

**“Stop! Hey, what’s that sound?
Everybody, look what’s going down!”**

or: what the last three years have taught me about Danish stops, luckily including something we did not already know, and including a radical proposal about how some of this may be underlyingly represented

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Verona/Tromsø PRx2



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Overview

- A primer on Danish stops
- Intervocalic voicing in Danish stops
- Regional variation in phonetics and phonology
- Q-CV: An extension of Q-theory



A primer on Danish stops

- Danish has six stop phonemes: /b d g p t k/
- In simple onset position,
 - /b d g/ are voiceless unaspirated [p t k]
 - /p t k/ are voiceless (highly) aspirated [p^h t^h k^h]
 - /t/ in particular has salient affrication [t^s]
- Since both sets are "phonetically lenis" (Grønnum: 1998), you'll often see transcriptions like these: [b̥ d̥ g̥]
- And to a lesser extent these: [b^h d^s g^h]



A primer on Danish stops

- We actually know *a lot* about the phonetics of Danish stops, mostly due to studies that are hidden away in old issues of *ARIPUC*

Acoustic Analysis of Stop Consonants

ELI FISCHER-JØRGENSEN

ELI FISCHER-JØRGENSEN

Les Occlusives françaises et danoises d'un sujet bilingue

PHONETIC ANALYSIS OF DANISH STOP CONSONANTS.

Eli Fischer-Jørgensen

KINESTHETIC JUDGEMENT OF EFFORT IN THE PRODUCTION OF STOP CONSONANTS

Eli Fischer-Jørgensen

Vocal Fold Adjustments in Aspirated and Unaspirated Stops in Danish¹

Birgit Hutters

THE EFFECT OF CONSONANT TYPE ON FUNDAMENTAL FREQUENCY AND LARYNX HEIGHT IN DANISH

NIELS REINHOLT PETERSEN



VOICING, TENSENESS AND ASPIRATION IN STOP CONSONANTS, WITH SPECIAL REFERENCE TO FRENCH AND DANISH

Eli Fischer-Jørgensen

A Preliminary Electromyographic Study of Labial and Laryngeal Muscles in Danish Stop Consonant Production

Eli Fischer-Jørgensen⁺ and Hajime Hirose⁺⁺

TAPE CUTTING EXPERIMENTS WITH DANISH STOP CONSONANTS IN INITIAL POSITION

Eli Fischer-Jørgensen

ASPIRATED STOP CONSONANTS BEFORE LOW VOWELS, A PROBLEM OF DELIMITATION, - ITS CAUSES AND CONSEQUENCES

ELI FISCHER-JØRGENSEN
AND
BIRGIT HUTTERS

A GLOTTOGRAPHIC STUDY OF SOME DANISH CONSONANTS

Børge Frøkjær-Jensen, Carl Ludvigsen, and Jørgen Rischel

TEMPORAL RELATIONS IN DANISH TAUTOSYLLABIC CV SEQUENCES WITH STOP CONSONANTS¹

Eli Fischer-Jørgensen

The effect of vowel height on Voice Onset Time in stop consonants in CV sequences in spontaneous Danish

Johannes Mortensen & John Tondering

A primer on Danish stops

- A popular analysis holds that there are complex alternation patterns in weak position (= coda, or onset before schwa)

Phoneme	Position	
	Strong	Weak
strong /t/	t	
weak /d/	d	d
		ð

Jakobson et al. (1951)

A primer on Danish stops

Phoneme	Strong	Weak
/p/	[p ^h]	[p]
/t/	[t ^h]	[t]
/k/	[k ^h]	[k]
/b/	[p]	[p ~ w]
/d/	[t]	[ð]
/g/	[k]	[k ~ w ~ j ~ Ø]
/v/	[v]	[w]
/j/	[j]	[j]

A primer on Danish stops

Phoneme	Weak
/p/	[p]
/t/	[t]
/k/	[k]
/b/	[w]
/d/	[ð]
/g/	[j]
/v/	
/j/	

A primer on Danish stops

- The evidence comes from alternations with irregular derivational morphology causing stress shift, e.g. the verbalizing suffix [-e:^hʔ]:

[kæ'lʌp]	<i>galop</i>	'gallop (n.)'
[kæ'lʌp ^h e: ^h ʔ]	<i>galopere</i>	'to gallop'
[væt]	<i>vat</i>	'cotton wool'
[væt ^h e: ^h ʔ]	<i>vattere</i>	'to apply cotton wool'
[lak]	<i>lak</i>	'lacquer (n.)'
[lak ^h e: ^h ʔ]	<i>lakere</i>	'to lacquer'

A primer on Danish stops

- Or nominalizing [-'ik], [-i't^he:ʔt]:

[so'liðʔ]	<i>solid</i>	'solid'
[soliti't ^h e:ʔt]	<i>soliditet</i>	'solidity'
[me't ^h o:ð]	<i>metode</i>	'method'
[met ^h o'tik]	<i>metodik</i>	'methodology'

- Or from strong verbal declension:

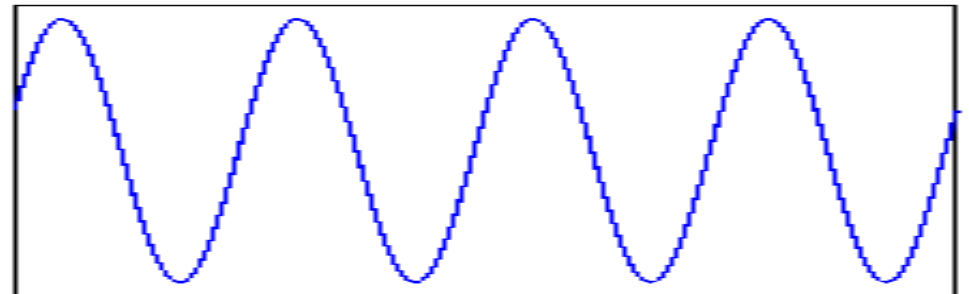
['pæ:i]	<i>bage</i>	'to bake'
['paʊvæɐ̯k]	<i>bagværk</i>	'baked goods'
[pakt]	<i>bagt</i>	'baked'

A primer on Danish stops

- In a forthcoming paper with two colleagues (Camilla Søballe Horslund & Henrik Jørgensen), we point out a number of problems with this analysis
 - Many words with final [w j] do not participate in such alternations, so there is no way of determining the underlying phoneme
 - The majority of relevant alternations come from highly specialized and late-acquired vocabulary, and it's unlikely that phonemic categories would fall into place that late
 - Some of the pairs (say, [k ~ j]) do not share any phonetic properties
- We propose that the alternations are better treated as suppletive forms, moving the burden of accounting for these from phonology → lexicon

Intervocalic voicing

- Like many other languages (Keating et al. 1983), Danish stops are often described as categorically voiced intervocalically
- RQs:
 - How often are stops voiced intervocalically, and in which environments?
 - Is stop voicing lenition?
 - Are /b d g/ or /p t k/ voiced most often?



