Acoustic cues to vowel identification: the case of /ʊ u uː/ in Saterland Frisian

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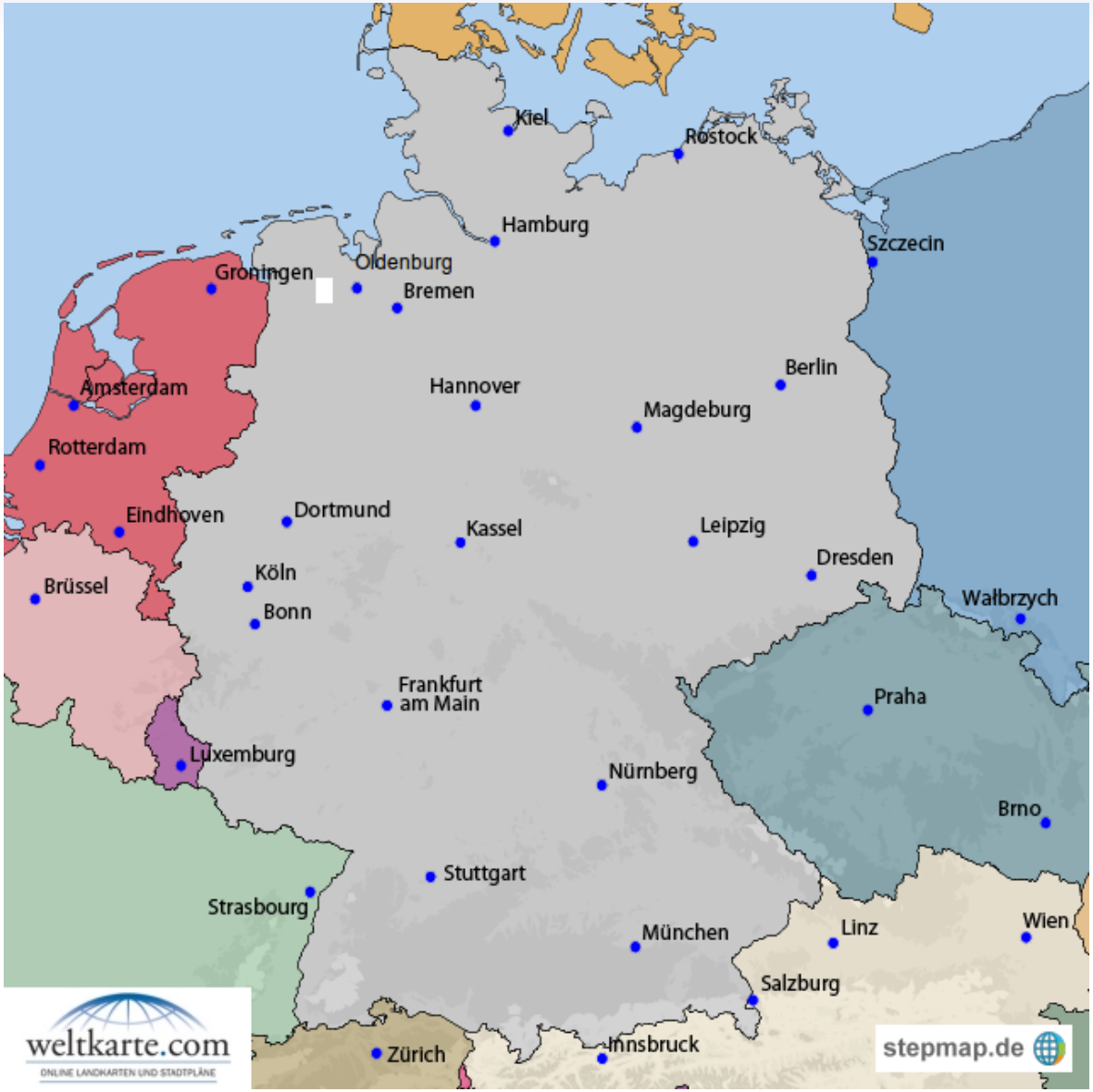
Phonetik & Phonology 9
Phonetisches Laboratorium, Universität Zürich
October 12, 2013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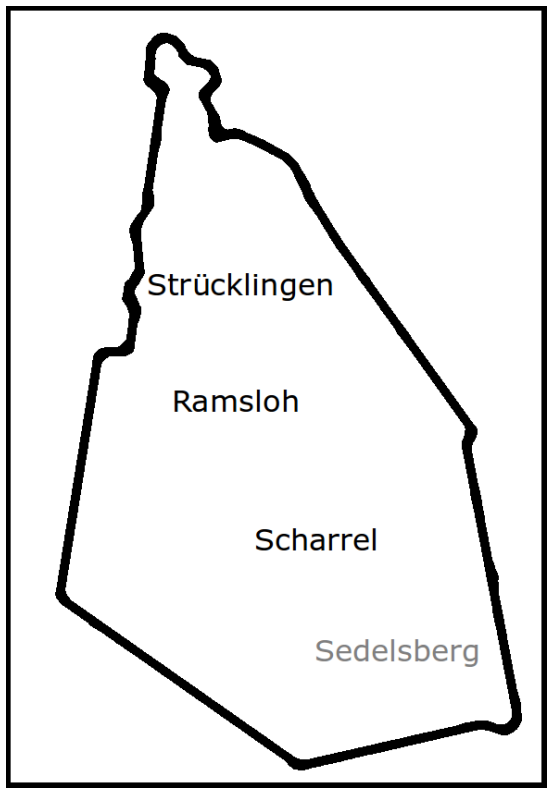
Saterland



Saterland Frisian is spoken in Strücklingen, Ramsloh and Scharrel by up to 1500 people.

