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INTERNATIONAL CONGRESS OF PHONETIC SCIENCES 2023

PRAGUE CONGRESS CENTER

IPS INSTITUTE OF PHONETICS AND SPEECH PROCESSING

The /t/ release in Jutland Danish

Decomposing the spectrum with functional PCA

Rasmus Puggaard-Rode
Institute of Phonetics and Speech Processing
Ludwig-Maximilians-Universität, Munich
r.puggaard@phonetik.uni-muenchen.de

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Two purposes of this study:

- Outline variation in /t/ affrication patterns in Jutland Danish

- Demonstrate the use of functional PCA in analyzing spectral shape


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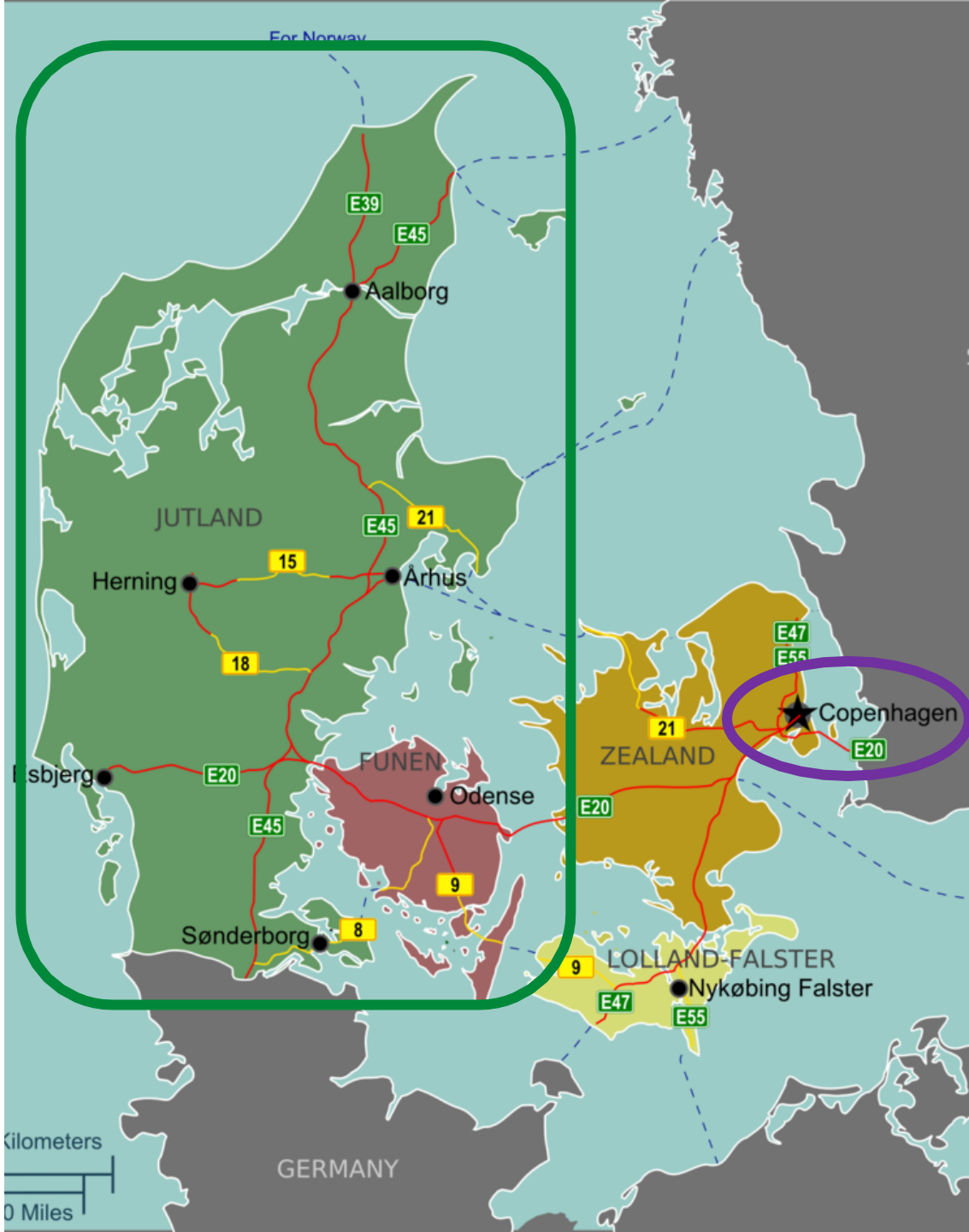
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Danish aspiration and affrication

- In Modern Standard Danish, /p t k/ are voiceless aspirated
  - /t/ in particular is prominently affricated
  - Often transcribed as [t^{s}]
    (Grønnum 1998)

Danish aspiration and affrication

- Some Jutlandic varieties use an unaffricated /t/ variant
  - Colloquially known as *tørt t* 'dry *t*'
- Variously claimed as a feature of
  - All Jutlandic varieties (Brink & Lund 1975)
  - Northern Jutlandic (Petersen 2009)
  - Western Jutlandic (Petersen et al. 2021)
  - All Jutlandic varieties *except* Eastern Jutlandic (Heger 1981)
- Articulatorily described as
  - Fronted relative to MSD /t/ (Nielsen 1984)
  - Backed relative to MSD /t/ (Espegaard 1996)

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Danish aspiration and affrication

- By exploring affrication patterns of Jutland Danish, we can …

  - ➢ Work towards solving the **mystery of missing affrication**
  - ➢ Learn more about the unexplored space in between aspirated stops and affricates
  - ➢ Link the results to other findings about phonetics and phonology, and variation and change, in the stops of Jutland Danish
    (Puggaard 2021; Puggaard-Rode 2023, forthc.)