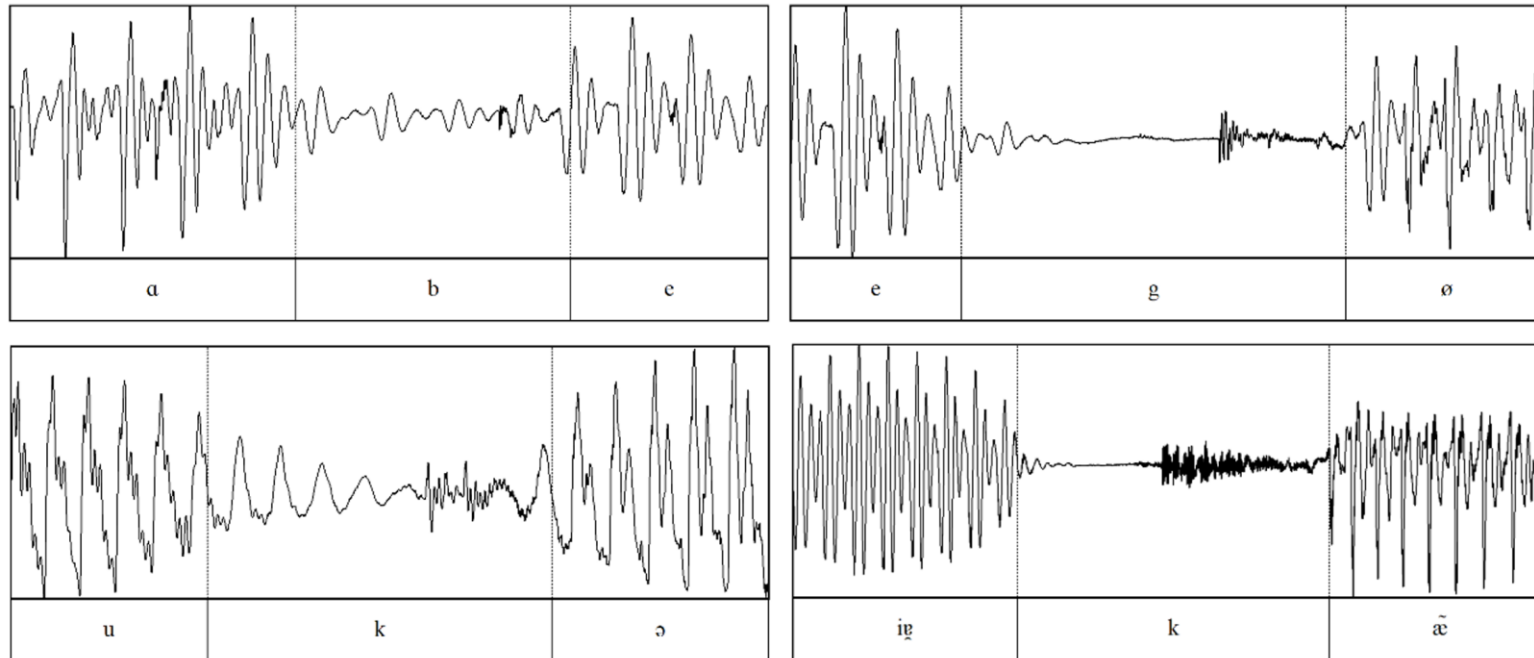
Intervocalic voicing

Why would /p t k/ be voiced most often?	Why would /b d g/ be voiced most often?	Why would there be no difference?
<ul style="list-style-type: none">• Intervocalic voicing is due to ‘voicing bleed’, and /p t k/ have the shortest closure• They are most ‘lenis’, i.e. produced with lowest degree of articulatory effort	<ul style="list-style-type: none">• They have less glottal spreading• (It just seems intuitively obvious, doesn’t it?)	<ul style="list-style-type: none">• Both sets have glottal spreading• Difference in articulatory effort may be insignificant• They are both ‘lenis’

Davidson (2016), Fischer-Jørgensen (1954), Fischer-Jørgensen and Hirose (1974), Hutter (1985), Grønnum (1998, 2005)

Intervocalic voicing - Method

- We used the DanPASS monologues
 - 18 speakers, ~3 hours of speech
- For each stop, we noted down if it was continuously voiced based on the waveform



Phoneme	Number
/b/	189
/d/	1,278
/g/	752
/p/	327
/t/	431
/k/	767
Total	3,744

Intervocalic voicing - Stats

- This was fitted to a logistic mixed effects regression model that looks like this:

