# Voiceless Back Dorsal Fricatives in Standard German

**Zoe Tholen/ 14665034**

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**Supervisor**: Cesko C. Voeten

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**Abstract**: One perception and one production experiment were employed to investigate the realization and judgement of the back allophone of the /x/ phoneme in Standard German. While the dialectal background of the speaker did not significantly predict the center of gravity of the uttered /x/, acoustic measures such as the duration of the utterance revealed themselves as more fitting predictors. Participant judgements from the perception experiment exhibited a lack of discrimination between [x] and [χ]. The results of these experiments, in combination with a review of historic and current literature on the back dorsal allophone, indicate that the common transcription as velar might be influenced by a bias against uvularity, as opposed to actual speech patterns. Above this, the data obtained calls for a more specific investigation of physical properties and the allophonic status of voiceless velar and uvular fricatives in SG.

**Key Words:** German, Phonetics, Sociophonetics, Word-List Reading, Map-Placement, Perceptual Dialectology, Ich-Laut, Ach-Laut, Spectral Analysis, Fricatives

# 1. Introduction

The main goal of many international phoneme transcription systems, such as the International Phonetic Association's widely used International Phonetic Alphabet (IPA), is to provide a standard tool to communicate phonetic information in writing, making it accessible to a larger number of audiences and purposes. In order to accomplish this, transcription systems have to be both simplistic enough to maintain their accessibility and practicality, and simultaneously demonstrate enough complexity to satisfactorily describe all phonetic categories found in the world's languages. For phoneticians, this can leave a conflict of interests, since places of articulation (PoAs) are gradient, but the number of symbols used should be finite. The IPA has achieved a middle ground by providing a basic set of symbols supplemented by diacritics, enabling the transcriber to choose the desired precision of the transcription. When generally describing the standard variety of a language, then, transcribers tend to use the minimal number of symbols needed to represent all phonemic categories present in the language. While this can come at the cost of some phonetic details, the identification of phonemic categories is normally still based on phonetic realities.

As for all languages, phonologists and phoneticians treating Standard German (SG) have to make such compromises. While the current thesis examines an instance where a compromise might not satisfy these two criteria, it is worth considering a successful transcription choice as a contrast first: SG has one /a/ vowel, which is produced quite centrally (Hoole & Mooshammer, 2002). Instead of using the centralization diacritic, [ä], however, the vowel is most commonly transcribed as [a]. In this case, abandoning the closer phonetic transcription is a permissible and helpful choice, since it is the realization of the only /a/ phoneme in SG, and does not stray too much from the actual pronunciation. It thereby strikes a balance between phonemic and phonetic transparency.

On the other side of the contrast stands a convention of transcription in SG which concerns a phoneme most commonly denoted as /x/ in IPA and the digraph ⟨ch⟩ in SG orthography. /x/ is realized as contextually allophonic variants, typically transcribed as the voiceless palatal fricative [ç] for the front allophone and the voiceless velar fricative [x] for the back allophone (e.g., Kentner, 2022). The two allophones appear in complementary distribution, where [x] occurs after back and central low vowels [uː, oː, ʊ, ɔ, aː, a] and [ç] occurs after front and central vowels [iː, yː, ɪ, ʏ, eː, øː, ə, ɛː, ɛ,  œ, ɐ] as well as the consonants [l] and [n] (Kentner, 2022). However, this distribution does not appear to account for all speech patterns of native SG speakers. When this issue comes up in the literature, authors usually cite either Kleiner (2018), as the first study to have systematically gathered speech data from all German dialects on this discrepancy, or Kohler (1977), the first source in which an optional uvular realization of the back allophone is acknowledged at all. While Kleiner (2018) claims that the dominant realization of the back allophone is [χ], Kohler attests a three-way allophonic variation (1977, 1995), which features [ç] under the conditions described above, [x] after close back vowels and [χ] after the open vowels [ɔ] and [a]/[aː]. To reiterate the contrast, in the case of the /a/ vowel, adapting the phonologically parsimonious transcription into the phonetic transcription is permissible because the phonological transcription itself does not disregard the phonetic reality. However, if the actual sound which the phonological or phonetic transcription means to describe is closer to a different IPA symbol (as it is the case for the data in Kleiner (2018)), or if the speech patterns reflect a greater number of predictable realizations than transcriptions accounts for (as it would be the case judging from Kohler (1977)), a phonetic transcription oriented at phonological parsimony seems less sensible.

While the patterns discussed in these two sources find acknowledgement in some other acoustic and articulatory studies, the discrepancy between the conventional transcription and the phonetic reality of many speakers is hardly otherwise addressed. When Kohler (1990) discusses his attested pattern, he goes so far as to refer to his proposed transcription as a "paradigm shift". However, since neither his pattern, nor the classical two-way allophony with [x] reflect the data in Kleiner (2018) very well, a review of this issue is in order.

To investigate the discrepancy, the present thesis explores the historical background as well as phonetic and phonological reasons for a possible mistranscription as well as variation dialectal patterns (Section 2). This is followed by two experiments gathering phonetic speech data and testing native speaker perception of the sound in question (Section 3). The data retrieved from these experiments is analyzed mainly from a dialectological perspective (Section 4), as the different regional interpretations of SG are identified as possible sources of variation by both Kleiner (2018) and Kohler, in a 1990 note adding onto his 1977 publication. Subsequently, the findings are contextualized in a general discussion of how the data obtained reflects dialectal patterns and relates to the data in Kleiner (2018) and the considerations in Kohler (1990) (Section 5), after which the paper ends in some concluding remarks (Section 6).

# 2. Background

## *2.1 Terminology*

As illustrated in the section to follow, terminology used for the issue at hand has varied and still varies, which is why the present section is dedicated to clarifying the transcription conventions and terms to be used in the current investigation. Firstly, not every phonetician uses the term “dorsal” to include the uvular place of articulation (PoA) (e.g. Delattre, 1971). However, to highlight the allophonic relation between [x], [χ] and the front allophone [ç], all of these will be referred to as dorsal sounds, in that they are all produced with the dorsum in SG. To avoid confusion with the palatal allophone, “back dorsal fricative” or “back allophone”, will be used to refer to the back realization(s) of what is commonly transcribed as ⟨/x/⟩. Due to the nature of the literature, which at times assumes that there is only one allophone that [ç] contrasts with, and at other times two, “back allophone” and the notation ⟨/x/⟩ will refer to all possible sounds produced in complementary distribution with the palatal front allophone, since the precise realization is questioned in the present work. Wherever the terms “uvular (fricative)” and “velar (fricative)” are used as nouns, they refer to either the velar realization of this allophone, i.e. the voiceless velar fricative [x], or the uvular realization of this allophone, i.e. the voiceless uvular fricative [χ] (and no other uvular or velar phone, unless specified). To highlight the fact that [x] and /x/ are merely the symbols commonly written down to describe this back allophone, and might not reflect the actual pronunciation, the notation of ⟨[x]⟩ or ⟨/x/⟩ is used to express that these potentially faulty transcriptions are treated here primarily as orthographic conventions (as implied by angle brackets). ⟨[x]⟩ can therefore be read as “the phone that is commonly transcribed as [x]”. Lastly, the term “uvularity” means to express a sound’s state of being uvular, or the degree to which it is uvular, and conversely “velarity” signifies the same for the velar.

## *2.2 Historical Transcription and Imprecise Terminology*

While the first 1888 version of the IPA only included /x/, exemplified by “German ach” (Phonetic Teachers’ Association, 1888), it was later published as a chart in which the voiceless uvular fricative was described by ⟨ʁ̥⟩ (International Phonetic Association, 1900). Perhaps in order to avoid confusion with its voiced counterpart ⟨ʁ⟩, or the uvular trill ⟨ʀ⟩, it was changed to the Greek letter ⟨χ⟩ in 1921 (Passy & Jones, 1921), which itself represents a velar fricative in modern Greek (Arvaniti, 2007). This fluctuation at the origin of the transcription of the voiceless uvular fricative, along with the fact that neither of the symbols above symbols could be typed on German typewriters, might have caused a rocky start to the classification of the sound in question. The voiceless velar fricative, on the other hand, appears as [x] from the inception of the IPA, but is termed “voiceless back fricative” instead, reflecting the lack of standardization and precision of phonetic terminology at this point in time. The International Phonetic Association used a sound from Arabic to exemplify the pronunciation of the voiceless uvular fricative once introduced, and continued to cite “ach” as an example for [x]. In one of the booklets released by the IPA (Passy & Jones, 1921), a velar fricative is attested to only “Northern German” (presumably what is now known as the Low German dialect continuum). This is perhaps the first instance of assuming the variation in the back dorsal fricative to be regionally conditioned.

Other early sources of the time utilize similarly nebulous terminology, as Solmsen (1897) appears to use the term “guttural” for all dorsal sounds, but primarily for velar obstruents, while Sprater (1911) understands the term to mean anything from dorsal to laryngeal sounds, vaguely classifying SG “ach” as “post guttural” (p. 800) and only mirrored by laryngeal consonants (p. 802). With this, Sprater is the first to disagree with the IPA notation of ⟨[x]⟩ as a velar fricative, presumably indicating that it should be understood to be articulated further back in the throat. However, he also labels what is now most commonly transcribed as [x] in many slavic languages (Wandl & Kavitskaya, 2023) as “pharyngeal” and simultaneously as “produced more closely to the palate” (Sprater, 1911, p. 802). These terms, culminate in a highly imprecise description of dorsals. Although lingua- and palatograms were already available at the time of Sprater’s research, the uncertainty around terminology from him and his peers’ writing demonstrates the shaky beginnings, contradictions and controversies of phonetic research on SG.

The discussed tension between phonological parsimony and phonetic precision in the transcription of the back allophone finds mention in early works such as Sprater (1911) and Schmidt et al. (1907), where it is argued that phonetic precision should be sacrificed in the case of non-distinctiveness, defending a broader transcription as [x] or /x/ despite an acknowledgement of the backness of the sound. This argument, in combination with the overall confusion around vocabulary for articulators and the growing popularity of IPA transcriptions might have laid the foundation for a sort of bias against uvular transcription.

Perhaps as a consequence, the uvular and velar PoAs are frequently conflated even in modern sources. For example, the German Pronunciation Database based on the German Pronunciation Dictionary (*Deutsches Aussprachewörterbuch*, Krech et al. 2009) transcribes the German rhotic as [ʁ], but classifies it under “velar”. With notation like this, the author implies either that these two can be conflated in any language, assuming that languages never differentiate between the two sounds, or that there is no need to discriminate between velar and uvular in SG specifically. The assumption that uvular and velar are the same PoA of course disregards languages that feature the voiceless uvular and the voiceless velar fricative as contrastive phonemes, such as (among others) Lak (Schulze, 2007), Lezgian (Haspelmath, 1993), Nuu-chah-nulth (Stonham, 1999), Adyghe (Colarusso, 1988) and Ubykh (Fenwick, 2011). A broad transcription of phones such as ⟨[x]⟩, then, can impede researchers' classifications and typological comparisons (e.g., none of the four descriptions of German in the Phoible (Moran & McCloy, 2019) databank include [χ]), or second languages learners from acquiring accurate pronunciation. Moreover, if the production of ⟨[x]⟩ varies by region, as suggested by Kohler (1990) and Kleiner (2018), then a generalizing transcription as ⟨[x]⟩ might come at the loss of such dialectal distinctions.

