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What drives non-linguists' hands (or mouse) when drawing mental dialect maps?

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Abstract

In perceptual dialectology, mental mapping is a popular tool used for eliciting attitudes and the spatial imprint of linguistic cognition from non-linguists, through tasking them with drawing about linguistic variations on maps. Despite the popularity of this method, research on the geometrical parameters of the shapes drawn on these maps has been limited. In our study, we utilized 500 mental maps, both digital and hand-drawn, introducing a new digital implementation for mental mapping (source code available). Our contribution presents the first perceptual dialectological outcomes of the 'Swiss German Dialects in Time and Space' project, which recorded a socio-demographically balanced corpus containing a large amount of quantitative personal data about participants that represent the entire Swiss German dialect continuum. Our first research question explores how various sociolinguistic variables and other variables related to personal background influence the geometrical parameters of shapes drawn, such as the number of shapes, their coverage of the language area, and their compactness. Statistical modelling reveals that dialect identity plays the most important role, while educational background, urbanity, and regional differences also affect more parameters. The second research question investigates the comparability between hand-drawn and digital mental maps, showing that they are generally comparable in terms of geometrical aspects, with minor limitations due to specific technical considerations in our digital method.

Keywords: perceptual dialectology, mental dialect maps, geographic information science, sociolinguistics, language attitudes, Swiss German.

1. Introduction

Perceptual dialectology often investigates the cognitive spatial categorization of language variation. Such studies attempt to unravel the spatial dimension of language attitudes, typically involving non-linguists in mapping tasks (Montgomery 2022: 162). Drawing mental maps of perceived language variation, made popular in perceptual dialectology by Preston (e.g. 1989), has been extensively used at smaller (e.g. Hofer 2004; Anders 2010; Stoeckle 2014; Jones 2021; Adam-Graf 2022) and larger spatial scales (e.g. Niedzielski and Preston 2000; Bucholtz et al. 2007; Evans 2013; Eppler and Benedikt 2017; Stoeckle and Schwarz 2019; Vardøy 2021). These studies usually involve the qualitative and aggregate examination of shapes drawn on maps and consider the (metalinguistic) observations assigned to these shapes by the participants, often accompanied by sociolinguistic interviews and perceptual tasks such as ratings of correctness or pleasantness, voice placement, and degree-of-difference tasks (Montgomery and Cramer 2016).

Qualitative research relates perceptions, attitudes, sociodemographic, and (socio-)linguistic data of non-linguists to shapes drawn or samples placed on mental maps. Identity and attitudinal factors playing a role besides geographical factors were demonstrated by Cramer (2010) and Montgomery (2011) in the example of geographically placing voice samples. On Cramer's map, for example, participants tended to separate cities from rural areas in Kentucky (2010: 248), while Montgomery shows that voice samples towards which attitudes are more positive may be placed closer to the own locality. Stoeckle (2014: 567) and Wellig (2017: 34) identified that younger participants attribute less importance to dialectal differences in German. Demirci (2002) and Al-Rojaie (2021) uncovered gendered differences in the perception of Turkish and Arabic, respectively, attributing it to the lower mobility of women. Adam-Graf (2022: 593) showed that the respondents' place of origin and the strength of their local identity do not significantly affect the number of areas elicited.

Quantitative research on shapes drawn includes many studies investigating levels of agreement based on overlaps of shapes (e.g. Stoeckle 2014; Montgomery and Cramer 2016; Eppler and Benedikt 2017; Jones 2021). Lameli, Purschke, and Kehrein (2008: 72–73) and Bounds and Sutherland (2018) studied the alignment of the shapes to the boundaries on the background maps. Calaza Díaz et al. (2015) have offered a method for comparing the positions of shapes drawn. Jones (2021: 39) tested the correspondence between the Regionality Index (Chambers 2000), which measures the extent to which an individual has been exposed to the reference locality where they live, and the number and types of shapes drawn but did not find a significant effect. Beyond their number and relative position, the *geometrical parameters* of these shapes, such as size, complexity, and their coverage of the area of interest, have not been quantitatively analysed, despite the observed variation. Lacking this quantitative analysis, investigation of socio-demographic and (socio)-linguistic data affecting these shape parameters is also largely missing.

As Cramer (2021: 10) argues, the quantitative analysis of shapes would be more accessible if mental maps were in digital formats. Perceptual dialectology has come a long way since the pioneering research with non-linguists mapping or accounting for their linguistic perceptions, aggregated in space using 'little arrows' between linguistically similar neighbours (Rensink 1955, interpreted in Preston 1989: 5), or visualized as 'difference boundaries' (Shibata and Long 1999, originally published by Shibata in 1959, and interpreted in Cramer 2021: 3). After Preston's seminal work on mental mapping (1989), qualitative analysis of pen-and-paper maps proliferated along with the first efforts to digitize these maps (Preston and Howe 1987; Onishi and Long 1997). Later, the introduction of Geographic Information Systems (GIS) tools (e.g. Cramer 2010; Montgomery and Stoeckle 2013) allowed for a georeferenced reproduction and aggregation of shapes. Although researchers have not been concerned whether digital elicitations return subpar results compared to hand-drawn maps in terms of perceptual information gained, and there has been long-standing interest in investigating mental maps in a georeferenced and aggregate manner, few implementations exist that elicit mental maps in a directly digital manner. Despite GIS-based (Sousa et al., 2020), and online solutions (Jones 2015, 2021), the only comparison available between hand-drawn and digital maps about the same area is Jones' (2015: 36) qualitative study.

In this article, we quantitatively address these research gaps through the following research questions:

RQ1. How do socio-demographic, attitudinal, and personality traits influence the geometrical parameters of shapes drawn on dialectal mental maps?

RQ2. Are geometrical parameters of shapes drawn on digitally elicited maps and hand-drawn maps comparable?

We address our research questions using data that corresponds to appeals for studies that elicit the perception of a socio-demographically diverse and balanced sample covering entire language areas (Montgomery 2022: 165), including appeals directed at Swiss German (Christen et al., 2015: 622; Purschke and Stoeckle 2019: 854). We investigate the following geometrical parameters (henceforth referred to as '*map parameters*'): *number of shapes* drawn, the combined coverage of the shapes relative to the whole German-speaking area in Switzerland (referred to as '*coverage*'), and the *compactness* of the shapes. In this manner, besides counting the dialects the participants distinguish, we research the portion of the language area they assign to distinct dialects and the geometrical complexity of the drawn shapes being more circular and vague or detailed and elaborate outlines.

We test the relationship between these map parameters and the following predictors: age cohort, gender, educational background, mode of the interview (virtual or in person), the drawing mode of the map (manual or digital), urbanity, and dialect region of the reference localities which the participants represent, attitudinal factors towards dialect, 'Big Five' personality traits (openness, conscientiousness, extraversion, agreeableness, and neuroticism – Tupes and Christal 1961; McCrae and John 1992), mobility, and social networks. The effects of these variables are tested in generalized multivariate linear models and linear mixed-effects models. Given the presence of both digital and hand-drawn maps within the corpus, this modelling framework assumes a significant role in assessing the comparability of the two drawing modes.