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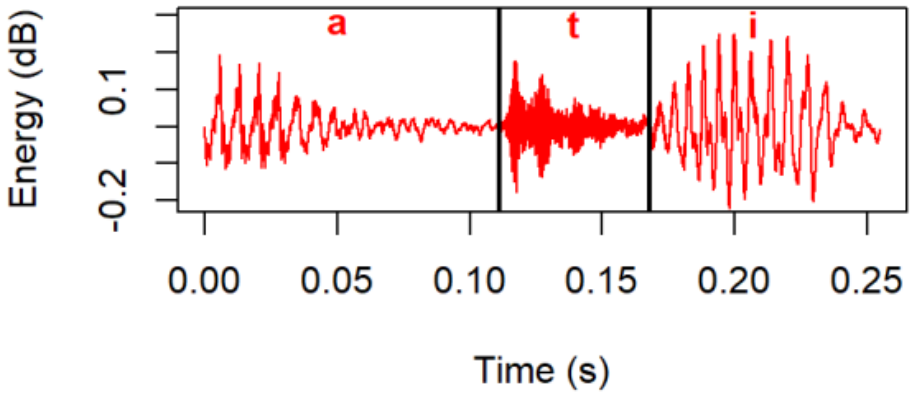
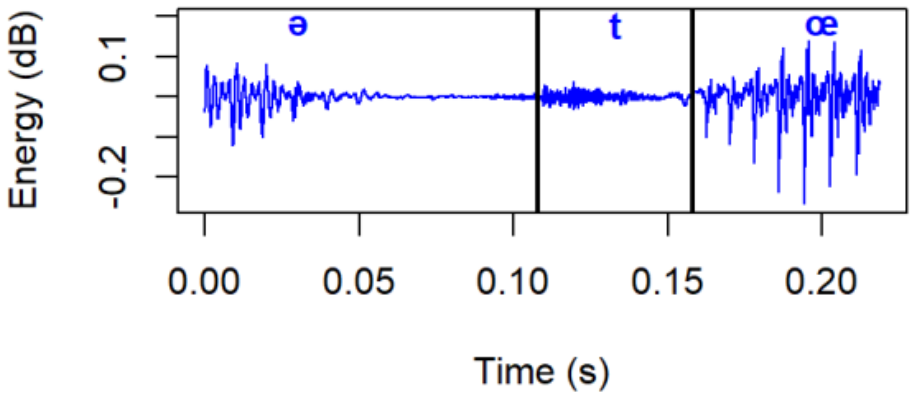
The data

- Analyzing traditional regional variation in Danish is **not at all straightforward**
  - Due to a political campaign for language standardization, Denmark is one of the most linguistically homogeneous countries in Europe (Kristiansen 1998, 2003; Pedersen 2003; Maegaard & Monka 2019)
  - Data come from a legacy corpus of sociolinguistic interviews recorded between 1971–1976 (RDL 1971–1976; Andersen 1981; Goldshtein & Puggaard 2019; Puggaard-Rode 2023)
    - Mostly NORM speaker population
    - Specifically chosen for dialect “purity”
    - 525 interviews
    - Total duration ~370 hours

The acoustics of affrication and aspiration

- **Coronal affrication**
  - A jet of air impinges on the upper front teeth in front of the coronal constriction
  - This results on turbulence noise in a broad range of frequencies mainly above 4 kHz
- **Aspiration**
  - Low frequency turbulence noise (mainly below 1 kHz) is generated at and near the vocal folds
  - This noise is colored by the resonance frequencies of the following vowel





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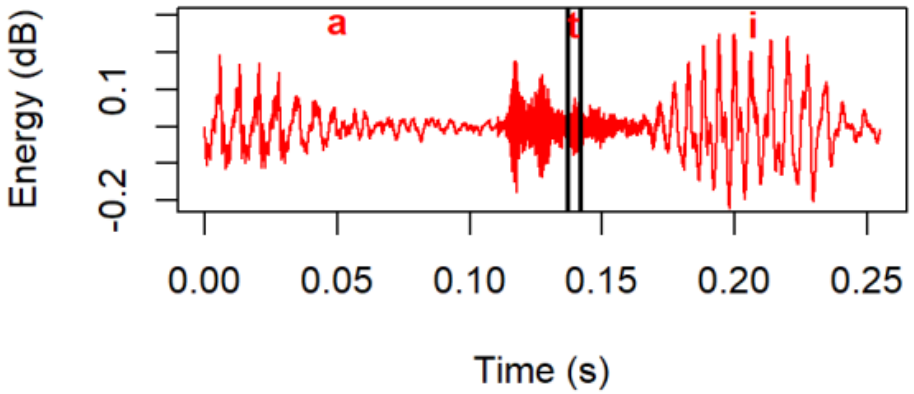

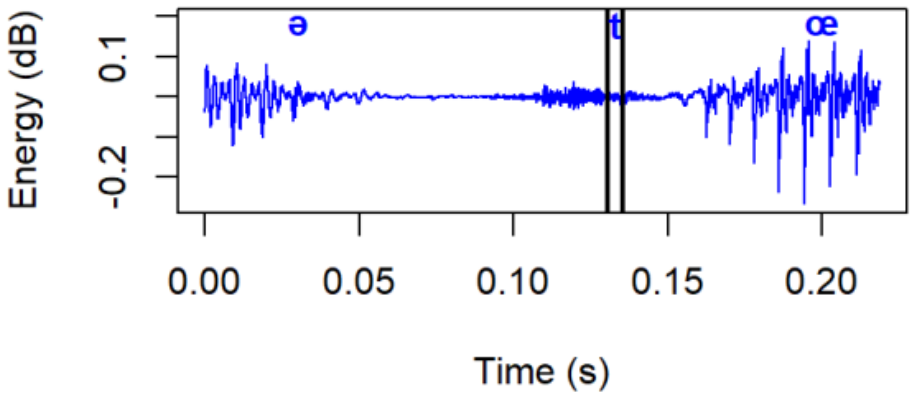

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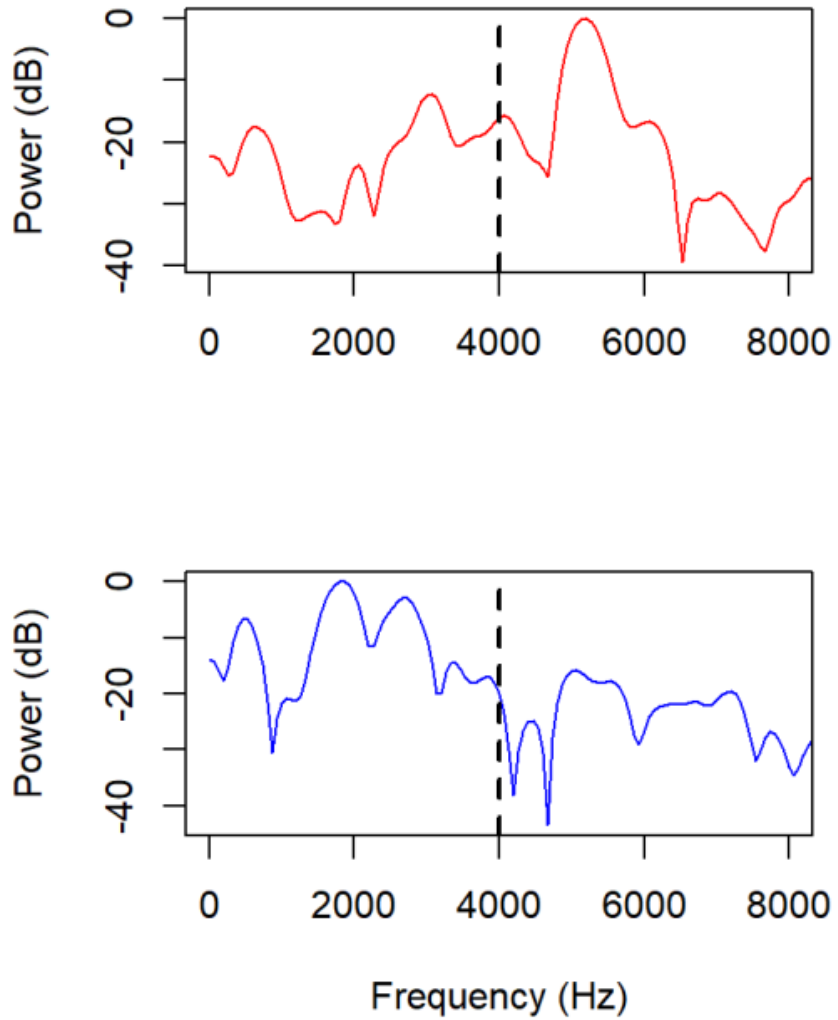