Introduction

- Saterland Frisian has a complete set of closed short tense vowels: /i y u/ (Sjölin, 1969; Fort, 1980; Kramer, 1982).
- Together with short lax vowels /ɪ ʏ ʊ/ and long tense vowels /iː yː uː/ they constitute series of phonemes that only differ by length and/or tenseness.
- Example of minimal triplet:

Saterland Frisian	IPA	English
ful	fʊl	full
fuul	ful	rotten
fúul	fuːl	much

Research questions

1. Which acoustic cues distinguish all of the sounds within a triplet?
2. How well do acoustic cues contribute to the discrimination of the three triplet words?

Potential cues

- vowel duration
- spectral features (F1, F2, F3)
- timing and scaling of f0

Tone accents in Saterland Frisian?

- Vowels with a stronger f0 dynamic are perceived as being longer (e.g. Lehiste, 1976; Yu, 2010; Cumming, 2011), an effect which is likely language-specific (Lehnert-LeHouillier, 2010).
- Siebs(1889) distinguishes between tone accents in Saterland Frisian (*Stoßton* versus *Schleifton*).
- Tröster-Mutz(1997, 2002) did not find evidence for tone accent differences in present-day Saterland Frisian.

Focus

- In our study we focus on:
  - The Saterland Frisian variety of Ramsloh
  - The triplet ful/fuul/fúul
  - Vowel duration, F1, F2, F3 and f0.

Experiments

- We conducted two experiments in order to elicit
  1. normal speech
  2. clear speech (maximizes discrimination between words)

1. Eliciting normal speech

- Saterland Frisian words were presented in written form to native speakers of Saterland Frisian on a computer screen.
- 12 different words:
  - two triplets (ful/fuul/fúul, Smitte/smiete/Smíete)
  - six filler words (Pot, Paad, Kat, leet, Täk, Poot)
- A session consisted of four blocks.
- Per block each of the 12 words was presented four times.

1. Eliciting normal speech

- Within each block the order of the words was randomized, so that a word was never followed by the same word or by a word belonging to the same triplet.
- The first block was preceded by three practice words (Pot, Paad, Kat).
- Total number of words presented in one session: 195 words.
- The experiment was carried out by two female native speakers, 66 and 78 years old.

Samples

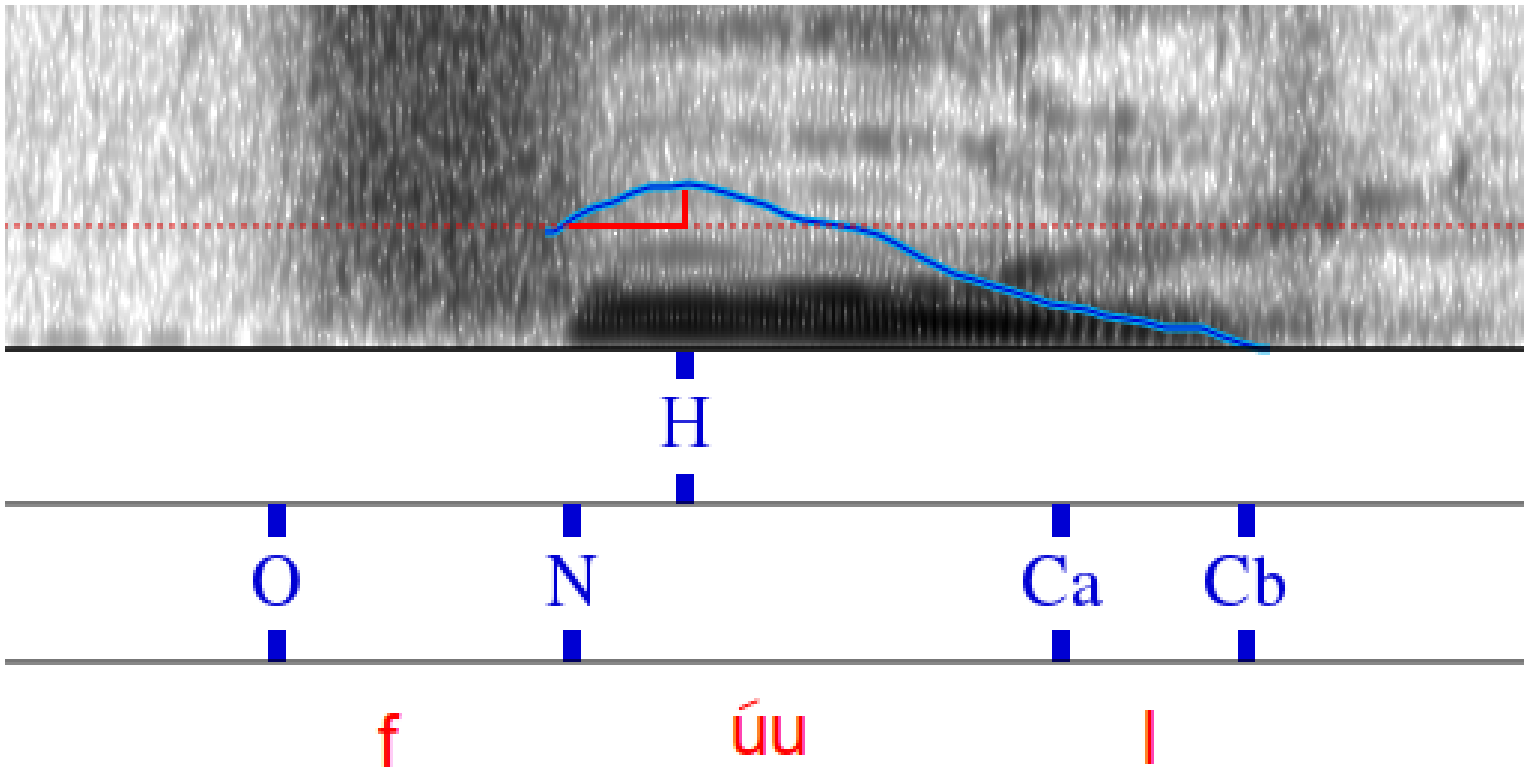
- 32 samples ($= 16 \times 2$ speakers) per triplet word are obtained.
- Word samples without a clear f0 peak are omitted. Remaining data:

ful	14
fuul	26
fúul	22
	62

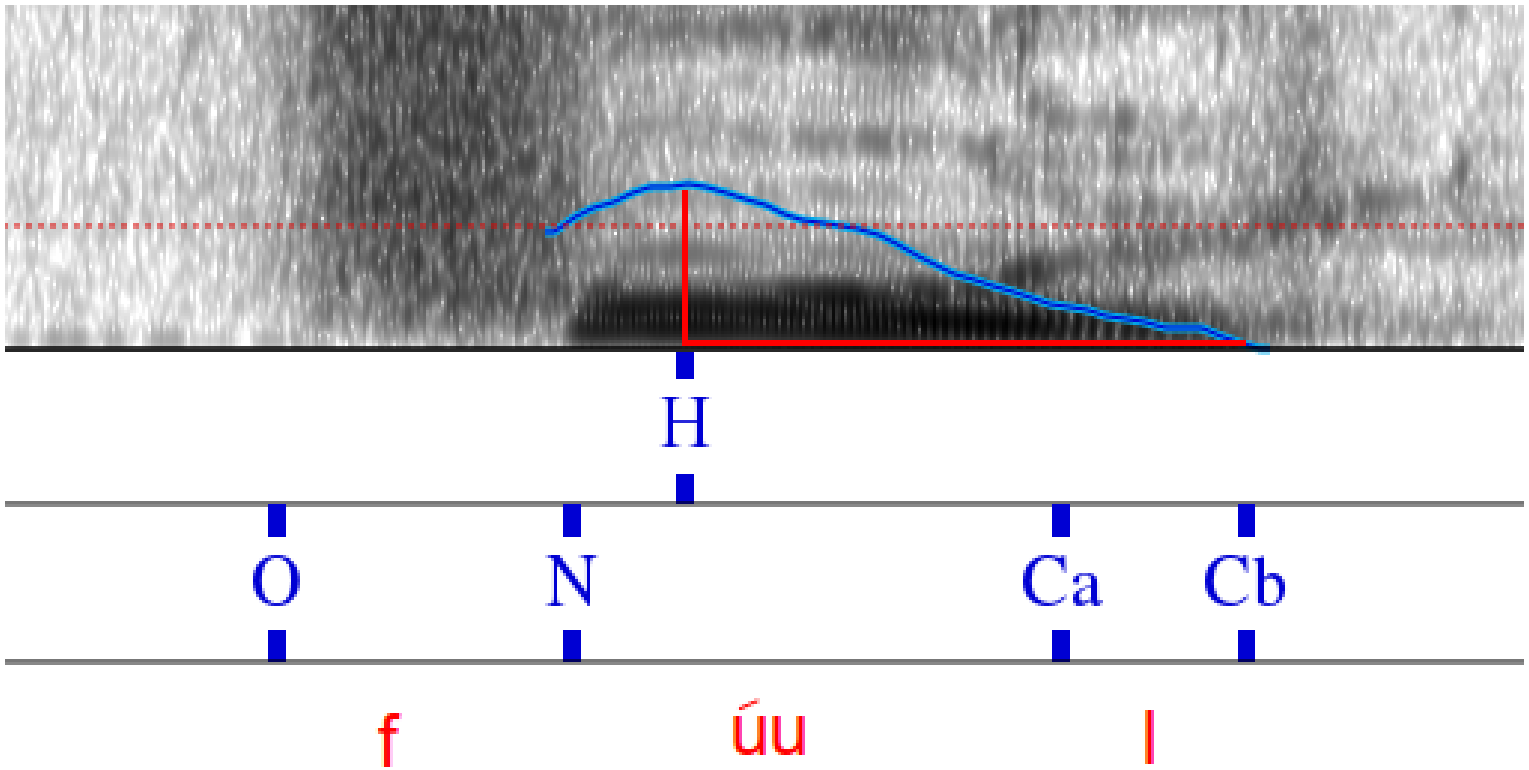
Measurements

- Using Praat for each word belonging to the fuul-triplet we measured:
  - duration of /f/, V, /l/ and VC.
  - F1, F2, F3 at 50% in the vowel
  - f0: steepness1 (rising), steepness2 (falling)