2. Methods

After describing the methodology we used for recording hand-drawn and digital mental maps, and for extracting the map parameters, we explain the predictor variables and the statistical models used for predicting the map parameters. Details about the online mapping interface and the digitization of the hand-drawn maps are available in Supplementary Appendix I. The comprehensive documentation of the statistical modelling along with more details on some predictors can be found in Supplementary Appendix II (https://osf.io/2g8pj).

2.1 The participants and the Swiss German Dialects Across Time and Space survey

Our study includes data from 500 participants of the 'Swiss German Dialects Across Time and Space'

(SDATS) survey (Leemann et al. 2020a). SDATS recorded 1,000 participants in total across 125 reference localities in German-speaking Switzerland,[1] with eight participants recorded in each locality: 4 older (60+ years old) and 4 younger (20–35 years old), with two male and two female participants in both age cohorts. The participants were local, that is, they grew up and lived most of their lives in the reference locality and at least one of their parents came from the region. The linguistic interviews took 2–3 hours in total each, and included the following tasks:

- phonetic, lexical, and morpho-syntactic items via picture and text prompts;
- read speech (Standard German);
- read speech (text the participant previously translated into their dialect);
- imitation task;
- spontaneous conversation with the interviewer; and
- mental mapping task

After the SDATS survey, participants also completed a 300+ item unsupervised questionnaire eliciting a variety of personal information, attitudes and personality traits, among others. The 500 participants in our study constitute a random sample of two older and two younger participants from each reference locality, two females and two males.

2.2 Materials and procedures

2.2.1 *The mental mapping task*

The mental mapping task was the last task in the linguistic interviews, conducted in person or online through videoconferencing (Leemann et al. 2020b). The mapping task itself was performed via an online mapping interface or manually on a printed map, after ascertaining which drawing mode was more convenient for the participant. Table 1 presents the number of participants with regard to interview and drawing modes.

Table 1. Contingency table of the interview and drawing modes in the study.

	Drawn by hand	Drawn digitally	Total
Interview in person	52	43	95 (19.38%)
Virtual interview	60	335	395 (80.6%)
Total	112 (22.85%)	378 (77.14%)	490

Due to the interview mode switch from in-person to digital during the COVID-19 pandemic in 2020 (Leemann et al. 2020b), to the fact that the online mapping interface was deployed only months after the switch, and to technical difficulties a number of participants experienced, every combination of in person/virtual interviews and hand-drawn/digital mental maps occurs.

After a short introduction to the mental mapping task, the interviewer gave the participant the following instructions (translated from German):

> Task 1: Please circle the area where people speak roughly the same way as you do.
> Task 2: Please circle other dialect areas that you know. Number them consecutively. There is no right or wrong way to do this.

Importantly, despite the instruction asking to 'circle' dialect areas, interviewers instructed participants most of the time to 'draw' on the map. Beyond the instructions, the task was open-ended, and the interviewers ($n = 18$) put as little further bias on the participant as possible, but they provided technical or geographical help verbally when it was necessary. The mapping task took about 5–20 min to complete and the entire task was also audio-recorded. In some cases during digital mapping, participants asked the interviewer or a helper who was present in their homes to draw instead of them. These maps ($n = 10$) were not considered in the statistical models.

2.2.2 *Hand-drawn and digital maps*

The same monochrome background map (see Fig. 1), created in `Mapbox`,[2] was used in both mapping modes. The map contains topographic relief, the national borders, the largest rivers, and lakes. The cantonal borders were deliberately omitted because they were shown to have a major influence on the drawing behaviour (Stoeckle and Schwarz 2019; Schiesser 2020: 152). Shapes on hand-drawn maps were drawn using an orange felt marker, except for the 'home dialect area', for which a red ballpoint pen was used, for more precision (see Fig. 2). The online mapping interface (source code available)[3] was built using `FreeDraw` (Timberlake 2020), based on `Leaflet`.[4] The cutout in Fig. 1 was used in print for interviews in person, and it was displayed in the online implementation with a frame (see Fig. 3). Supplementary Appendix I explains the capabilities of the online interface in detail. Due to the rapid development of the interface during the coronavirus (COVID-19) pandemic, not all potential problems could be debugged but the user experience of the online interface was uniform for each participant.

2.2.3 *Extraction of the map parameters*

The shapes drawn using the online interface were instantly saved in `geojson` files, while the shapes on hand-drawn maps were manually digitized (see Fig. 4) in `QGIS` (QGIS.org 2022), using generic tools and the `beePen` plugin (Alberti 2021), also resulting in

Figure 1. The map cutout used for the mental mapping task in both mapping modes.

geojson files. The digitization process is detailed in Supplementary Appendix I.

The three map parameters (*number of shapes*, *coverage of the German-speaking areas*—see Fig. 5, and *compactness of the shapes*—see Table 2) were calculated in R (R Core Team 2022), using the geojsonio (Chamberlain and Teucher 2022), the spatialEco (Evans 2021), the rgeos (Bivand and Rundel 2021), and the cleangeo packages (Blondel 2022), based on the geojson files resulting from the digital mapping and the digitization process. More details and the source code of the map parameter calculation are available in Supplementary Appendix II (Section 3.1).

Numerous measures of shape complexity or compactness exist (e.g. Schwartzberg 1965; Brinkhoff et al. 1995; Li, Goodchild, and Church, 2013). In this study, the *Polsby–Popper score* (Polsby and Popper 1991) was used, which is the ratio of the area of a polygon (A_p) to the area of a circle whose circumference is equal to the perimeter of the polygon (L_p). The *Polsby–Popper score* of a polygon ranges from 0 to 1, where scores closer to 0 indicate that the polygon is spiky, and scores closer to 1 indicate a more compact, circular polygon, in line with the instructions of the drawing task. For this study, the scores were inverted, thus C_p (*compactness)* values closer to 0 mean more compact, and values closer to 1 mean more complex polygons.

2.3 Statistics

2.3.1 *Predictor variables*

Socio-demographic variables often related to variation in linguistic cognition (age, gender, and educational background) were tested as predictors of the map parameters (see Table 3). Indices measuring linguistic mobility and social networks' dialectal diversity were included in the models to account for the effects of social contexts. Researchers have been interested in the spatial variation of non-linguists' linguistic perceptions, including differences with regards to regionality (e.g. Stoeckle 2014) and urbanity (e.g. Evans 2016:1). In this study, regional differences were tested by categorizing the reference localities into dialect areas adopted from Scherrer's (2021) hierarchical clustering

