Is $-s$ a Northernism? Spatial patterns in German speakers' selection of plural endings

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Abstract

This project investigates the spatial distribution of plural morphology in German. Standard German exhibits eight surface plural patterns, typically analysed as four underlying plural endings. Prior dialectological work has claimed that the productive $\{-s\}$ ending is a "Northern" feature. This study tests that claim using data from a completion task administered to 219 native speakers self-reporting affiliation with dialect areas across the German-speaking region. Participants produced plural forms for 33 real and nonce nouns. After cleaning and normalising responses, each speaker was mapped to dialect polygons and assigned to one of the macro-regions: *Low*, *Central*, or *High* German.

Statistical analysis revealed no significant differences ($p > 0.05$) in {-*s*} usage between High, Central, and Low regions. However, spatial autocorrelation using distance-band weights (500km) detected weak but significant clustering (Moran's I=0.25, p=0.02), driven by a low-usage "cold spot" in East-Central dialects and a high-usage cluster in southern areas. A mixed-effects logistic model with random intercepts for speaker and item indicates that variation is more strongly attributable to lexical properties of the items than to regional affiliation.

These findings reject a simple North–South account and suggest that lexical and individual-level variation play a larger role in conditioning {-*s*} pluralisation than macro-regional dialect.

1 Introduction

The German plural system is notoriously complex for second-language learners [17]. Plural formation in a language such as English is relatively straightforward: affix {-*s*} on the end, with some exceptions, with most nouns having one plural form codified in the dictionary. In contrast, Modern Standard German (MSG, the language used in, for example, schools and publications) possesses eight ways to mark the plural (see Table 1) and a long list of exceptions to the ambiguous rules [4]. Many German nouns also have multiple acceptable, competing plural forms. A number of linguistic studies have endeavoured to untangle the mystery of the German plural system, but there is still no broad agreement on how to classify it.

These plural markers are especially intriguing from a spatial perspective: {-*s*} – the most controversial due to its divergent behaviour in comparison to the other plural

	Marker	Example		Marker	Example
1	`-er`	*Kind* → *Kinder*	5	`-e`	*Schuh* → *Schuhe*
2	`-er`+umlaut	*Wald* → *Wälder*	6	`-e`+umlaut	*Kuh* → *Kühe*
3	`-0`	*Fenster* → *Fenster*	7	`-(e)n`	*Straße* → *Straßen*
4	`-0`+umlaut	*Vater* → *Väter*	8	`-s`	*Auto* → *Autos*

Table 1: The eight German plural markers. '`-0`' indicates a zero ending (i.e., no overt ending). {-*s*} is commonly referred to as a feature from northern German. Adapted from [11].

markers [11] – is thought to be a northern feature [5, 3, 12]. If this is the case, we would expect to see a spatial distribution concentrated more in the North and less in the South of the German-speaking area. Yet, no study has mapped plural-s quantitatively across the MSG dialect continuum. This project therefore aims to investigate this claim using a dataset of pluralised nouns produced by 219 native speakers collected by the author in 2018 and linked to dialect polygons. It is hypothesised that:

1. *Speakers with more self-reported northern dialect influence will more frequently affix {-s} to nouns in the dataset.*
2. *Spatial clustering will reveal hotspots of s-affixation in northern dialect areas.*

Statistical testing and spatial autocorrelation (Moran's I – an established measure in dialectometry – and LISA) are conducted to examine the differences in s-affixation between regional areas, contributing the first dialect heatmap of plural-s based on speaker-level data. Beyond documenting language phenomena, such digital linguistic maps also serve to boost the accessibility and comparability of linguistic research. [6, 10]. Understanding how plural-s spreads or clusters geographically contributes to dialectology, language change theory, and has implications for second-language instruction. A clearer understanding of plural-s diffusion will inform L2 textbooks and morphological theory alike.

This paper is organised as follows: Section 2 reviews the visualisation of linguistic features with respect to dialect variation. Section 3 describes the dataset, its collection and its processing. Section 4 presents the results and discusses the findings. Finally, Section 5 reviews the conclusions and offers directions for future research.

2 Background

2.1 Mapping language, dialects and morphology

Linguistic maps serve to situate linguistic data in space, visualising the areal distribution of linguistic features [6, 10]. Lines called 'isoglosses' are used to show where a certain linguistic feature reliably starts appearing and can denote trends in any linguistic phenomenon. Significant numbers of overlapping isoglosses designate groups of speakers with common linguistic habits and are used to define dialect areas [2], making dialect inherently spatially defined. A dialect refers to the systematic usage of certain linguistic features by a group of speakers in a geographical region in relation to a 'standard' language [2, 15]. The distributions of these features are not random and tend to co-occur with certain extralinguistic social features [15]. However, the edges of dialect areas are not rigid and do not denote sharp changes; a feature may be found beyond the boundary of an isogloss. It is therefore important to remember that linguistic maps denoting dialect areas are reflecting salient, general trends in speakers' language use.