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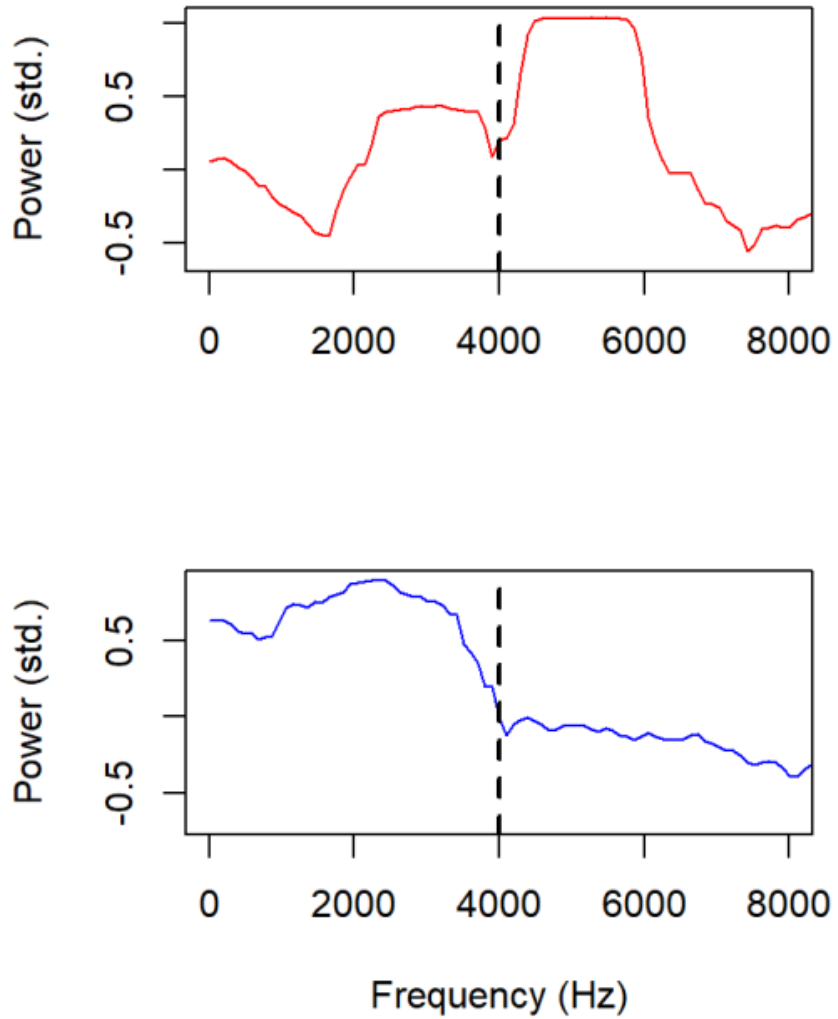

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Analysis pipeline

- Annotate stop releases
  - 5,169 tokens of /t/ annotated
    (see Puggaard 2021)
- Generate multitaper spectra from 5 ms snippet at the mid-release
  (Reidy 2013, 2015); `multitaper` 1.0-15 in R (Rahim 2014)
  - Does the noise at mid-release mainly reflect a **coronal noise source** or a **glottal noise source**?
- **Summarize main sources of spectral variance with functional principal component analysis**
  (e.g. Gubian et al. 2015); `fdapace` 0.5.9 in R (Zhou et al. 2022)
- Fit PC scores to spatial generalized additive models
  (e.g. Wieling et al. 2011, 2014); `mgcv` 1.8-41 in R (Wood 2017)

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Functional PCA

- Used to determine the **principal shapes of variance** in curves without imposing predetermined shapes
  - As opposed to e.g. spectral moments or DCT coefficients
- Each principal component corresponds to a source of variance relative to the average spectral shape
  - 5 PCs explain 95% of the variance in spectral shape
  - PC1 accounts for 58.4% of all shape variance

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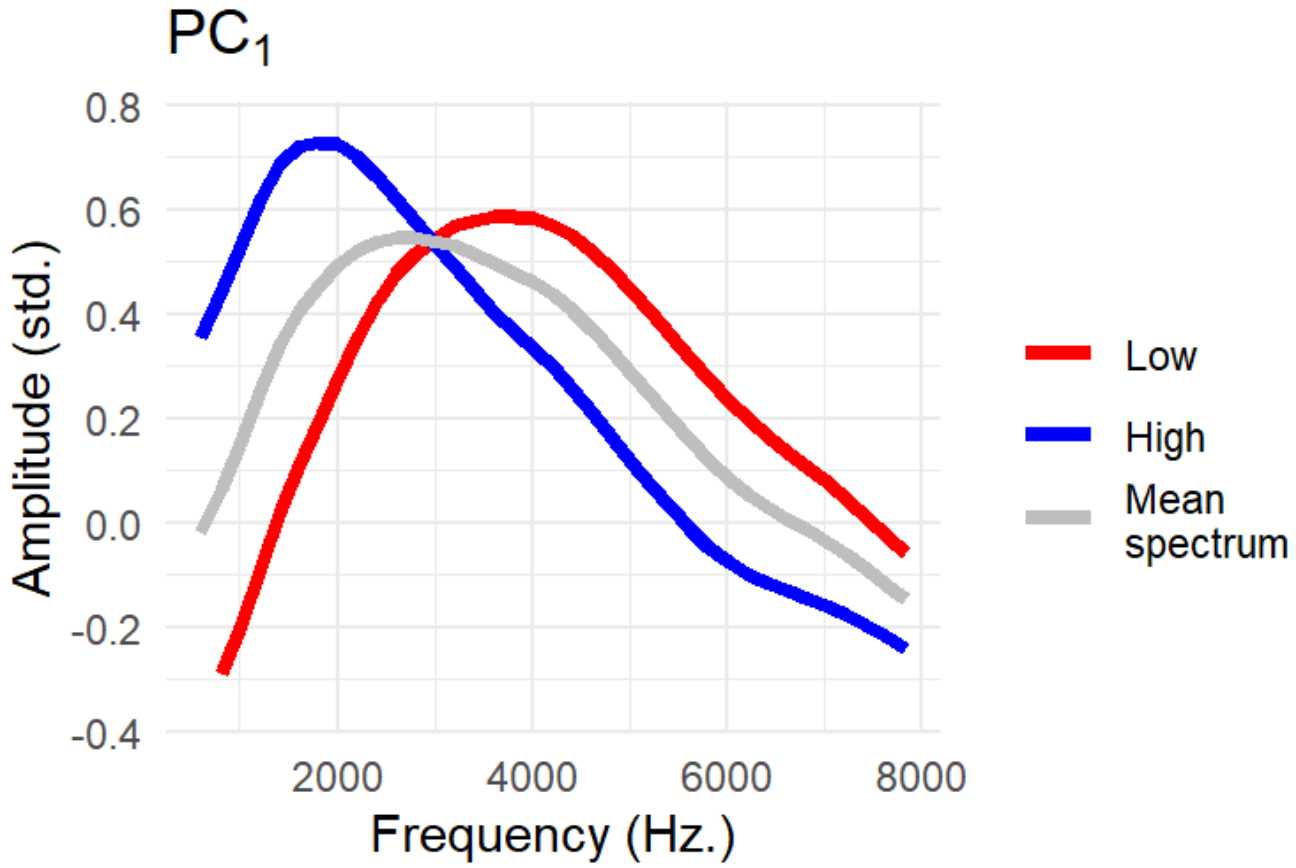