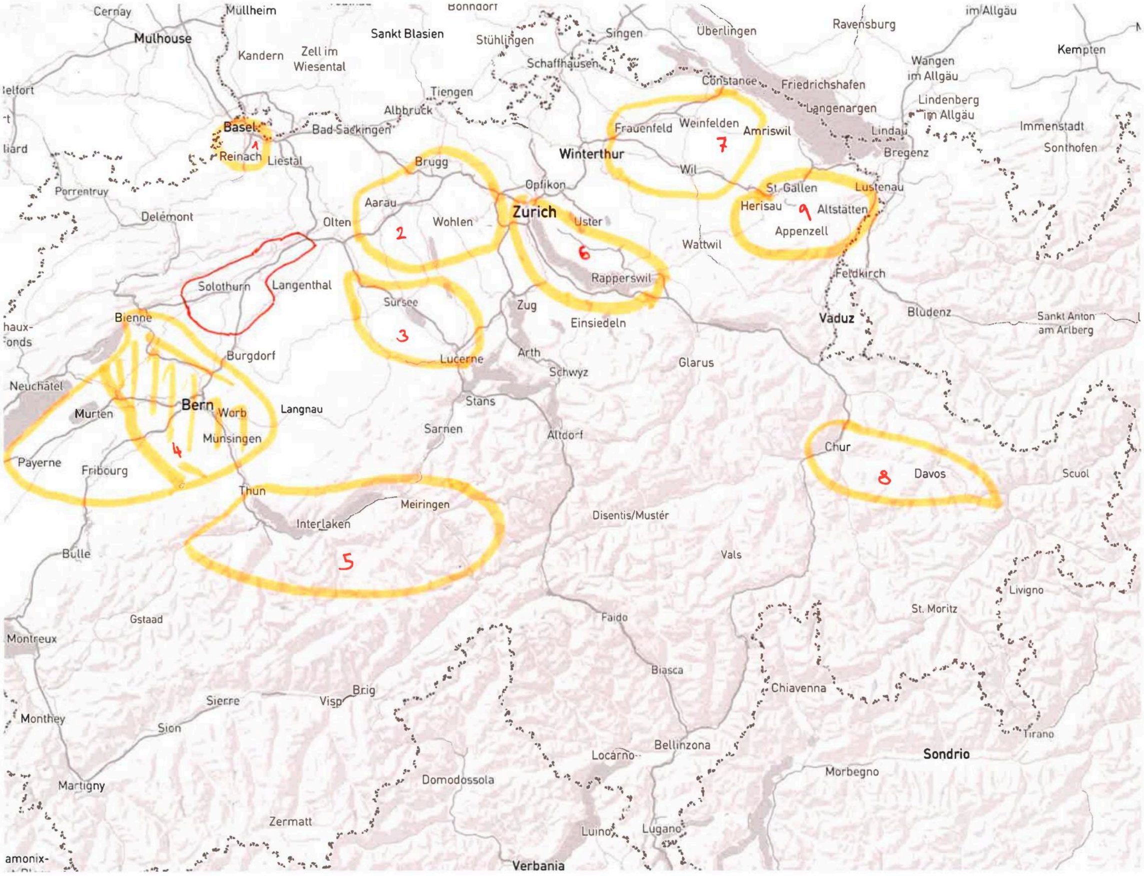

Figure 2. Scan of a hand-drawn map.

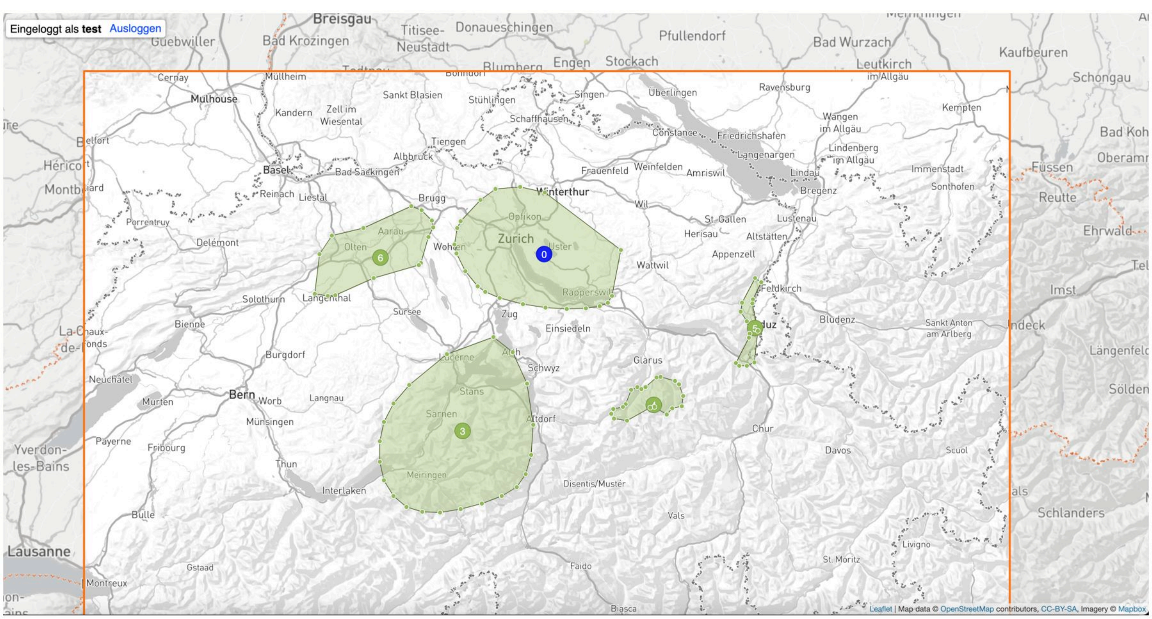

Figure 3. A screenshot of the online interface in a browser.

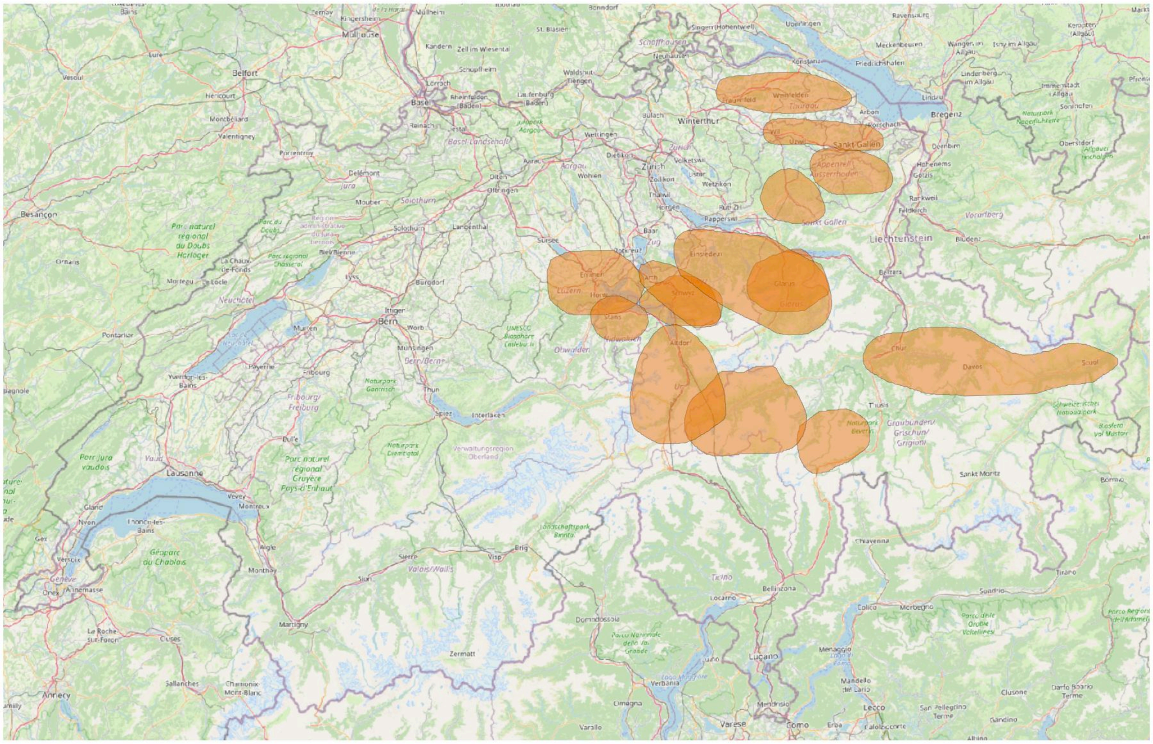

Figure 4. Example of hand-drawn shapes digitized in QGIS.