2.1.1 German dialects

Regional variation in the German language is not as simple as dividing up the German-speaking area up into its respective countries. The systematic use of language differs greatly between speakers, even within small areas [2]. The modern German language exhibits three strata of variation: (1) supra-regional Standard German across the DACH region, (2) larger regiolect areas, which are made up of (3) super-local *Mundarten* [2, 18]. This third stratum is what is generally meant when referencing dialect in a German context.[1]

Modern German dialects are classified into three regional areas: Upper, Central (together comprising the High German area) and Lower (see Appendix D). Upper dialects lie in the southern German-speaking area across Austria, Switzerland, Bavaria and Baden-Württemberg and include Bavarian (*bairisch*) and Alemannic (*alemannisch*). Central dialects such as Upper Saxon (*sächsisch*) are found across the middle of Germany, including, for example, Saxony and Thüringen. Low German dialects such as Westphalian (*westfälisch*) are found in the North of Germany around Hamburg and Brandenburg.

Two of the most famous isoglosses in the German language are the Benrath and the Speyer lines, which separate the High, Central and Low dialect areas from each other. A key linguistic trend reflected by the Benrath line, which separates High and Low German, is a phonological one (the High German Consonant shift, *Zweite Lautverschiebung*) where $/k/$ shifted to $/x/$ in certain environments. This sound change started in the South and made its way northwards, not making it all the way to the North of the German-speaking area. Low German dialects therefore retain the $/k/$ sound in the pronunciation of words such as *ich/ik* ('I') and *machen/maken* ('to make/do'). Such variation can present in all linguistic domains, from phonology to vocabulary (e.g. 'Butcher': *Fleischer* (East) vs *Metzger* (South) vs *Schlachter* (North) [1]), to morphosyntax (such as noun gender, past tense verb forms or plural endings) [4].

2.1.2 Studying dialects

A number of techniques and approaches exist for investigating language in space. The first German dialect map was made at the turn of the 20th Century by Georg Wenker. The comparison of aggregate data to describe dialects was pioneered by Jean Seguy (1973) and Hans Goebel (1984) [16]. Today, the *Atlas Alltagssprache* project at the University of Marburg[2] runs the *SprachGIS* project to assist linguists with mapping

[1] For a deeper discussion of dialect and diglossia within the German-speaking area, see [2].
[2] https://www.atlas-alltagssprache.de/

their data. The project regularly disseminates a questionnaire to investigate German language phenomena on a small number of individual words or phrases as examples of phenomena of interest, the answers to which are mapped as points at postcode locations. However, they do not employ spatial statistics – this project takes that step further.

One difficulty with investigating dialect is its relatively low prestige compared to standard language, meaning it can be difficult to elicit from speakers without the right context. As long as the elicitation procedure is standardised, thus making the distortion of actual use identical for all informants, we can make generalisations from the data [16]. Questionnaires and interviews are standard elicitation techniques and the results of oral and written elicitation match remarkably well [16], meaning that written data – such as that contained in the dataset employed in this project – can be meaningfully generalised to spoken language. As a field, dialectology is increasingly leaning into spatial statistics and GIS technologies.

2.2 The German plural system

A leading approach considers the MSG plural system through the lens of prosodic morphology, which says that German uses a trochaic syllable (stressed + unstressed foot) to mark the plural category [19, 20]. This paves the way for a number of prosodically predictable alternations, where the language possesses four plural morphemes, {*-s*}*,* {*-n*}*,* {*-r*}*,* {*-0*}, with predictable schwa epenthesis (insertion of the central vowel [ə]) in the case of an unstressed, stem-final full syllable in the singular form. In orthography, this schwa materialises as the letter 'e' before the final plural consonant. We therefore observe four pairs of endings in complementary distribution: *-(e)s, -(e)n, -(e)r, -(e)*. The system is intricately linked with noun gender (e.g., all feminine suffixes combine with $\{-n\}$ in the plural) [11]. Umlaut is a productive process available as an additional suprasegmental feature to signify the plural category. Unfortunately, the dataset employed in this project has too few examples of umlaut to come to any robust conclusions about its spatial distribution, so analysis is constrained to the plural endings only.

{*-s*} is especially curious [11]: Its behaviour diverges noticeably from that of the other three plural endings in that it can be affixed to environments where the others cannot and is not constrained by noun gender. It is also the least frequent yet most productive ending, and is reportedly increasing in popularity. It appears to be applied to what Wunderlich calls "untypical nouns" [21].