Steepness1 (duration1, size1)



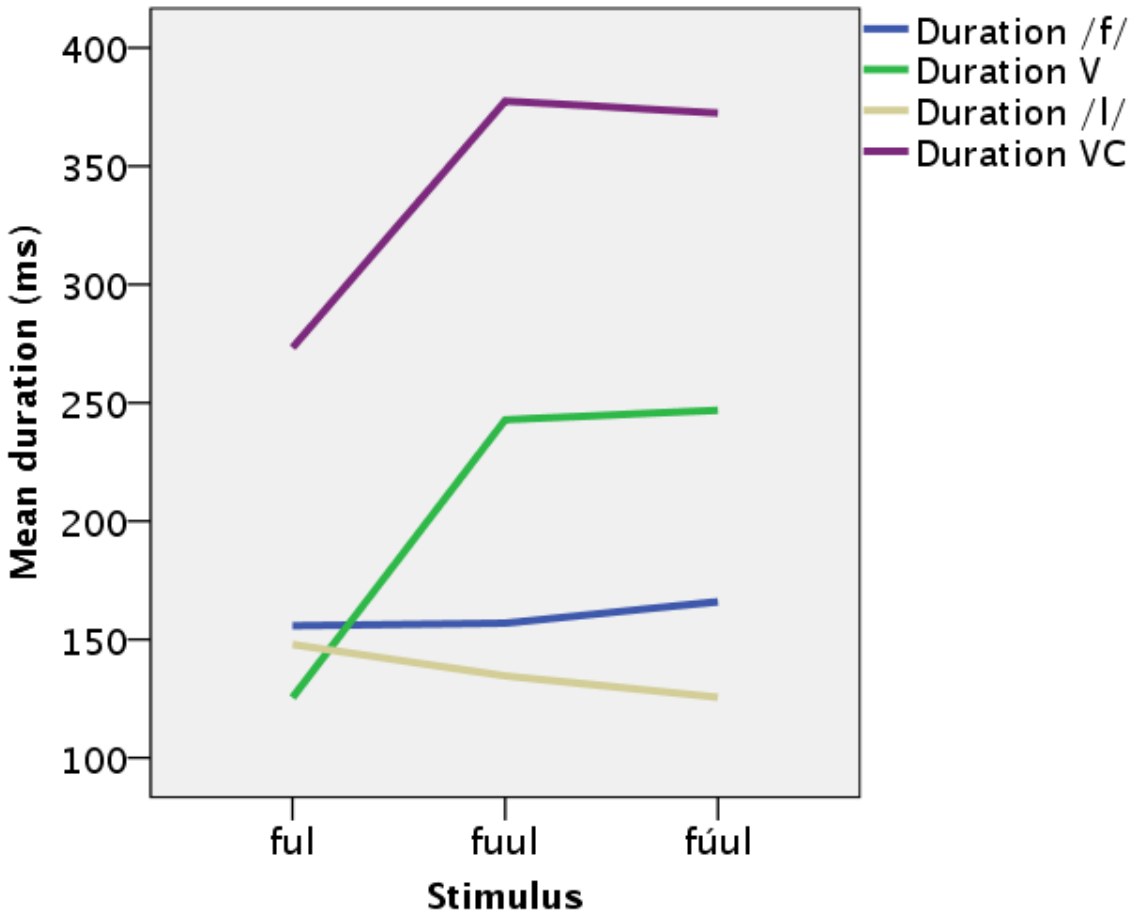
Steepness2 (duration2, size2)