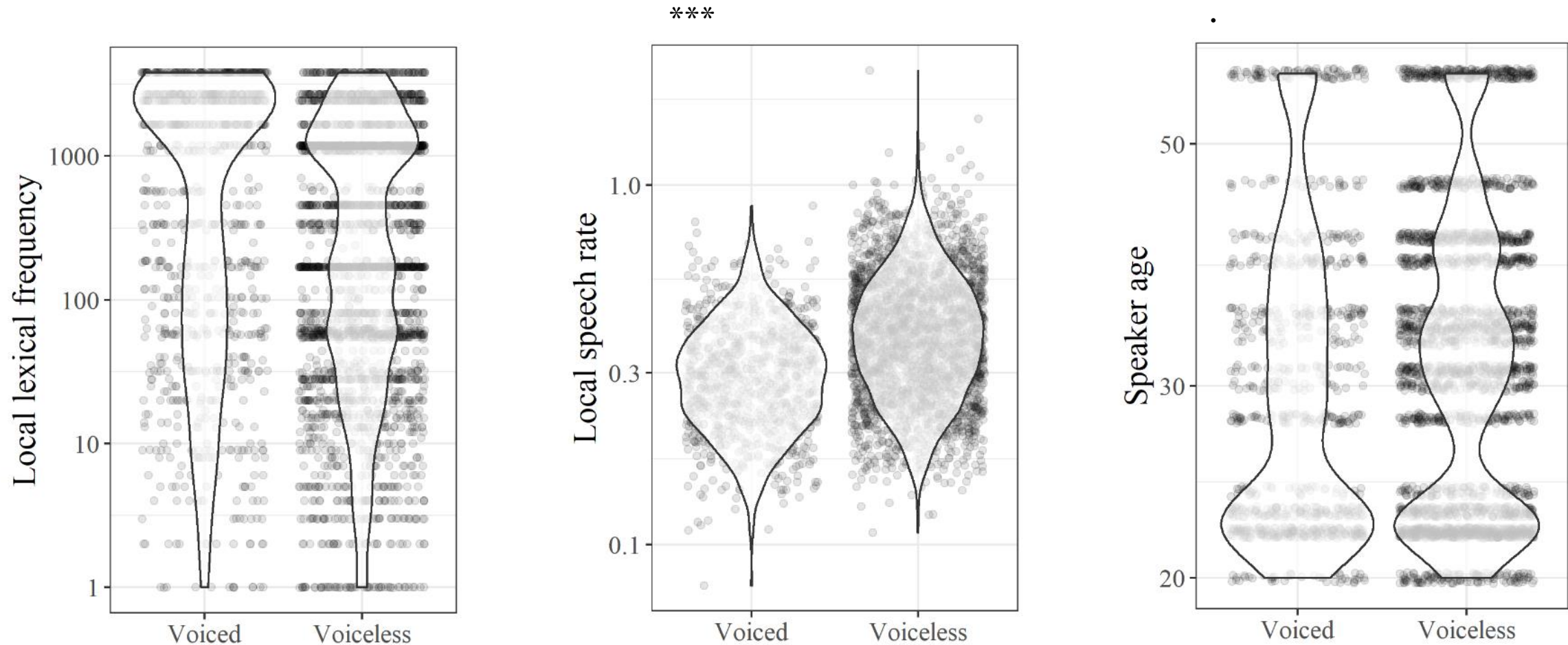
continuous closure voicing \sim phonological laryngeal setting + stress +
place of articulation + stød + preceding stød +
high vowel + central vowel +
morphological boundary + speech rate + age +
(laryngeal setting + stress | individual speaker) +
(speech rate + age | word)

- This model accounts for 67% of the variation in the data

Intervocalic voicing - Results

- Stops are voiced around **25%** of the time; /b d g/ ~40%, /p t k/ ~5%
- Higher odds of voicing:
 - Unaspirated (20.7)
 - Central vowel (2.0)
 - Stød (2.1)
 - Affix boundary (3.7)
- Lower odds of voicing:
 - Velar (2.9)
 - Stress (2.3)
 - Stød on preceding syllable (5.4)

Intervocalic voicing - Results

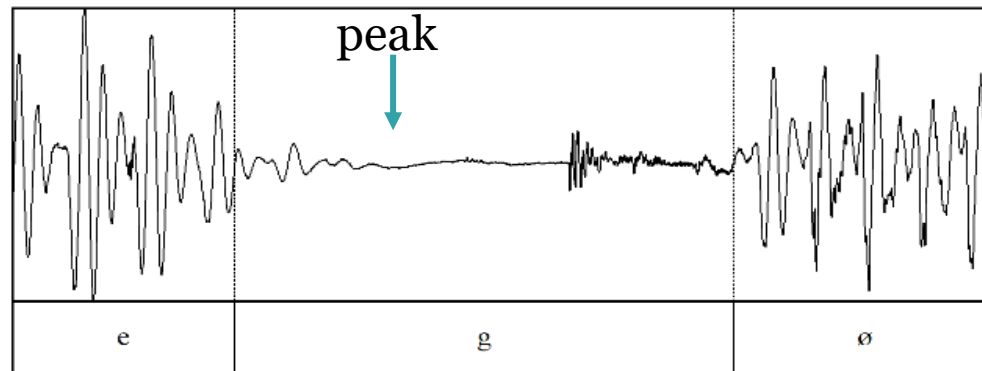


Intervocalic voicing - Discussion

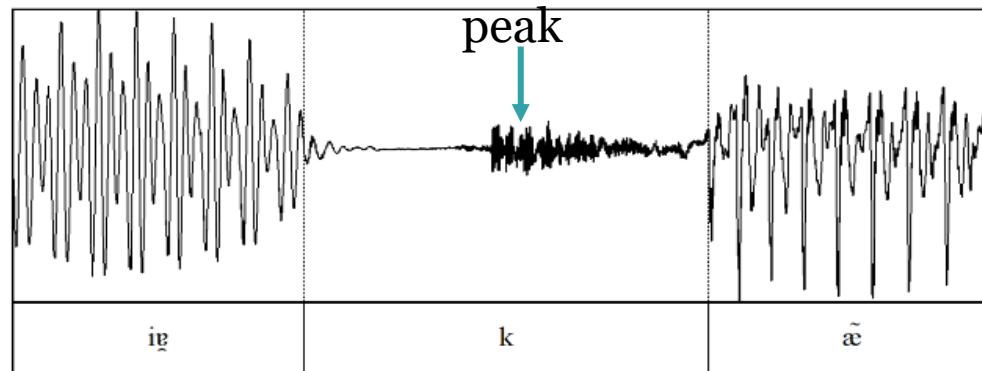
- Stops are certainly *not* voiced categorically in intervocalic position
 - Voicing is actually natural in intervocalic position (Westbury and Keating 1986)
 - This seemingly means that **voicing is actively blocked in all stops**
- Voicing behaves like a lenition phenomenon
 - It co-occurs with high speech rate, central vowels, affix boundaries, and is negatively correlated with stress
- **How can this lenition be modeled phonologically?**
 - As the loss of a phonologized glottal spreading gesture