of Swiss German dialects, which was based on data from the linguistic atlases SDS (Sprachatlas der deutschen Schweiz – Hotzenköcherle et al., 1962–2003) and SADS (Glaser 2021). In addition, the reference localities were categorized, based on federal statistical data (FSO 2020) and the authors' perception, into central cities ('urban'), their agglomerations ('agglomeration'), rural hubs of importance ('local centre'), and villages with few urban traits ('rural') (see Fig. 7). Attitude and personality variables were extracted from the SDATS questionnaire data using factor analysis. Regarding attitudes, participants' stance on statements (Table 4) was recorded on 7-point Likert scales, and condensed into factors using exploratory factor analysis (EFA). The factors emerging from EFA overlapped with theoretical groupings and were named 'personal dialect use and accommodation effects' (Att_{pers}), 'dialect identity' (Att_{id}), 'perceived past and future dialect change in Swiss German' (Att_{change}), and 'attitudes towards Standard German' (Att_{sg}). Regarding personality traits, the 'Big Five' personality traits (Tupes and Christal 1961; McCrae and John 1992), recorded via standardized German questions (Satow 2012), were extracted using confirmatory factor analysis. The underlying questionnaire items are available in Supplementary Appendix II (Section 2.1).

2.3.2 *Statistical analyses*

Some factors may not only affect dialect perception per se but also the way participants handle the task. In our models, we predict effects on map parameters separately while controlling for all predictor variables from Table 3. For predicting the *number of shapes* and *coverage* value, multivariate linear models were implemented. For predicting *compactness*, a linear mixed-effects model was implemented, using the `nlme` package (Pinhiero and Bates 2022) to handle shapes with outlying *compactness* values. This way we predict the *compactness* of single shapes rather than the average *compactness* of all shapes drawn by each participant. We entered all variables in Table 3 as fixed effects in the models. For the mixed-effect models, random intercepts were entered for 'participant'. Collinearity was tested for all models by calculating the generalized variance-inflation factors (GVIFs), using the `car` package (Fox and Weisberg 2019). Slight collinearities were found for Region only, due to the fact that the categories of urbanity are inhomogeneously distributed across Regions. In addition, we ran models with added interaction terms with possible combinations of variables that were significant in model results. For more details of the modelling, refer to Supplementary Appendix II (Section 3).

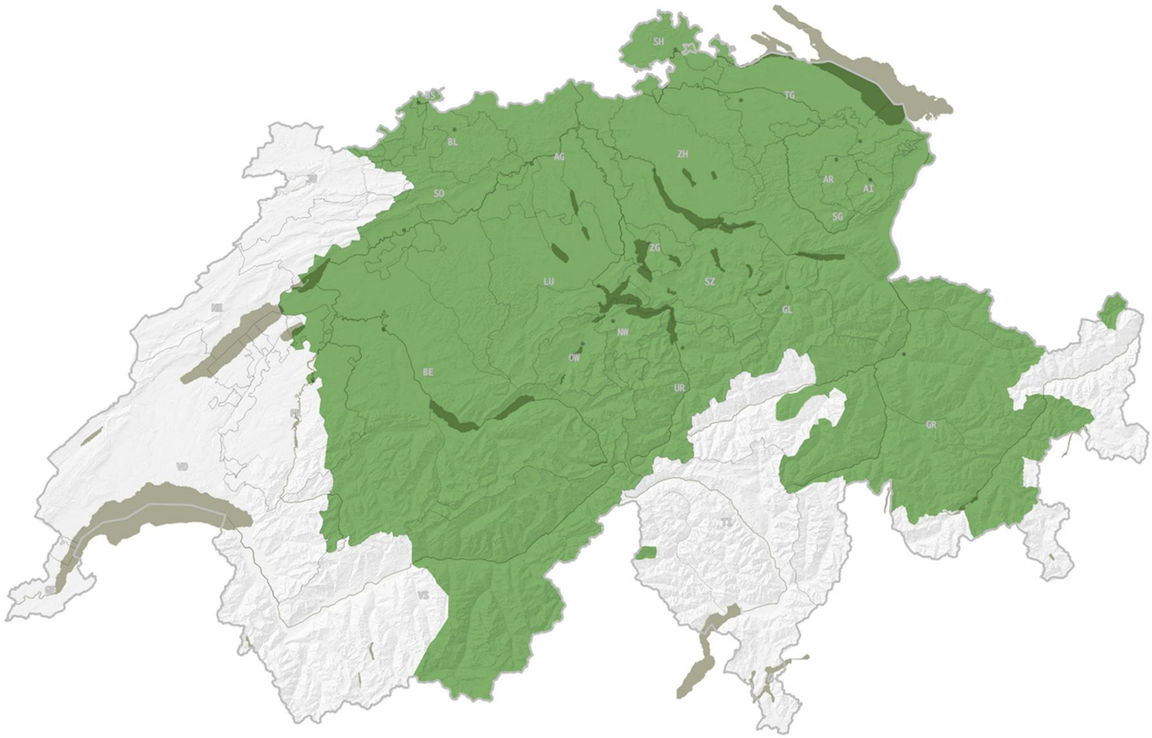

Figure 5. The polygon (in green), representing the German-speaking areas of Switzerland, used for testing the combined coverage of the shapes drawn.

Table 2. Extraction of the map parameters.

Parameter	Method of extraction	Range	Mean	SD
Number of shapes	Count of polygons in participant's geojson file	1–48	15.85	6.49
Coverage of the German-speaking area	$\frac{Area\ of\ union\ of\ shapes\ drawn}{German-speaking\ area\ of\ Switzerland}$	0– 100%	47.75%	22.54%
Compactness of the shape	Based on the Polsby-Popper score of a shape: $C_p = -\left(4\pi * \frac{A_p}{L_p^2}\right)$ where A_p = area of the polygon, and L_p = length of the polygon's perimeter. We invert the Polsby–Popper scores for this study.	0–1 (see Fig. 6)	0.3337	0.1723

3. Results

In this section, we present the results of the statistical models that are statistically significant and summarize our findings. The table in Fig. 8 summarizes the model results with effect plots for all factors that significantly affect map parameters. For numerical model outputs, see Supplementary Appendix II (Section 3.2).

