mobility (e.g., Auer 2007; Britain 2013, 2016), pervasive dialect contact and levelling (e.g., Auer 2011; Buchstaller et al. 2017), and ubiquitous peer-pressure (e.g., Conrad 2017) are restricting the role of Swabian in daily life. Hence it is not surprising that this change is further advanced with speakers who have lost (or are losing) their Swabian identity. Much research has shown (e.g., Labov 1962; Wolfram & Schilling-Estes 1996) that diphthong trajectories can be recruited to project notions of local identity (e.g., locals who feel their traditional way of life is being threatened with the encroachment of modernisation). Wieling and his colleagues have supported these findings with data from the Netherlands and Italy, showing that larger, richer and younger communities move away from the dialect and toward the standard language (Wieling et al. 2011; Wieling et al. 2014). Conrad (2017) reports similar effects for the younger generation in Luxembourg. Our findings indicate that local orientation and dialect identity play a significant role in language change, inciting or retarding the adoption of innovations.

The rate of change between 1982 and 2017 is smaller in Stuttgart than in Schwäbisch Gmünd, yielding support to our argument that the change was already in progress in Stuttgart in 1982, which provided less room for change. Speakers in Stuttgart increased the distance between the two diphthongs in low-frequency words. One explanation for this apparent reversal might lie in the evolving status of the dialect vis-à-vis the standard language (Auer & Spiekermann 2011; Preston & Robinson 2005). Despite the external forces mentioned above, Swabian appears to be losing some of the stigma it had 30 years ago. Winfried Kretschmann, the governor of Baden-Württemberg, a proud proponent of Swabian, exclaims, *ich spreche schwäbischer als früher*, 'I speak more Swabian-like now than before' (Frankfurter Allgemeine Zeitung 2018).[12]

[12] Kretschmann is 70 years old, approaching retirement age, hence his return to his Swabian roots might be explained by the sociolinguistic principle that speakers revert to more conservative dialect features later in life.

Unless the vital impact of socio-cultural factors such as dialect identity are taken into account, our findings, on the surface, appear to contradict Todd et al.'s (2019) exemplar-based model stating that changes that increase phonetic similarity happen in high-frequency words first.[13] It may also be the case that high SOI speakers are resisting the innovation in high-frequency words based on the premise that high-frequency words are more deeply entrenched in the lexicon and hence more resistant to change (Tomaschek et al. 2019). Finally, the interaction between SOI and frequency may be related to speaker saliency and accommodation: since they occur more often, high-frequency words are more salient, hence low SOI speakers desiring to sound more standard may be accommodating by reducing the diphthong contrast in word they use more often.

The interaction between dialect identity and word frequency and their collective impact on language change cannot be discounted. The effects of lexical frequency in our study point to the powerful interaction between internal linguistic processes and external societal forces. Three findings from Schwäbisch Gmünd underscore this point. First, high SOI speakers are resisting the change and retaining a robust distinction between the diphthongs in high-frequency words. Second, both low and high SOI speakers in Schwäbisch Gmünd increased the contrast between the diphthongs from 1982 to 2017 in low-frequency words in voiced environments, resisting the innovation and retaining this solid marker of Swabian identity. Third, high Swabian oriented speakers in Schwäbisch Gmünd appear to be hypercorrecting in 2017 with low-frequency words, holding on to the conservative diphthong distinction. The effects of hypercorrection are well established in the hegemony of the standard language. As

[13] One difference between the current study and Todd et al.'s which could be producing differing results is that they focused only on monosyllabic words, whereas we include longer, more distinctive words.

Trudgill (1992:78) notes, “it is clear that hypercorrection gives rise at the macro leve1 to large-scale linguistic change and results in interdialect forms becoming an integral part of a particular dialect.”

In sum, Milroy (2003:163) maintains that “changing local ideologies shape trajectories of linguistic change” and shifting indexicalities help speakers preserve or construct their linguistic identities in ways that reflect their individual lifespan trajectories and reflect what is important to them. In Swabia, the indexicalities and social meaning of the [ai] diphthong variants reflect these perspectives: speakers like Rupert and Markus index progress and success by adopting innovative, supralocal forms. Speakers such as Anneliese and Siegfried, on the other hand, impart the traditional values of “home and hearth” by conserving the historical diphthong distinction. The choice to speak Swabian or not is confirmed by prolific comments in the interviews. Pepin, with his low Swabian orientation, commented, *von dem her war i mal typisch und zum Glück nimme so arg* ‘at that time [when I was a Schwab] I was typical and luckily not so much anymore’, while Louise, with her high orientation to Swabia(n), exclaimed, *i bin e Schwââb und bleib ôiner* ‘I’m a Schwab and will stay one’. Comments such as these paint a highly complex picture with respect to the interaction between socio-cultural factors, such as community and identity, and internal linguistic processes, such as manner of articulation and word frequency, calling for more collaborative research between sociolinguists and psycholinguists.

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