Intervocalic voicing - Discussion

- /b d g/ have a spreading gesture of small magnitude and low functional load

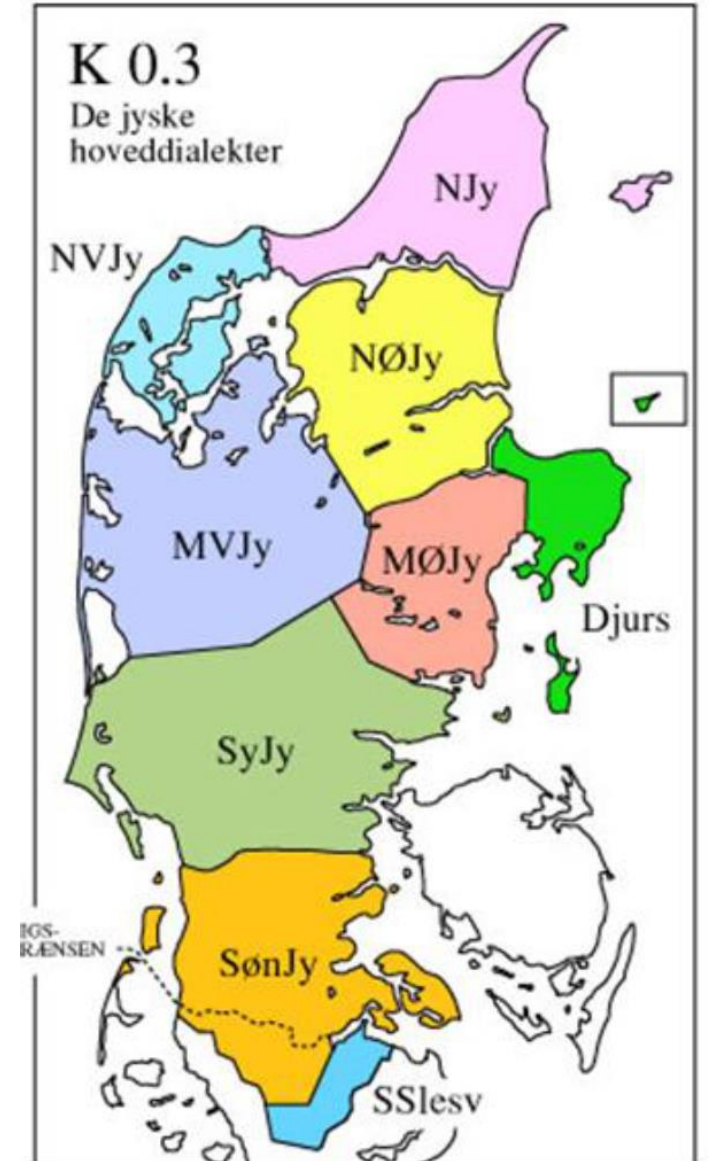


- /p t k/ have a spreading gesture of great magnitude and high functional load



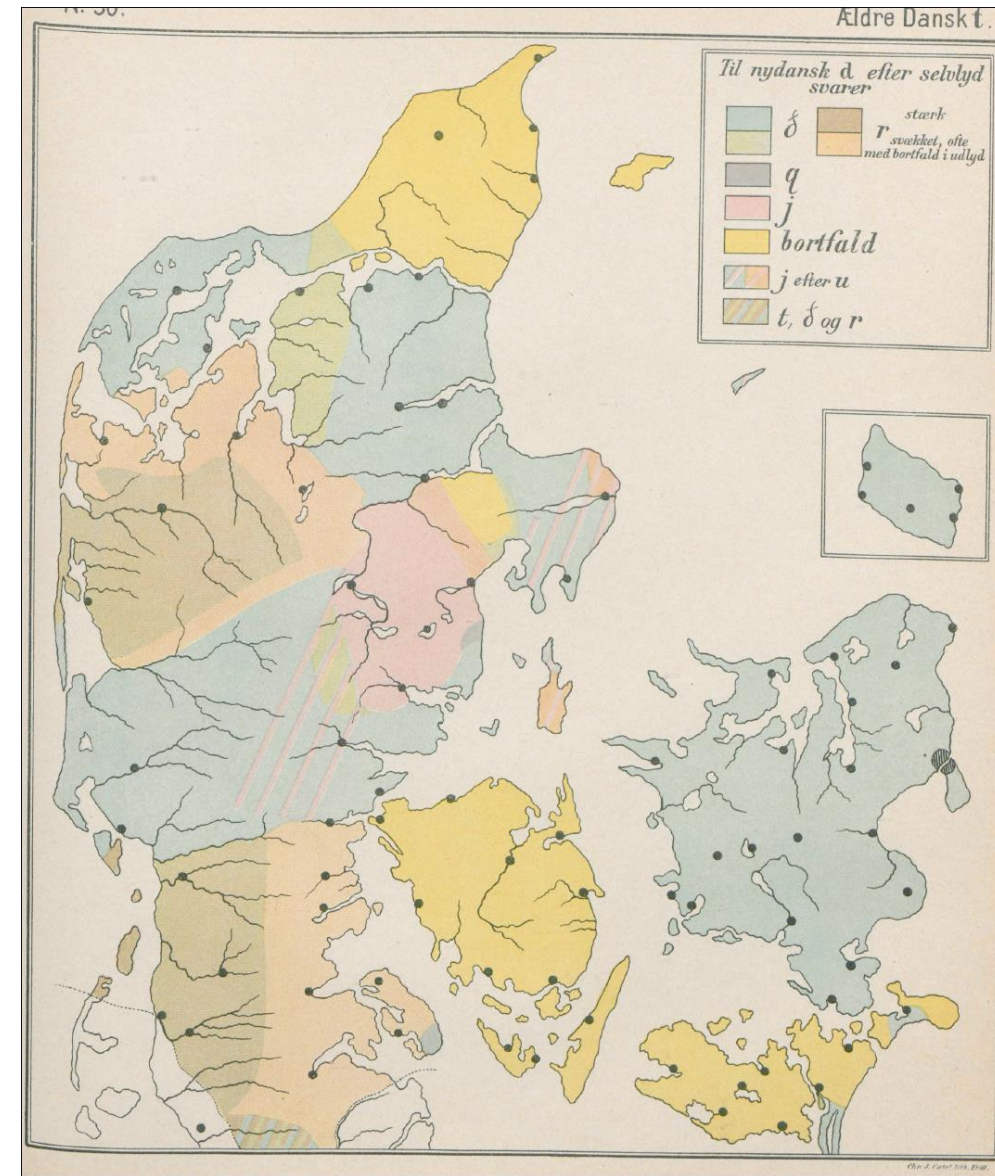
Regional variation

- ~100 years ago, regional variation was abundant in Danish
- In the past century, Denmark has been subject to rapid dialect leveling
 - Such that it is now sometimes described as one of the most homogenous language communities in the world
- Dialectology was huge in the early 1900s, so we know a lot about dialect geography – usually filtered through early 1900s structuralism