3.1 Number of shapes

Participants drew, on average, 15.85 shapes ($SD = 6.44$). Educational background is the strongest predictor of the *number of shapes* drawn, followed by regionality, urbanity, and dialect identity (Att_{id}). Regarding educational background, compared to *Edu1* (secondary vocational baccalaureate), those with *Edu4* background (university or college degree) draw 4.3 more shapes on average ($SE = 0.773$, $t = 5.563$, $P < .001$). In terms of urbanity, compared to urban participants (predicted $M = 14.23$, 95% CI 12.69–15.78), rural participants and participants from agglomerations draw more shapes on average ($M = 16.71$, 95% CI 15.81–17.60, and $M = 16.04$, 95% CI 14.69–17.39). Regional differences are present, for example, with participants from the 'East'

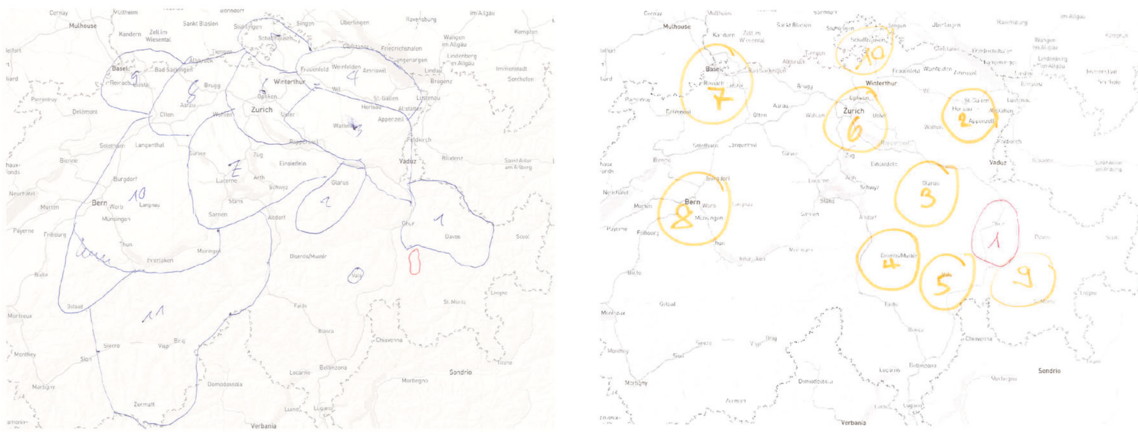

Figure 6. Two hand-drawn maps illustrating shapes that are more complex (left, $\bar{C_p} = 0.3539$) and more compact (right, $\bar{C_p} = 0.085$) on average.

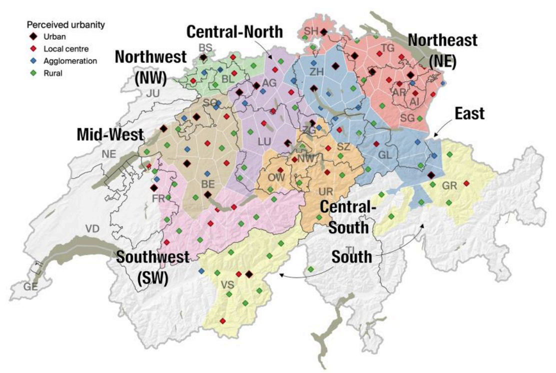

Figure 7. Spatial variables used in the study. The 125 SDATS reference localities are shown according to their level of urbanity. The Region variable is demarcated using qualitative colours.

($M = 17.35$, 95% CI 15.88–18.81), the 'Central-North' ($M = 16.61$, 95% CI 15.01–18.2), and the 'Northeast' ($M = 16.43$, 95% CI 15.03–17.84), drawing significantly more shapes than those from the 'Northwest' ($M = 13.75$, 95% CI 11.54–15.96). As for the attitudinal factors and personality traits, higher scores for Att_{id} and openness mean more shapes drawn ($\beta = 0.864$, $SE = 0.342$, $t = 2.524$, $P = .012$, and $\beta = 1.553$, $SE = 0.698$, $t = 2.225$, $P = .027$), while a higher conscientiousness score means less shapes drawn ($\beta = -1.536$, $SE = 0.76$, $t = -2.021$, $P = .044$). In addition, in some models interaction terms reach significance, for example, when Att_{id} and Region are involved. Map drawing mode or interview mode does not significantly affect the *number of shapes* drawn.

3.2 Coverage

Participants covered 47.75 per cent of the German-speaking area on average ($SD = 22.55$ per cent). The age cohort is the strongest predictor of *coverage*. The younger cohort covers more of German-speaking Switzerland, on average, than the older cohort ($\beta = 17.99$ per cent,[5] $SE = 2.5$ per cent, $t = 7.188$, $P < .001$). Regarding educational background, participants in *Edu4* cover significantly more area than those in *Edu1* ($\beta = 9.67$ per cent, $SE = 2.64$ per cent, $t = 3.67$, $P < .001$). Two language attitude factors show a significant effect. Higher Att_{id} values indicate higher *coverage* ($\beta = 0.026$, $SE = 0.012$, $t = 2.226$, $P = .026$), while higher values representing consciousness about personal dialect use and accommodation effects (Att_{pers}) indicate lower *coverage* ($\beta = -0.017$, $SE = 0.008$, $t = -1.992$, $P = .047$). Effects, though above the significance threshold ($.1 > P > .05$), are present with regard to regionality and conscientiousness (the more conscientious a participant is, the less area they covered).

While the interview mode does not significantly affect map coverage, the map drawing mode does have a significant effect: on average, participants with unknown digital drawing mode cover less area than those drawing by mouse or by hand ($\beta = -8.94$ per cent, $SE = 3.56$ per cent, $t = 2.51$, $P = .012$, and $\beta = -7.97$ per cent, $SE = 4.01$ per cent, $t = 1.987$, $P = .048$). However, the difference among known drawing modes is not significant ($F = 0.811$, $P = .445$).

3.3 Compactness

The average *compactness* of the shapes drawn is $\bar{C_p} = 0.334$ ($SD = 0.172$). Mapping mode is the factor with the highest impact on this parameter. By hand, participants draw more compact shapes, on average ($\bar{C_p} = 0.292$, 95% CI 0.276–0.309), than by any digital mode (by mouse: $\bar{C_p} = 0.346$, 95% CI 0.335–0.357, by touchpad: $\bar{C_p} = 0.327$, 95% CI 0.313–0.341). Importantly, those with unknown digital drawing mode draw the most complex shapes