It should be mentioned here that the novel three-way allophonic pattern described in Kohler's 1977 and 1995 “*Einführung in die Phonetik des Deutschen*” (Introduction to German Phonetics) is amended in a 1990 note which Kohler uses to identify the inclusion of [χ] into description of the SG as a “paradigm shift” (p. 44). He, too, argues that the literature had been unjustly biased against the description of uvulars and that although the transcription ⟨/x/⟩ can be permissible as purely phonological in theory, /χ/ should still be favoured even in the phonological discourse, as the words he had identified to contain the uvular, i.e. where an open back vowel precedes the back allophone, are higher in number than the words he had identified to contain velars, i.e. words featuring close back vowels before the back allophone. In the note, he also criticizes the arguments that ⟨/x/⟩ should be maintained for its simplicity in spelling or its established tradition. Instead, so his argumentation, the uvular way of transcription should be favored because of its frequency of occurrence, because it offers a higher contrast to the palatal transcription of the front allophone, and to create awareness for the existence of the uvular in general and in SG specifically. Despite recognizing that [ç], [x] and [χ] are realizations of the same phoneme, he argues for a twofold notation as /ç/ (to refer to the front allophone) and /χ/ (to refer to the back allophone), as an IPA chart cannot satisfyingly depict the fact that SG features a phoneme that ranges from palatal to uvular in its realization, and because the phonological rule splitting the phoneme in three allophones can be outranked by morphological rules (producing pairs like ['fʁaʊ.çən] and ['ʁaʊ.xən]). This line of argument is reflected in Kohler's 1977 and 1995 description of SG, but so is the transcription as ⟨/x/⟩. As the note reveals, this was rather a preference of the editor than a choice made by Kohler. Kohler's three-way allophony has since been adopted into numerous accounts of the SG phonetic inventory (e.g., Brenner et al., 2006, Hall, 2000, Robbinson, 2001), so a "paradigm shift" seems indeed to have taken place, but this shift has recycled the printed ⟨/x/⟩ notation, instead of ⟨/χ/⟩ as favored by Kohler.

While this might form the most significant, albeit accidental, reinforcement of an anti-uvularity bias in the literature, there is also evidence against Kohler's attested pattern itself. Specifically, the data presented in Kleiner (2018) contrasts with Kohler's assumptions in that they mainly testify for a uvular realization of ⟨/x/⟩. Although some South-Eastern varieties of SG (parts of Bavaria and Austria) do indeed tend to feature a velar fricative in coda position after [u], the majority of speakers were producing [χ] consistently. This data goes against the classically attested two-way allophony necessarily containing a velar fricative, but it also clashes with Kohler in his assignment of speech patterns to regions, who at times attests his three-way allophony to all regional interpretations of SG (cf. 1977, 1995), and at times ascribes this pattern to his own "northern" SG. While some other sources concerned with acoustics use [χ] (e.g., Jannedy & Weirich, 2016), the approach of this issue from both a phonetic and dialectological perspective is not specifically and systematically addressed prior to Kleiner (2018). The prominent argument reflected in Kleiner pointing to a possible mistranscription is that the uvular and velar PoAs can be quite difficult to distinguish perceptually, for example because of the rounding of the preceding vowel, or co-articulation at both PoAs. This is why they opted to employ a gradient transcription ranging in six steps from pre-velar to uvular with clear, scraping involvement of the uvula. As Kleiner offers compelling evidence, but only looks at a limited amount of data for just four words, does not offer statistical analysis and relies on the auditory judgement of the researchers, further investigation is needed.

### *2.3 Phonological and Phonetic Description*

Different areas' intersections with phonetics and phonology result in different discourses about the present issue. Historical evidence from Yiddish, which features both a voiced and a voiceless uvular fricative (Kleine, 2003, King & Beach, 2008) with prominent scrape, can be consulted. After Yiddish split off from Middle High German, a large portion of the Yiddish speaking population left the German speaking area for Eastern Europe, while another portion remained in the West (Weinreich, 2006). Both of these dialects retained their uvular features, despite Eastern Yiddish coming in contact with Slavic languages and their velar fricatives (see above) and alveolar rhotics. This points to the existence of both uvular fricatives in Middle High German (King & Beach, 2008). In turn, this strengthens the possibility of an anti-uvularity bias interfering with correct transcription in the history of the phonetic study of SG, as the introduction of the uvular [ʁ] had formerly been seen as caused by French influence on German, dated to a time after the Yiddish migration.

Sources participating purely in phonological discourse usually propagate the ⟨[x]⟩ notation. Where a uvular realization finds mention, it is in reference to Kohler (e.g. Robbinson, 2001) and it is emphasized that phonologists need not concern themselves with the specific phonetic implementation, echoing the phonological parsimony argument discussed above. Literature treating SG phonetics, on the other hand, at times adapts the notation as [x], and at other times acknowledges the contrast with the uvular speech data (e.g. Steinberg et al., 2012). Still other phonetics sources simply use [χ] without discussing or referring to the discourse at all (e.g. Jannedy & Weirich, 2016).

An interesting articulatory consideration present in Kleiner (2018), which is, to the author's knowledge, unidentified in prior work, is the possibility of a uvular fricative being articulated without audible scrape, i.e. the swinging of the uvula during the frication period. Kleiner expresses this by differentiating [χ̟], [χ] (non-scrape uvulars) and [χᴿ] (scrapy uvulars). The term "scrape" has no consistent formalization and almost exclusively finds use in early literature on Arabic (Gairdner & Oxon, 1918), recent literature on Dutch (eg. Smorenburg & Heeren, 2020, Brinksma & Jansen, 2019, Mees & Collins (1982), van der Harst & Van de Velde, 2008) and some literature on Persian, where it is very consistently conflated with velar articulation (see Koutlaki, 2002: "x: voiceless velar uvular with scrape", or Trimingham 1960: "x: As in the German 'ach', Scotch 'loch', with a strong uvula scrape"). The current thesis will follow this notation as "scrape" as it isolates the specific phenomenon at hand from the frication produced during the fricative. Other sources on uvular fricatives describe this phenom as a trill-like vibration of the uvula (Ladefoged & Maddieson, 1996) or simply as a quasi-periodic signal (Alkhairy, 2003).

Although there appears to be no articulatory study on the precise mechanisms of scrape, one can assume that it occurs due to a Bernoulli effect triggered by the high pressure of the frication. In this event, the strong airflow might lift the uvula up towards the velum (Figure 1), upon which the airflow loses pressure due to being released, letting the uvula drop back against the dorsum (Figure 2), creating periodic patterns of (relative) closure, strong bursts and then waning air flow.

**Figure 1**[1]

*Uvula directed towards the dorsum during [aχ].*

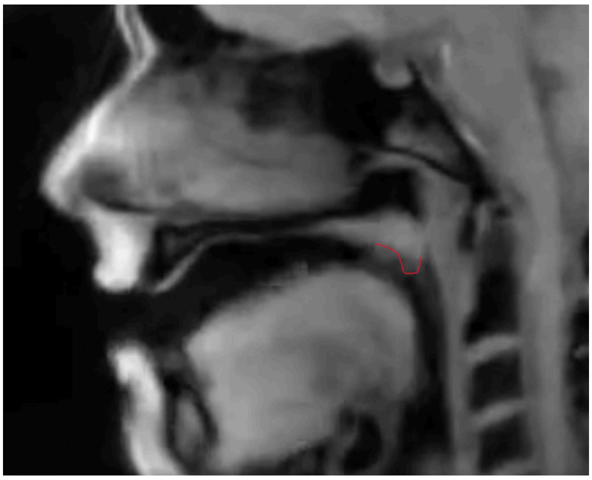
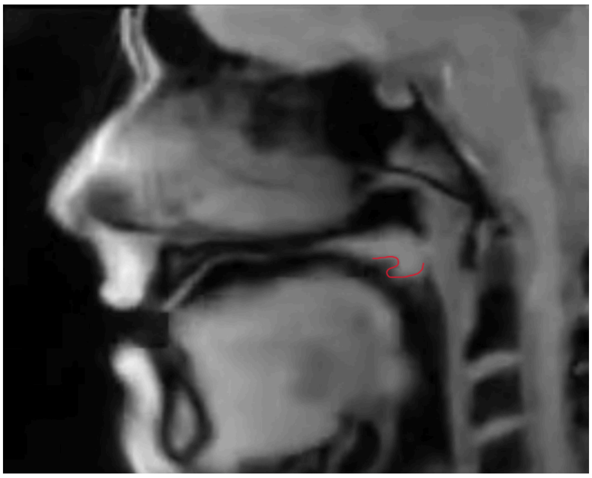


**Figure 2**[1]

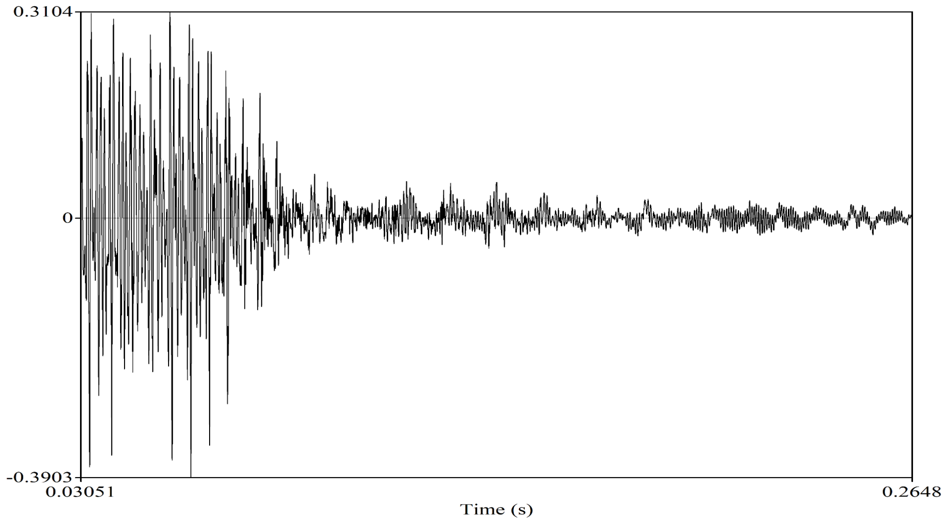
*Uvula directed towards the velum during [aχ].*



This results in a fricative waveform that shows periodicity with around 80 Hz for the speaker from Figures 1 and 2 (for waveform see Figure 3, compare to Alkhairy, 2003, who found an average periodicity of 90 Hz across participants)

**Figure 3**

*Waveform of the same [aχ] produced in Figures 1 and 2.*




To return to the differentiation between scrape and non-scrape uvulars, it can be assumed that a pronunciation of a uvular fricative *without* the triggering of the Bernoulli

[1] Both Figure 1 and Figure 2 are taken from a real-time MRI recording of the speech organs during production in Uecker et al. (2010). Although the place of origin of the speaker is not specified, it is notable that he exhibits scrape on all ⟨[x]⟩ instances.

effect would shrink the perceptual difference between [χ] and [x] significantly, since this would reduce the stridency and leave the listener with only the backness of the noise to distinguish between the two. If one also considers the fact that the back allophone mostly appears in coda position (except as a result of syllabification where it becomes an onset in unstressed syllables with -[ə] or -[ən]/[n̩], e.g., [mˈa.χn̩] "to do"), then it seems likely that mistranscription as [x] might simply be caused by lacking perceptual cues for [χ], as the phone usually occurs without enough duration or pressure to trigger the Bernoulli effect and scrape. Scrape might therefore merely be a sufficient acoustic condition for uvularity which cannot replace a necessary condition of, for example, uvular-typical spectral characteristics. However, accepting the possibility of non-scrape uvulars also means accepting the fact that velars and uvulars, in so far as they are both dorsal, almost form a gradient which it is difficult to assign cross-linguistically distinctive phonetic features to.