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- Each token gets a **score for each PC** indicating how closely its shape matches

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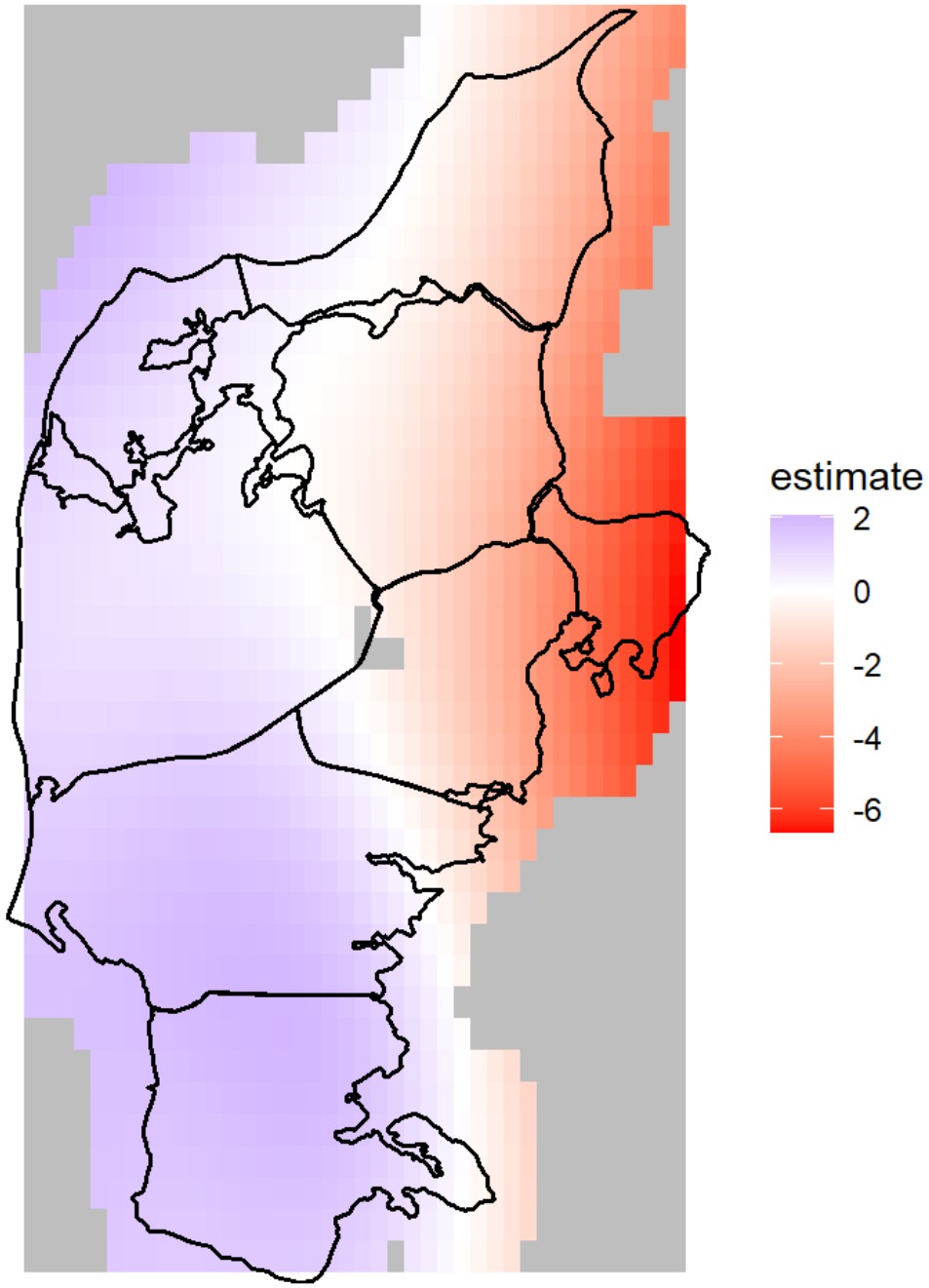
GAMMs

- GAMM predicting s_1 with
  - …a two-dimensional non-linear geographical variable (coordinates)
  - …multiple linear covariates known to affect the spectral shape of stop releases + by-speaker random slopes
- The linear covariates are ‘nuisance variables’, but they also serve as a sanity check
  - Do PCs pattern as predicted?
- In the interest of time, I will focus on the geographical effect here