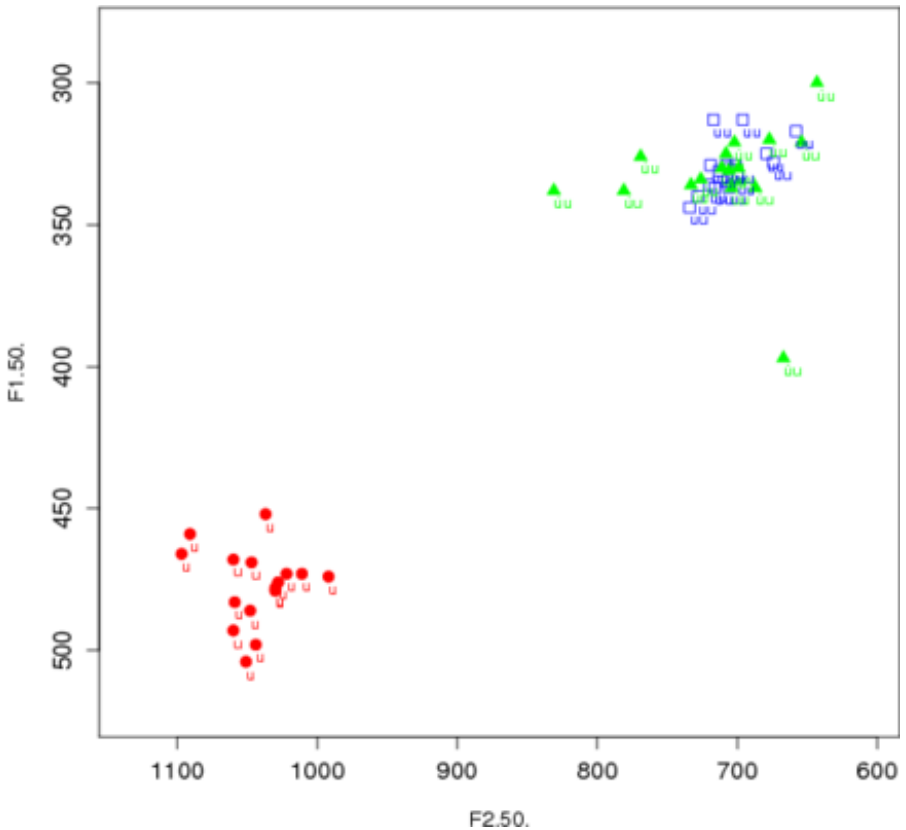
First research question

- Which acoustic cues distinguish all of the sounds within a triplet?

