Exploring an approach for modelling lectal coherence

by Karen V. Beaman
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Abstract

This paper presents an exploratory approach for modelling and measuring the concept of lectal coherence – the logical unity of idiolects, dialects, sociolects, regiolects, etc. – and how coherence can shape variation and foster or constrain language change. Twelve phonological and morpho-syntactic features of Central Swabian, a variety of German spoken in the southwestern part of the country, exemplify differences in lectal coherence across two communities (Stuttgart and Schwäbisch Gmünd) and two points in time (1982 and 2017). Following the traditional quantitative variationist approach pioneered by Labov (1963), coupled with Guttman-like (1944) implicational scaling, and drawing on concepts from the order and LATTICE theory of mathematics (Partee, Ter Meulen, and Wall 1993), the proposed model brings together three views of coherence – covariation, implicational scaling, and LATTICE theory – to demonstrate a holistic approach to the study of linguistic coherence and its influence on language change. The research question this investigation explores is: does lectal coherence enable or inhibit linguistic change? The hypothesis tested in this study is that more coherent lects are less vulnerable to change and convergence while less coherent lects are more susceptible.

Keywords: sociolinguistics, language variation and change, linguistic coherence, dialects, quantitative models, longitudinal studies, lifespan change, Swabian, German.

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1. Introduction

Fifty years ago, Weinreich, Labov, and Herzog (1968:188) observed that "idiolects do not provide the basis for self-contained or internally consistent grammars," rather it is the grammar of the speech community, governed by social factors, which reflects regularity and coherence and where linguistic change occurs. Hence, one approach to explaining the regularity of linguistic variation and orderly heterogeneity is the notion of coherence. According to Guy & Hinskens (2016), the concept of orderly heterogeneity implies that "speech communities are sociolinguistically coherent .... [meaning that] the community should collectively behave in parallel: variants (or rates of use of variants) that index a given style, status, or a social characteristic should co-occur" (Guy & Hinskens 2016:2). These authors claim that "to the extent that linguistic variables systematically co-vary, they can be characterized as displaying coherence" (Guy & Hinskens 2016:1).

Co-variation is one method for determining coherence; however, another approach utilises Guttman (1944) "scalogram analysis" to identify the underlying, orderly structure of the variation revealing implicational-like patterns (Bickerton 1973; DeCamp 1968; Fasold 1970; Greenberg 1963; Rickford 2001). A recent variation analysis using implicational scaling techniques is Ghyselen & Van Keymeulen's (2016) study of the Belgian dialect of *Tussentaal.* These researchers found that, as a result of dialect loss, destandardisation, and demotisation, the dialect-standard constellation in Flanders has transformed from a diglossic into a largely

[1] I wish to thank the following people for their review and feedback on earlier versions of this paper: Jenny Cheshire, Greg Guy, Frans Hinskens, and Dirk Speelman, as well as the audience from ICLaVE10 at Fryske Academy in Leeuwarden where I first presented this research. Any deficiencies remaining are of course my own.

diaglossic repertoire. They argue that *Tussentaal* “is not just a random idiolectal mix of dialect features, but that it is structured by implicational principles shared across the speech community” (Ghyselen & Van Keymeulen 2016:15). In fact, “speakers do not randomly mix dialect features when speaking *Tussentaal*; clear patterns were found whereby the presence of one dialect feature automatically implies the presence of other features” (Ghyselen & Van Keymeulen 2016:14).

Auer's (1997) concept of “co-occurrence restrictions” advocates a similar method for categorising repertoires and partitioning them “along continua of standard-dialect realizations” (Auer 1997:95). He maintains that tight, bi-directional co-occurrence restrictions (i.e., strong coherence) dichotomise lects while loose, uni-directional ones (i.e., weak coherence) promote greater variation which can stimulate language change (cf. Auer’s 'intermediate forms'). Remarking on the role of social factors, Auer adds, “it seems that given the appropriate social backing, any co-occurrence restriction may be turned upside down” (Auer 1997:95). An overall concern with linear scaling, whether bi-directional or uni-directional, is in its strictness and inability to account for inherent linguistic variation or the influence of social factors. Hence, the challenge for the current study in characterising linguistic coherence is to generalise the concept of an implicational structure to one more representative of ‘the linguistic situation’ and more inclusive of the myriad factors influencing orderly heterogeneity.

Yet another approach employed by some researchers to uncover patterns of coherence across several variables is cluster analysis (Hinskens 2020; Horvath and Sankoff 1987; Meyerhoff and Klaere 2017; Wieling and Nerbonne 2011). One of the earliest such studies was carried out by Horvath and Sankoff (1987) who investigated variation in four vowels in Sydney Australia using principal components analysis (PCA), a data reduction method that determines similarities between groups based solely on linguistic criteria. More recently, Meyerhoff and Klaere (2017) used constrained correspondence analysis (CCA), which incorporates researcher designated constraints (e.g., “village membership”) to guide the aggregation algorithms (a semi-supervised method in contrast to the unsupervised PCA method). Hinskens (2020) combined both correlational (factor analysis) and distance-based measures (cluster analysis) to investigate the relative vulnerability of features in two different groups of Dutch dialects. All of these approaches found greater or lesser degrees of coherence, based on the number and the nature of the linguistic variables and social factors analysed.

The aim of this paper is two-fold: (1) to explore a new theoretical method for modelling and measuring linguistic coherence across different linguistic varieties and (2) to test the proposed model by analysing coherence across 12 linguistic variables in Swabian, a dialect spoken in southwestern Germany. A major assumption underlying this research is the implicational nature of language variation and change; specifically, greater lectal coherence implies that changes in one variant trigger changes in another variant such that multiple related variables co-occur within a unified variety. The overall hypothesis of this study is that more coherent lects are more resistant to change, while less coherent lects are more vulnerable to change, paralleling Milroy's (1987) findings that the most closed social networks are the most resistant to innovations. To test this hypothesis, a new methodological construct based on variable frequency analysis, implicational scaling, and LATTICE theory is explored, which I call the Lectal Lattice.[2]

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[2] The author wishes to thank James Garrett for suggesting the LATTICE concept to represent lectal coherence and for developing the R script to depict it. Of course, any deficiencies in the model are entirely my own responsibility.

2. Data and Methods

This section describes the data and methods employed in this investigation, covering the speech communities, data collection and preparation, the dependent linguistic variables, and the extra-linguistic predictors.

2.1. Speech Communities

This research investigates a variety of German, Central Swabian or *Schwäbisch*, a group of High German dialects belonging to the Alemannic family, which is spoken by just over 800,000 people or one percent of the German population (see Figure 1). Two communities were selected for this research: the large international city of Stuttgart and its surrounding suburbs and the mid-sized town of Schwäbisch Gmünd and the neighbouring rural villages. Stuttgart, a large urban area with over one million inhabitants, is the heart of Swabia and home to many well-known global firms, including Daimler-Mercedes-Benz, Porsche, Bosch, and Siemens. With 60,000 inhabitants, Schwäbisch Gmünd lies 100 kilometres east of Stuttgart. A typical mid-sized German town, *Gmiind* [gmyːnd], as it is called by the locals, is surrounded by small rural villages with 77% of the land dedicated to woodland and agriculture.[3]

Attitudes toward Swabian vary: it is either loved or loathed. It is highly stigmatised by some and adored by others, as these two quotations from native Swabians show:

(1)
wenn i Urschwâbe hör, also die mã gar ned versteht, des denkt mã immer, des isch e Fremdsprache ja, … muss mã halt manchmal de Kopf schüttle, aber so find i des … kôi schlimme Sprâch … i find e Dialekt isch nie schlecht
'if I hear really old-Swabian, that you can't even understand, then you always think, that's a foreign language, yeah, … sometimes you just have to shake your head, but I don't think it's a bad language … I think a dialect is never bad.' (Bertha 1982)

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[3] Drawn from: http://www.schwaebisch-gmuend.de/.Viewed on 22-jan-2020.