estimate
2
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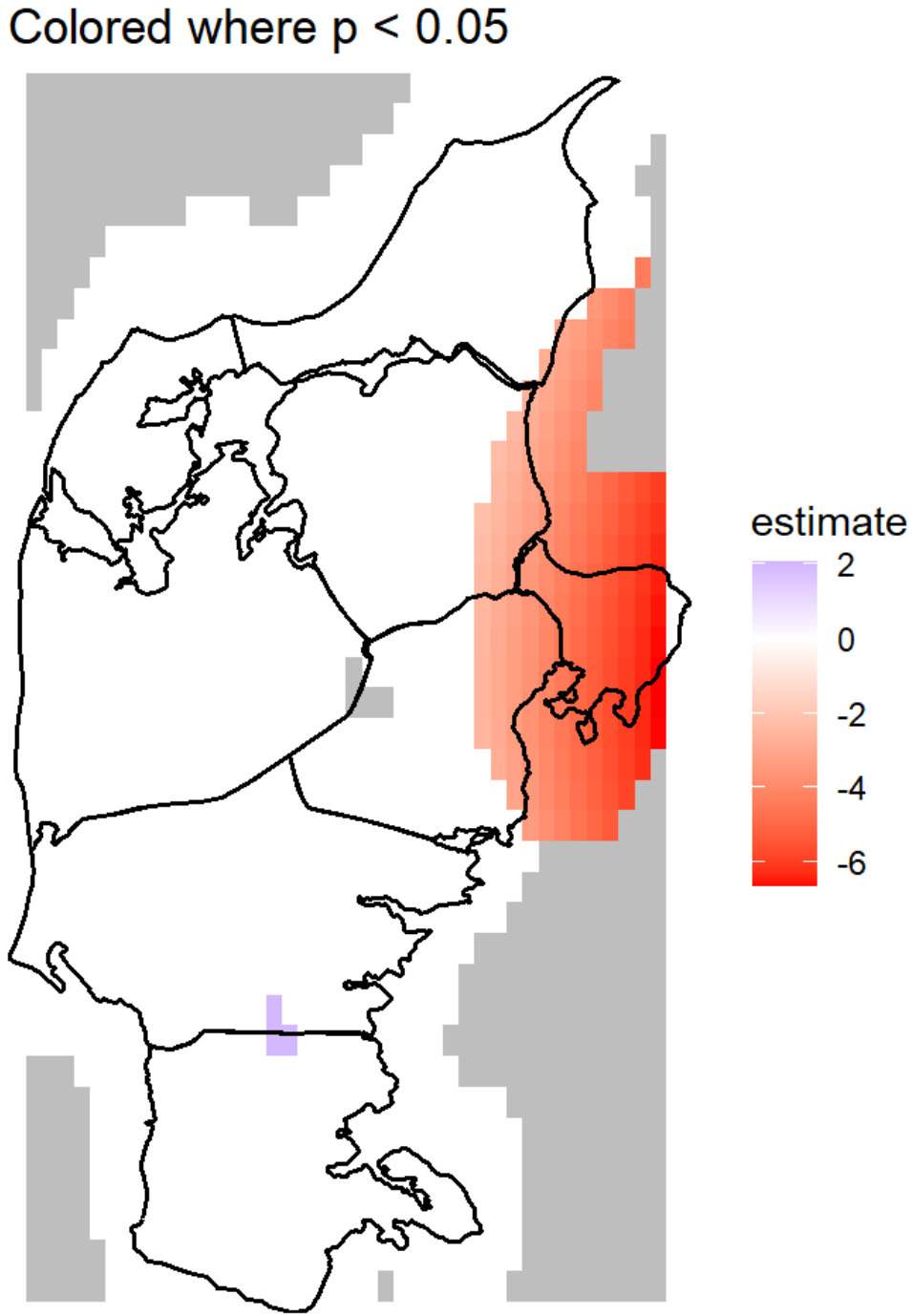
Colored where p < 0.05
estimate
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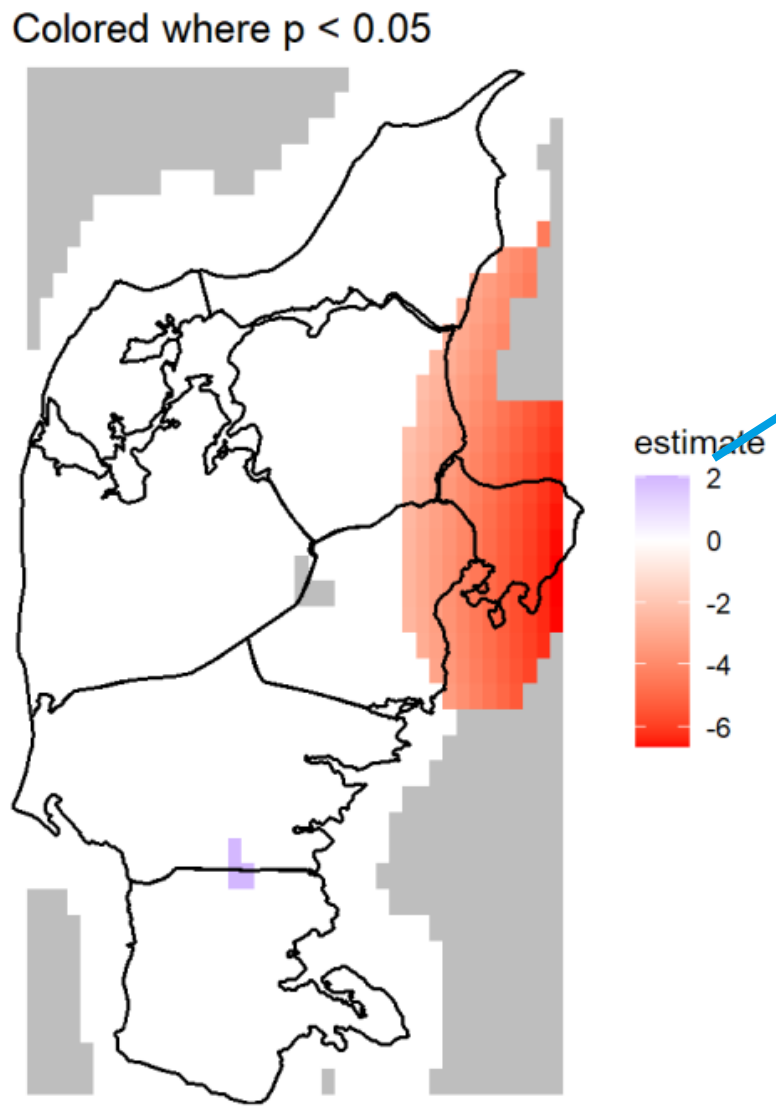
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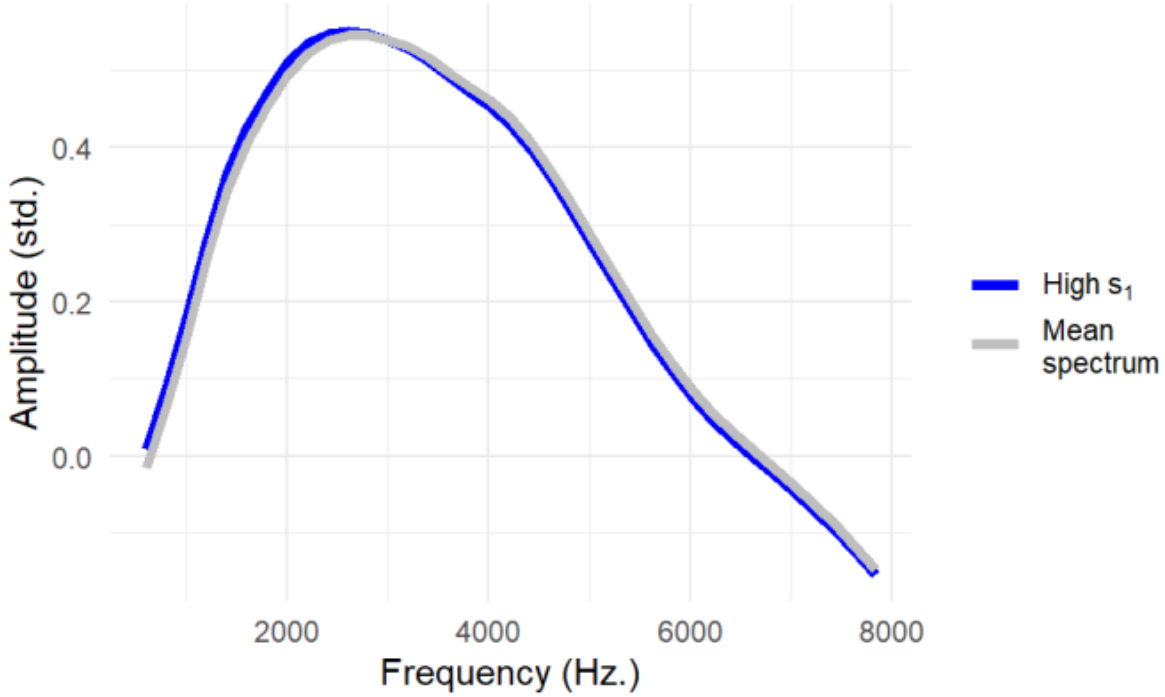
Amplitude (std.)
0.4
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2000
4000
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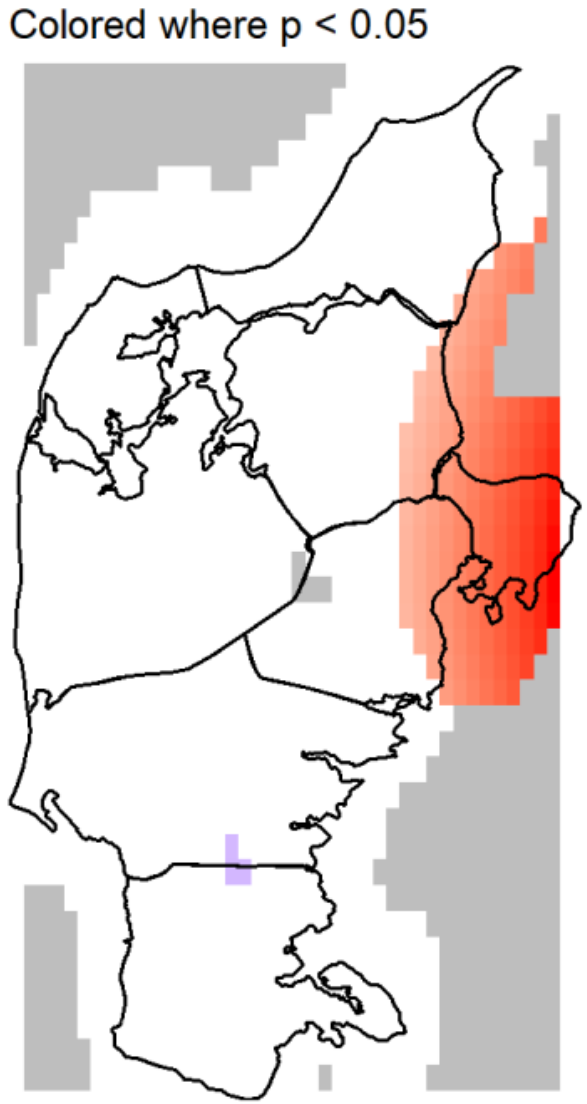
8000