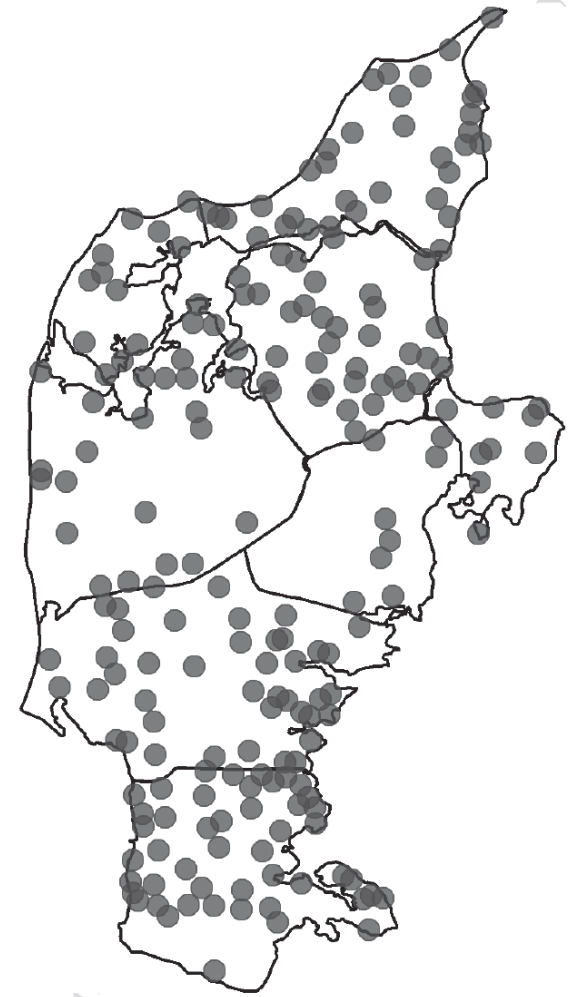
Regional variation

- It's well-known that these varieties differ in their implementation of stops
 - Stops have developed in different ways, and weak alternations differ greatly
 - There's overt variation in /t/ in particular, with some varieties lacking the salient affrication of Standard Danish
 - The phonetics of this is spectacularly understudied



Regional variation

- A huge documentation effort was made in the 1970s especially, so we now have recordings from reasonably high quality sociolinguistic interviews from around 500 different locations in the country
 - 3/4 male speakers
 - Mostly between 70-90 years old (mean = 77.4)
- These were recently digitized, and are freely available online
 - In total, this is more than 14 days of data



Regional variation

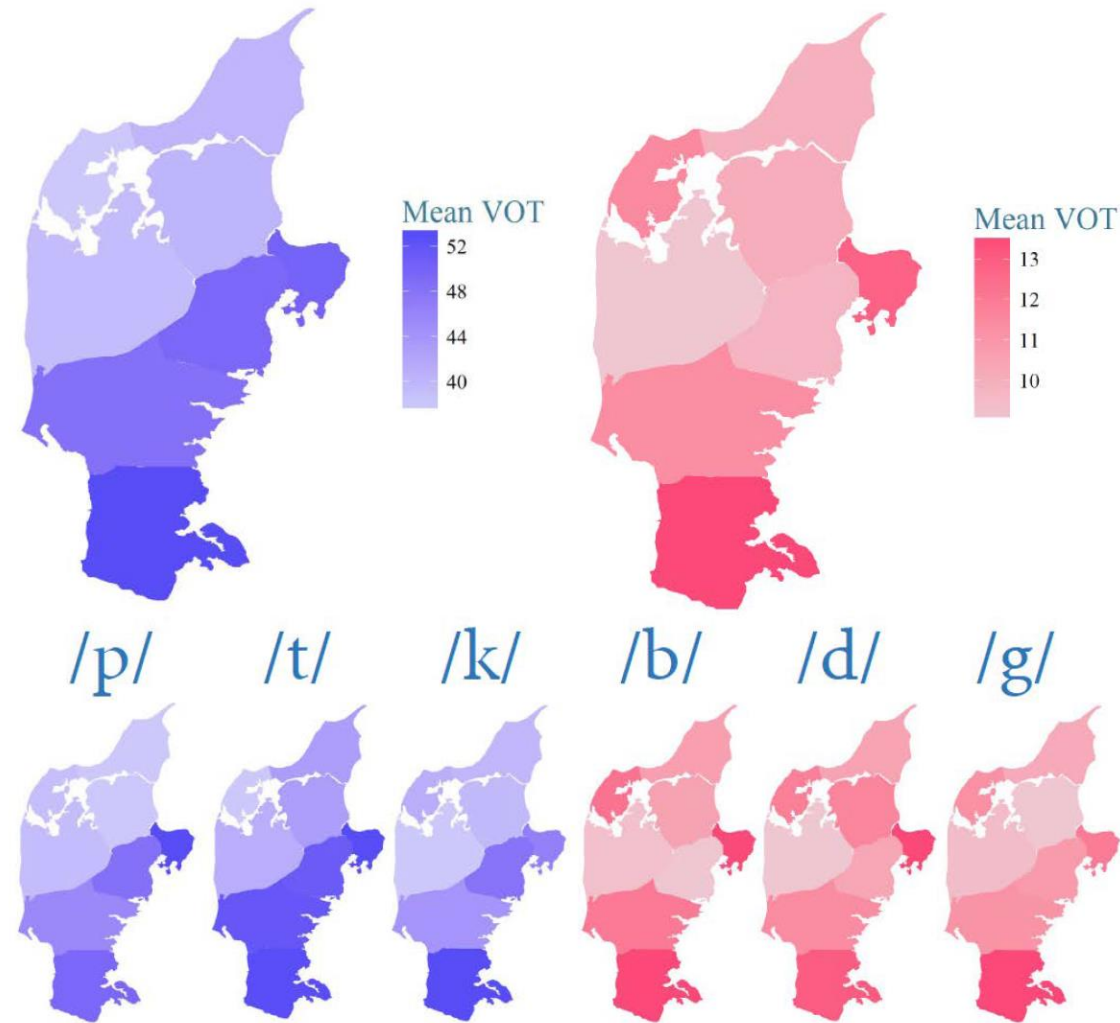
- I set out to systematically explore variation in aspiration and affrication in the stops of these varieties
- 70-100 stops from each of the 213 speakers
- From all stops: VOT
- From /p t k/: COG