It has been posited that {*-s*} as a plural marker entered German via French [13], Dutch or Old Saxon, with its continued frequent use in the present day likely supported by language contact with English [11]. From a dialect perspective, {*-s*} is reportedly more popular with Northern German speakers [7, 3], especially in colloquial language [5], and is coming to replace the zero plural where both forms appear in the *Duden* dictionary [14, 9]. Such *s-0* alternations are present in the dataset employed in this project and present a ripe opportunity for analysis, alongside the nonsense words that take on the role of new words entering the language.

This project investigates whether plural-s is geographically clustered in contemporary German. While this morphological variation is known anecdotally, no spatial statistical analysis has been conducted to test its clustering across dialect areas. This study applies geospatial statistical methods (Moran's I and LISA) to speaker-level elicited data to detect spatial autocorrelation and test whether plural-s shows non-random geographic clustering.

3 Methods

See Appendix A for details on the software and hardware used to conduct this project. All associated code can be found in the GitHub repository.[3]

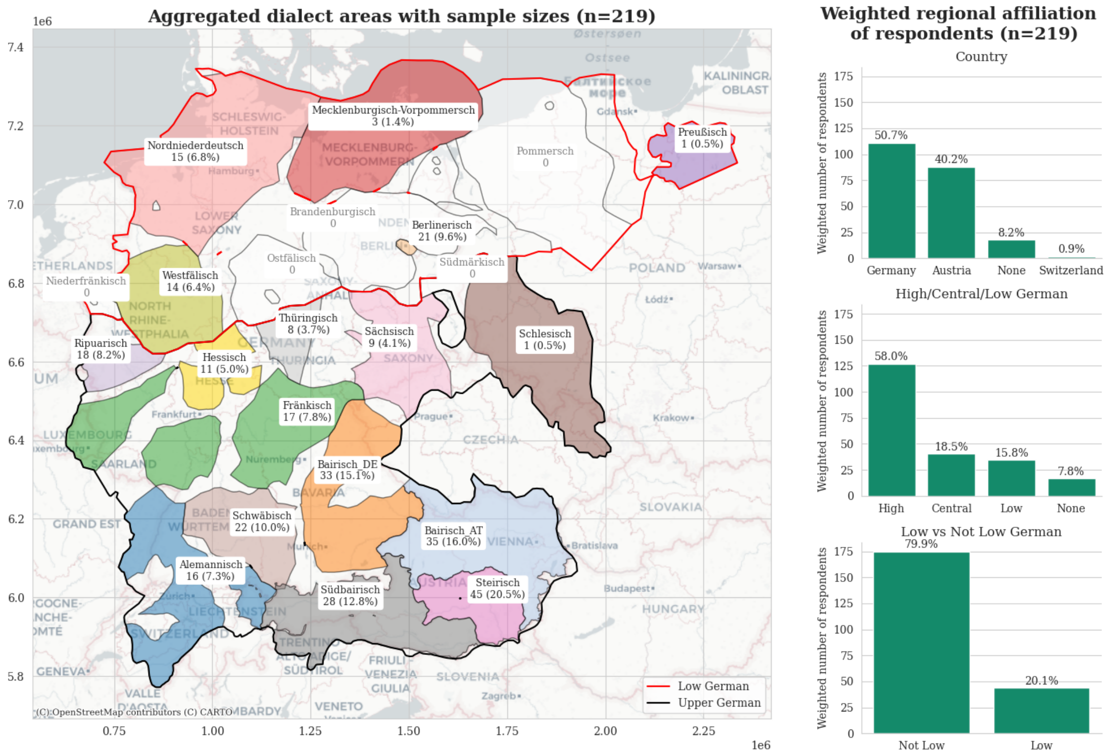

Figure 1: Overview of dialect sample sizes and regional affiliation in the dataset. Each coloured region shows a dialect group labelled with the number and percentage of respondents present in the dataset. White areas indicate regions without responses. Samples are skewed towards the High German area.

3.1 Data acquisition

This private dataset was collected by the author in 2018. 219 native German speakers were recruited via social media platforms and word-of-mouth to conduct a completion

[3] https://github.com/emmammolloy/mapping-german-plurals

task administered via Google Forms. Participation was anonymous and voluntary.[4]

The dataset contains information about the respondents' gender, age, bilingualism status, time spent abroad, and the dialects they believed to have had the main influence on their German. Age, gender, bilingualism status and time spent abroad were were not considered relevant factors for analysis. No respondents were excluded as all reported themselves to be native German speakers. The dataset includes a hand-coded column specifying each individual's regional affiliation, but this was recalculated by mapping responses to regions using a Python script to increase reliability.

Respondents were asked to type out the plural form of 42 nouns, some existing and some nonsense, presented in their singular form in the context of a MSG sentence. The sentences were presented in a random order to avoid priming effects. The tokens belonged to three categories, all balanced in terms of grammatical gender: known $s - 0$ alternations, novel nonsense words with different word-final phonological environments, and fillers. The nine filler words were not included in the analysis because, as expected, they exhibited 96–100% preference for the expected dictionary-codified plural markers and did not show any effects of regional affiliation.