Frequency (Hz.)
High s_1
Mean spectrum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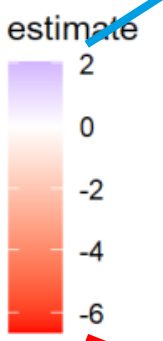
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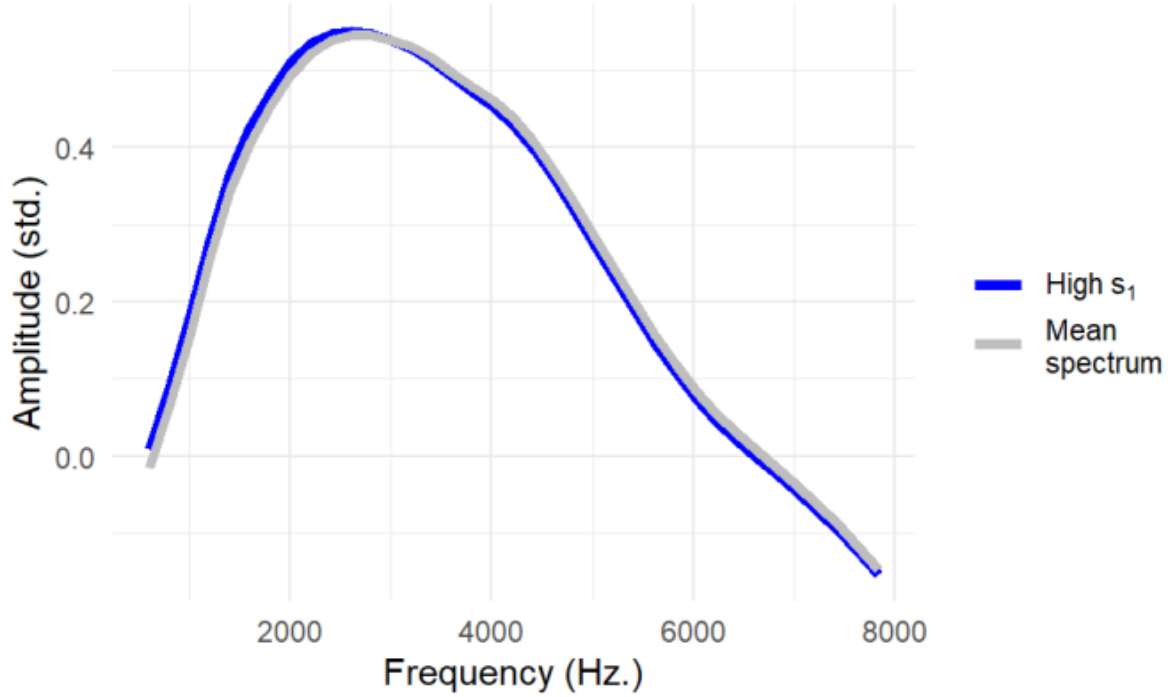
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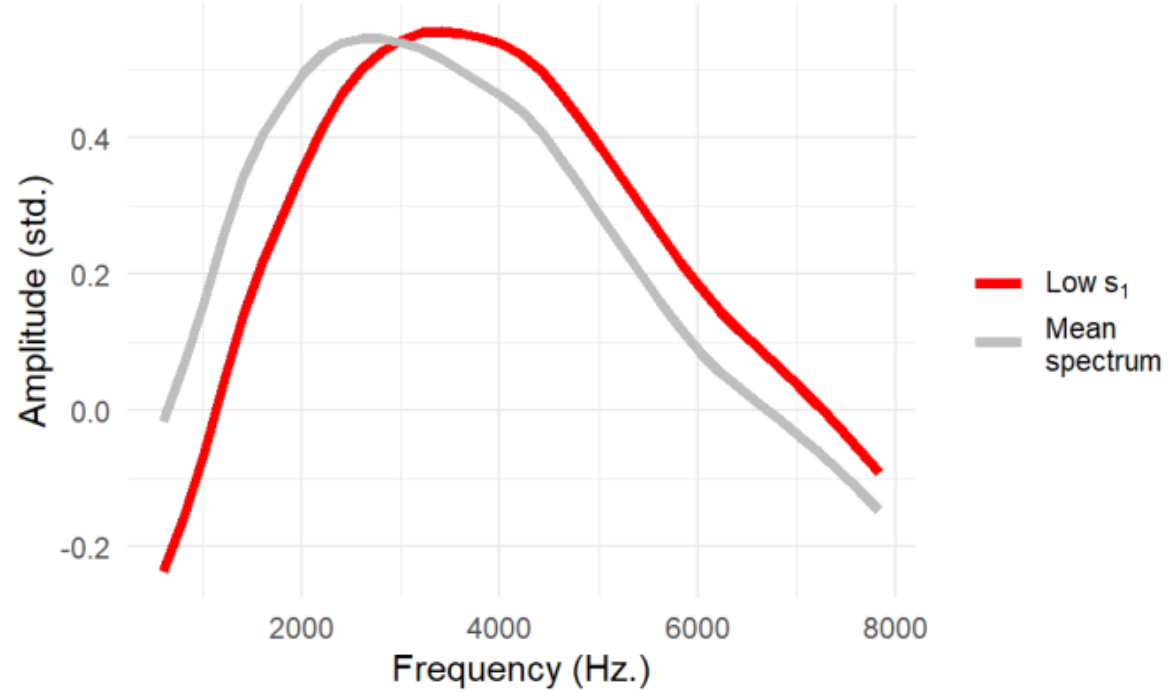
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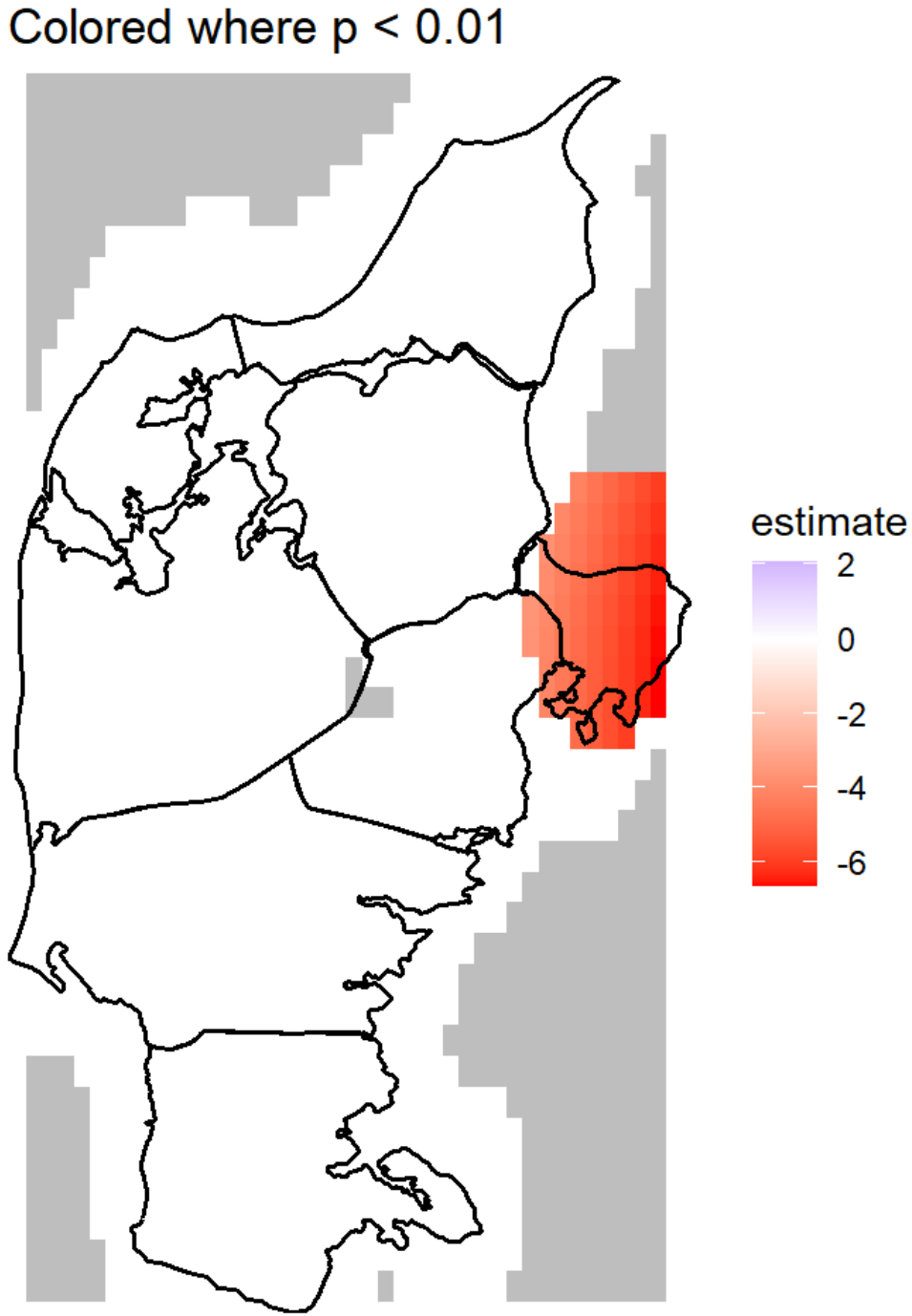
Colored where p < 0.01
estimate
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Discussion