Consonant	Number
(b)	2,212
(d)	2,369
(g)	2,273
(p)	1,386
(t)	5,169
(k)	4,095
Total	17,504

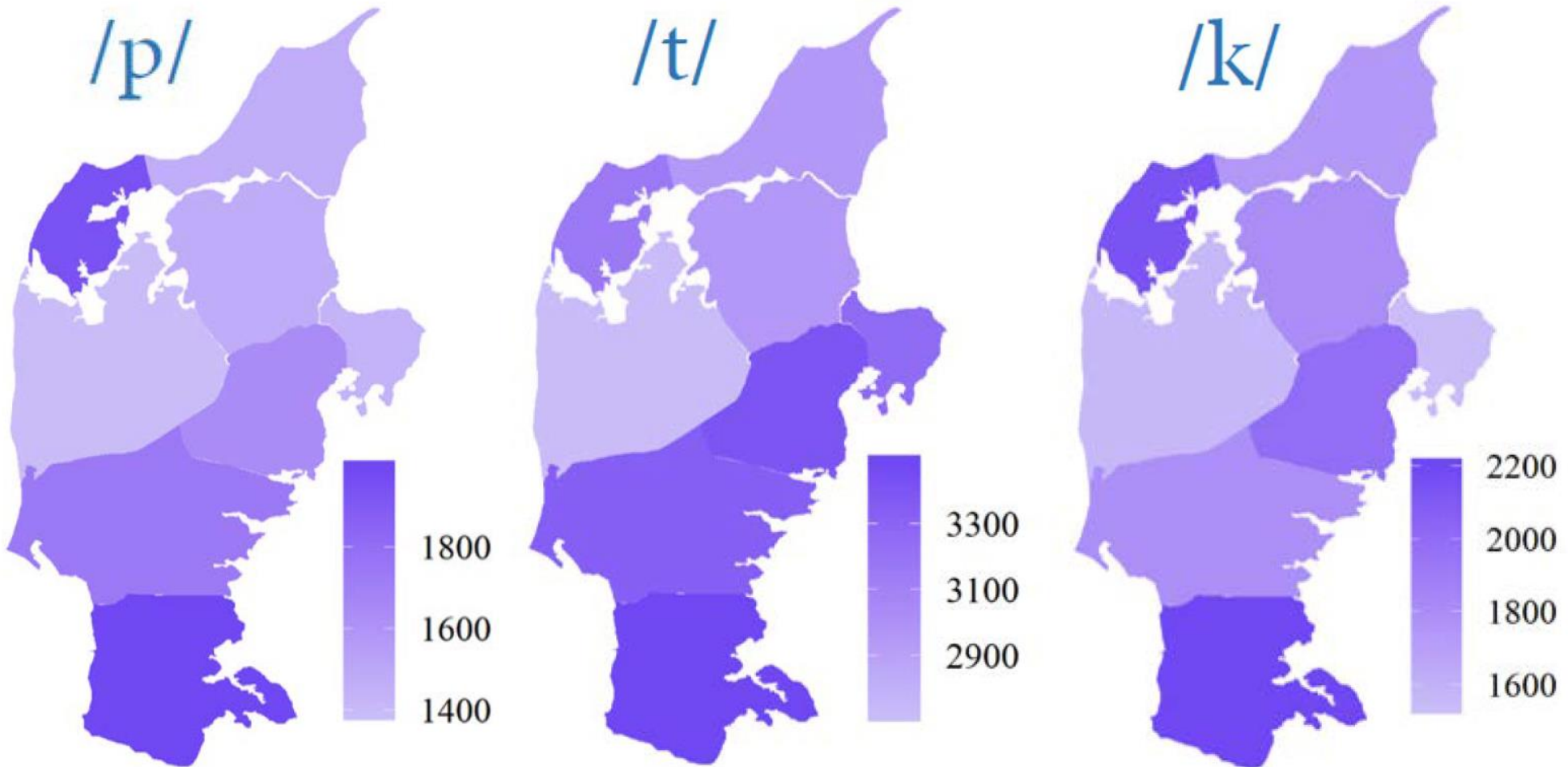
Regional variation – VOT

Aspirated stops

Unaspirated stops



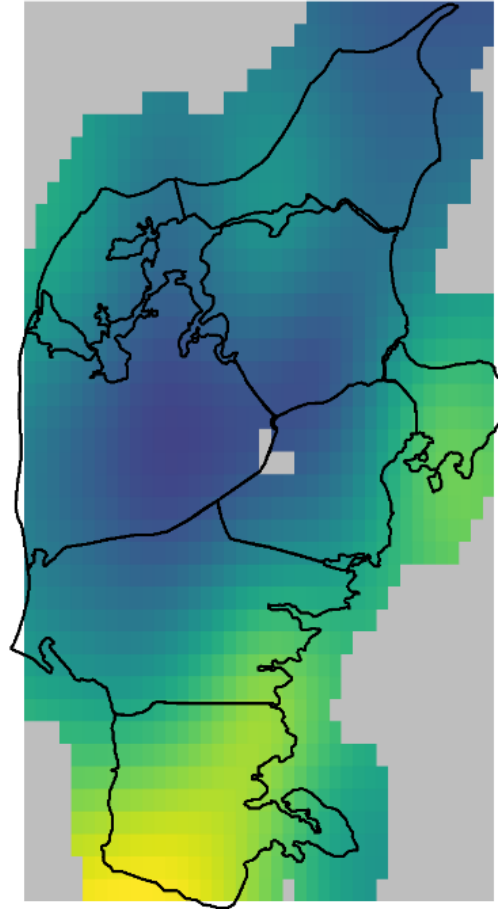
Regional variation – COG



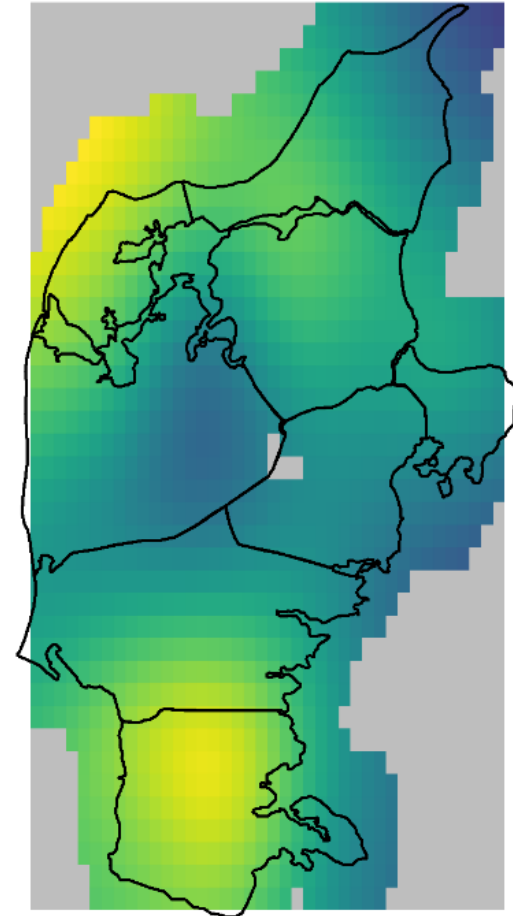
Regional variation

- This data was separately fitted to generalized additive mixed models
 - I'll skip the details, but the gist is I can model geographic variation dynamically rather than linearly
- Interestingly, the regional patterns do not differ by place of articulation

Main effect only, VOT



Main effect, COG

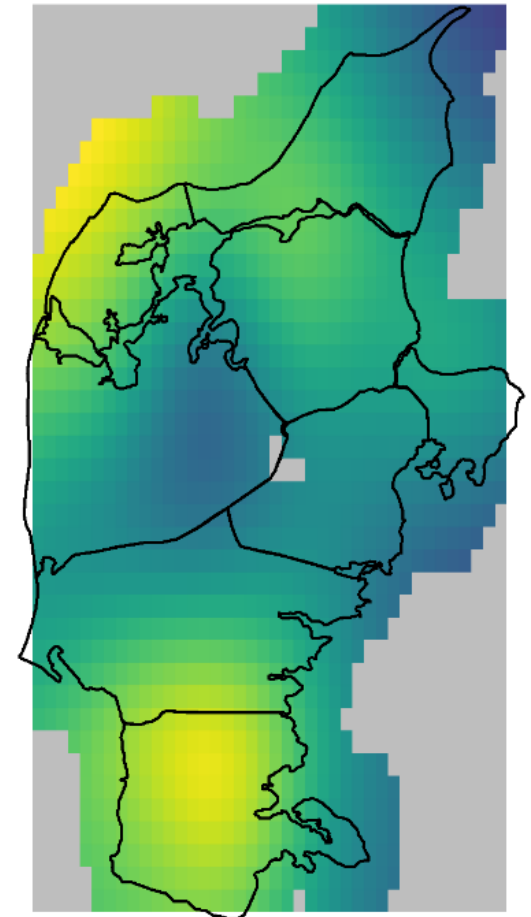
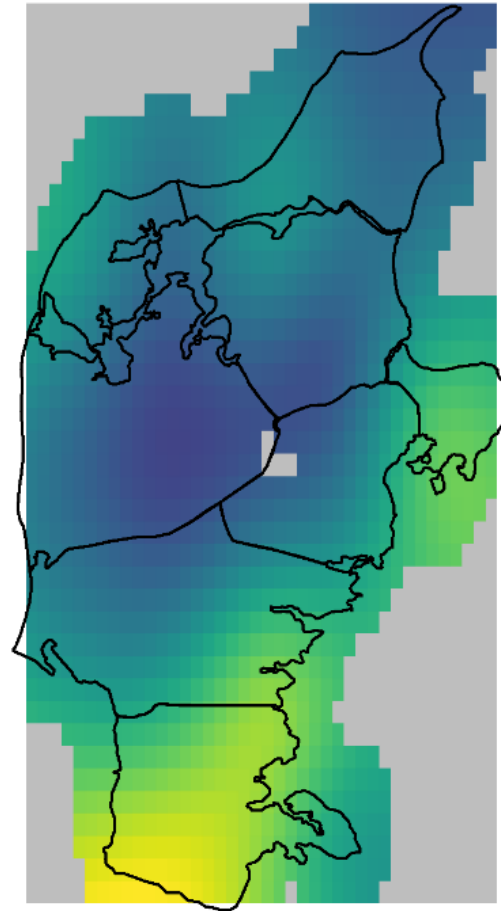


Regional variation

Predicted spirantization patterns

	VOT	COG
low	/b d g/ → [v ð, ɣ]	/p t k/ stable
high	/b d g/ → [f s x]	/p t k/ → [f s x]

Main effect only, VOT Main effect, COG



Regional variation – Discussion

- Main finding:
 - Hey there's this thing that used to be undescribed that we now have detailed knowledge of!
 - There's complex regional variation in the production of stops in Jutland Danish
 - And some evidence that these patterns are reflected in phonological developments and synchronic lenition patterns
- **Seemingly insignificant phonetic detail is not only reproduced systematically, but also interacts with phonology**