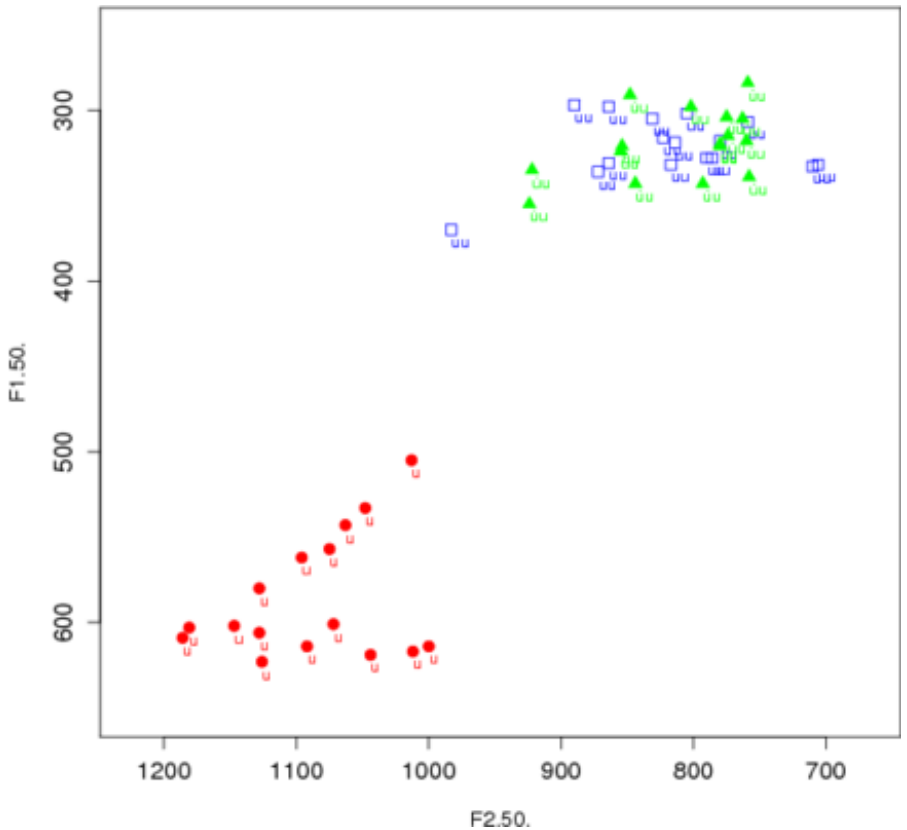
Duration differences



Vowel plots

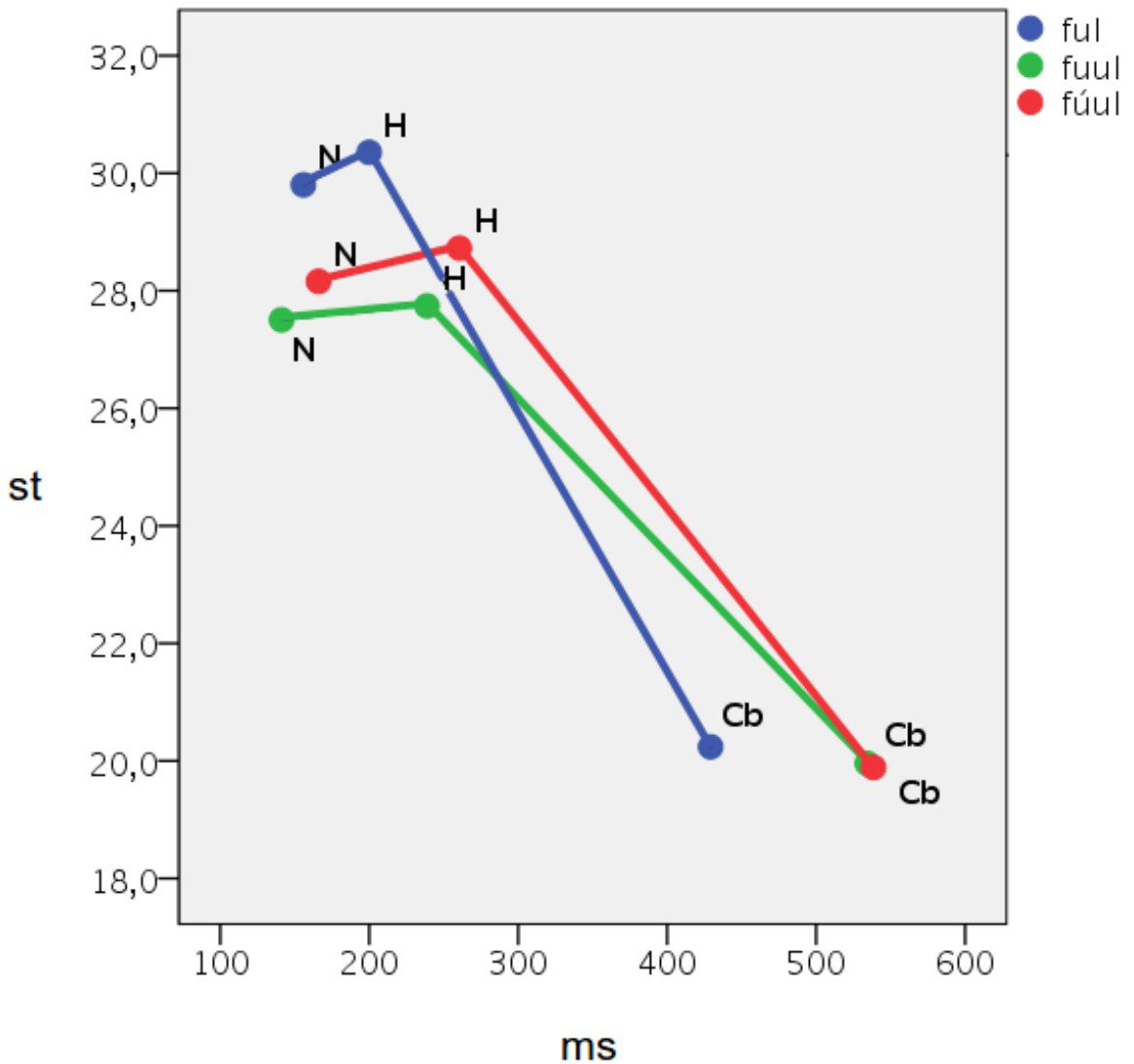


78 years old speaker



66 years old speaker

Pitch contours



Distinction of words

	sig.	sig. 1 vs 2	sig. 1 vs 3	sig. 2 vs 3
duration /f/				
duration V	***	***	***	
duration /l/	***		**	
duration VC	***	***	***	
F1	***	***	***	
F2	***	***	***	
F3	**		*	
steepness1				
duration1				
size1				
steepness2	***	***	***	***
duration2				
size2				

Second research question

- How well do acoustic cues contribute to the discrimination of the three triplet words?

Prediction of words

- Using General Estimating Equations we predict the stimulus (ful or fuul or fúul) on the basis of the acoustic variables.
- For each predictor the percentage of correctly predicted stimuli is calculated.

Prediction of words

variable	sig.	% correct
duration /f/		45.2
duration V	***	62.9
duration /l/	***	41.9
duration VC	***	48.4
F1	***	58.1
F2	***	53.3
F3	*	41.9
steepness1		41.9
duration1	***	38.7
size1		41.9
steepness2	***	41.9
duration1		29.0
size2		41.9

Prediction of words

	% correct
duration V	62.9
duration V + F1	64.9
duration V + F1 + F2	69.3
duration V + F1 + F2 + steepness1	69.3
duration V + F1 + F2 + steepness1 + steepness 2	71.0

2. Eliciting clear speech

- Saterland Frisian words were presented in written form to native speakers of Saterland Frisian on a computer screen.
- Triple words only are presented:
  - ful/fuul/fúul
  - Smitte/smiete/Smíete

2. Eliciting clear speech

- One session consists of two blocks:

block	triple	number of triplets	number of words	
1	fuul	2	6	practice
1	fuul	8	24	
1	smiete	2	6	practice
1	smiete	8	24	
2	fuul	8	24	
2	smiete	8	24	

2. Eliciting clear speech

- In each part the words are presented in a randomized order so that a word is not followed by the same word.
- A word is always presented together with the other members of the triplet, the word to be pronounced is marked.

fúul

fuul

ful

ful

fuul

fúul

fuul

fúul

ful

2. Eliciting clear speech

- The two subjects in this experiment are the same as in the normal speech experiment.
- The reader and the listener are separated by a screen during the experiment.
- For each word the listener noted whether she heard ful, fuul or fúul.
- Procedure:
  - block 1: subject 1 is reading, subject 2 is listening
  - block 1: subject 2 is reading, subject 1 is listening
  - block 2: subject 1 is reading, subject 2 is listening
  - block 2: subject 2 is reading, subject 1 is listening