- Coronal noise source in /t/ release midpoints is largely absent in traditional Jutland varieties
  - This is **unlike** Modern Standard Danish!
    (Puggaard-Rode 2022)
- It is however present in parts of Eastern Jutland, particularly in and around Djursland

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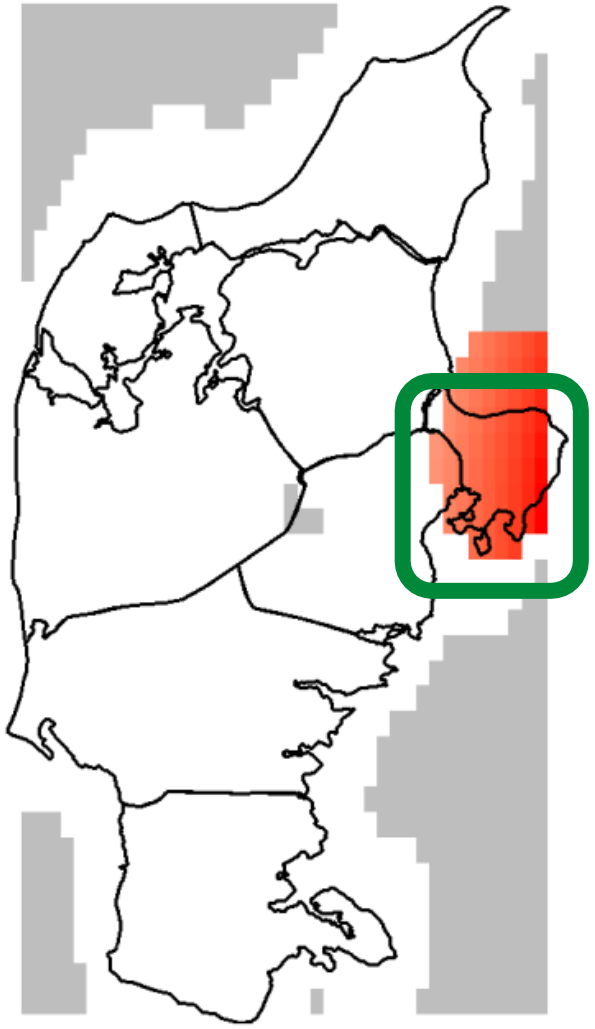
- Djursland is…
  - The location of the main water route between Jutland and the island of Zealand, i.e. the locus of MSD
  - Immediately north of Aarhus (Jutland's largest city)