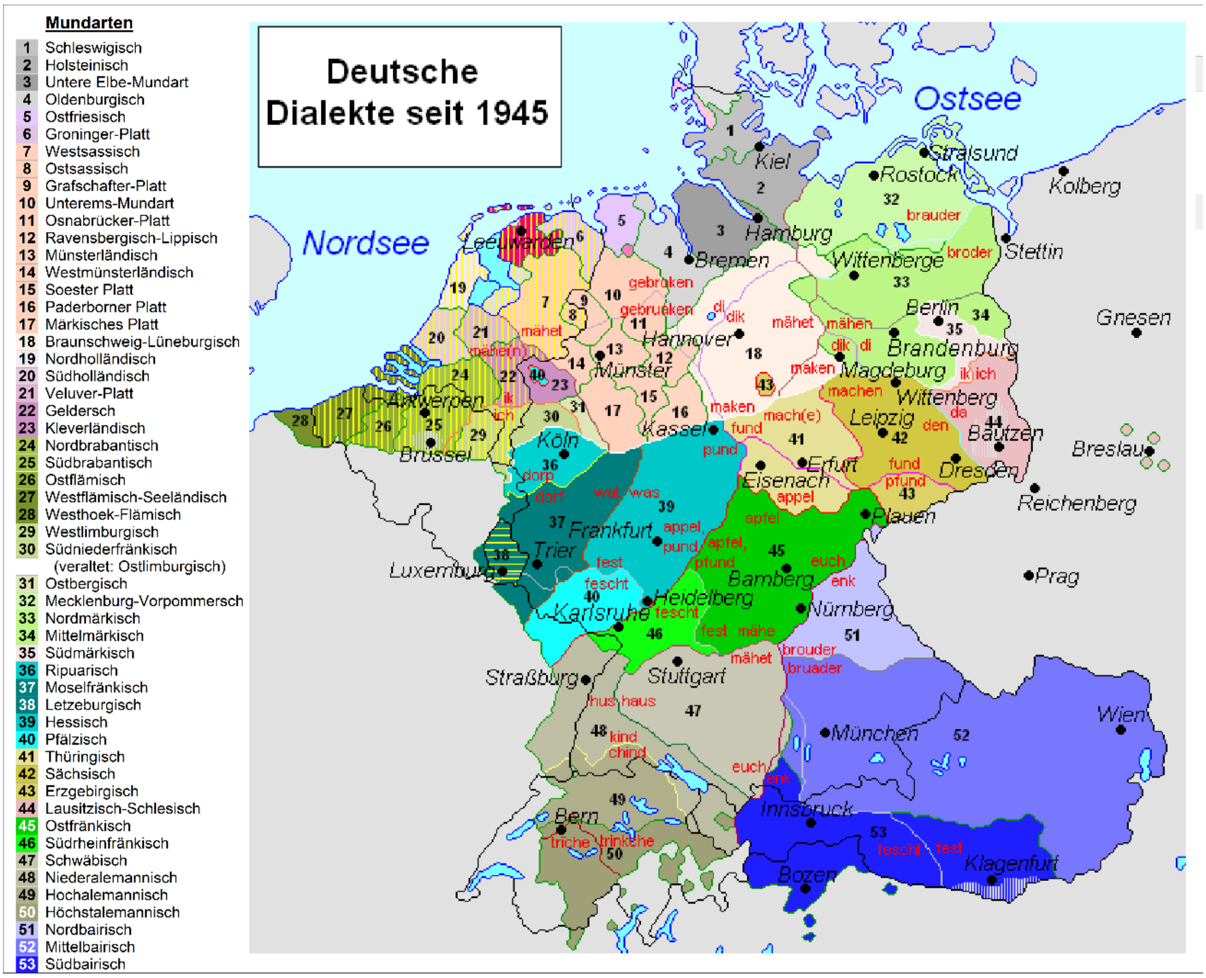
There is a multitude of ways a fricative can be analysed and distinguished in PoA from other fricatives, notably the shape of the fricative's spectrum (e.g. Mayer, 2014), formant transitions from and to vowels (e.g. Alkhairy, 2003) and center of gravity (CoG) (e.g. Sharp et al., 2023). The latter is perhaps the most straight-forward, since its logic of being a measure of PoA underlies basic source-filter model assumptions (Fant, 1970): The further back the PoA, the larger the oral cavity through which the sound can resonate, the more intensity of the sound happens at lower frequencies, the lower the CoG (Jongman, 2024). Although this is of course complicated by factors such as lip rounding, CoG should be a suitable measure to distinguish two similar sounds at different PoAs, such as the voiceless velar and the voiceless uvular fricative, from each other. The relevance of CoG for the current study also lies in its ease of implementation and comparison. Since one of the scholars from the institute that produced Kleiner (2018) explicitly suggests that the regional difference in PoAs of dorsal fricatives should be researched by comparing CoGs (Gorisch, 2022), this is the avenue the current study will take. CoG values for SG uvular fricatives vary: Mayer (2014) distinguishes velar and uvular fricatives in SG, mentioning a global peak in the spectra of uvulars at around 1000 Hz with a local peak at around 2500 Hz (the CoG can be assumed to fall somewhere in between these values, depending on the kurtosis of the spectrum) and reporting a peak below 2000 Hz with gradual decline for the spectra of velars (implying that the CoG might lie at around 2000 Hz). This is confirmed in Jannedy and Weirich (2016), who find CoGs of ca. 800 – 2700 Hz for participants from Buxtehude, and ca. 1100 – 3600 Hz for participants from Jena. However, Jannedy and Weirich calculated this from just five stimuli produced by three participants each per city (totaling 15 data points for each fricative). Weiss (2008) finds CoG values of around 3500 – 3800 Hz. Interestingly, this last source differentiates [x] and [χ] on the basis of Kohler (1995), but finds no real difference in CoG between them, just as it would be expected from Kleiner (2018). Although not to an great extent, Weiss (2008) does find emphasis, i.e. the loudness and duration of the fricative, to be a CoG-altering factor, which connects to the above assumption that a Bernoulli effect might not be triggered during fast or quiet production.

### *2.4 Dialectal Evidence*

As can be seen from the phonetic and historical exploration, most sources looking at phonetic realities of the fricative in question do cite the variety of SG spoken as a possible indicator for uvularity, and thereby CoG, of the back dorsal fricative (see Kohler, 1990, Kleiner, 2018, Weiss, 2008, Jannedy & Weirich, 2016). As the question of what should be considered standard, if the respective standard in Luxemburg, Liechtenstein, Austria and Switzerland should be considered SG, what should be considered dialect and which sociological causes and consequences are attached to these terms merits a separate dissertation. "Dialect" will here indicate varieties across the Central European Germanosphere that differentiate themselves from each other on the basis of regional factors, whereas "standard"/"SG" is used to refer to the supra-regional standardized variety. Since SG is not based on one particular dialect, it needs to be pointed out that "varieties of SG" or "regional interpretations of SG" will here refer to the SG that is spoken in different geographical points, which experience different degrees and kinds of influence from the native dialects. As Herrgen and Schmidt (2019) note, not all borders of German dialects have been agreed upon, which is why there are little dialect maps of the whole dialect continuum. Figure 3 is an approximation compiled by Et Mikkelsen (2007).

**Figure 3**

*German dialect continuum.*




The different German dialects are maintained to varying degrees, for some speakers, SG is reserved for formal and educational setting, as well as supra-regional communication, whereas many others exclusively use their regional interpretations of SG. Notably, the *front* allophone of the dorsal fricative is one of the features that distinguishes different interpretations of SG, as it rances from post-alveolar (in some Middle German dialect areas) to a uvular, velar or plosive realization (in some Upper German dialect areas). Although it is not necessarily intuitive to assume the back allophone has a similarly distinctive character, it is an idea worth exploring. An issue of comparing dialectological literature on the back allophone is that many typologists are not primarily concerned with phonology, and simply adapt those phonological phenomena that do not appear to contrast with SG. As a consequence, there might be a disproportionate reporting of [x] in the literature, where [χ] would be more fitting. Many authors simply note that an "ach"-sound exists in the dialect in question but fail to specify how this sound is realized. Moreover, authors describing Austrian and Swiss German, might have additional interest in distinguishing their varieties from Standard German and its dialects, as they are treating national differences. For a rough overview, Table 1 was compiled to showcase attested patterns of dorsal fricatives in a selection of dialects, compared to the data found in Kleiner (2018).

**Table 1**

*Overview of the realisation of back dorsal fricatives in some German dialect groups (Grey cells indicate a lack of data in the given source, green cells illustrate that most of the data in Kleiner can be explained by the ascribed pattern and red cells illustrate the opposite case).*

| **Dialect (with number according to Figure 3)** | **Source** | **Front Allophone** | **Back Allophone** | **Rhotic** | **Back Allophone in Kleiner (2018)** |
|---|---|---|---|---|---|
| **Low German Dialects (Spoken in Northern Germany, Excluding Dialects in the Netherlands)** | | | | | |
| Northern Low Saxon (1 – 4) | Elmentaler, 2019 | | x | r | some x, mostly χ |
| Westphalian (9 – 17) | Elmentaler, 2019 | | x | r | mostly χ |
| Eastphalian (18) | Elmentaler, 2019, Ehlers, 2019 | | x, χ | ʁ/x | some x, mostly χ |
| Mecklenburgisch-Vorpommersch (32) | Ehlers, 2019 | ç | χ | ʀ | mostly χ |
| Marchian (33 – 34) | Ehlers, 2019 | k | k | r | mostly χ |
| **Middle German Dialects (Spoken in Central Germany and Luxembourg)** | | | | | |
| Ripuarian & Moselle Franconian (36 – 37) | Froitzheim, 1984 | ɕ/ʃ | x/χ | ʁ | some x, mostly χ |
| Luxembourgish (38) | Gilles & Trovain, 2013 | ɕ | χ | ʁ, ʀ | χ |
| Hessian (39) | Keil, 2017 | | x | ʀ | mostly χ |

| | | | | | |
|---|---|---|---|---|---|
| Thuringian (41) | Harnisch, 2015 | ç | x | ʀ | some x, mostly χ |
| Upper Saxon (42) | Anders, 2010 | ç/ɕ/ʃ | x | ʁ | χ |
| Lusation-Silesian (44) | Anders, 2010 | ç/ɕ | x | ʁ/ ɻ | some x, mostly χ |
| Erzgebirgisch (43) | Anders, 2010 | ç/ɕ | x | ʁ | some x after [u], otherwise χ |
| South Marchian (35) | Ehlers, 2019 | ç | χ | r | some x, mostly χ |
| **Upper German Dialects (Spoken in Southern Germany, Switzerland, Liechtenstein and Austria)** | | | | | |
| East Franconian (45) | Harnisch, 2019 | ç | x | r | mostly x after [u], otherwise mostly χ |
| South Franconian (46) | Harnisch, 2019 | ʒ | x | r | some x after [u], otherwise χ |
| High Alemannic (Swiss German) (49 – 50) | Kraehenmann, 2001 | x | x | ʀ | some x, mostly χ |
| Northern Bavarian (51) | Harnisch, 2015 | ç/x | x | ʀ/r | mostly χ |
| Central Bavarian (52) | Zehetner, 1978 | ç | x | r/ʁ | mostly x after [u], otherwise mostly χ |
| Southern Bavarian (53) | Moosmüller, 1991 | ç | x | ʀ | mostly x |

Although a limitation of Table 1 is that the sources do not always specify whether the regional standard or the native dialect is described, it shows that the data in Kleiner (2018) is only reflected in dialectological literature to a limited extent. However, since most of the sources in the table focus on a general description of the dialects as opposed to phonetic descriptions, and because similar dialect groups do not exhibit similar patterns in Table 1, it seems possible that the sources claiming that ⟨/x/⟩ is realized at [x] might simply be adhering to the transcription tradition. In fact, the review of these sources proved difficult because many scholars referred simply to the absence or existence of an "ach" sound in the particular dialect. While this is a useful fact in terms of German dialectology (as it divides dialects according to the Benrath Line isogloss (Wiesinger, 2017) in dialects realizing ⟨/x/⟩ as a fricative or plosive), it is not a useful distinction for the current investigation and might in general exemplify a lack of awareness on the current issue, just as emphasized by Kohler (1990). This only reinforces the point that more data and new approaches towards the issue are necessitated.