(2)
meine Kinder schämen sich sogar heutzutage Schwäbisch, also die verbinden Schwäbisch mit irgendwas, was sie nicht möchten.… dieser dörfliche Zusammenhalt stoßen die eher ab.
‘nowadays my children are actually ashamed of Swabian, well they associate Swabian with something they don’t like.… they are more likely to reject this village solidarity’ (Helmut 2017)

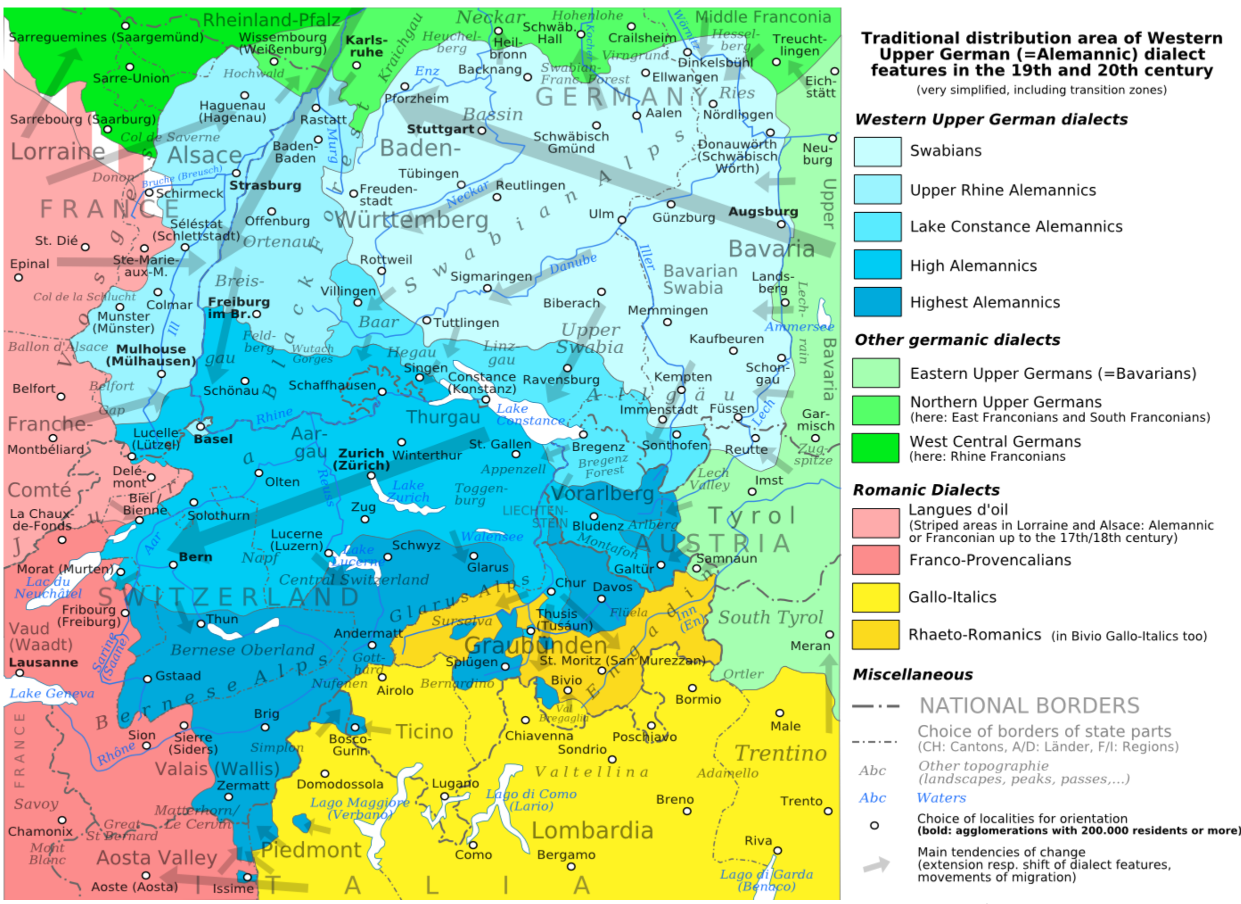

Figure 1. *Map of the Swabian and Alemannic Dialect families.*[4]

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2.2. Swabian Corpus

The data for this study are drawn from a real-time panel study of 20 native Central Swabian speakers, first recorded 1982 and then re-interviewed between 2017-2018. Table 1 provides the breakdown by speaker demographics. High and low education was measured by the speakers' completion of their *Abitur*, 'German college preparatory exam'. All speakers were of a similar socio-economic status, quasi upper-middle class.

Study Year	Age Groups	Sex	Stuttgart Hi Edu	Stuttgart Lo Edu	Schwäbisch Gmünd Hi Edu	Schwäbisch Gmünd Lo Edu	Total
1982	**Group A:** ages 30-60	M	0	0	0	1	**1**
	Born 1922-1952	W	0	1	0	2	**3**
1982	**Group B:** ages 18-29	M	4	0	6	0	**10**
	Born 1953-1964	W	1	1	3	1	**6**
2017	**Group C:** ages 61-88	M	0	0	0	1	**1**
	Born 1929-1956	W	0	1	0	2	**3**
2017	**Group D:** ages 30-60	M	4	0	6	0	**10**
	Born 1957-1987	W	1	1	3	1	**6**
Subtotal			**10**	**4**	**18**	**8**	
TOTAL			**14**		**26**		**40**

Table 1. *Panel Study Corpus – Speaker Demographics*

The data collection methods followed the Labovian sociolinguistic paradigm, consisting of semi-structured sociolinguistic interviews, conducted by native Swabian speakers with the primary investigator in attendance in the role of friend-of-a-friend (Milroy and Milroy 1985). To increase compatibility across years, the same survey instrument and interviewing techniques were used in both 1982 and 2017, covering questions about the speaker's childhood, games, friends, hobbies, local festivals and activities, and attitudes toward the Swabian language.

Transcriptions were completed in ELAN (Wittenburg et al. 2006) by native German speakers, students at the University of Tübingen. A standard orthography was developed for easily and distinctly transcribing the Swabian dialect forms. All transcripts were validated by a second transcriber and verified by the principal investigator to ensure standards were followed and to neutralise any potential transcriber bias. The dataset consists of 40 interviews (20 from 1982 and 20 from 2017), comprising 43 hours for a total of 162,964 words, 72,550 in 1982 and 90,414 in 2017 (the interviews were slightly longer in 2017 and in Schwäbisch Gmünd).

2.3. Linguistic Variables

The dependent variables investigated in this study are 12 Swabian dialect features – six phonological and six morphosyntactic – all highly representative of the rich palette of features available to the Swabian speaker (see Table 2). All variables were coded for a binary distinction between the dialect variant and the standard German variant. In the present study of lectal coherence, no conditioning factors have been considered. A brief description of each follows.

Code	Name	SWG~STD (IPA)	Swabian Examples
	PHONOLOGICAL VARIABLES:		
AIS1	MHG /i:/ Diphthong [**əi** ~ ai]	**[əɪ]** ~ [aɪ]	*da dued mã in den Zylinder obe der* ***Dêig*** *nei* 'then you put [it] into the cylinder above the dough'
ANN	Nasal ‘a’ before 'n' [**ã** ~ an]	**[ã]** ~ [an]	***mã kã*** *es mit em normale [Mehl] mache* 'you can make it with a normal [flour]'
FRV1	Unrounded Front Vowel [**e:** ~ ø:]	**[ɛ]** ~ [ø]	*so guet wie* ***meeglich*** *probier es* 'as good as possible [I] try it'
FRV2	Unrounded Diphthong [**ai ~** ɔʏ]	**[aɪ]** ~ [ɔɪ]	*bin gern auf* ***Baim*** *gestiege* '[I] liked to climb trees'
LEO	Lower Long Vowel [**ɛ**: ~ e:]	**[ɛ**:**]** ~ [e:]	*dâ e baar Jâhr* ***lääbe*** 'live a few years there'
STPA	Palatal Coda -st [**ʃt** ~ s]	**[ʃt]** ~ [st]	*da* ***darfsch*** *ja bloß hundertdreißig fahre in Italien* 'then you're only allowed to drive 130 in Italy'
	MORPHOSYNTACTIC VARIABLES:		
EDP	Plural Verb Inflection: **-ed** ~ -en	**[əd]** ~ [ən]	*die* ***finded*** *es wichtich* 'they think it important'
IRV1	Irregular Verb: **gange** ~ gehen	**[gangə]** ~ [ge:ən]	*willsch du an Telefon* ***gange*** 'do you want to answer the telephone'
IRV3	Irregular Verb: **hen** ~ haben	**[hɛn]** ~ [ha:bən]	*mr* ***hen*** *e aldes Haus khet* 'we have had an old house'
PVB	Periphrastic Subj: **dääd** ~ würde	**[dædə]** ~ [vʏʁdə]	*es* ***dääd*** *beeinflusse* 'it should influence'
SAF1	Diminutive Suffix: **-le** ~ -chen	**[lə]** ~ [çən/laɪ̯n]	*dass er en* ***Mädle*** *mâg un se ihn mâg* 'that he likes a girl and she likes him'
SAF5	Past Participle Prefix: **Ø** ~ ge-	**[θ]** ~ [gə]	*un hen hier e Haus* ***[ge]baut*** 'and they have built a house here'

Table 2. *Swabian linguistic variables under investigation (dialect variant shown in bold).*