Freely adapted from Grice's Maxmemes

”Hold on Rasmus, weren’t you going to talk about Q-Theory?”

- Quite new framework of phonological representation
- Short for ”quantized” – tripartite division of traditional segments
- Very big on edge effects
- Has mostly been used to model strange segment types, like triphthongs, contour tones, circumoralized nasals

$$\hat{Q} = \begin{bmatrix} q \\ L \\ +\text{back} \\ -\text{high} \\ \dots \end{bmatrix} \begin{bmatrix} q \\ H \\ +\text{back} \\ -\text{high} \\ \dots \end{bmatrix} \begin{bmatrix} q \\ L \\ +\text{back} \\ -\text{high} \\ \dots \end{bmatrix}$$

Q-theory

- In a paper with Janet Grijzenhout and Bert Botma, we're stress testing Q-theory – to see whether it's also useful for more common segment types.
- We're doing things a little differently though.
- We assume four different 'types' of subsegments:
 - C Cv cV V

Q-CV

- C
 - Complete constriction, defaults to [ʔ]
- Cv
 - Constriction that allows turbulent passage of air, defaults to [h]
- cV
 - Constriction that allows essentially free passage of air but with some major constrictions, defaults to ... nothing?
- V
 - Free passage of air, defaults to [ə]

Q-CV

plain stop

C	C	C
pl.	pl.	pl.

post-aspirated stop

C	C	C	Cv
pl.	pl.	pl.	

pre-aspirated stop

Cv	C	C	C
	pl.	pl.	pl.

pre-glottalized stop

C	C	C
	pl.	pl.

ejective

C	C	C
pl.	pl.	