### *2.5 The Present Thesis*

After having reviewed historical, phonetic and dialectological discourses on patterns of uvularity of the back allophone ⟨[x]⟩, a mainly dialectological approach will be taken to quantify these patterns, i.e. to gather insight removed from an anti-uvularity bias on the way in which ⟨[x]⟩ is realized in varieties of SG. Based on previous research and a review of some German dialects, it can be hypothesized that the realizations of the back dorsal allophone are indeed informed by regional standards, although not always in a way that is reflected in Kohler (1977), Kleiner (2018) or earlier research.

To investigate this, both a map-based accent recognition perception task (Voeten & Pinget, to appear) and a word-list reading production task were employed to yield data of native speakers of SG. Production data above what Kleiner (2018) can provide is necessitated by the need for tailored data which allows for not only the investigation of dialect as a predictor, but also potential phonetic and phonological factors which are discussed in Kohler (1990), Kleiner (2018) and Weiss (2008). Compared to Kleiner, the current, more extensive word-list reading task employed here has the advantage that it enables statistical analysis of acoustic data due to the large phonetic dataset obtained, whereas both Kohler and Kleiner have relied on individual auditory impressions. Above this, more data across more articulatory contexts was elicited here, which supplements Kleiner's descriptive report with a more holistic analysis. In response to Gorisch's (2022) suggestion that this sort of data should be analyzed by measuring the CoG of the back dorsal fricative, and in the attempt to isolate a quantifying variable for uvularity which might be more reliable than subjective auditory impressions (especially with the confounding sporadic absence of scrape), CoG is used to operationalize uvularity.

The second experiment, in which participants placed recordings of stimuli produced with velar and uvular fricatives on a map, speaks to both the geographically specified perception of the allophone and the ability to discriminate [x] and [χ], should they form two allophones of a three-way allophonic variation as brought forth by Kohler (1977). Since former research has often lacked a distinction between the two back allophones, no study has, to the author's knowledge, investigated perceptual differences between them made by SG speakers. Perceptual dialectology is therefore a novel approach to the issue at hand, which reveal interesting hints to the perceptual preferences for, and the phonological status of, ⟨[x]⟩. Although participant-specific geographical knowledge cannot be accounted for, this type of task theoretically has the advantage that every participant can provide data on (their perception of) any dialect. Although the lack of clarity on this issue might imply that speakers of SG do not consciously or subconsciously distinguish between [x] and [χ] as allophones or even just as distinct phones, as they do distinguish the front allophone from the back realization quite consciously, no research has addressed this possibility either

As a secondary goal, this research also aims to explain and compare patterns in the data to the previously described patterns on the basis of phonetic characteristics.

# 3. Methodology

Participants self-administered an online experiment at the place and on the desktop device of each participant's choosing, programmed by Dirk Vet in Experiment Developer (Vet, 2025). The experiment was fully conducted in Standard German and split into a production and a perception part, which were taken by the same population. The research was approved by the Ethics committee of the Faculty of Humanities at the University of Amsterdam with the reference number FGW-6432 and participants provided informed consent prior to completing the tasks.

### *3.1 Participants*

Recruitment took place via snowball sampling. Participants from all age groups and regions in the European Germanophone area were asked to take part. In total, 13 native speakers (8 female, 5 male, mean age = 41.2 years, SD = 18.9 years) participated. In the first phase of the survey, they confirmed that they were able to read and speak SG natively before the commencement of the experimental phase and detailed their language background, i.e. which dialects and languages they spoke or were exposed to. Participants came from seven different dialectal backgrounds, out of which seven participants indicated that their local dialect was the Ripuarian spoken in Aachen, a Central German Dialect[2]. The other dialectal backgrounds, i.e. the Ruhr dialect (a substratum of Low and Central German dialects found in the Ruhr area), the Low German of Hamburg, Swabian Alemannic (an Upper German dialect), South Low Franconian area featured one participant each. One participant failed to answer this question.

### *3.2 Procedure and Stimuli*

All participants took part in the production experiment before continuing on to the perception experiment without interruption. Prior to the commencement of the production part, participants had a chance to test their own microphone, and were provided with instructions and an example of the task along with the expected answer to illustrate the difference between casual and enunciated reading.

During the production experiment, participants were presented with 10 blocks of 15 stimuli consisting of one word each (150 words in total). The blocks were presented in randomized order, with an inter-block interval of 100 ms. During each block, participants were asked to read out the stimuli presented, once casually, and once enunciatedly, i.e. slowly, loudly and clearly. This was to gather both more naturalistic data (absent in Kleiner, 2018) and data of good quality for analysis. As soon as a participant pressed the space bar to proceed to the next block, the recording was stopped. The next recording at appearance of the stimuli.

Stimuli were devised by obtaining all SG lemmas containing ⟨uch⟩, ⟨ach⟩ and ⟨och⟩ (representing each of the five vowel contexts, [uː, oː, ʊ/aʊ̯, ɔ, aː/a], triggering the back dorsal allophone) from the CELEX database (Baayen, Piepenbrock & Gulikers, 1995**)**. Stimuli were usually taken in their infinitive (for verbs), positive (for adjectives) or nominative (for nouns) forms, unless the target sound only appeared in an otherwise inflected form of the lemma. No two stimuli were derived from the same lemma. In order to get the maximal amount of stimuli, the retrieved items were not balanced in articulatory context or controlled for frequency. As some of the five vowels triggering the back allophone form fewer lemmas than others (e.g., the sequence ⟨och⟩ with [oː] instead of [ɔ] was only found in two lemmas), stimuli were supplemented with pseudowords created with Wuggy (Keuleers & Brysbaert, 2010), a pseudoword generator which takes SG phonotactic constraints into account. With

[2] Since most German dialects are not colloquially known under their linguistic classifications, these used here were not named by participants themselves. Instead, participant answers were used to find the closest fitting dialect description.

these pseudowords, each vowel category was stocked up to 30 items, forming a total of 150 stimuli. Since this is a relatively high number of items for an online experiment, no fillers were used. The only vowel that did not have too few tokens was [aː]/[a], at 53 lemmas containing ⟨ach⟩ in CELEX, which is why the 23 most infrequent or ambiguous items (e.g., homographs) were deleted from the list. An additional six words from this vowel were replaced by nonwords in order to balance the amount of pseudowords and real words in the experiment (arriving at 75 real word stimuli and 75 pseudoword stimuli). Since almost all possible naturally qualifying words were taken as stimuli, all vowel conditions have a different real-to-pseudo-word-ratio. As a result, the final stimuli were selected as the best compromise between using real word items for validity and using enough stimuli to achieve reliability. The full list of all stimuli can be seen in Appendix A. Pseudowords were presented in SG orthography, which has no way of distinguishing the tense/lax contrast of the vowels before ⟨ch⟩. Participants were therefore instructed to read words they did not recognize with [oː] and [uː] if they contained ⟨uhch⟩ or ⟨ohch⟩, respectively, instead of ⟨uch⟩ and ⟨och⟩. This small additional task was also meant to ensure that participants were using their active phonological knowledge and to divert the attention from the fricative, making up for the lack of fillers.

**Table 2**

*Example Real Word Stimuli by Trigger Vowel*

| Vowel | Total Number of Real Word Stimuli | Example Stimuli | Translation |
|---|---|---|---|
| [uː] | 8 | Buch<br>wuchern | book<br>to grow rampantly |
| [oː] | 2 | hoch<br>malochen | high<br>to work hard |
| [ʊ] | 24 | Bruch<br>Taucher | fracture<br>diver |
| [ɔ] | 17 | Koch<br>Hochzeit | cook<br>wedding |
| [a]/[aː] | 24 | Fach<br>Sache | subject<br>thing |

**Table 3**

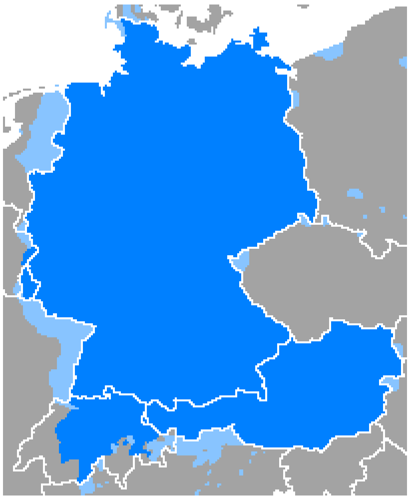
*Example Pseudoword Stimuli by Trigger Vowel*

| Vowel | Total Number of Pseudoword Stimuli | Example Stimuli |
|---|---|---|
| [uː] | 22 | guhche<br>nuhcht |
| [oː] | 28 | dohcher<br>abohcht |
| [ʊ] | 6 | puchtig<br>verlucht |
| [ɔ] | 13 | sochtest<br>drochen |
| [a]/[aː] | 6 | kach<br>rahchte |

After participants concluded the production experiment, they proceeded to the perception part. This map placement task required participants to listen to recordings of single-word stimuli and select the point on a map of Germanophone Europe.

**Figure 3**

*Map of Germanophone Europe[3] used for the map-placement task. From: Wikimedia Commons (2013).*



[3] While some of the details in the colouring of this map are contested, it was deemed to be the most fitting because of its lack of biasing labels and sufficiently accurate for participants.

Participants were told that these words were extracted from recordings of a speaker imitating different dialects. Due to the nature of the stimuli and the task, a statement expressing that they might not be confident in their judgement and that, in this case, they should indicate their best guess, was included. As discussed, even linguists have struggled to precisely label velars and uvulars in German, so participants were briefed in this way to minimize discomfort in the form of frustration for the task. The 150 stimuli were presented in randomized order and played automatically 100 ms after the participant had clicked a place on the map during the preceding trial.

The stimuli used for the perception experiment consisted of the read-aloud real word stimuli from the production experiment, pronounced by a male native speaker. All stimuli were recorded twice, once with [χ] in all words, and a second time with [x]. In order to control for as many articulatory factors as possible, stimuli were cross-spliced in Praat (Boersma & Weenink, 2025). The [x] and [χ] segments to be spliced into the other items were selected by computing the CoG of all [x] or [χ] intervals (see script in Appendix B) and taking the sound segment of the interval with the median CoG for each of the two fricatives. Since the uvular segment with the median CoG did not have sufficient length to feature multiple scrape periods (which would have yielded unnatural results from the overlap-add algorithm that the splicing was performed with) an interval two places away from the median was selected as the best [χ] instead. The two original words ("Epoche", for the best uvular segment and "Tuch" for the best velar segment) were scaled to an intensity of 60 dB and global peak of 0.99 Pa individually, and their [x] and [χ] intervals were adjusted to the nearest positive-going zero crossing. The resulting best [x] and [χ] segments were then both inserted into the uvular recordings by script (see Appendix C), as these were closer to the speaker's natural speech pattern. The same script also scaled all sounds to 0.99 Pa and 60 dB and adjusted the original [x] or [χ] intervals to the nearest positive going zero crossings. Where usually cross-splicing is performed with the full TD-PSOLA algorithm (Moulines & Charpentier, 1990), the best [x] and [χ] segments were only lengthened to fit the time range of the original interval with the lengthen (overlap-add) function of the algorithm, since pitch contour and level only minimally affect the perception of voiceless fricatives. The resulting stimuli were then converted to stereo (required format for Experiment Developer) by script (see Appendix C) before being implemented in the experiment.