1. **Rounding of diphthong of MHG /i:/ origin** (AIS1) is a stereotypical feature of Swabian, hence standard German forms such as *klein* [klaɪn] 'small' and *allein* [alaɪn] 'alone' are realised as *glôi* [glɔɪ] and *allôi* [alɔɪ] in Swabian.
2. **Nasalisation of /a/ before /n/** (ANN) is a traditional feature of Swabian, hence words such as *man kann* [man kan] 'one can' and *Anfang* [anfaŋ] 'beginning' are realised as *mã kã* [mɑ̃ kɑ̃] and *Ãfang* [ɑ̃fɑŋ] in Swabian.
3. **Unrounding of the front vowel /ö/** (FRV1) is typical in Swabian, so that standard German words such as *möglich* [møːklɪç] 'possible' and *schön* [ʃøːn] 'beautiful' are realised as *meeglich* [mɛːglɪç] and *schee* [ʃɛː] in Swabian.
4. **Unrounding of the front vowel /ü/** (FRV3) is typical in Swabian, so that standard German forms such as *Küche* [kyːçə] 'kitchen' and *Gmünd* [gyːmunt] are realised as *Kiiche* [kɪːçə] and *Gmiind* [gɪːmund].
5. **Opening of long /e:/** (LEO) is a regional dialect feature, so that standard German forms such as *lesen* 'read' [leːzn] and *Lehrer* 'teacher' [leːʁɐ] are pronounced as *lääse* [læːs] and *Läährer* [læːʁɐ] in Swabian.
6. **Palatalisation of /st/ in syllable-coda position** (STP) is a highly productive feature of Swabian and the Alemannic dialects, hence words such as *machst* [mɑxst] 'you do/make' and *nächst* [nɛːçst] 'next' are realised as *machscht* [maxʃ] and *nächsht* [nɛːçʃ] in Swabian.
7. **Present tense plural verb inflexion** (EDP) -*en* in standard German (for 1st, 2nd, and 3rd person plural) is realised as *-ed* in Swabian, so that standard forms such as *sie finden* 'they find' and *wir gehen* 'we go' are realised as *sie finded* and *mer ganged* in Swabian.
8. **Verb *gehen* 'go'** (IRV1) has an irregular conjugation in Swabian, hence forms such as *ich gehe* 'I go' and *weitergeht* 'continue' are realised as *i gang* and *wêitergâht.*

9. **Verb *haben* 'have'** (IRV3) has an irregular conjugation in Swabian, for example, the past participial has different realisations, *ghet*, *ghed*, *khet,* or *khed* in Swabian versus *gehabt* 'had' in standard German.
10. **Periphrastic subjunctive *tun* 'do/make'** (PVB) is typical in Swabian, so forms such as *er dääd lache* 'he would laugh' and *es dääd beeinflusse* 'it would influence' in Swabian vary with the standard German periphrastic subjunctive using *werden* 'to become', *er würde lachen* and *es würde beeinflussen.*
11. **Diminutive suffix *-le*** (SAF1) is highly productive and varies with the standard German suffix *-chen* (or the older suffix *-lein).* Hence, forms such as *Mädle* 'little girl', *Tellerle* 'little plate', and *Unterschiedle* 'small difference' vary with standard German forms *Mädchen, Tellerlein,* and *klein Unterschied*.
12. **Past participle prefix *-ge*** (SAF5) is typically dropped in Swabian, hence forms such as *hen kriegt* 'have received' and *isch umzoge* 'has moved' vary with the standard German constructions *haben gekriegt* and *ist umgezogen*.

Strict adherence to the *principle of accountability* was ensured through the use of a bespoke Swabian-German Lexicon (SGL), compiled from all words in the 40 transcripts which contained tokens (either Swabian or standard German) of one of the 12 features under investigation. False starts and repetitions were excluded. In total, 50,875 tokens for the 12 linguistic variables were extracted, 21,714 from 1982 and 29,161 from 2017, with an average of over 1,000 tokens per speaker in 1982 and over 1,400 tokens per speaker in 2017.

2.4. Extra-linguistic Predictors

Due to space limitations, only two extra-linguistic factors are considered in the current study: (1) two recording years (1982 and 2017) and (2) two communities (Stuttgart and

Schwäbisch Gmünd). Additional social factors influencing the Swabian dialect situation have been reported on elsewhere (Baayen, Beaman, and Ramscar 2021; Beaman 2020, 2021; Beaman and Tomaschek 2021).

3. Analysis and Results

The analysis and results begin with an overview of the changing dialect situation in Swabia with respect to the 12 linguistic variables under investigation. Next, the Lectal Lattice is described and its construction explained, followed by an examination into the linguistic coherence in the two communities across the two recording periods. Finally, the differences and advantages of the Lectal Lattice over other data reduction methods and graphical representations are discussed.

3.1. Linguistic Variables

Table 3 shows the results of a generalised linear regression model (generated by the R *predict* function using the *glmer* function in the package *lme4* version 1.1-21), which modelled the frequency of the dialect variant versus the standard variant for each of the 12 linguistic variables, considering the two recording periods, two communities, two sexes, and Swabian orientation as fixed effects and speaker and interviewer as random effects (see Beaman (2021) for further information). The phonological variables are on the left and the morphosyntactic ones on the right, sorted by decreasing probability of occurrence in 1982. The "prob" column shows the probabilities of the non-standard variant, the "diff" column shows the difference in usage between 1982 and 2017, and the "sig" column shows the significance level. A couple of interesting patterns can be observed in data. First, as is quickly apparent, all variables indicate highly significant attrition across the two recording periods (sig = "***" for $p < .001$), demonstrating that considerable dialect levelling is occurring in Swabian (see Beaman (2020) for further information on dialect levelling in Swabian). Second, with the exception of the two Swabian affixes (‘-*le*’ and ‘*ge*-’), the morphosyntactic variables have receded more than the phonological ones; these two features have receded to a similar degree as the phonological ones. Future research on the diminutive suffix (-*le*) may reveal this variable to be lexical rather than morphological, while dropping of the past participle prefix (*ge*-) may be a case of phonological reduction rather than a morphological distinction. Third, some variables have receded significantly more than others, in particular, IRV1, use of the irregular verb [gange] versus standard [gehe], while others, such as, STP, palatalisation of coda [ʃt] versus [st], retain a fairly high level of usage. The reasons for this lie largely in the levels of saliency (“overt speaker awareness”) and stigma associated with the variables (see Beaman 2020 for a detailed discussion on the change in the individual variables).

Phonological Variables

Variable	Year	n	lodds	prob	diff	sig
STP st~ʃt	1982 2017	4761 5716	1.0209 0.3531	73.5% 58.7%	-14.8%	***
ANN an~ã	1982 2017	2717 3027	-0.3574 -1.1245	41.2% 24.5%	-16.6%	***
FRV3 ɑɪ~ɔɪ	1982 2017	1747 2692	-0.7085 -1.5589	33.0% 17.4%	-15.6%	***
LEO e~æ	1982 2017	1827 3291	-0.7873 -1.3648	31.3% 20.4%	-10.9%	***
FRV1 ø~e	1982 2017	1365 1401	-1.0740 -1.9615	25.5% 12.3%	-13.1%	***
AIS1 aɪ~ɔɪ	1982 2017	3914 4975	-1.5848 -2.4723	17.0% 7.8%	-9.2%	***

Morphosyntactic Variables

Variable	Year	n	lodds	prob	diff	sig
EDP ən~əd	1982 2017	628 954	3.3772 0.3800	96.7% 59.4%	-37.3%	***
PVB 'tun'	1982 2017	122 181	0.7723 -0.5178	68.4% 37.3%	-31.1%	***
IRV1 gaŋə	1982 2017	266 418	0.7516 -1.6163	68.0% 16.6%	-51.4%	***
IRV3 hɛn	1982 2017	1022 1843	0.2948 -1.2758	57.3% 21.8%	-35.5%	***
SAF1 -lə	1982 2017	1707 2277	-1.1095 -1.9970	24.8% 12.0%	-12.9%	***
SAF5 gə~ɸ	1982 2017	1638 2386	-1.2181 -2.0182	22.8% 11.7%	-11.1%	***

Table 3. *Swabian linguistic variable predictions by recording year and variable type, generated by the R predict function based on the results of a linear regression model with glmer (from Beaman 2021, Table 5). All differences are significant at the p < .001 level.*

3.2. Dialect Change in Swabia

Figure 2 depicts the changing dialect situation in Swabia through the analysis the 12 linguistic variables using Principal Components Analysis (PCA) (*prcomp* function in package *stats*, version 3.5.3), a data reduction method which has been used by many sociolinguists as a heuristic to group speakers based solely on their linguistic behaviour (Horvath and Sankoff 1987). PCA reduces the dimensionality of multivariate data to a small set of derived factors (i.e., principal components), each representing a summarisation of the linguistic features that co-occur with high frequency. Two PCAs were conducted, one for the proportion of usage of the dialect variant for the six phonological variables and one for the proportion of usage of the dialect variant for the six morphosyntactic variables. In Figure 2, PC1 for the phonological variables is plotted on the horizontal axis (explaining 69.5% of the variation) and PC1 for the morphosyntactic variables on the vertical axis (explaining 78.1% of the variation). The upper right corner approximates 100% usage of all dialect variants, while the lower left corner verges toward 100% usage of the standard German variants. Plus signs mark each speaker’s dialect usage in 1982, and dots denote each speaker’s usage in 2017. With two exceptions, all speakers have experienced dialect attrition as can be seen by the overall trend with the plus signs (1982) at the top of the graph (indicating greater dialect usage) and the dots (2017) at the bottom of the graph (revealing greater standard usage).