Samples

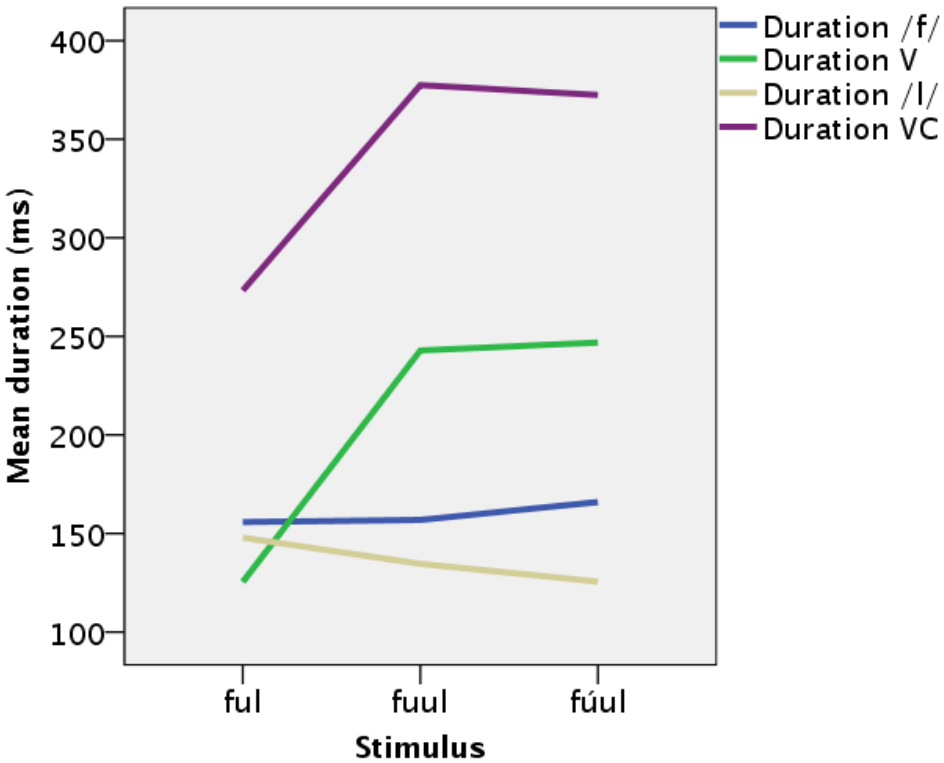
- 32 samples ($= 16 \times 2$ speakers) per triplet word are obtained.
- Word samples without a clear f0 peak are omitted. Remaining data:

ful	11
fuul	16
fúul	25
	52

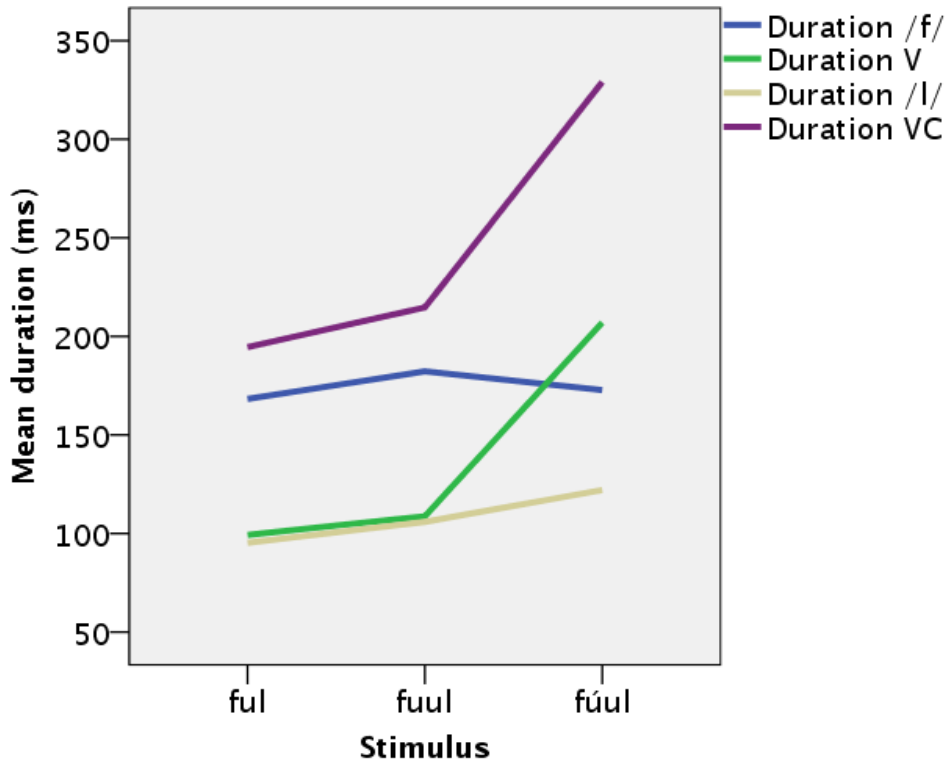
First research question

- Which acoustic cues distinguish the sounds within a triplet?