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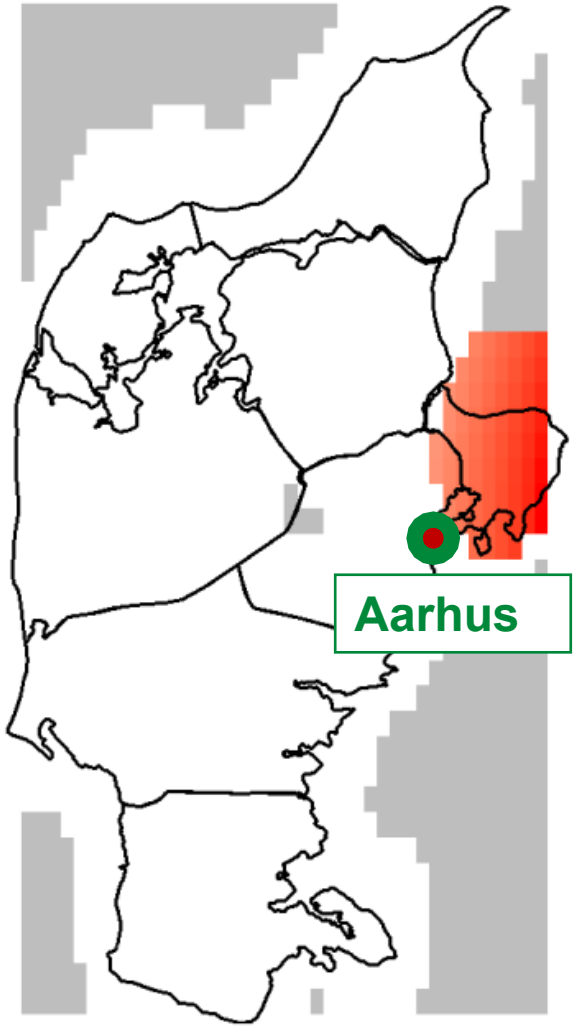
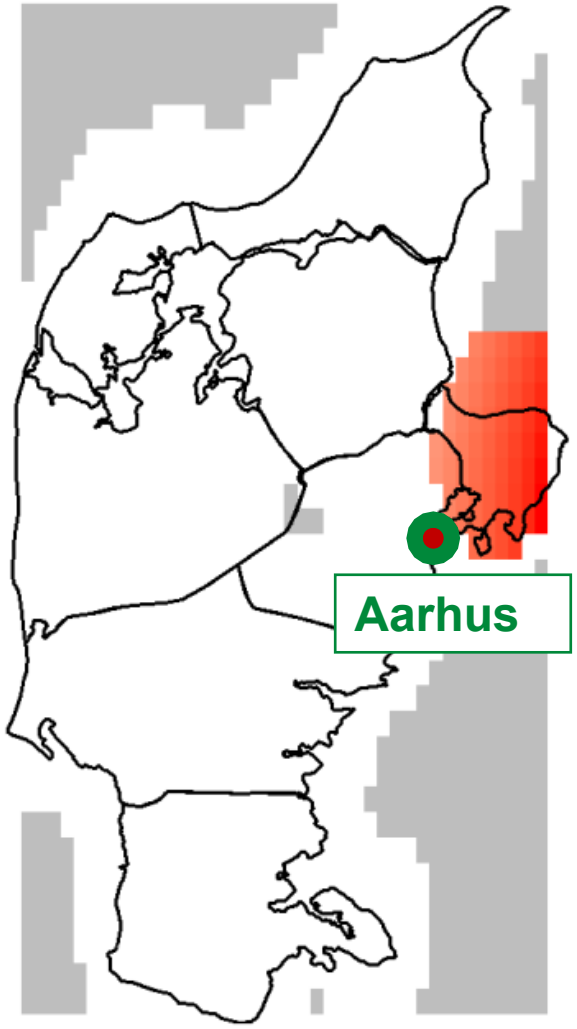


Discussion

- This could suggest that affrication was not a traditional feature of **any** Jutland varieties
  - The *cascade model* of interdialectal influence predicts that change spreads between urban centres in a manner predictable from population and distance (Trudgill 1974; Labov 2003)
  - ➢ Aarhus and surrounding areas were likely **early adapters** of /t/ affrication



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Discussion

- FPCA was used to capture an aspect of regional variation that was otherwise difficult to capture
- It also behaves as predicted in other respects
  - Noise concentrated at higher frequencies…
    - Before high vowels
    - Before non-back vowels
    - In female speakers
- …Suggesting that it is indeed suitable for analyzing noisy spectra!
- For more details:
  - rpuggaardrode.github.io/icphs2023

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Tak for opmærksomheden!

[ˈtʰɑk fʌ ʌpˈmæɐ̯ksʌmheɤ̯ˀn]

r.puggaard@phonetik.uni-muenchen.de
@RPuggaardRode
rpuggaardrode.github.io/icphs2023