3.2 Data manipulation and transformation

3.2.1 Data cleaning and normalisation

All samples were cleaned and processed. A number of data cleaning steps were taken:

- Column names were translated into English to improve transparency.
- Gender and bilingualism status were converted to binary values.
- Variant spellings and irrelevant comments in the dialect column were normalised or removed to support consistent downstream matching.
- Information about time spent abroad was separated into two columns: duration and location.
- Token responses were cleaned by retaining only the first answer (if multiple were given), removing punctuation and whitespace, and excluding cases with ambiguous typos or where a different word stem had been pluralised (e.g., *Park* vs *Parkanlagen*, 'park facilities').
- Tokens were further normalised by consolidating surface variants by removing umlauts and harmonising spellings so that ending choice could be more easily counted upstream using a rule-based script comparing the singular and normalised plural forms.

[4]Find more details on the questionnaire and the data collection process in [11]. The data was collected as part of the author's Bachelor's thesis, but was not analysed with any statistical or geospatial methods, only percentage proportions of ending choice per token were reported and analysed.

Once the data was processed, the plural ending frequency distributions were calculated and totalled for each respondent. The mean and median proportion of s-affixed tokens was then calculated for each region.

3.2.2 Spatial data and aggregation

Each respondent was classified according to their affiliated dialects. The dialect area *.geojson* data, based on Wiesinger's canonical classification (see Appendix D), was acquired from the REDE SprachGIS project [1]. Dialect transition zones (*Übergangsgebiete*) were excluded from the analysis as their ambiguous boundaries make them unsuitable for spatial aggregation. Since basemaps use the Web Mercator projection ($EPSG:3857$), the coordinate reference systems of all GeoDataFrames were converted to this CRS prior to saving and plotting.

The *geojson* files divide Bavarian into Upper, Central and Lower Bavarian, which broadly corresponds to northern Bavaria, northern Austria and southern Austria respectively, with a large transition zone across central Austria. Because a substantial proportion of respondents reported Austrian dialects, the REDE SprachGIS polygons were supplemented with *.geojson* data for the Austrian federal states, obtained from *SimpleMaps*,[5] as the state boundaries tend to align closely with dialect areas (e.g., *Kärnten* with *Kärntnerisch*, *Burgenland* with *Burgenländisch*). This allowed the Bavarian dialect area to be split into four areas in order reduce sample size variance: Bavarian (Germany), Bavarian (Austria), Styrian (*steirisch*, the largest sample group, n=60), and Southern Bavarian.

Self-reported dialect influences are necessarily subjective and may not precisely reflect actual linguistic usage, but participants' perceived affiliation serves as a practical proxy in the absence of more granular indicators such as postcode data. It also captures socially relevant factors, such as exposure to a parent's dialect, that may not align strictly with residence location

3.2.3 Assigning participants to dialect regions

To enable more granular and statistically robust comparisons, these dialect areas were aggregated at two spatial levels: (1) **Region**: High, Central, Low German; (2) **Dialect**: subdialects present in the REDE SprachGIS files were merged together (e.g., *Höchst-*, *Hoch-* and *Niederalemannisch* → *Alemannisch*) (see Figure 1). Individuals' reported dialects were mapped to these aggregated dialect geometries (e.g., *Hamburgerisch* → *Nordniederdeutsch*). This served both a practical purpose, ensuring alignment with available spatial data, and a statistical one, by increasing the number of observations per group. Merging rarer subdialects into broader aggregates helps avoid sparsity and overfitting in any downstream quantitative analysis, while disaggregating larger groups where there is enough data adds nuance. A power analysis (α=0.05, target power=0.8) showed that groups require n>14 to detect a medium effect (Cohen's d=0.5); ten of the seventeen dialects fall below this threshold, so only large effects can be detected there.

[5] https://simplemaps.com/gis/country/at/

Two slightly ambigious dialects encountered were *Plattdeutsch* and *Bairisch*: *Plattdeutsch*, spoken across the Low German area, was assigned to the *Mecklenburg-Vorpommerisch* group to avoid overrepresentation of the *Nordniederdeutsch* group, which already had 15 samples. *Bairisch* – spoken across Bavaria and Austria – was assumed to refer to German Bavarian, as Austrian speakers were more likely to use more specific, local dialect names, such as *Salzburgerisch*.

Participants who reported no dialect influences (n=18) were classified as having no regional affiliation and were excluded from the analysis to better isolate spatially influenced effects. Participants who reported multiple regional affiliations were excluded at the regional level (final n=202), and those who reported multiple dialect affiliations were excluded at the dialect level (final n=132) to avoid violating the independence assumption and enable a cleaner regional comparison. Although the small sample size would make it preferable to retain as many participants as possible in order to maximise statistical power, weighting participants according to the number of dialects they name would introduce a level of sample dependence.