### *3.3 Data Analysis*

The statistical data analysis for the data from both experiments was conducted in R (R Core Team, 2025).

#### *3.3.1 Production Experiment.*

Speech data was analyzed by retrieving manually annotated [x] or [χ] intervals from text grids via a script (see Appendix E) which also provided acoustic characteristics (CoG, duration, energy, power) averaged across the interval as output. As there is, to the author's knowledge, no established, practical, physical measure for scrape, CoG is used as an operationalization of uvularity. All acoustic data was normalized by undergoing log-transformation by gender prior to statistical analysis. A linear mixed-effects model was used to analyze the relationship between Dialect and CoG. Dialect, i.e. the answer participants gave as the dialect that was spoken in their place of origin, was manually coded as a categorical variable with the five levels "ac" (Aachen Ripuarian), "ru" (Ruhr dialect), "ha" (Hamburg Low German), "schw" (Swabian Alemannic) and "na" (the participant did not answer the question). Additionally, linear regression models were used to test whether the acoustic measurements taken by the script show correlation with CoG. The nature of the task (enunciated vs. casual pronunciation) caused variation in these acoustic measures which could be used to investigate the secondary research aim to find out if uvularity relates not only to regional variation but also to phonetic circumstances.

#### *3.3.2 Perception Experiment.*

Following Voeten & Pinget [to appear], the relationship between the PoA of ⟨[x]⟩ in the stimuli and the geographical location that participants associated with the stimuli was analyzed in a logistic model, using the glm function in R. The relative coordinates in % which participants had clicked served as the predictor for uvularity. For this, all values for y-coordinates were first flipped (as the raw data featured 0% (0) as the top left corner of the picture, and 100% (1) as the bottom left), after which x- and y-coordinates were centered to the middle of the picture by detracting 0.5 from every data point. Additionally, heatmaps contrasting these responses were created with the function stat_density_2d included in ggplot in R (Wickham, 2016) used to visually identify around which areas the responses clustered.

# 4. Results

Generally, neither the production, nor the perception experiment yielded significant results, but secondary analyses point to other effects that might be of interest.

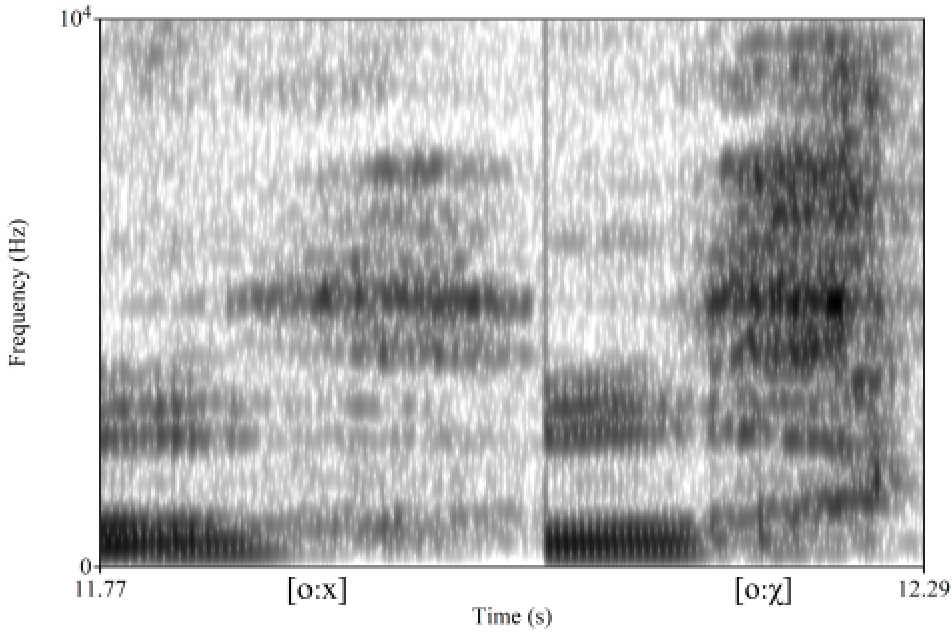
### *4.1 Results of the Production Experiment*

No participant produced perfect data. In total, about 7.9% of all ⟨[x]⟩ instances were either omitted or mispronounced (a mispronunciation here is considered a realization of the ⟨ch⟩ digraph which is not [x] or [χ]) and therefore not included in the CoG analysis. Apart from this, the recordings of three of the thirteen participants had to be discarded for the production experiment due to poor microphone quality.

The PoAs of ⟨[x]⟩ realizations varied both within and between subjects: although most participants tended to have a "preferred" realization, all participants produced both scrape and non-scrape ⟨[x]⟩ intervals. No statistical measure was employed to explore the influence of vowel quality on uvularity, but participants produced many instances of scrape/non-scrape variation that did not fit into Kohler's ascribed pattern (e.g. Figure 4 shows Participant B's realization of two consecutive words including ⟨ooch⟩ once with scrape and once without, although this sequence should always be velar in these words according to Kohler).

**Figure 4**

*Pronunciations of ⟨ooch⟩ as in ⟨sprooch⟩ (left hand side, non-scrape realization) and ⟨poocht⟩ (right hand side, scrape realization) during enunciated speech by Participant B.*



The CoG analysis itself yielded somewhat unexpected results, as CoG values were generally higher than the values for SG mentioned in 2.3, and fricatives that were clearly uvular showed higher CoG values than clearly velar ones. For comparison, Participant D, who most consistently produced non-scrape, velar-sounding fricatives had much lower CoG values than Participant E, who most consistently produced scrape (see Figure 6). These results contrast with the notion that sounds that are produced further back in the throat should display lower CoG as they resonate through a larger oral cavity. The fact that the opposite is reflected in the data at hand entails that in the following data analysis, positive correlations between a predictor and the log-transformed CoG can be interpreted to mean that high values for the independent variable predict uvularity.

Prior to statistical analysis, some specific outliers could be identified as caused by measurement errors in Praat and were removed from the dataset. The linear mixed-effects model did not show a significant difference in the log-transformed CoG values of the different dialects (see Table 4).

**Table 4**

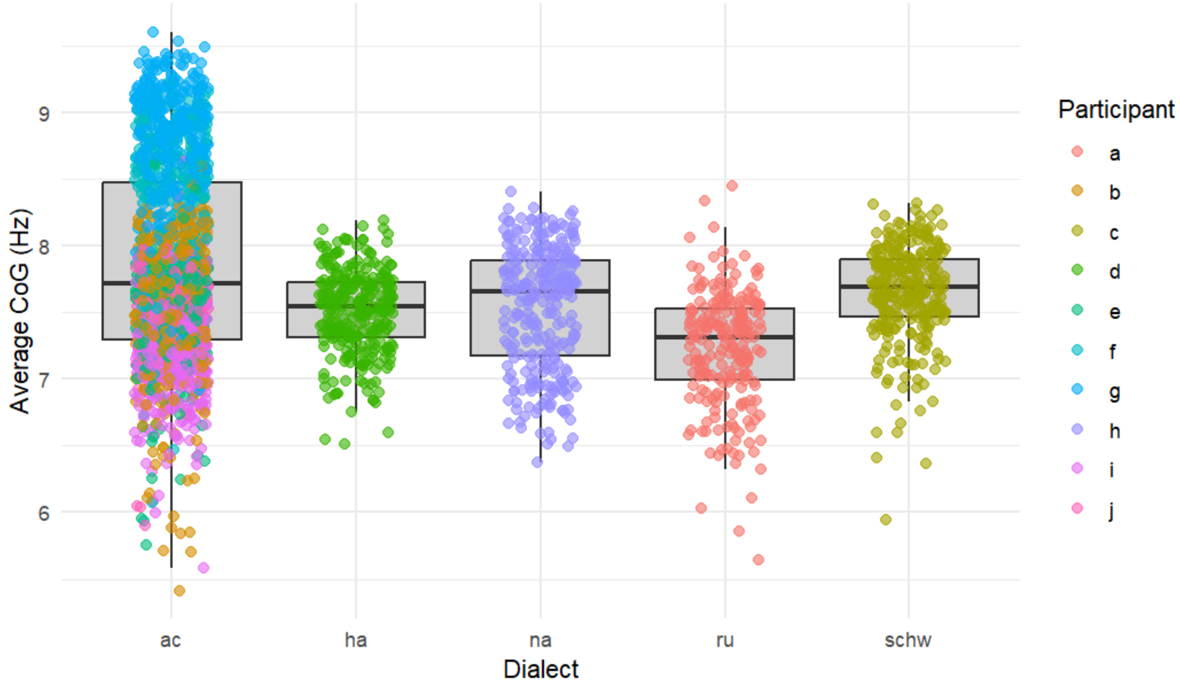
*Results of model lmer(log_Average_CoG_Hz ~ Dialect + (1 | Participant))*

| | β̂ | SE | DF | *t* | *p* |
|---|---|---|---|---|---|
| Intercept | 7.824 | 0.267 | 5.001 | 29.306 | **<.001*** ** |
| Hamburg dialect | −0.315 | 0.706 | 5.000 | −0.446 | .674 |
| No Answer | −0.287 | 0.706 | 5.000 | −0.406 | .701 |
| Ruhr Dialect | −0.595 | 0.707 | 5.004 | −0.842 | .438 |
| Swabian Dialect | −0.174 | 0.706 | 5.001 | −0.246 | .815 |

As expressed by these results and illustrated in Figure 6, there was variation in CoG values within and between participants, but no significant difference between the dialects.

**Figure 6**

*Log-Transformed CoG Values by Dialect and Participant*




Following the above assumption that the airflow in some instances might not be strong enough to trigger the Bernoulli effect, the duration, power and energy of the intervals were used as predictors of CoG in linear regression models. All variables were considerably skewed to the right by outliers, which were therefore removed by discarding all data points that were 1.5 interquartile ranges away from the interquartile boundary. All three models showed highly significant positive correlations between their predictors and the log-transformed CoG values, meaning that Duration, Power and Energy impact uvularity, Duration having the greatest effect.

**Table 5**

*Results of model lm(log_Average_CoG_Hz ~ log_Duration )*

| | β̂ | SE | *t* | *p* |
|---|---|---|---|---|
| Intercept | 7.360 | 0.043 | 170.404 | **<.001*** ** |
| Duration | 2.160 | 0.261 | 8.266 | **<.001*** ** |

**Table 6**

*Results of model lm(log_Average_CoG_Hz ~ log_Energy )*

| | β̂ | SE | *t* | *p* |
|---|---|---|---|---|
| Intercept | 7.619e+00 | 1.942e−02 | 392.389 | **<.001*** ** |
| Duration | 2.378e+03 | 5.490e+02 | 4.332 | **<.001*** ** |

**Table 7**

*Results of model lm(log_Average_CoG_Hz ~ log_Power)*

| | β̂ | SE | *t* | *p* |
|---|---|---|---|---|
| Intercept | 7.638 | 0.020 | 387.678 | **<.001*** ** |
| Duration | 336.445 | 86.721 | 3.880 | **<.001*** ** |

### *4.2 Results of the Perception Experiment*

The results of the logistic model indicated that there was no significant difference in the chance of higher or lower x- or y-coordinates assignment occurring for velar fricatives vs. uvular fricatives in the stimuli.