The dotted ellipse at the top of Figure 2 (drawn at two standard deviations from the mean of the group) encircles the speakers from Schwäbisch Gmünd in 1982. The small, compact nature of this ellipse indicates that there was considerable homogeneity among the speakers in 1982, at least with regard to the use of these 12 dialect variants. The dashed ellipse in the middle of Figure 2 encircles all speakers in 1982, signalling a stronger tendency toward the standard variants when the speakers from the urban centre of Stuttgart are combined with those of

Schwäbisch Gmünd. Finally, the longest ellipse encircles all speakers in 2017, highlighting two key findings: (1) the Swabian dialect has moved closer to the standard language in 2017 than it was in 1982, as seen by the placement of the pluses (in the upper right) and the dots (in the lower left), and (2) there is noticeably greater diversity in dialect and standard usage in 2017 than there was 1982 (as demonstrated by the size of the 2017 ellipse). Drawing from my own ethnographic observations from over five years living in the region, in 1982 both communities exhibited many, dense, multiplex social relationships, whereas by 2017, community ties had weakened and social connections have become considerably more dispersed, particularly in Stuttgart. In fact, many of the Stuttgart speakers, who were all close friends in 1982, had completely lost contact with one another by 2017, requiring considerable detective work on my part as the principal investigator to locate these individuals to re-interview them.

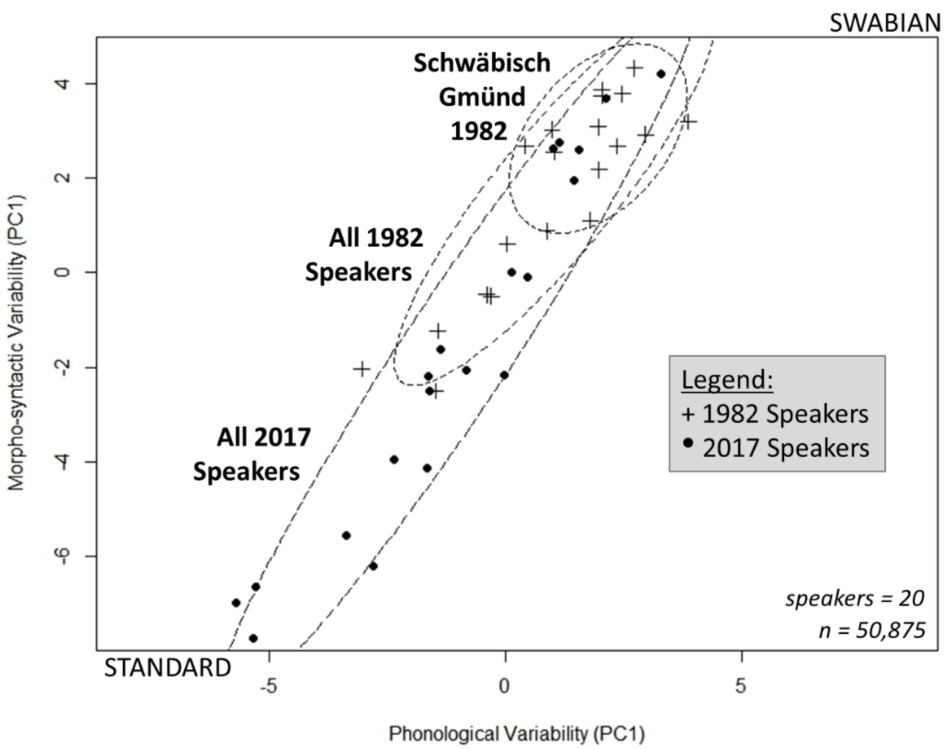

Figure 2. *Change in Swabian dialect usage for 12 linguistic variables for two communities over a 35-year time span: plus signs represent speakers' proportion of dialect usage in 1982 and dots their dialect usage in 2017.*

3.3. Lectal Coherence

The theoretical question this paper seeks to address is to what extent do varying lects reflect coherence and what do differing levels of coherence tell us about linguistic change. By measuring the level of coherence in an individual lect (e.g., the 1982 speakers, the 2017 Stuttgart speakers), we can compare it with another lect and thereby examine the impact that coherence has on language variation and change.

Lattices

To depict and measure lectal coherence, this paper draws on the concept of a LATTICE, a construct from the order theory of mathematics and universal algebra (Partee, Ter Meulen, and Wall 1993, chapter 11). Linguists have used LATTICES in phonology, syntax, semantics, neurolinguistics and computational linguistics, but not yet in sociolinguistics or variation studies. A LATTICE is an abstract structure that uses binary relations to examine the hierarchical or implicational relationships within a given set of elements. It consists of a PARTIALLY ORDERED SET, called a POSET, in which an order relation ($\leq$) exists between some of the elements in the set. A LATTICE generalises the data from a straight line (such as x implies y implies z) to a multi-dimensional picture, which can be depicted by a Hasse diagram, as illustrated in Figure 3. In a Hasse diagram, the elements of the POSET are represented as nodes and the order relations between the elements are represented as links between the nodes.

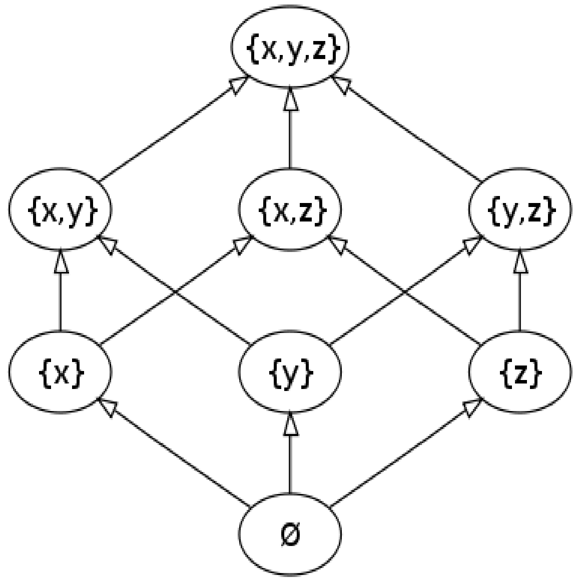

Figure 3*. Lattice demonstrating sets and subsets, visualised as a Hasse diagram.*

To somewhat overgeneralise in the interest of brevity, every two elements in a LATTICE have a least upper bound, called a JOIN, and a greatest lower bound, called a MEET. The relationship between the elements depicted in Figure 3 is one of inclusion: for any two elements, you can move up the LATTICE to find an element that is included by both (the JOIN) or step down the LATTICE to find an element that is included by both (the MEET). LATTICES exhibit the principle of DUALITY, which means that they function equally in both directions – top-down or bottom-up. Thus, in turning a LATTICE upside down, the MEETS become JOINS, and the JOINS become MEETS (see Partee, Ter Meulen, and Wall (1993), Chapter 11, for details on the construction and interpretation of LATTICES).

It is important to note that POSETS can represent elements at many different levels. The Lectal Lattice comprises two types: (1) POSETS in which the elements are individual linguistic variables, which are then aggregated into an idiolect for a single speaker (as illustrated in subsequent Figures 4 and 5), and (2) POSETS in which the elements are the idiolects of individual speakers which can then be aggregated into different linguistic varieties, such as dialects, regiolects, sociolects (as illustrated in Figures 6 and 7).

Pairwise Comparisons

Borrowing from these theoretical concepts, a Lectal Lattice can be constructed to depict the hierarchical and implicational relationships among the variables in a lect, which can then be visualised as Hasse diagram. The first step in developing a Lectal Lattice is to create post hoc PAIRWISE COMPARISONS for each speakers' set of linguistic variables, arranged in two-by-two contingency tables. Figure 4 illustrates an example POSET for speaker Angela in 1982. The 12 linguistic variables (AIS1 through STP) generate a POSET of 144 pairs of variables. Using the Suissa & Shuster Exact test with the Holm-Bonferroni method (Holm 1979), each pair of variables is tested to determine whether there is a significant difference in frequency of usage (i.e., proportion of non-standard variant divided by the total variants for the feature). When a statistically significant difference is found ($p < .05$) (specifically, when the variable in the row is lower than the variable in the column maintaining the implicational order) the pair is assigned a 1, otherwise a 0 is assigned. In a POSET every pair of variables need not be related significantly for the pattern to be valid, allowing for uncertainties or inadequacies or unknowns in the dataset, which of course is common with sociolinguistic data.