As can be seen in Figure 1, the dataset is skewed towards High German speakers due to a large number of respondents from Austrian and Bavarian dialect areas. Such imbalances in group size can affect both statistical power and the robustness of cross-group comparisons. Rather than excluding excess samples or applying artificial weighting, these regions were disaggregated into smaller dialect subgroups as described above.

3.3 Statistical analysis

A Shapiro–Wilk test failed to reject the null hypothesis of normality in the distribution of percentage of s-affixation (W=0.99, p=0.19). Levene's test, however, indicated unequal variances across the regional groups (F=9.7, p=0.0001), but not across the aggregated dialect groups (F=1.28, p=0.2). However, many dialect groups ultimately contained fewer than ten speakers. Therefore variance-robust tests were chosen: Low vs. non-Low German, Welch's paired t-test (t=0.28, p = 0.78, df=57); High vs. Central vs. Low German, Kruskal–Wallis test (H=9.7, p=0.008); 17 dialect groups, Kruskal–Wallis (H=21.4, p=0.17).

Global spatial autocorrelation of mean s-affixation proportion per dialect was assessed with Moran's I. Due to the removal of transition zones, polygons are non-contiguous. Therefore, *KNearestNeighbour* (k=1–5) and *DistanceBands* (d=50–600 km) weight matrices were tested to ensure that each dialect group has neighbours. Since *KNN* did not yield a fully connected graph, *DistanceBands* was selected as the optimal contingency. Spatial autocorrelation was tested across thresholds from 50 to 600 km. Local Indicators of Spatial Association (LISA) were then computed to locate the clusters driving the global pattern.

4 Results & Discussion

4.1 Statistical analysis

At the regional level, s-affixation appears fairly uniform across the DACH area (see Figure 2a and b). No region exhibits any statistically significant differences, indicating no meaningful difference in levels of speakers' s-affixation across Low and Not Low areas (n=202, t=0.08, p=0.93, df=57) or High, Central and Low areas (H=0.58, p=0.75).

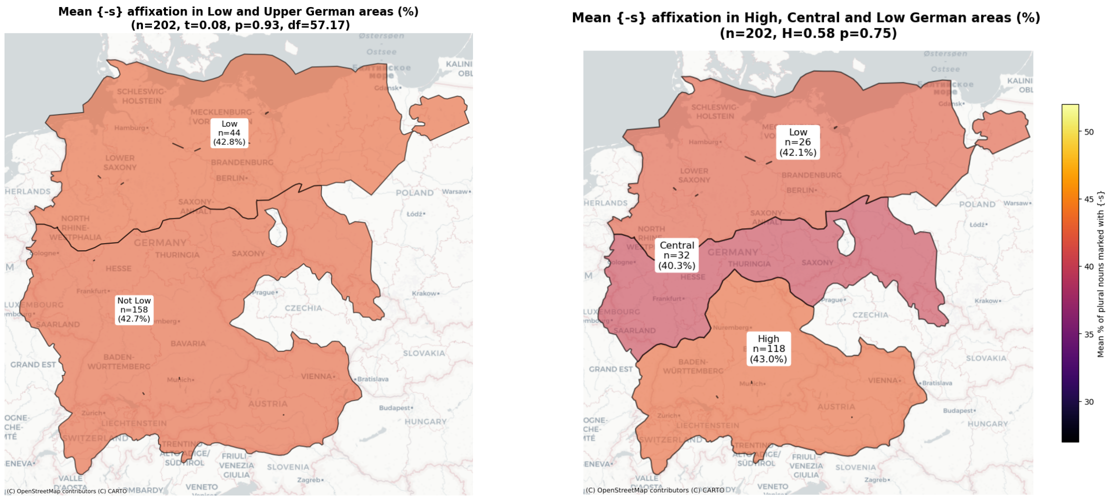

Figure 2: Mean s-affixation at a regional level. There is minimal variation in s-affixation at this spatial level.

A slightly more nuanced picture appears at the aggregated dialect level. Figure 3 shows the mean proportions of s-affixed tokens produced by respondents affiliated with each dialect area. When excluding samples sizes of n=1, the highest levels of s-affixation can be observed in the North West of the DACH area in the *Nordniederdeutsch* dialect area, which is not surprising if {-s} is in fact a Northernism, and, contrary to expectations, in Austrian *Bairisch* (45%). The lowest levels of s-affixation can be seen in central Germany in *Hessisch* and *Sächsisch* (<30%) and *Thüringisch* (38%). Although variation is evident across dialects, differences largely remain close to the overall average (mean=43%, SD=10.5) – and ultimately no significant difference in levels of speakers' s-affixation is detected (n=132, F=1.61, p=0.07).