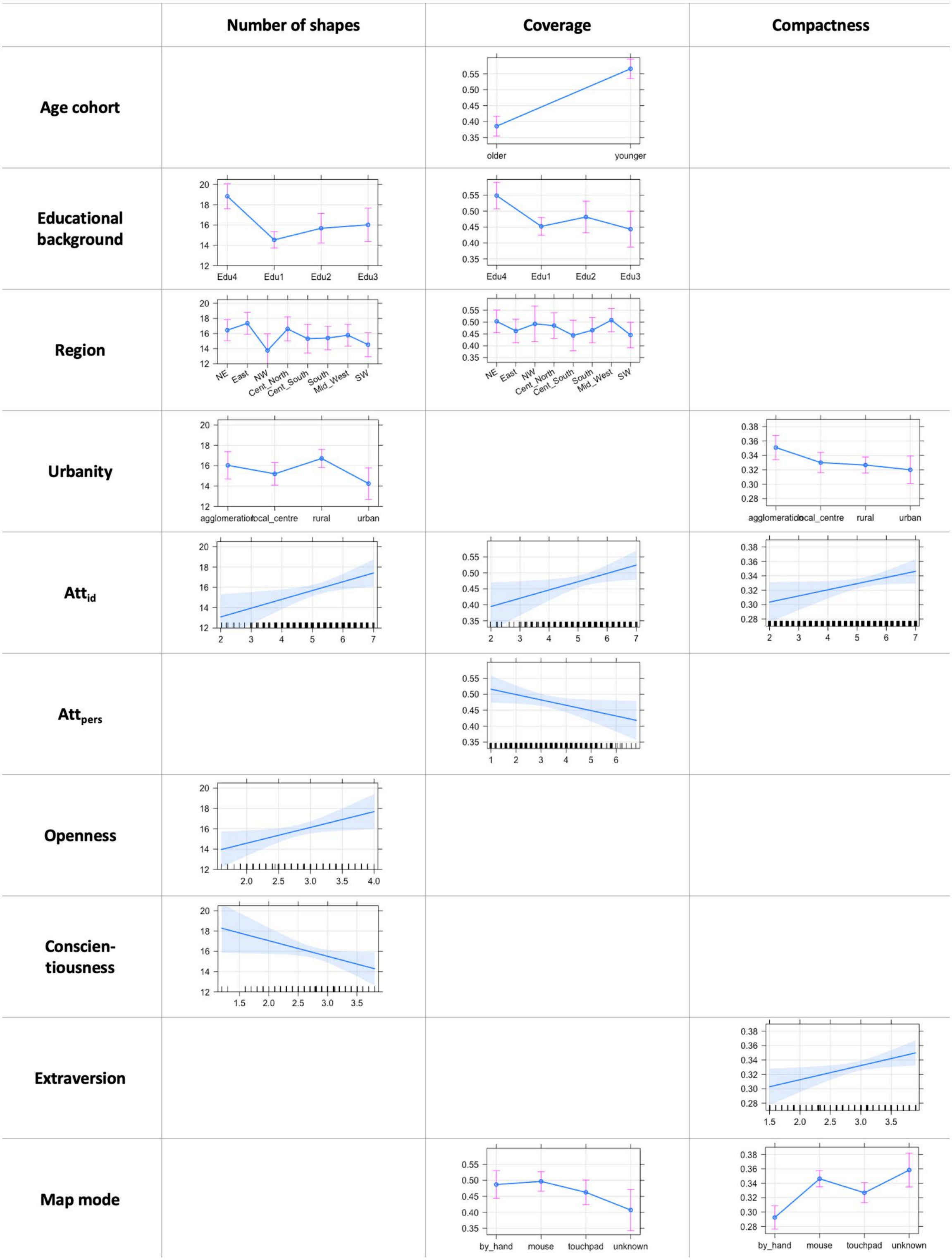

Figure 8. Predictors with significant effects on map parameters, presented as effect plots.

Table 3. The predictor variables used for modelling the map parameters

Sociodemographic variables, contacts, and mobility	
Age	Young (20–35 years old, $n=250$)
	Old (60 years or older, $n=240$)
Gender	Female ($n=246$)
	Male ($n=244$)
Educational Background[a]	'*Edu1*': Secondary vocational baccalaureate ($n=244$)
	'*Edu2*': Secondary vocational education ($n=80$)
	'*Edu3*': Tertiary vocational education ($n=57$)
	'*Edu4*': University or college degree ($n=109$)
Social Network Index (*SNI*)	Index based on the participant's three closest contact persons (Steiner et al. 2023)
Linguistic Mobility Index (*LMI*)	Index of exposure to other dialects throughout the participant's life due to long-term mobility (Jeszenszky, Steiner and Leemann, accepted)
Spatial variables	
Urbanity	Rural ($n=54$)
	Local centre ($n=31$)
	Agglomeration ($n=22$)
	Urban ($n=18$)
Region	Dialect regions ($n=8$, see Fig. 7), based on clustering (Scherrer 2021)[b]
Language attitudes (also see Table 4)	
Attid	Factor based on 5 questions, 7-point Likert-scale
Attpers	Factor based on 5 questions, 7-point Likert-scale
Attsg	Factor based on 3 questions, 7-point Likert-scale
Attchange	Factor based on 4 questions, 7-point Likert-scale
Personality traits	
Openness	Scores (range 1–5) based on standardized questionnaire (Satow 2012)
Conscientiousness	
Extraversion	
Agreeableness	
Neuroticism	
Mapping and Interview method	
Interview mode	In person ($n=95$)
	Virtual ($n=395$)
Map drawing mode	By hand ($n=112$)
	Digitally:
	By mouse ($n=207$)
	By touchpad ($n=127$)
	Unknown ($n=44$)

[a] Categories set based on https://www.sbfi.admin.ch/sbfi/en/home/education/swiss-education-area/swiss-education-system.html
[b] dialektkarten.ch

($\bar{C}_p=0.358$, 95% CI 0.335–0.382). The difference between drawing by mouse and by touchpad is also significant ($F=16.41$, $P<.001$). Urbanity becomes a significant predictor, with urban dwellers drawing more compact shapes than those from agglomerations ($\beta=0.031$, $SE=0.013$, $t=2.411$, $P=.0163$). Moreover, participants with lower Att_{id} and lower extraversion scores draw more compact shapes ($\beta=0.009$, $SE=0.004$, $t=1.99$, $P=.047$, and $\beta=0.02$, $SE=0.009$, $t=2.296$, $P=.022$). Interaction terms entered in additional models only reach near-significant effects ($.1>P>.05$).

4. Discussion

In this section, we discuss the effects of sociolinguistic variables on the geometrical parameters of shapes drawn on mental maps of dialect areas, addressing RQ1. Then we discuss drawing and interview mode with regard to RQ2, focusing on whether digitally elicited maps are comparable to hand-drawn maps. We conclude by elucidating the limitations of the study and future research prospects.

Regarding RQ1, focused on socio-demographic, attitudinal, and personality traits influencing the map parameters, we have seen a number of explanatory variables with significant effects. In the following, we offer explanations for the effects of these variables in the order they appear in Table 3. Age only affects the *coverage* parameter, with the younger cohort covering more of German-speaking Switzerland, in line with the qualitative findings of Stoeckle (2014: 567) and Wellig (2017: 34). Having less life experience and having grown up with more 'levelled' dialects (Christen 1998) than the older cohort, younger

Table 4. The attitude variables and the questionnaire items (in English and original German) based on which they were calculated using factor analysis.