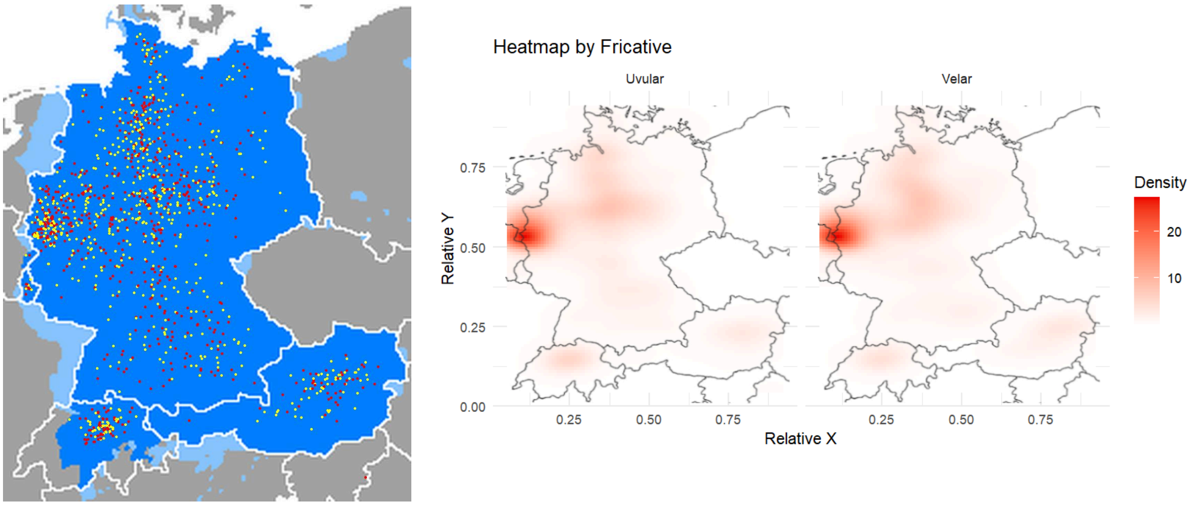
**Table 8**

Results of model glm(formula = Fricative_binary ~ x_centered + y_centeredN, family = binomial).

| | β̂ | SE | *z* | *p* |
|---|---|---|---|---|
| Intercept | 0.244 | 0.286 | 0.854 | .393 |
| x_centered | −0.188 | 0.249 | −0.756 | .450 |
| y_centeredN | −0.271 | 0.275 | −0.986 | .324 |

**Figure 5**

*Distribution and heatmap of all participant responses to uvular (red/ left) and velar (yellow/ right) stimuli.*




As can be seen from the models and visualizations, categorizations for velar and uvular were very equal. As the heat map shows, certain points were clicked consecutively multiple times. In fact, only two participants clicked a different pixel for every single stimulus, while the other nine had at least some consecutive stimuli for which they did not move their cursor before clicking, which might be part of the reason for the lack of effect.

## 5. Discussion

If the goal of the production experiment was to replicate Kleiner's (2018) experiment with more data to analyse how CoG as a function of uvularity is impacted by dialects and other factors, and the goal of the perception experiment was to explore the research question through perceptual dialectology methodology to illustrate the role of [x] and [χ] as allophones to a listener, both experiments succeeded in delivering results with compelling implications, but failed in rejecting the main null hypothesis that these are not dependent on regional variation. While the methodologies employed are fit to address the goals and the obtained data still holds value, these goals have failed to converge into a satisfying answer of the research question, which might in part be due to the implementation of the methodology.

### *5.1 Methodological Considerations*

Overall, participants showed and reported confusion during the tasks, which might have been alleviated by more (perhaps in-person) guidance, or less pseudo-word stimuli in the production task, since they appeared to have a confounding effect. Stimuli were also not controlled for postconsonantal and long-distance preconsonantal articulatory context, and short-distance preconsonantal context was not included in the analysis as a variable. In the interest of completeness, it should also be reiterated here that the number of stimuli in each block, as well as an absence of filler stimuli, were more aimed at reducing participant fatigue than achieving a valid method.

In terms of data processing, a more intuitive approach of using index scores (cf. Labov, 1966) of uvularity (with different levels for clearly uvular, ambiguous and clearly velar) and testing for a relationship with CoG, Dialect and the phonetic measures named above, was not used although it could have been a more reliable predictor for the production experiment. This choice was made because there was no reliable and convenient way of categorizing the raw data into the different levels, as the speech signals showed different kinds of ambiguity, some of which due to suboptimal recording conditions of the individual participants. That being said, CoG as a gradient operationalization of uvularity comes with the leap of faith that these two actually are linearly related. This is a leap of faith because the question whether non-scrape uvulars and scrapy uvulars follow the same linear CoG trend was not addressed here, and has not been explicitly addressed elsewhere to the author's knowledge. On top of this, Kleiner (2018) and Van der Harst and Van de Velde (2008) warn that the uvula might swing even from airflow constricted at the velum, so that the velar noise might be overpowered by the scrape. As discussed in Section 4.1, the data does seem to identify CoG as a suitable tool to distinguish uvular fricatives from velar ones, though it should also be said that the CoG measure was not found to be a suitable tool to distinguish all sounds across PoAs from uvular sounds. This might be because of the physical nature of uvular fricatives. What differentiates scrape from trill is the strong airflow, causing at least the some period to not have a full closure at the uvula, whereby the air produces a high-frequency sound by being pushed through the narrow space, not unlike the additional obstacle causing high-frequency frication in the production of sibilants. This noisier, more perceptually prominent, strong turbulence produced with more pressure due to the typical obstruction of airflow by the uvula is how uvular fricatives are considered [+strident], compared to [−strident] velars (Jakobson et al. 1952). . While this high-frequency frication might explain why the CoG of the scrapy uvulars of Participant E were so high, this still stands in conflict with data in earlier research and leads back to the problem of classifying non-scrape uvulars. Above this, it suggests that CoG might be better employed for a differentiation of PoAs for strident fricatives and for mellow fricatives respectively. The contrast to the literature might also stem from the fact that some reference values, such as Mayer (2014), conflate uvulars and velars in SG, as it is tradition. In some cross-linguistic literature on languages that do feature a phonemic distinction between uvulars and velars, higher values for uvular CoG are attested: Gordon et al. (2002) finds uvular CoG values for Aleut at 4358 Hz and Montana Salish at 4043 Hz. While the value for velar fricatives in Aleut is around the same as for uvulars, Montana Salish uvular CoG values find themselves halfway between the values for [x] and [ʃ], which confirms the assumptions made about the data at hand, i.e. that while CoG can distinguish uvular and velar fricatives, it might be a better tool to distinguish uvulars from other stridents than to distinguish uvulars from all other PoAs. However, considering other cross linguistic data from Siwe (Sharp et al., 2023), in which uvular fricatives showed significantly lower CoG values (859 Hz) than velar fricatives (1315 Hz) also paints uvular CoG as a language-specific issue. This is a bit of a problematic assumption for dialectological research, as one might question how comparable the above data is between dialects. After all, Jannedy & Weirich (2016) found a significant difference between the CoGs in the two cities examined.

Similarly, the perception experiment could have been handled more intuitively by applying a chi-squared test to a cross tabulation of relevant dialect groups and the number of responses they received based on the uvularity or velarity of the stimulus. However, seeing as dialect is arguably a continuous variable and there were no apparent clusters of responses to velar or uvular stimuli, the current approach can be deemed as more suitable.

### *5.2 Overall Interpretation*

The classically attested pattern of a two-way allophonic variation necessarily including [x] is not reflected in the data, as all participants did exhibit scrape on at least some stimuli. However, as mentioned, scrape might be more of a sufficient, as opposed to a necessary, condition for uvularity. This is to say that while the presence of scrape always signifies the presence of a uvular fricative, the absence of scrape does not entail the absence of uvularity. As discussed, the current analysis did not focus on classifying the exact conditions under which scrape in contrast to non-scrape uvularity takes place and can therefore not make any reliable statements about the exact patterns that can be found in SG.

Considering the joint evidence from both experiments, a lack of phonologization of a [x] and [χ] contrast as suggested by Kohler (1990) is evident. While the palatal front allophone stands in complete complementary distribution with the back allophone and these two should be recognized as distinct with ease by any SG speaker, the back allophone seems not to be distinguished with a similar phonological rule in judgement or realization. Instead, evidence from the production experiment, in which all participants produced both scrape and non-scrape fricatives across all vowels, points to situational phonetic factors influencing scrape. This is supported by the fact that the duration of the fricative and the power and energy with which it is produced have been shown to impact CoG significantly. Uvularity with scrape therefore seems to happen coincidentally, not phonologically, in the dialects examined. The same might be assumed for uvularity without scrape, but, as mentioned, the current analysis cannot testify for this.

There is of course no way to reach certainty on why the results of the perception experiment showed next to no effect and were not significant. However, probable causes could be one or a combination of the following factors: (1) there is no regional variation on the current issue, (2) participants' lack of metalinguistic or geographical knowledge interfered with the execution of the task, or (3) participants did not perceive a difference. Next to the fact that some participants reached out to report that (3) was the case (as is also reflected in the many clicks on the same pixels), it is worth to consider the observation that many participants who reported growing up where Aachen Ripuarian was spoken predominantly chose this same area as a reaction to both velar and uvular stimuli.

**Figure 7**

*Judgments from participants with Aachen Ripuarian as their home dialect, the red cluster in the West overlaps with the geographical location of Aachen.*