4.2 Spatial autocorrelation

A threshold of 500km produced the highest significant autocorrelation (I=0.245, p=0.024) while ensuring full connectivity of the spatial weights matrix. Lower thresholds led to disconnected components (islands), while higher thresholds showed diminishing spatial structure. This is a small, positive global spatial correlation, where 0 indicates a random

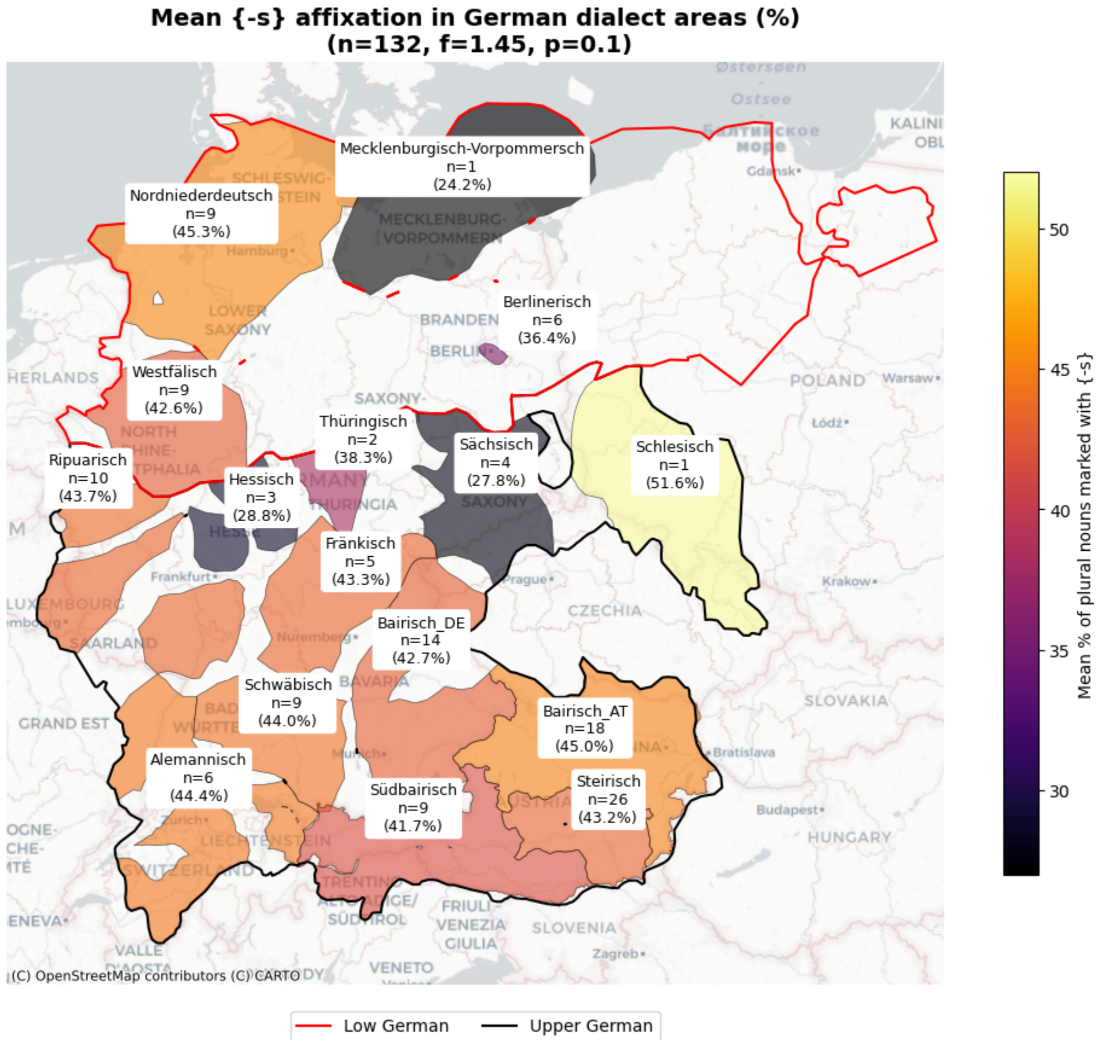

Figure 3: Mean s-affixation by dialect area. No significant difference in s-affixation was detected between any of the various groups, despite some variance in affixation levels.