Angela 1982

	AIS1	ANN	EDP	FRV1	FRV3	IRV1	IRV3	LEO	PVB	SAF1	SAF5	STP
AIS1	--	0	1	0	0	1	0	0	0	1	0	1
ANN	0	--	1	1	1	1	0	0	0	1	0	1
EDP	0	0	--	0	0	0	0	0	0	0	0	0
FRV1	0	0	1	--	0	0	0	0	0	1	0	0
FRV3	0	0	1	0	--	0	0	0	0	1	0	1
IRV1	0	0	0	0	0	--	0	0	0	0	0	0
IRV3	0	0	1	0	0	0	--	0	0	1	0	1
LEO	0	0	1	0	0	1	0	--	0	1	0	1
PVB	0	0	0	0	0	0	0	0	--	0	0	0
SAF1	0	0	0	0	0	0	0	0	0	--	0	0
SAF5	0	0	1	1	1	1	0	0	0	1	--	1
STP	0	0	0	0	0	0	0	0	0	0	0	--

Angela 1982 SORTED Rank = 28

	ANN	SAF5	AIS1	LEO	IRV3	FRV3	FRV1	PVB	IRV1	STP	EDP	SAF1
ANN	--	0	0	0	0	1	1	0	1	1	1	1
SAF5	0	--	0	0	0	1	1	0	1	1	1	1
AIS1	0	0	--	0	0	0	0	0	1	1	1	1
LEO	0	0	0	--	0	0	0	0	1	1	1	1
IRV3	0	0	0	0	--	0	0	0	0	1	1	1
FRV3	0	0	0	0	0	--	0	0	0	1	1	1
FRV1	0	0	0	0	0	0	--	0	0	0	1	1
PVB	0	0	0	0	0	0	0	--	0	0	0	0
IRV1	0	0	0	0	0	0	0	0	--	0	0	0
STP	0	0	0	0	0	0	0	0	0	--	0	0
EDP	0	0	0	0	0	0	0	0	0	0	--	0
SAF1	0	0	0	0	0	0	0	0	0	0	0	--

Figure 4*. One speaker's* POSET *illustrating pairwise comparisons for 12 linguistic variables. 0 = non-significant pair and 1 = significant pair based on Suissa & Shuster (1985) Exact test (p < .05) using the Holm-Bonferroni method.*

The speakers' POSETS are then sorted first by significant pairs and then according to the frequency of the dialect variant, generating a new sorted POSET as exemplified on the right in Figure 4. The sorted POSETS are RANKED by summing the significant pairwise comparisons. In Figure 4, Angela in 1982 has a RANK of 28 because there are 28 significant pairwise comparisons in the 12 linguistic variables under investigation. RANK allows us to calculate the DISTANCE between two different lects (two idiolects in this example), a value that denotes the number of pairs that would have to change for the two lects to be identical.

In the next step, neighbouring POSETS, i.e., those that are most similar, are mathematically JOINED; specifically, all neighbours lying at the same minimum DISTANCE are joined one by one. Figure 5 demonstrates Angela's 1982 POSET being joined with Markus' 1982 POSET, to create a new POSET which will become NODE[5] 101 in the 1982 LATTICE. In this example, there are six joined pairs, indicated in dark grey, which is the mathematical DISTANCE between Angela and Markus' lects. To build the LATTICE, all POSETS are connected with their nearest neighbours and

Angela 1982 SORTED Rank = 28

	ANN	SAF5	AIS1	LEO	IRV3	FRV3	FRV1	PVB	IRV1	STP	EDP	SAF1
ANN	--	0	0	0	0	1	1	0	1	1	1	1
SAF5	0	--	0	0	0	1	1	0	1	1	1	1
AIS1	0	0	--	0	0	0	0	0	1	1	1	1
LEO	0	0	0	--	0	0	0	0	1	1	1	1
IRV3	0	0	0	0	--	0	0	0	0	1	1	1
FRV3	0	0	0	0	0	--	0	0	0	1	1	1
FRV1	0	0	0	0	0	0	--	0	0	0	1	1
PVB	0	0	0	0	0	0	0	--	0	0	0	0
IRV1	0	0	0	0	0	0	0	0	--	0	0	0
STP	0	0	0	0	0	0	0	0	0	--	0	0
EDP	0	0	0	0	0	0	0	0	0	0	--	0
SAF1	0	0	0	0	0	0	0	0	0	0	0	--

V

Markus 1982 SORTED Rank = 28

	SAF5	ANN	LEO	AIS1	FRV1	FRV3	IRV3	PVB	IRV1	EDP	SAF1	STP
SAF5	--	0	0	1	1	1	1	0	1	1	1	1
ANN	0	--	0	0	0	0	0	0	1	1	1	1
LEO	0	0	--	0	0	0	0	0	1	1	1	1
AIS1	0	0	0	--	0	0	0	0	0	1	1	1
FRV1	0	0	0	0	--	0	0	0	0	1	1	1
FRV3	0	0	0	0	0	--	0	0	0	1	1	1
IRV3	0	0	0	0	0	0	--	0	0	1	1	1
PVB	0	0	0	0	0	0	0	--	0	0	0	0
IRV1	0	0	0	0	0	0	0	0	--	0	0	0
EDP	0	0	0	0	0	0	0	0	0	--	0	0
SAF1	0	0	0	0	0	0	0	0	0	0	--	0
STP	0	0	0	0	0	0	0	0	0	0	0	--

=

Node 101 1982 JOINED POSET Rank = 31

	SAF5	ANN	LEO	AIS1	IRV3	FRV1	FRV3	PVB	IRV1	EDP	SAF1	STP
SAF5	--	0	0	1	1	1	1	0	1	1	1	1
ANN	0	--	0	0	0	1	1	0	1	1	1	1
LEO	0	0	--	0	0	0	0	0	1	1	1	1
AIS1	0	0	0	--	0	0	0	0	1	1	1	1
IRV3	0	0	0	0	--	0	0	0	0	1	1	1
FRV1	0	0	0	0	0	--	0	0	0	1	1	1
FRV3	0	0	0	0	0	0	--	0	0	1	1	1
PVB	0	0	0	0	0	0	0	--	0	0	0	0
IRV1	0	0	0	0	0	0	0	0	--	0	0	0
EDP	0	0	0	0	0	0	0	0	0	--	0	0
SAF1	0	0	0	0	0	0	0	0	0	0	--	0
STP	0	0	0	0	0	0	0	0	0	0	0	--

***Figure 5**. Joining POSETS with nearest neighbours based on DISTANCE to create NODES in the lattice. 0 = non-significant pair and 1 = significant pair based on Suissa & Shuster (1985) Exact test (p<.05) using the Holm-Bonferroni method. Dark grey cells highlight pairs joined in creating the new POSET.*

[5] Node numbers are arbitrary, assigned sequentially, used to uniquely identify the different nodes in the LATTICE.

joined into new POSETS. It's POSETS within POSETS – or "turtles all the way down" – and up, of course, to maintain the DUALITY of the LATTICE.

The Lectal Lattice

Figure 6 presents an exemplary Lectal Lattice for the 20 Swabian speakers in 1982. The vertical axis represents the RANK, and the horizontal axis represents the FILE, i.e., the left-to-right right line-up of the individual lects based on the first principal component. The LATTICE was created with standard R functions, including *plot*, *points*, *lines* and *text*. It is a SEMI-LATTICE because it does not display all of the points in the LATTICE, rather only the significant ones, which greatly simplifies visualisation by eliminating redundant and irrelevant information.

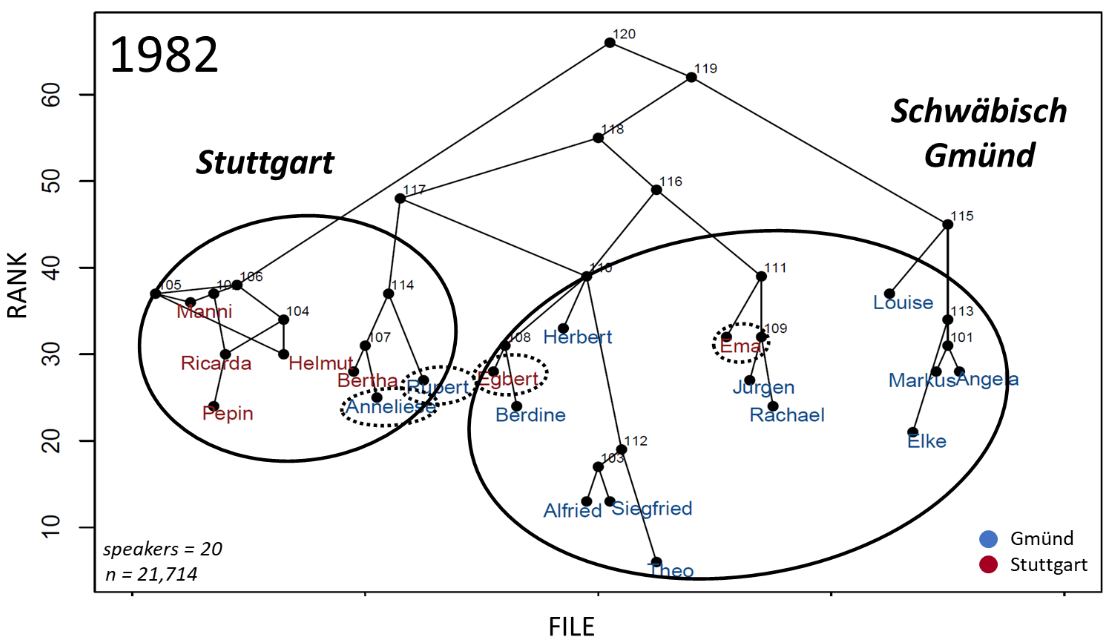

***Figure 6**. Lectal Lattice for 20 Panel speakers in Stuttgart and Schwäbisch Gmünd in 1982.*

Each point in the Lectal Lattice represents a lect, either a single idiolect or a group of lects that have been joined, such as a dialect, a sociolect, a regiolect, or even a particular style, stance, or register. The points for each speaker's idiolect form the foundation of the LATTICE, which are labelled in Figure 6 with the speakers' pseudonyms. On the far right in Figure 6, NODE 101 from Figure 5 is visible showing the JOIN of Angela and Markus' lects.