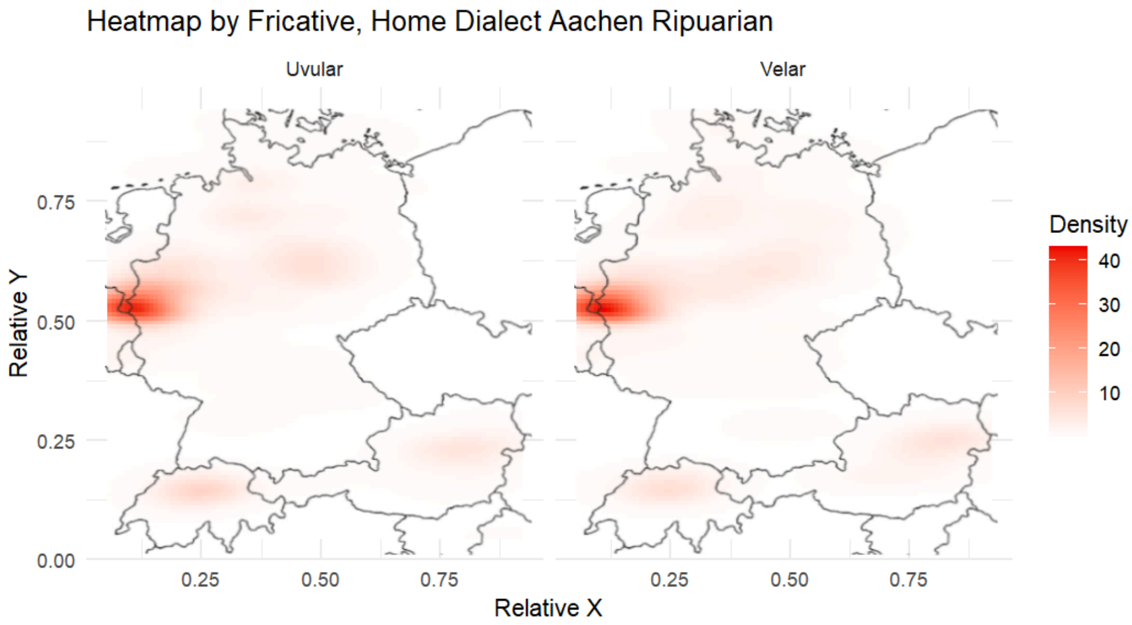
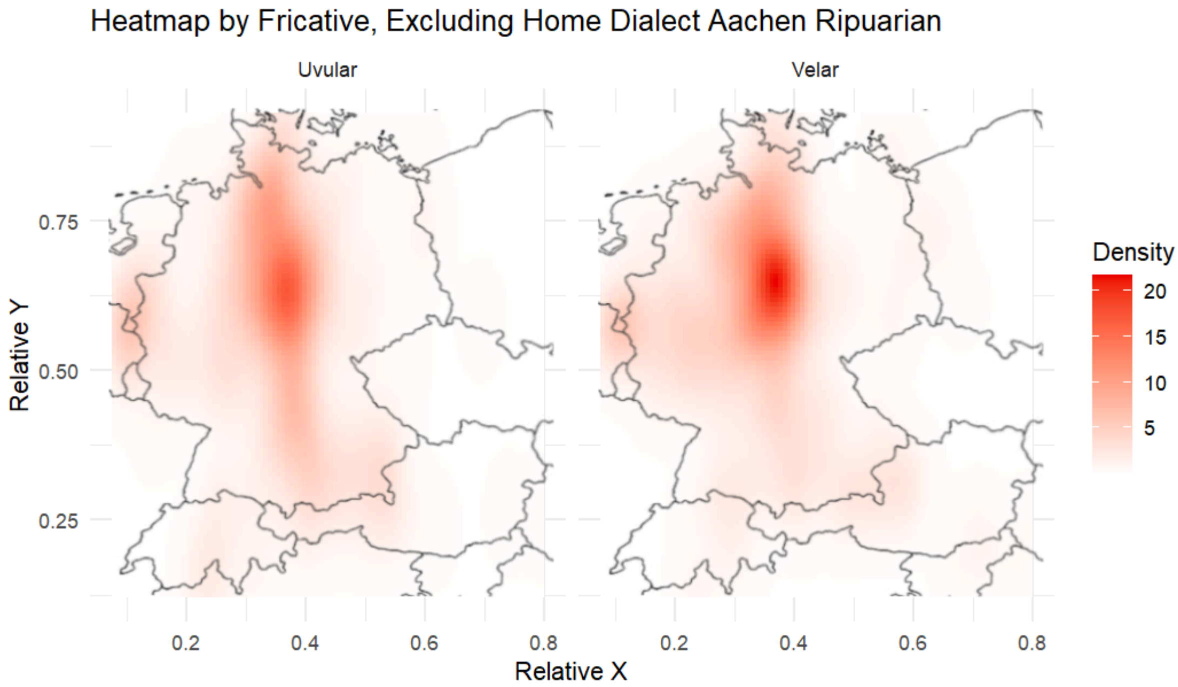



**Figure 8**

*Judgments from all participants who did not indicate Aachen Ripuarian as their home dialect, the red cluster in the center overlaps most closely with the geographical location of Hanover.*




This might imply that participants did actively engage what metalinguistic knowledge they had, but upon not recognizing either sound as strange concluded that it must be from around where they were from[4].

Overall, participants' answers are strewn across different areas between subjects, and yet balance each other's responses to velar and uvular stimuli out almost perfectly on a group level. This might be interpreted to favour (1) as a reason for non-significance, although this interpretation is perhaps the most speculative made so far.

To summarize, if we consider the evidence from the production part and assume that, as participants have reported, the lack of effect in the perception task is truly due to a perceived lack of contrast between velar and uvular stimuli, then the three-way complementary allophonic variation suggested by Kohler is just as contradicted by the data at hand as the classical two-way [x]/[ç] variation.

As mentioned, the data at hand points to variation being a mix of ideolectal and situational phonetic factors, but further analysis would be needed to make concluding remarks on the precise predictors of uvularity. Specifically, data from more dialects would be needed to identify the role of regional variation. It would be especially interesting to collect data from the Austro-Bavarian dialect area, as this was the only one clearly shown to exhibit

[4] For completeness, it should be mentioned that Aachen might be a special case not only because most data stems from participants that are from there, but also because the Benrath isogloss line runs just to the north of the city, inhabitants might therefore simply find different realizations of the back dorsal fricative more permissible.

velarity in Kleiner (2018). As mentioned above, an advantage of methodologies testing perception as an avenue into dialectology is that participants from everywhere theoretically deliver data on all dialects. However, this advantage could not be reaped from the experiment, presumably due to the three factors identified above.

Instances such as the deliberate grouping of [ʁ] and [x] into one velar category by the German Pronunciation Dictionary (Krech et al., 2009) might demonstrate a lack of relevance attached to this issue by previous research. Conversely, the fact that a pronunciation dictionary, which should give precise phonetic information, conflates these two can be seen as an argument for the assumption that the phonetic realities of dorsal fricatives are not sufficiently researched in SG . This becomes especially problematic, when one considers that the allophones discussed are regularly taken as prime examples for the voiceless palatal and velar fricatives. Often, pronunciation guides (e.g. Krech et al., 2009, Siebs, 1969) feature descriptions such as "like German *ach*" (for velars) or "like German *ich*" (for palatals). This might not only become a problem for L2 acquisition and speech therapy, but it also risks incorrect transcriptions of other languages containing uvular fricatives. For example, literature on Castilian Spanish often transcribes the sound described by ⟨j⟩ as [x] (eg. Martínez Celdrán et al., 2003), despite this very sound being one to distinguish many European Spanish varieties from American Spanish varieties on the basis of its perceived stridency (Richards, n.d.). The same is true for other languages such as Persian, where scrape can frequently be heard despite the popular transcription as [x] (Majidi & Ternes, 1991).

If distinctions like these are not made in phonetic research, phoneticians rob themselves of the vocabulary to speak about these languages. A possible anti-uvularity bias implies that right now, it is unknowable how many languages that are transcribed as velar feature the uvular fricative. Some other languages do feature both sounds as contrastive, with separate representations in the language's orthography (see above), which motivates in itself why these two sounds, despite falling on the same fricative spectrum, are distinct and should be recognized as such. If it is the case that uvular and velar fricatives are effectively interchangeable enough to be transcribed as one in a language, this should at least be motivated, which is not the case for SG, where the imprecision of the transcription has here been identified as not satisfactory to describe SG speech.

# 6. Conclusion

The current study investigated the uvularity of the back allophone of ⟨/x/⟩ in SG against the discrepancy between the common transcription as ⟨[x]⟩ and the common realization as [χ]. This was mainly approached from a dialectological perspective, since the two sources describing the uvularity of the sound in question mention this as a probable cause for variation. A word-list reading task and a map-placement task failed to yield significant results on the relationship between uvularity (operationalized as CoG) and Dialect. The null hypothesis could not be rejected. However, acoustic data could be used to make assumptions towards the secondary goal of this investigation, which was to scrutinize formerly described patterns of uvularity. To this effect, the still widely used, pre-Kohler description as a two-way allophonic complementary distribution with a palatal and a velar allophone was not reflected in the data, as all participants produced uvular fricatives, although with different patterns. These patterns showed within- and between- participant variation and, in combination with the apparent lack of distinction between uvulars and velars during the perception task, can be seen as evidence against the three-way allophonic distribution suggested by Kohler. In sum, dialect cannot be excluded or identified as a predictor for uvularity, but the data most likely points to a combination of idiolectal, phonetic and, perhaps, dialectal factors.

The main merit of the current investigation is therefore not the specification of the "actual" pattern used in SG, but rather the provision of a broader discussion on how and why attested patterns might fail to describe SG speech: In the light of Kleiner's data and the current data showing that at least some people's speech exhibits (nearly) only uvular realizations, the common transcription as velar might speak of an "anti-uvularity-bias", especially when the historical imprecisions in the description and transcription of back dorsal sounds (as discussed in Section 2) are taken into account. After identifying the potential causes here, future research needs to treat the symptoms, and whether this bias should be combated by a new standard transcription as ⟨[χ]⟩ needs to be evaluated by future studies which might find a more fitting description for non-scrape uvulars to quantify SG uvularity more holistically.

In general, future research could address the data obtained here by performing a more holistic analysis, i.e. considering other acoustic properties such as spectral shape (global peak, local peaks, kurtosis) and formant transitions, treating the articulatory context, effects of pseudo-words and word-frequency, gender and age of participants, performing proper cluster analysis on the perception data, or finding a way to perform the more intuitive approaches to the data outlined in Section 5.2. Future studies might also replicate the current experiment with improved methodology: Participant confusion on the perception test could be forecome by employing a forced-choice labelling task or a nativeness judgement task, perhaps in combination with the matched-guise technique. Improved production data, on the other hand, could come from an extended task with pseudowords which also elicit the back dorsal allophone in word-initial position (as this might make a naturalistic, yet salient pronunciation more likely), or utilizing corpus data from speakers using SG more consciously, such as politicians or news reporters. This might test if speakers prefer [χ] or [x] when deliberately standardizing their speech as much as possible, or if this is not a distinction which is important at all in SG.

Apart from this, equipment constraints excluded the perhaps most suitable approach, an articulatory study using imaging technology such as MRI or ultrasound. Other approaches could include educating participants from different regions on [χ] or [x] and having them produce the contrast on demand, or test their perception of the contrast for Ganong effects (Ganong, 1980). Lastly, a more phonological avenue might be taken to investigate the underlying phonological processes with the help of synchronic (such as word-final /g/ becoming ⟨[x]⟩ in some dialects, or ⟨[x]⟩ becoming voiced due to general fricative voicing in others (Herrgen & Schmidt, 2019)) and diachronic (such as the mentioned sound change data from Yiddish and other Germanic languages) evidence. Future research might also address the dorsal SG phonological inventory more broadly to see if, e.g., the realization of the front allophone or the rhotic, which are both quite diverse between German varieties, can be related to the realization of ⟨[x]⟩.