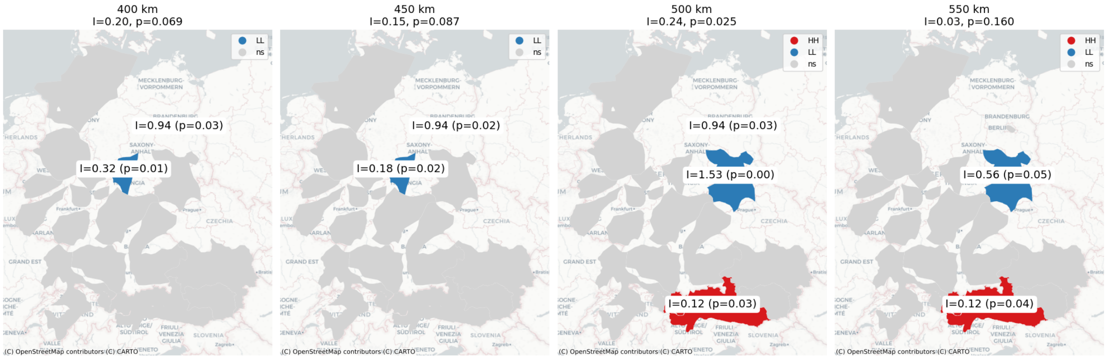

Figure 4: LISA clustering. Local spatial autocorrelation revealed a cold spot in central Germany and a hotspot in the southern part of the DACH region.

spatial pattern and +1 indicates that similar values cluster together more than would be expected under spatial randomness. Visualising the clusters at the local level (see Figure 4) revealed this pattern is driven by two statistically significant clusters:

1. in Central/Eastern Germany – *Berlinerisch*, *Thüringisch*, *Sächsisch* (I=0.32–0.94). This cluster straddles the Central and Low German regions. However, Berlin (above the Benrath line) is sometimes described as a dialect with a Central German substrate, which could explain its clustering with *Thüringisch* and *Sächsich*, which are both part of the *Ostmitteldeutsch* family and were also both part of the former DDR, thus plausibly forming a cohesive dialect area.

2. in the South of the DACH area, although the effect appears small (I=0.12). Klein & Kopf [8] report an increasing amount of s-plurals in the Alemannic dialects specifically, particularly for younger people. As the dataset is skewed towards younger respondents, this could explain the higher levels in this group. This trend warrants further investigation.

These results suggest small areas of differing s-affixation behaviour are present across the DACH region. Wunderlich [21] puts forward an optimality theory constraint-based approach for the existence of such variation, where a number of rules (such as typicality) constrain speakers' output options, and they pick the most optimal to produce. It is unclear, however, which features are involved in the ranking of optimal outputs, but it is plausibly modulated by an individual's unique experiences.

The token "*die Datscha*" (a Russian borrowing meaning 'summerhouse') offers an intriguing window into this theory. Proportionally, 23% of respondents whose dialect influences cover the geographical area of the former GDR prefer the {-*s*} ending, while 47% of the respondents from the former West Germany do so. Conversely, 70% of Eastern German respondents prefer the {-*n*} ending, while only 40% of the respondents from the former West Germany do so. This difference is statistically significant (χ^2=5.22, p=0.02, V=0.16). In contrast, a Welch's t-test comparing all responses from the former East and Former West German dialect areas was not significant (t=-1.85, p=0.06, df=215). This is suggestive of other forces beyond simply dialect determining plural ending assignment. Further inspection of other tokens could yield other interesting results regarding the interaction of token characteristics and how an individual's schemas are influenced by their geographical background – but this is beyond the scope of this project.[6]

These findings do not support Hypothesis 1, which predicted significantly higher levels of s-affixation in the North, nor do they reveal the expected clustering predicted by Hypothesis 2 in the Low German area.

4.3 Limitations

It must be noted that the small sample size limits interpretability and generalisability. With a larger sample size, particularly with more respondents covering the entirety of the Low German region, these trends could be probed further. Considering the relatively small effect sizes, the dataset may be underpowered to detect significant effects. Furthermore, if {-*s*} is common in colloquial northern German dialects [5], it could be that the effect was not visible within the standard language context used in the elicitation process. As mentioned in Section 2, this is a common obstacle when trying to elicit dialect data.

5 Conclusion & Future Work

Contrary to expectations, there is no clear trend in this dataset suggesting that {-*s*} as plural ending is more popular among people affiliated with Northern dialect areas. Instead, we see similar levels throughout the western central and the southern parts of the DACH region, including Alemannic and Bavarian. Whether this is a new and developing phenomenon is unclear. Furthermore, clustering instead revealed a cold spot in the *Ostmitteldeutsch* area and a hotspot in the South. More robust conclusions would require a larger dataset that more comprehensively covers all dialect areas with more balanced representation.

To move beyond the synchronic snapshot provided by this dataset, a similar diachronic analysis using historical corpora could be used to explore how s-affixation trends have changed over time. Authors from the beginning of the 20th Century (e.g. [12]) note clear North–South trends in their analyses: perhaps there is a significant dialect effect further back in time where dialects were more distinct and less affected by Standard German. Further analysis could also be done on specific dialect corpora (e.g., recordings of *Plattdeutsch* speakers) which have had verifiable success at eliciting dialect-coloured language than the standard-language context of the questionnaire used in this study.