From this picture, we can easily see that the speakers fall into two fairly distinct groups, the speakers from Stuttgart on the left and the speakers from Schwäbisch Gmünd on the right, with only a few exceptions or outliers, which can be explained. Rupert and Anneliese from Schwäbisch Gmünd are grouped with the more standardised supra-regional lect of Stuttgart. These two speakers are a few years older and have a higher level of education than the other speakers from Schwäbisch Gmünd (both were studying to be doctors in 1982, one a PhD, the other an MD), which may explain why they use more standardised forms than their cohorts. Ema from Stuttgart is grouped with the more conservative dialect speakers in Schwäbisch Gmünd. She is one of the oldest speakers, hence her dialect usage reflects a greater number of traditional Swabian forms which is more in line with speakers from Schwäbisch Gmünd.

Turning to 2017, Figure 7 presents an exemplary Lectal Lattice for the same 20 panel speakers 35 years later. On the right side of the graphic, we see some preservation of the conservative Schwäbisch Gmünd lect; however, on the left, we now see a very different picture. Over the 35-year timespan of this study, some speakers from Schwäbisch Gmünd have "fused" with speakers from Stuttgart, moving in the direction of greater standardisation, a supralocal lect or regiolect, a lect that is not necessarily geographically situated, rather one that is linguistically closer to the standard language (Britain 2010). This finding further demonstrates that the Swabian dialect is undergoing levelling, changing from a geographical or horizontal variety to a sociolectal or vertical variety, as a result of the extensive social and demographic changes taking place in contemporary German society (Auer 2005).

However, Figure 7 reveals that more than half of the Schwäbisch Gmünd speakers have retained their conservative dialect features over the years. Other research has established that dialect attrition and retention is highly influenced by speakers' notions of local orientation (cf. *Ortsloyalität* 'place loyalty' (Mattheier 1987)) and interlocutor accommodation (Auer and Hinskens 2005; Hinskens, Auer, and Kerswill 2005; Trudgill 1986), a phenomenon reported on elsewhere (Beaman 2021, 2021). Many of the speakers who have moved away from the conservative lect to the fused regiolect are those who live and work regularly with speakers from other dialect groups (cf. Ammon 1973), such as Markus and Rupert who both travel extensively across Germany for their work. Speakers who have retained the conservative dialect, such as Angela and Siegfried, maintain the strongest local orientation to Swabia over their lifespan (Baayen, Beaman, and Ramscar 2021; Beaman 2021; Beaman and Tomaschek 2021).

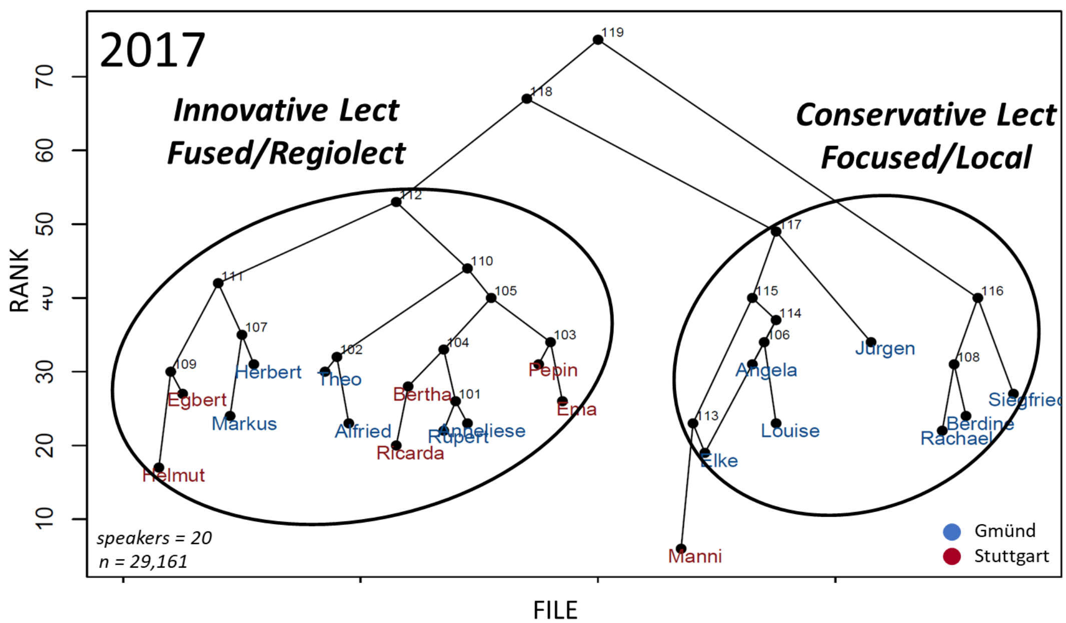

Figure 7. *Lectal Lattice for 20 Panel speakers in Stuttgart and Schwäbisch Gmünd in 2017.*

PCA and the Lattice

To illustrate the differences and advantages of the Lectal Lattice, Figure 8 presents the results of a Principal Component Analysis (PCA) for the 20 Swabian panel speakers. 1982 is on the left, 2017 is on the right, PC1 is on the horizontal axis, and PC2 on the vertical axis. In 1982, PC1 and PC2 together account for 62% of the variation, and in 2017 PC1 and PC2 together account for 82% of the variation. Not surprisingly, the PCA results are quite similar to the Lectal Lattice, albeit with a different graphical representation. In 1982, we again see two very distinct lects, Stuttgart speakers on the left and Schwäbisch Gmünd speakers on the right. The PCA for 2017 also depicts a changing picture of the dialect situation in Swabia. We can still delineate the Stuttgart and Schwäbisch Gmünd groups; however, we see a fusing of the two lects in the middle of the graph. The PCA in Figure 8 corroborates the findings from the Lectal Lattice in Figure 7, both of which reveal greater diversity among the Swabian speakers in 2017 than in 1982.

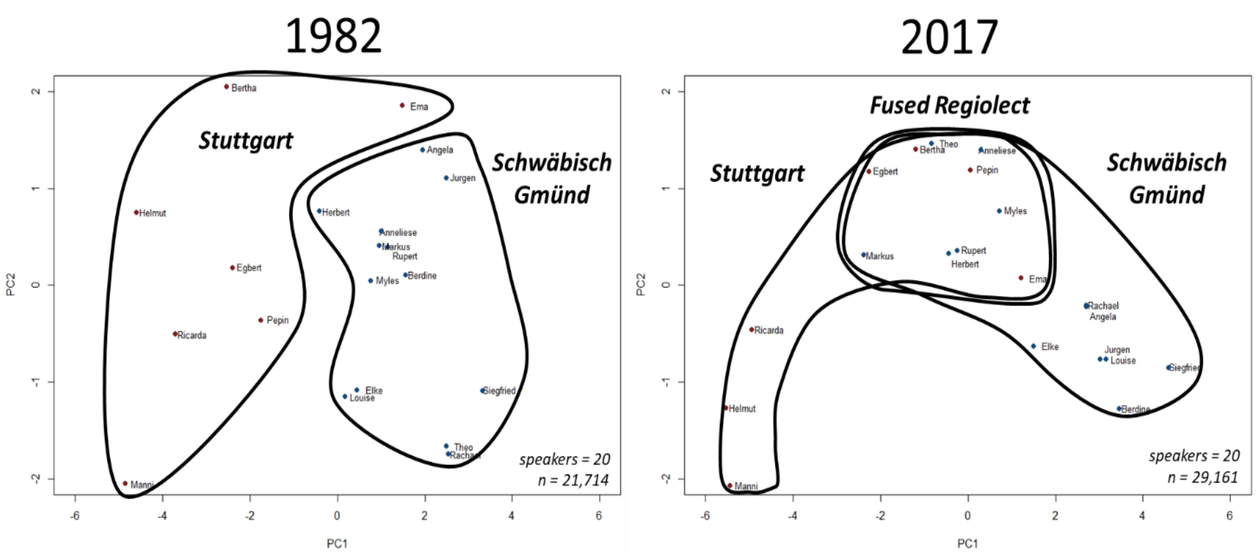

Figure 8*. Principal Components Analysis (PCA) depicting distinct Stuttgart and Schwäbisch Gmünd lects in 1982 and the fusing of lects in 2017.*

Both PCA and the Lectal Lattice are data reduction methods that unveil significant groupings of speakers based on linguistic factors alone. One advantage of the Lectal Lattice over PCA is in the graphical display: the hierarchical depiction of related lects exposes the underlying relationships between lects without the researcher having to run multiple PCA models and manually compare and contrast the results. Another important advantage of the Lectal Lattice over PCA is in the calculation of the distance between lects: with principal components, distance is calculated based only on the frequencies of the variables; with the Lectal Lattice, distance is determined based on both the frequencies and the implicational order of the variables. However, the greatest advantage of the Lectal Lattice over PCA and other data reduction methods is the ability to calculate, measure and compare how closely different lects and groups of lects cohere, as explained in the following section.