Attpers — Personal dialect use and accommodation effects	
When I speak to people from another dialect area, I make sure to avoid certain words or phrases.	*Wenn ich mit Leuten aus einem anderen Dialektgebiet spreche, achte ich darauf, gewisse Wörter oder Wendungen zu vermeiden.*
(-) I always speak the same way, regardless of whether my counterpart speaks a similar dialect or not.	*(-) Ich rede immer gleich, egal ob mein Gegenüber einen ähnlichen Dialekt spricht oder nicht.*
When I speak to strangers from other dialect regions, I pay attention to my choice of words.	*Wenn ich mit fremden Leuten aus anderen Dialektregionen spreche, achte ich auf meine Wortwahl.*
I often find myself using words and phrases that are not actually said that way in my dialect.	*Ich ertappe mich oft, wie ich Wörter und Wendungen brauche, die man in meinem Dialekt eigentlich nicht so sagt.*
When I speak to people from another dialect area, I adapt.	*Wenn ich mit Leuten aus einem anderen Dialektgebiet spreche, passe ich mich an.*
Attid — Dialect identity	
I am proud to be a resident of the place where I live.	*Ich bin stolz, ein/e Bewohner/in meines Wohnortes zu sein.*
I think it's nice when people from other regions notice which dialect I speak.	*Ich finde es schön, wenn Leute aus anderen Regionen merken, welchen Dialekt ich spreche.*
I think it's a pity when young people no longer know many dialect words and phrases.	*Ich finde es schade, wenn junge Leute viele Dialektwörter und -wendungen nicht mehr kennen.*
I think it's a pity when an acquaintance moves to another region and after a few years no longer speaks our dialect.	*Ich finde es schade, wenn ein Bekannter in eine andere Region zieht und nach wenigen Jahren schon nicht mehr unseren Dialekt spricht.*
(-) Dialects change, that doesn't bother me.	*(-) Dialekte verändern sich halt, das stört mich nicht.*
Attsg — Attitude towards Standard German	
(-) High German is a foreign language for me.	*(-) Hochdeutsch ist für mich eine Fremdsprache.*
I like to speak High German.	*Ich spreche gerne Hochdeutsch.*
When I speak High German, I feel comfortable.	*Wenn ich Hochdeutsch spreche, fühle ich mich wohl.*
Attchange — Perceived past and future dialect change in Swiss German	
I think Swiss German dialects have changed a lot in the last 50 years.	*Ich finde, schweizerdeutsche Dialekte haben sich in den letzten 50 Jahren stark verändert.*
I'm afraid that in 50 years we German-speaking Swiss will all speak almost the same.	*Ich befürchte, dass wir Deutschschweizer in 50 Jahren alle fast gleich sprechen.*
I think Swiss German dialects will change a lot in the future.	*Ich denke, schweizerdeutsche Dialekte werden sich in Zukunft stark verändern.*
I think young people speak very differently from old people.	*Ich finde, junge Leute sprechen ganz anders als alte.*

Statements with a negative sign affect are considered for the variable with a reversed score.

participants may perceive less regional diversity, thus they may be less inhibited in categorizing more areas on the map. Audio records often show that older participants preferred to be certain about dialect areas before drawing them, which is corroborated by higher conscientiousness ($F = 20.95$, $P < .001$) and lower extraversion score ($F = 7.02$, $P = .008$) in the older cohort. The difference could also be related to tiredness ensuing more often in the older cohort after having already spent 1.5–2 h in the linguistic interviews.

Educational background has an effect on the *number of shapes* and their *coverage*. Participants with university or college degrees (*Edu4*) draw more and cover more than those with a secondary vocational baccalaureate (*Edu1*). This may also be due to the more frequent requirement to show one's theoretical knowledge faced by people with higher educational backgrounds. Likewise, higher education and associated occupations and mobility (Schiesser 2020: 109; FSO 2021) might allow *Edu4* participants to have a more extensive knowledge of dialects, through having a higher chance to encounter people from various parts of the country.

Similarly to most previous studies (see, however, Demirci 2002 and Al-Rojaie 2021), gender did not show a significant effect. The social network index (*SNI*) and the linguistic mobility index (*LMI*) showed no significant effect here, contrary to previous studies confirming the influence of social networks (Stoeckle 2014) and mobility (Clopper and Pisoni 2006; Wellig 2017; Fiechter 2022). However, *SNI* and *LMI* are not intended to capture physical mobility and only include information about a limited number of social contacts.

Urbanity has an effect on the *number of shapes* and *compactness*. The urbanity categories are heterogeneous in terms of educational background, attitudinal and personality traits (for statistical calculations, see Supplementary Appendix II—Section 3.3), and affordance of mobility. Agglomeration dwellers draw a greater number and more complex shapes, while their urban counterparts draw fewer, larger, and more vague shapes, which we may attribute to mobility patterns. Agglomeration dwellers may commute more (FSO 2021: 2) and engage in mundane mobility in the city and countryside alike, consequently being more primed for noticing dialectal differences. Simultaneously, urban dwellers may visit the agglomeration and the surrounding countryside less often than their agglomeration counterparts do (FSO 2021: 2), which may prompt a less diversified linguistic knowledge of their surroundings. Intertwined with the mobility patterns, agglomeration dwellers may have a stronger need to identify themselves in space and to differentiate themselves (Schiesser 2020: 4) from cities, especially within the converging dialectal variation (Christen 1998) which characterizes Switzerland.

Regions only mean a significant difference in the *number of shapes*. Regions cluster together SDATS reference localities based on dialectal similarity. They exhibit heterogeneity across urbanity, educational background, linguistic attitudes, and personality traits, as verified through the tests presented in Supplementary Appendix II (Section 3.3). Similarly, Ebert et al. (2022) and Militaru et al. (2024) also found regional differences in psychological characteristics including the Big Five personality traits. Since Regions are slightly collinear to these variables, we attribute regional differences to the co-varying traits. The specific regional differences in the Swiss-German dialect area are, in these regards, beyond the methodological scope of this article and we leave a more differentiated regional analysis open for future research, which may involve aggregate GIS analysis (e.g. Montgomery and Stoeckle 2013), with shapes analysed based on (e.g. spatial) subsets of participants (e.g. Adam-Graf 2022).

Among attitudinal factors, the importance of dialect identity (Att_{id}) is evident from significantly affecting all three map parameters, in line with perceptual dialectology's focus on the spatial imprint of linguistic identities and attitudes (e.g. Cramer 2010; Preston 2016). Through these effects, a connection seems to unfold between the identification with one's own dialect and the detailed perception of dialectal variation which has to date not been quantitatively researched. This detailed perception, on average, leads to a larger number of shapes drawn, and more complex shapes, covering greater areas. Consciousness about personal dialect usage and accommodation (Att_{pers}) affects *coverage* negatively. A higher Att_{pers} value indicates a greater inclination for accommodation, which may mean less interest in dialect variation and a more vague perception of dialect categories, thus the participant covers less area on the map. Conversely, participants more conservative about their dialect usage and less willing to accommodate may be more conscious about dialectal variation.