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# Appendix A: Stimuli

Real Word Stimuli:

| Nr. | Vowel | Stimulus | Translation |
|---|---|---|---|
| 1 | [uː] | Buch | book |
| 2 | | wuchern | to grow rampantly |
| 3 | | Tuch | cloth |
| 4 | | Kuchen | cake |
| 5 | | Fluch | curse |
| 6 | | suchen | to search |
| 7 | | Buche | beech tree |
| 8 | | ruchlos | heinous |
| 9 | [oː] | hoch | high |
| 10 | | malochen | to work hard |
| 11 | [ʊ]/[aʊ̯] | Bucht | bay |
| 12 | | auch | too |
| 13 | | Bruch | fracture |
| 14 | | Bauch | stomach |
| 15 | | Zucht | breeding |
| 16 | | Hauch | whiff |
| 17 | | brauchen | need |
| 18 | | Sucht | addiction |
| 19 | | Wucht | impact |
| 20 | | Taucher | diver |
| 21 | | fauchen | to hiss |
| 22 | | stauchen | to compress |
| 23 | | rauchen | to smoke |
| 24 | | Spruch | saying |

| | | | |
|---|---|---|---|
| 25 | | Strauch | shrub |
| 26 | | Flucht | escape |
| 27 | | fuchteln | to wave frantically |
| 28 | | Schlucht | canyon |
| 29 | | Jauche | sewage |
| 30 | | Geruch | smell |
| 31 | | Schluchzer | sob |
| 32 | | jauchzen | to frolock |
| 33 | | Schlauch | hose |
| 34 | | Schmauch | dense smoke |
| | | straucheln | to stumble |
| | | Frucht | fruit |
| | | Lucht | Attick |
| | | Lauch | leek |
| 35 | [ɔ] | Tochter | daughter |
| 36 | | Koch | cook |
| 37 | | Loch | hole |
| 38 | | Hochzeit | wedding |
| 39 | | pochen | to throb |
| 40 | | Docht | wick |
| 41 | | Woche | week |
| 42 | | noch | still |
| 43 | | doch | yes |
| 44 | | Epoche | period |
| 45 | | kroch | crept |
| 46 | | mochte | liked |
| 47 | | blochen | to wachs a floor |

| | | | |
|---|---|---|---|
| 48 | | Joch | yoke |
| 49 | | stochern | to poke |
| 50 | | Rochen | ray (banomorphi) |
| 51 | | Knochen | bone |
| 52 | [a]/[aː] | achtlos | careless |
| 53 | | Sache | thing |
| 54 | | Bach | creek |
| 55 | | lachen | to laugh |
| 56 | | Weihnachten | christmas |
| 57 | | Schach | chess |
| 58 | | machen | to do |
| 59 | | Nachbar | neighbour |
| 60 | | Fach | subject |
| 61 | | Krach | noise |
| 62 | | Macht | power |
| 63 | | Wache | guard |
| 64 | | Dach | roof |
| 65 | | Rache | revenge |
| 66 | | einfach | simple |
| 67 | | Sprache | language |
| 68 | | nach | after |
| 69 | | Achtung | attention |
| 70 | | betrachten | to consider |
| 71 | | gedacht | thought |
| 72 | | flach | flat |
| 73 | | schwach | weak |
| 74 | | gebracht | brought |

| | | | |
|---|---|---|---|
| 75 | | Nacht | night |

Pseudo Word Stimuli:

| Nr. | Vowel | Stimulus |
|---|---|---|
| 76 | [uː] | Duuchend |
| 77 | | uuchten |
| 78 | | einuuchern |
| 79 | | skuuchlas |
| 80 | | Juuchner |
| 81 | | spuuchen |
| 82 | | Nuucher |
| 83 | | Struucht |
| 84 | | Wuuchte |
| 85 | | bepuucht |
| 86 | | stuuchen |
| 87 | | luuchte |
| 88 | | juucht |
| 89 | | zwuuchen |
| 90 | | einluuchs |
| 91 | | Fuuchlung |
| 92 | | unluuche |
| 93 | | kruucht |
| 94 | | aschnuuch |
| 95 | | buuchteln |
| 96 | | schmuuch |
| 97 | | Duuchke |
| 98 | [oː] | stroocht |
| 99 | | joochtben |

| | | |
|---|---|---|
| 100 | | Pfloocht |
| 101 | | Toochbeit |
| 102 | | Schlooch |
| 103 | | Hoochter |
| 104 | | benoocht |
| 105 | | verkoocht |
| 106 | | gezoocht |
| 107 | | toochen |
| 108 | | Schooche |
| 109 | | groochern |
| 110 | | rooch |
| 111 | | noochel |
| 112 | | Schooch |
| 113 | | foochieren |
| 114 | | Boochet |
| 115 | | toochal |
| 116 | | fürwooch |
| 117 | | spoocher |
| 118 | | denoochal |
| 119 | | Prooche |
| 120 | | eingoochig |
| 121 | | Toochner |
| 122 | | goochlos |
| 123 | | bepoochten |
| 124 | | Koocht |
| 125 | | wooch |
| 126 | [ʊ]/[aʊ̯] | mauch |

| | | |
|---|---|---|
| 127 | | pluchtens |
| 128 | | huchbe |
| 129 | | Lucht |
| 130 | | Wauche |
| 131 | | kauchsten |
| 132 | [ɔ] | Bochter |
| 133 | | floch |
| 134 | | zochend |
| 135 | | Gocht |
| 136 | | spochen |
| 137 | | Foche |
| 138 | | Schroch |
| 139 | | flocheln |
| 140 | | amsoch |
| 141 | | Ochtes |
| 142 | | rochieren |
| 143 | | abocht |
| 144 | | lockoch |
| 145 | [a]/[aː] | hacht |
| 146 | | Kaache |
| 147 | | achlas |
| 148 | | fachte |
| 149 | | gaach |
| 150 | | plaache |

# Appendix B: Script 1 – CoG Analysis for Stimuli

```
# this script is for velar sounds, for uvular change file path, variable
names and "V" to "U"

clearinfo
appendInfoLine: "Segment", tab$, "Average_CoG_Hz"

#directory
directory$ = ;DIRECTORY

textgridList = Create Strings as file list: "textgridList", directory$ +
"*.TextGrid"
numFiles = Get number of strings

for i from 1 to numFiles
    selectObject: textgridList
    fileName$ = Get string: i
    baseName$ = replace$(fileName$, ".TextGrid", "", 0)
    soundFile$ = directory$ + baseName$ + ".wav"
    tgFile$ = directory$ + fileName$

    Read from file: soundFile$
    sound = selected("Sound")

    Read from file: tgFile$
    tg = selected("TextGrid")

    # All intervals are on tier 5
    phonemeTier = 5
    selectObject: tg
    numIntervals = Get number of intervals: phonemeTier
    totalCoG = 0
    vCount = 0

    for j from 1 to numIntervals
      selectObject: tg
        label$ = Get label of interval: phonemeTier, j
        if label$ = "V"
            vStart = Get start time of interval: phonemeTier, j
            vEnd = Get end time of interval: phonemeTier, j

            selectObject: sound
            vPart = Extract part: vStart, vEnd, "rectangular", 1, "yes"
            spectrum = To Spectrum: "yes"
            cog = Get centre of gravity: 1.0

            totalCoG = totalCoG + cog
            vCount = vCount + 1

            removeObject: vPart, spectrum
        endif
    endfor

    appendInfoLine: baseName$, tab$, string$(avgCoG)

    removeObject: sound, tg
endfor
```

# Appendix C: Script 2 – Splicing, Aligning and Adjusting Intensity and Duration of Spliced Stimuli

```
# this version performs splicing at zero crossings, scales originalSound to
60dB and 0.99 peak and adjusts the duration
# best V already is adjusted for zero crossings and intensity (via Scale
peak...0.99, Scale intensity ... 60dB)
# this script splices the best V into all uvular stimuli. For uvulars: change
everything to U. splice best U into all uvulars.

input_folder$ = ; DIRECTORY
tier_number = 5  ; "U" is always on tier 5
output_folder$ = ; DIRECTORY

wavList = Create Strings as file list: "wavList", input_folder$ + "*.wav"
numFiles = Get number of strings

for i from 1 to numFiles
      Read from file: "...bestV.wav" ; DIRECTORY
      bestV = selected("Sound")
      bestVDuration = Get total duration
      selectObject: wavList
      wavFileName$ = Get string: i
      baseName$ = replace$(wavFileName$, ".wav", "", 0)
      textGridPath$ = input_folder$ + baseName$ + ".TextGrid"

      Read from file: input_folder$ + wavFileName$
      originalSound = selected("Sound")
      Read from file: textGridPath$
      textGrid = selected("TextGrid")

      # scale intensity and peak
      selectObject: originalSound
      Scale intensity: 60
      Scale peak: 0.99

      # zero crossings
      selectObject: textGrid
      tierNumber = 5
      intervalIndex = 2
      t1 = Get start time of interval: tierNumber, intervalIndex
      t2 = Get end time of interval: tierNumber, intervalIndex

      selectObject: originalSound
      newt1 = Get nearest zero crossing: 1, t1
      newt2 = Get nearest zero crossing: 1, t2

      newDuration = newt2 - newt1

      # adjust duration
      factor = newDuration/bestVDuration
      selectObject: bestV
      newbestV = Lengthen (overlap-add): 75, 300, factor

      # replace V segment
      selectObject: originalSound
      Extract part: 0, newt1, "rectangular", 1, "yes"
      part1 = selected("Sound")

      selectObject: originalSound
```

```
	totalDuration = Get total duration
	Extract part: newt2, totalDuration, "rectangular", 1, "yes"
	part2 = selected("Sound")

	resampledV = newbestV

	plusObject: resampledV
	plusObject: part2
	Concatenate
	midSound = selected("Sound")
	plusObject: part1
	Concatenate
	finalSound = selected("Sound")

	outputName$ = output_folder$ + baseName$ + "V_spliced.wav"
	Write to WAV file: outputName$

	removeObject: originalSound, textGrid, part1, part2, resampledV,
midSound
endfor
```

# Appendix D: Script 3 – Converting Stimuli to Stereo

```
# This script converts the spliced stimuli to stereo

input_folder$ = ; DIRECTORY
output_folder$ = ; DIRECTORY

wavList = Create Strings as file list: "wavList", input_folder$ + "*.wav"
numFiles = Get number of strings

for i from 1 to numFiles
	selectObject: wavList
	wavFileName$ = Get string: i
	Read from file: input_folder$ + wavFileName$
	sound1 = selected("Sound")

	selectObject: sound1
	sound2 = Copy: "new" + wavFileName$
	selectObject: sound1, sound2
	newSound = Combine to stereo

	removeObject: sound1, sound2

	selectObject: newSound
	outputName$ = output_folder$ + "stereo" + wavFileName$ + ".wav"
	Write to WAV file: outputName$
endfor
```

## Appendix E: Script 4 – Retrieving Data from Participant Recordings

```
# this script extracts "f" intervals and prints their cog, duration, energy
and power. participant data needs to be filled in manually.
# because every participant has up to 300 data points, praat will crash if
all data is processed simultaneously. this script is made to process each
participant's data individually.

clearinfo
appendInfoLine: "Segment", tab$, "Participant", tab$, "Dialect", "Interval",
tab$, "Average_CoG_Hz", tab$, "Duration", tab$, "Energy", tab$, "Power"

directory$ = ; DIRECTORY

textgridList = Create Strings as file list: "textgridList", directory$ +
"*.TextGrid"
numFiles = Get number of strings

for i from 1 to numFiles
    selectObject: textgridList
    fileName$ = Get string: i
    baseName$ = replace$(fileName$, ".TextGrid", "", 0)
    soundFile$ = directory$ + baseName$ + ".wav"
    tgFile$ = directory$ + fileName$

    Read from file: soundFile$
    sound = selected("Sound")

    Read from file: tgFile$
    tg = selected("TextGrid")

    # CoG from f intervals in tier 1
    phonemeTier = 1
    selectObject: tg
    numIntervals = Get number of intervals: phonemeTier
    totalCoG = 0
    vCount = 0

    for j from 1 to numIntervals
    selectObject: tg
        label$ = Get label of interval: phonemeTier, j
        if label$ = "f"
            fStart = Get start time of interval: phonemeTier, j
            fEnd = Get end time of interval: phonemeTier, j
        fDuration = fEnd - fStart

        selectObject: sound
        energy = Get energy: fStart, fEnd
        power = Get power: fStart, fEnd

            selectObject: sound
            fPart = Extract part: fStart, fEnd, "rectangular", 1, "yes"
            spectrum = To Spectrum: "yes"
            cog = Get centre of gravity: 2.0
            totalCoG = totalCoG + cog
            fCount = vCount + 1
```

```
            appendInfoLine: baseName$, tab$, "; PARTICIPANT ID;", tab$, ";
PARTICIPANT AGE;", tab$, "; PARTICIPANT GENDER; ", tab$, "; DIALECT;", tab$,
j, tab$, string$(cog), tab$, string$(fDuration), tab$, string$(energy), tab$,
string$(power)
            removeObject: fPart, spectrum
        endif
    endfor

    removeObject: sound, tg
endfor
```