Implicational Coherence

The motivation behind the Lectal Lattice is the development of a method to evaluate the coherence of lects, that is, how tightly (or loosely) multiple variables co-occur within a given lect. With a quantifiable, objective measure of coherence, we can test the overall hypothesis of this research that more coherent lects are more resistant to change, while less coherent lects are more vulnerable to change. The POSETS in the Lectal Lattice provide a method for quantitatively assessing the level of coherence in any given lect by measuring the number of significant pairwise comparisons that follow the implicational pattern. Quite simply, implicational coherence is calculated by summing the 1's above the diagonal (i.e., significant pairs based on Suissa & Shuster (1985) Exact test ($p < .05$) using the Holm-Bonferroni method, as shown in Figure 4), subtracting the 1's below the diagonal (i.e., those deviating from the pattern), and then dividing by the total number of significant pairs in the POSET. The following formula describes the calculation for implicational coherence (IC):

$$IC = \frac{\sum_{i=1}^{n} x_i^{\omega} - \sum_{i=1}^{n} x_i^{\beta}}{\sum_{i=1}^{n} x^i}$$

To illustrate how the IC formula works, Figure 9 shows the POSETS for the top-most nodes from the Lectal Lattices in 1982 (NODE 120 from Figure 6) and 2017 (NODE 119 from

Figure 7). Following the IC formula, in 1982 there are 60 significant pairwise comparisons above the diagonal and 6 below the diagonal, (60 – 6) / 66 = .818, signifying a highly coherent lect in 1982 at 82%. However, the POSET for the top-most node in 2017 reveals double the number of deviants (12 versus 6) and hence an implicational coherence of only 68%. While the current sample size is quite small for tests of statistical significance, a common problem in panel study research (Cukor-Avila and Bailey 2017), a two tailed z-test shows this difference in coherence between the 1982 lect and the 2017 lect to be significant (z-value = 5.83; p < .001; n = 78).

1982

Node 120 IC = 82% Rank = 66

	AIS1	SAF5	ANN	LEO	FRV1	FRV3	PVB	IRV1	IRV3	STP	SAF1	EDP
AIS1	--	1	1	1	1	1	1	1	1	1	1	1
SAF5	1	--	1	1	1	1	1	1	1	1	1	1
ANN	0	1	--	1	1	1	1	1	1	1	1	1
LEO	0	0	1	--	1	1	1	1	1	1	1	1
FRV1	0	0	1	0	--	0	0	1	1	1	1	1
FRV3	0	0	1	0	0	--	0	1	1	1	1	1
PVB	0	0	0	0	0	0	--	0	1	1	1	1
IRV1	0	0	0	0	0	0	0	--	1	1	1	1
IRV3	0	0	0	0	0	0	0	0	--	1	1	1
STP	0	0	0	0	0	0	0	0	1	--	0	1
SAF1	0	0	0	0	0	0	0	0	0	0	--	0
EDP	0	0	0	0	0	0	0	0	0	0	0	--

2017

Node 119 IC = 68% Rank = 75

	SAF5	AIS1	FRV3	FRV1	ANN	LEO	IRV3	IRV1	EDP	PVB	STP	SAF1
SAF5	--	1	1	1	1	1	1	1	1	1	1	1
AIS1	1	--	1	1	1	1	1	1	1	1	1	1
FRV3	0	1	--	1	1	1	1	1	1	1	1	1
FRV1	0	0	1	--	1	1	1	1	1	1	1	1
ANN	0	0	1	1	--	1	1	1	1	1	1	1
LEO	0	0	1	0	1	--	1	1	1	1	1	1
IRV3	0	0	1	0	1	1	--	1	1	0	1	1
IRV1	0	0	0	0	0	0	0	--	1	0	1	1
EDP	0	0	0	0	1	0	0	0	--	0	1	1
PVB	0	0	0	0	0	0	0	0	0	--	1	1
STP	0	0	0	0	0	0	0	0	1	0	--	1
SAF1	0	0	0	0	0	0	0	0	0	0	0	--

***Figure 9**. POSETS with pairwise comparisons for 12 variables for the top-most nodes in the 1982 and 2017 Lectal Lattices, demonstrating implicational coherence percentages.*

Figure 10 presents the Lectal Lattices from 1982 and 2017 with the implicational coherence percentages displayed for each node. It is interesting to note that all NODES in the 2017 lattice indicate lower levels of coherence than the NODES in the 1982 lattice, demonstrating the pervasive breakdown in the coherence of the Swabian dialect over the last 35 years. In comparing the Implicational Coherence indices with the results from the previous PCA, PC1 yields an R^2 value of .165, while IC shows a R^2 value of .196, demonstrating that the notion of Implicational Coherence does a better job of explaining the variance in the data.

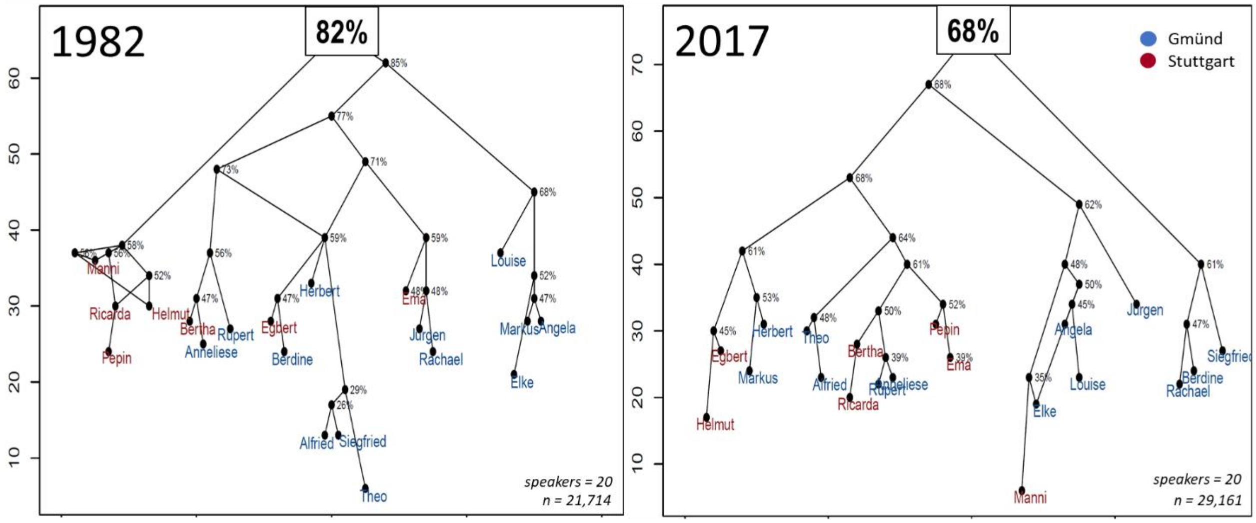

Figure 10. *Lectal Lattices for 20 Swabian Panel speakers in 1982 and in 2017 displaying implicational coherence for each node in the lattice.*

It is worth noting that an implicational scale can be drawn for any POSET using traditional notation to show the patterning of the variables for that lect. For example, the following implicational scale describes the Swabian variety spoken in 1982 (Node 120), both the main pattern and the deviant pattern (see Section 2.3 for a description of the variable labels):

$$\text{AIS1} < \text{SAF5} < \text{ANN} < \text{LEO} < \left\{\begin{matrix} \text{FRV1} \\ \text{FRV3} \end{matrix}\right\} < \left\{\begin{matrix} \text{PVB} \\ \text{IRV1} \end{matrix}\right\} < \text{IRV3} < \text{EDP1};$$

$$\text{AIS1} > \text{SAF5} > \left\{\begin{matrix} \text{ANN} \\ \text{FRV1} \\ \text{FRV3} \end{matrix}\right\} > \text{STP}$$

An example helps to explain the interpretation of this implicational scale: if, for example, a speaker uses the Swabian variant for ANN (Nasalisation of /a/ before /n/), by implication that speaker is also likely to use the Swabian variants to the left in the scale (i.e., SAF5 and AIS1), however not necessarily the variants to the right. Note that the curly brackets denote variables that do not have an implicational relationship with each other (e.g., the two front rounded vowels, FRV1 and FRV3 or PVB and IRV1), rather these groups of variables pattern in the same way. The second row in an implicational scale describes a deviant pattern of variable usage which is valid for some subset of speakers. For these speakers, use of ANN implies use of STP and optionally FRV1 and FRV3 but not necessarily the variants to the left, SAF5 and AIS1 (see Rickford (2001) for further discussion on the interpretation of implicational scales). In short, the Lectal Lattice is based on implicational patterns derived from the ordering between variables, as well as on the frequency of the variables in deriving the order. It addresses several major problems with traditional implicational scaling, most importantly, by not being as strict and thereby allowing for variation in the variable pairings and by factoring in the effect of deviants rather than ignoring them.