Higher conscientiousness negatively affects the *number of shapes* drawn. Conscientiousness is related to orderliness, carefulness, and diligence (McCrae and Costa 1987: 85), also affecting the way participants handle the task. Those showing higher conscientiousness levels may be more reluctant to draw areas when unsure about their spatial extent. The trend of conscientiousness negatively affecting *coverage* ($P = .079$) can also be attributed to this claim. Openness positively affects the *number of shapes* drawn, which we attribute to two mechanisms. First, characterized by intellectual curiosity and preference for variety (McCrae and Costa 1987: 85), open participants may like the playfulness of the task more, and may use the opportunity to keep drawing for a longer time. Second, openness is associated with larger social circles, likely granting more awareness about different dialect areas. Nevertheless, openness not influencing *compactness* may mean that this awareness of variation, on average, does not necessarily entail an interest or knowledge deep enough to (intend to) draw detailed boundaries. Extraversion causes participants to draw more detailed shapes, which might again be attributed to handling the task. Extroverted participants may have fewer inhibitions (McCrae and Costa 1987: 85), which manifests itself in drawing in a detailed manner, and they may feel less inhibited when using new technologies and possibly making mistakes.

Regarding RQ2, no significant effect of the interview mode was found on the map parameters, in line with the findings of Leemann et al. regarding the comparability of in-person and virtual modes of SDATS linguistic interviews (2020b). Mental map tasks, thus, may be conducted via virtual or in-person supervision, without affecting the contents drawn on maps. However, the comparability of hand-drawn and digital maps in our study is not flawless. The drawing mode not affecting the *number of shapes* means that the digital drawing mode does not prompt the average participant to draw less or more. Regarding coverage, known drawing modes (drawing by hand, mouse, or touchpad) do not make a significant difference, suggesting comparability. Known modes result in a larger average coverage compared to the unknown digital drawing mode ($n = 44$). Unknown drawing mode is frequently associated with technical issues, corroborated by longer audio recording durations, which often entailed technical incapability. Technical issues and incapabilities often lead to maps not fully corresponding to the ideas of the participant (hence often little coverage).

Regarding *compactness*, drawing mode is associated with large differences between hand-drawn maps and all digitally drawn maps. This issue ties in with the technical limitations of the study, namely the digitization of hand-drawn shapes and the automatic simplification occurring with digitally drawn shapes, detailed below. Thus, for researching shape compactness, we do not recommend implementing methods using the same technical solutions as we did.

4.1 Limitations

Most limitations of the study stem from the interface and the digitization of the hand-drawn maps. In general, the drawing tool and the elements of the background map may obscure participants' intentions (Bounds and Sutherland 2018). Beyond this, spatial cognition might not correspond to the actual recognition of dialect areas (Schiesser 2020: 27–28), that is, participants might have an idea about a dialect's spatial extent but may not be able to reflect it in drawing.

The technical abilities of the participants and the virtual interview mode caused various technical problems. As digital mapping, especially in a virtual interview, was rather tedious for technically less capable participants, some admittedly finished the task before completing a drawing that would correspond to their ideal portrayal of dialect perception. Beyond the fact that digitally drawn shapes were slightly simplified in the online tool by default, it was easy to draw small shapes unintentionally, which were difficult to remove even with the help of the interviewer (see video in Supplementary Appendix I). Despite this discrepancy, we found that drawing mode did not significantly affect the *number of shapes* drawn. Such small polygons, however, are especially affected by the shortcomings of the Polsby–Popper compactness formula, which in essence places a polygon on the spectrum of circular to spiky. The formula correctly identifies round shapes drawn as compact, but it identifies elongated, triangular, and rectangular shapes, often occurring in digital maps, as complex, although the human eye would identify them as compact. We addressed this predisposition to unintentional polygons by modelling *compactness* of single shapes rather than the average *compactness* per participant. A more ideal formula by Brinkhoff et al. (1995) would have allowed for quantification corresponding to the visual perception of shape complexity, but its output was biased for the hand-drawn shapes due to the formula's sensitivity to the numerous vertices inserted by the `beePen` tool during the digitization process.

Finally, we may assume that the interviewer effect and the task instructions that were given to the participants had a potential impact on the way respondents have drawn the shapes. However, the approach was chosen to maintain a standardized and easily interpretable task for our participants and the Polsby–Popper score, despite its limitations, provides a numerical measure that aligns well with the instructions, the instructions actually given and the communication between the interviewer and the participant may have impacted the parameters of shapes drawn.

5. Conclusion and future prospects

This study contributes a methodology to perceptual dialectology for testing the degree to which sociodemographic and sociolinguistic variables may affect geometrical parameters of dialect areas' shapes drawn on maps. The analysis of map parameters discussed here can be readily implemented in a number of studies with digitized shapes already available. In addition, our digital mapping tool (source code available) may be customized according to researchers' needs.

We have seen that dialect identity affects all parameters, while educational background, regionality, and urbanity also play an important role, affecting two parameters each. In addition, age, openness, extraversion, conscientiousness, and personal dialectal accommodation also affect some map parameters. The success of predicting map parameters prompts reverse testing whether map parameters can predict attitudinal and personality factors. Hence, map parameters could contribute a less conspicuous quantitative characterization of linguistic attitudes, for which there is a need in perceptual dialectology (Preston and Robinson 2005: 2–4). For some promising preliminary results in these regards, see Supplementary Appendix II (Section 3.4).

In terms of the mental maps recorded in SDATS, there are a number of opportunities for future research. Given that SDATS has surveyed 1,000 participants in a manner that is balanced for age, gender, educational background, and reference localities, along with a linguistic interview complete with more than 300 items of metadata, several established avenues of perceptual dialectology involving mental maps could be further explored. Systematically studying the perceptual dialectological value of the audio recordings and exploring their contents from a psycholinguistic perspective also suggests intriguing possibilities as the records may be informative about dialect identities, perception, and geometric parameters of shapes drawn. It would be also possible to test the effect of instructions given by the interviewer on the geometric parameters. In addition, cleaning the mapping tasks' audio recordings of excess time spent with instructions, technical difficulties, and casual chat to establish task length may be useful for indicating engagement in the task.

Supplementary data

Supplementary data is available at *DSH* online.

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Author contributions

Péter Jeszenszky (Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Resources, Software, Validation, Visualization, Writing—original draft, Writing—review & editing), Carina Steiner (Conceptualization, Formal analysis, Investigation, Resources, Writing—original draft, Writing—review & editing), Nina von Allmen (Conceptualization, Data curation, Formal analysis, Investigation, Resources, Writing—original draft, Writing—review & editing), Adrian Leemann (Conceptualization, Funding acquisition, Investigation, Project administration, Resources, Supervision, Writing—original draft, Writing—review & editing)

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Notes

1. Swiss German has a special diglossic situation with dialects enjoying high prestige compared to Standard German (e.g. Berthele 2004; Studler 2017) and they do not have a strong orientation to social class. Dialectal variation manifests itself mostly as spatial dialect areas, although 'dialect levelling' is ongoing (Christen 1998; Juska-Bacher 2010).
2. www.mapbox.com
3. map.dialektatlas.ch, source code available at https://github.com/verticalmeadows/sdats-draw-a-map
4. leafletjs.com
5. For categorical variables, β estimates and *SE* are presented as percentages covered, since in this case the linear model estimates can be directly translated to the predicted percentage difference between the default level and the level in question.

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