Q-CV

bilabial click

C	C	C
lab	lab	vel

unaspirated affricate

C	C	C	Cv
pl.	pl.	pl.	pl.

aspirated affricate

C	C	C	Cv	Cv
pl.	pl.	pl.	pl.	

singleton stop

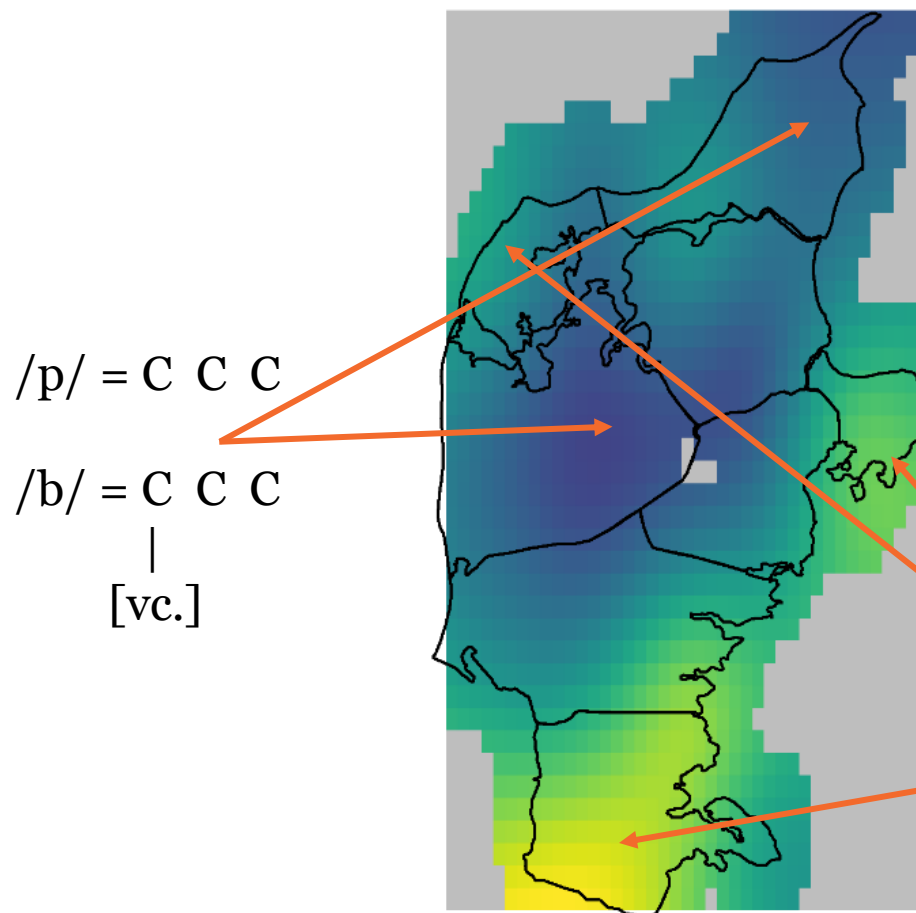
C	C	C
pl.	pl.	pl.

geminate stop

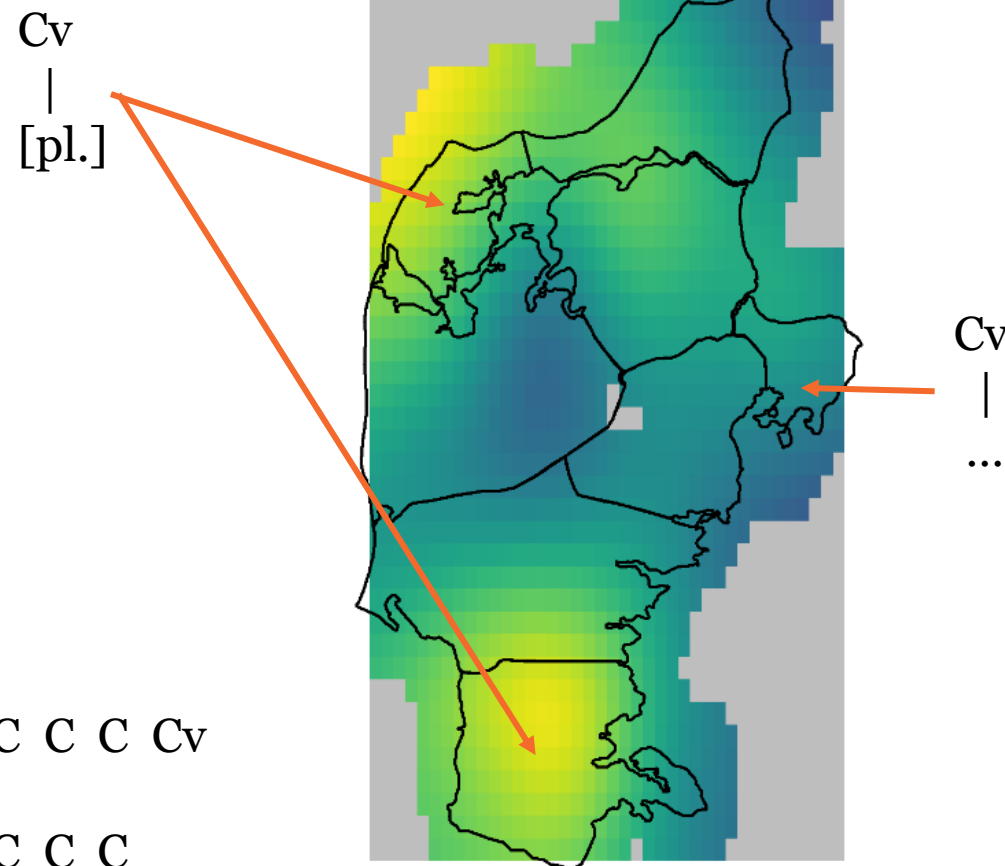
C	C	C	C
pl.	pl.	pl.	pl.

Q-CV and Jutland Danish

Main effect only, VOT



Main effect, COG



Q-CV

- **Advantages**

- Contrasts which are essentially quantity-based can be modeled in terms of quantity
- Most laryngeal features for obstruents can be scrapped; architecture is simple
- Works well for explaining coarticulation
- Aspiration and voicing are fundamentally different, show different behavior

- **Disadvantages**

- It's not straightforward to represent voicing, and especially things like implosives and hypervoicing

pre-voiced stop
C C C
|
vc.

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Tak for jeres opmærksomhed!



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