Coherence and Language Change

At the core of this research is the question of whether lectal coherence enables or inhibits linguistic change. As previously stated, the main hypothesis of this investigation is that more coherent lects are less vulnerable to change and convergence while less coherent lects are more susceptible to change. To test this hypothesis and validate the new method proposed in this paper, separate Lectal Lattices were built for each community by recording year (see Figure 11). Most notable is the considerably lower level of coherence in Stuttgart (59% and 61%) than in Schwäbisch Gmünd (80% and 77%) for both recording periods. Other research has shown that the extensive dialect levelling occurring in Swabian, is predominately situated in the large urban centre of Stuttgart (Auer 2005; Beaman 2020, 2021). Using Van Hofwegen and Wolfram's (2010) "Dialect Density Measure", a token-based approach that calculates the proportion of dialect variants across all possible variants for the 12 dialect features in this investigation (Beaman 2020, 2021), dialect density has declined considerably more in Stuttgart (from 41.0% in 1982 to 18.2% in 2017, n=16,482) than in Schwäbisch Gmünd (from 54.3% in 1982 to 40.9% in 2017, n=25,220). These findings provide support for the hypothesis that the less coherent dialect of Stuttgart is more susceptible to change than the more coherent dialect of Schwäbisch Gmünd. The supposition underlying this premise is that strong coherence binds linguistic variables together making them more resistant to outside influences (e.g., "change-from-above"), much like the strong social ties in closed social networks resist outside innovation (Milroy 1987).

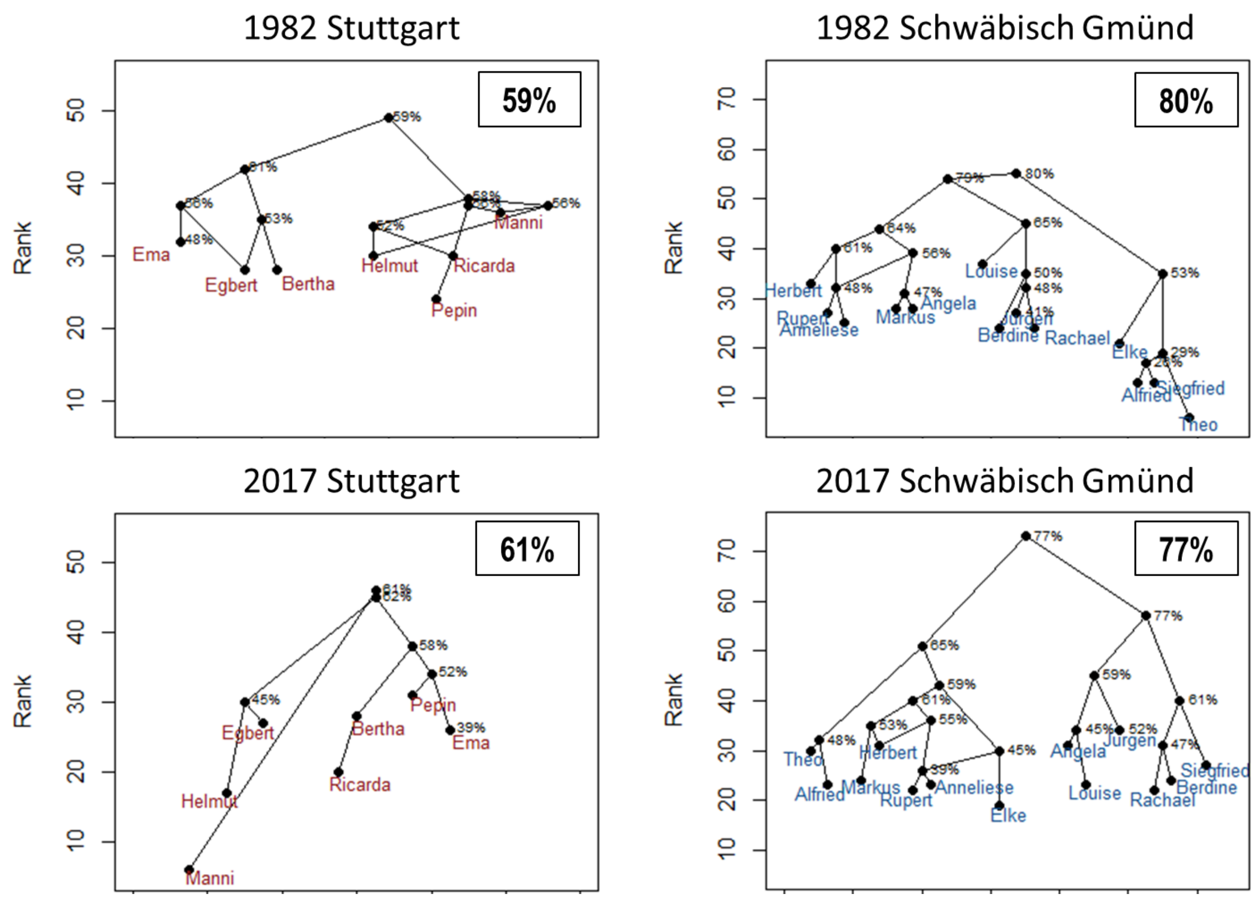

Figure 11. *Individual Lectal Lattices for Stuttgart and Schwäbisch Gmünd in 1982 and in 2017 showing change in implicational coherence in real-time.*

Limitations and Future Opportunities

This paper has presented an exploratory model into a potential new method for measuring, visualising, and comparing coherence across lects; however, it is not without some limitations. Future refinement of the Lectal Lattice should consider the following opportunities:

1. <u>Structure and shape of the graphs:</u> the structure and shape of the Lectal Lattice, particularly with respect to the horizontal axis (based on PC1) is arbitrary. Future

refinement should consider a method for comparing the generated graphs to an MDS (multidimensional scaling) analysis to enhance the structure of the graphs and provide better visualisation of the differences.

2. Proportion of idiolects sharing the same pattern: currently the Lectal Lattice is built from significant patterns that occur in a least one idiolect in the lect, meaning that all pairwise comparisons are treated equally. Future development should take into account the frequency of occurrence of each pattern, i.e., the proportion of speakers with the same pattern, and weight the calculation of rank and implicational coherence based on the number of speakers exhibiting each pattern.
3. Variables with very low or very high token counts: the current implementation does not account for variables with very high or very low token counts. While none of the 12 variables in the current study are skewed in this way, this situation needs to be considered when expanding the Lectal Lattice to other datasets.
4. Positioning of the ellipses depicting similar lects: currently the positioning of the ellipses encircling similar lects is a manual process made by an informed researcher. An expanded implementation of the Lectal Lattice could include additional researcher-defined criteria about the speakers and the variables to assist in identifying and depicting similar lects.
5. Additional intra- and extra-linguistic predictors: the current study has considered only recording year and community as predictors of lectal coherence. Additional social predictors, such as speakers' gender, age, identity and so on, as well as sociolinguistic predictors, such as the stigma/prestige, and other aspects of the variables, such as saliency and dialect variety, can be incorporated into the model to uncover more nuanced aspects of lectal coherence.

6. Additional communities and variables: the current study has tested only two implementations of the Lectal Lattice based on 12 variables and 20 speakers from 35-year panel study (1982 and 2017). Further exploration should consider additional communities, time slices and variables in order to provide a deeper analysis of the relationships and coherence between variables in a lect (see Beaman 2020 for an extension of the Lectal Lattice to an apparent-time study).
7. Larger dataset: a common problem with panel study datasets is the small token count making it difficult to conduct rigorous tests of statistical significance. An opportunity for future research is to test the concept of the Lectal Lattice against larger and more complex datasets to assess its explanatory power and determine its robustness.

4. Conclusion

Early in the variationist paradigm, Fasold (1970) argued that the combination of frequency analysis and implicational scaling leads to more revealing insights than either approach can individually (Fasold 1970:562). Using a new mathematical construct borrowed from LATTICE theory, this paper advances Fasold's claim by exploring a method for combining statistically significant differences in the proportion of dialect use with implicational scaling techniques to measure the levels of coherence in differing lects. The Lectal Lattice introduced in the paper supports the investigation of the relationship between lectal coherence and linguistic variation and change. By measuring levels of implicational coherence between the variables in a lect, the Lectal Lattice provides an approach for predicting which lects may be more susceptible to variation and change and which may be more resistant.

The Lectal Lattice offers several benefits over other methods in identifying unified lects and assessing coherence. First, it provides superior explanatory value over principal components by exposing the significant relationships between variables based on pairwise comparisons. Second, rather than a single linear chain, such as with an implicational scale, the Lectal Lattice is multidimensional, rendering a single visualisation that reveals the logical groupings and hierarchical ordering of similar lects. Third, LATTICE methodology with its variable POSETS proposes an independent statistical method for calculating the level of coherence of different lects. Fourth, the Lectal Lattice offers a method for testing the hypothesis of this investigation that less coherent lects are more vulnerable to change by providing a means to compare the variation in the structural relationships between variables across different lects. Indeed, the findings from this preliminary investigation reveal Stuttgart to be the less coherent lect and hence the one more open to change, which was verified by a steep reduction in dialect density (23%) over the 35-year time-span of this study.

Finally, LATTICE theory supports Weinreich, Labov, and Herzog (1968) that coherence or "orderly heterogeneity" is found in the aggregate grammar of the speech community rather than in the individual, reinforcing the widely-held premise that individuals in a community behave in parallel, reflecting regularity and coherence. As Figures 10 and 11 reveal, coherence across the lifespan of these Swabian speakers has diminished over time. The Swabian of 2017 is less coherent than the Swabian of 1982, particularly in the urban centre of Stuttgart, suggesting that modern Swabian remains highly vulnerable to ongoing change with continued levelling and convergence to standard German the most likely outcome.

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