In sum, while this study does not support the hypothesis that {-*s*} is a Northernism in present-day German, further research – with larger and more balanced datasets, ideally

[6] A *BinomialBayesMixedGLM* Bayesian logistic mixed-effects model showed that a larger variance was attributable to the tokens themselves (SD=2.24) than to speakers (SD=0.69) or regional affiliation (SD<0.1), suggesting that the variance exhibited is more attributable to characteristics of the tokens themselves, which were constructed so as to differ in terms of phonology and typicality, than to dialect affiliation.

spanning both time and modality – is needed to determine whether this has always been the case, and if not, when and why that shift occurred.

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A Metadata Tables

Table 2: Data metadata

D1: Data licence
Private survey data: "German Plural Endings", collected by the author in 2018 – not redistributable (participants promised anonymity). **Dialect polygons:** REDE SprachGIS — CC BY 4.0. **Austrian state boundaries:** SimpleMaps GIS — CC BY 4.0. **Basemap tiles:** OpenStreetMap © contributors — ODbL 1.0.
D2: Dataset name and properties
Name: German Plural Endings **Creator:** Emma Molloy, collected for BA thesis at University of Cambridge, where the data not analysed with any statistical or geospatial methods, only percentage proportions were reported. **Format:** CSV, 219 rows × 49 columns (7 respondent information, 42 tokens) **Fields:** `speaker_id`, demographics (age, gender, etc.), dialect(s), 33 test token responses, 9 filler responses **Spatial granularity:** Self-reported dialect affiliation (categorical); no GPS coordinates **Temporal coverage:** Spring 2018 **Demographics:** Majority monolingual female aged 19–30; most spent <1 year abroad **Data quality:** Normalised manually; <3% missingness
D3: Additional dataset notes
Representativeness: Skewed toward Austrian and Bavarian dialect speakers (see Fig. 1) **Limitations:** No postcode/GPS precision; subjective self-report of dialect affiliation

Table 3: Software metadata

S1: Current software version
Python 3.12.8, JupyterLab 4.0
S2: GitHub repo
`https://github.com/emmammolloy/mapping-german-plurals`
S3: Legal software licence
None
S4: Computing platform / OS
macOS 15.4.1
S5: Installation requirements / dependencies
All dependencies listed in `environment.yml` in repo
S6: Special software
None
S7: Additional information
None

B Contribution statement

This was an individual project.

C AI tools used

ChatGPT4-o was used for debugging and proofreading, explicitly not for text generation.

D Wiesinger's canonical dialect boundary map

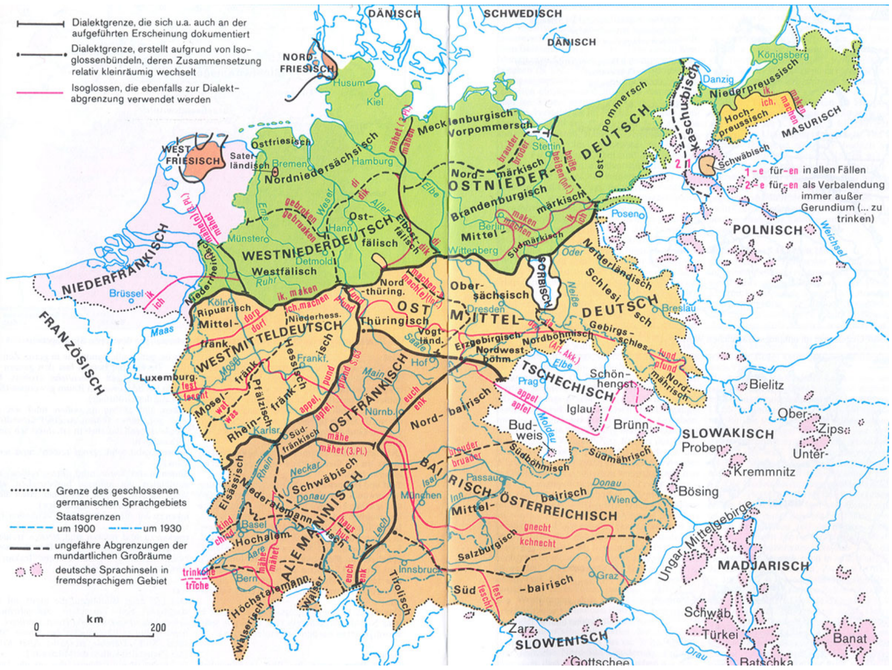

Figure 5: Wiesinger's German dialect map. A number of isoglosses are depicted in red; black lines denote the edge of dialect areas as defined by bundles of isoglosses. Green dialects comprise the Low German dialect area, while orange areas denote High German. Central areas are depicted in light orange.