Duration differences



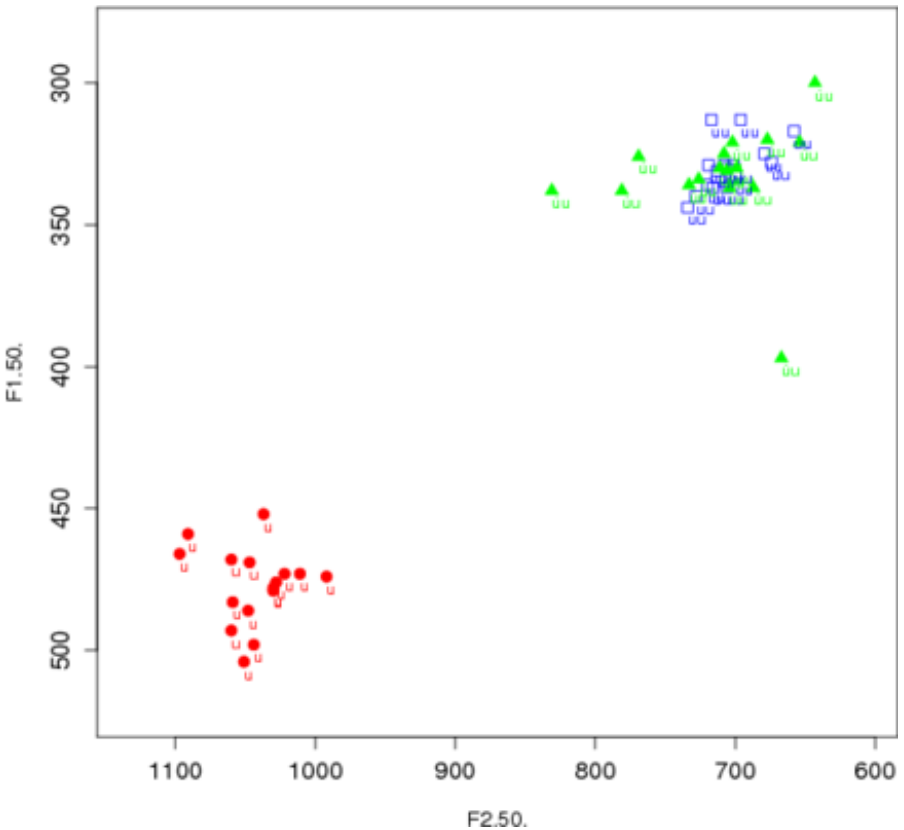
normal speech



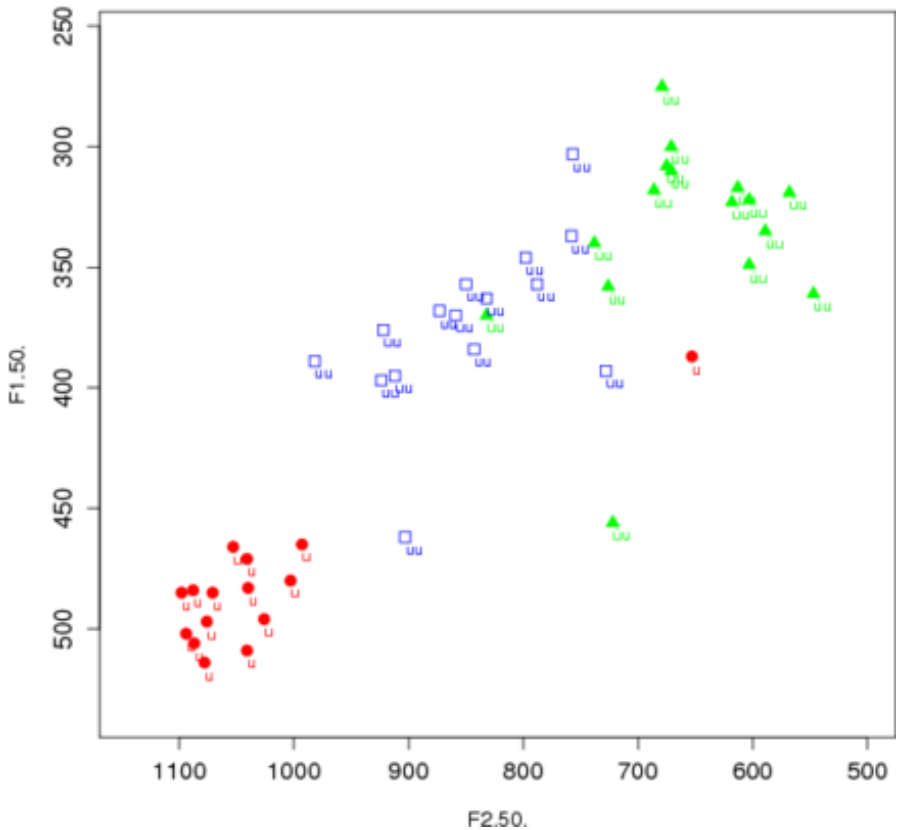
clear speech

Vowel plots

78 years old speaker



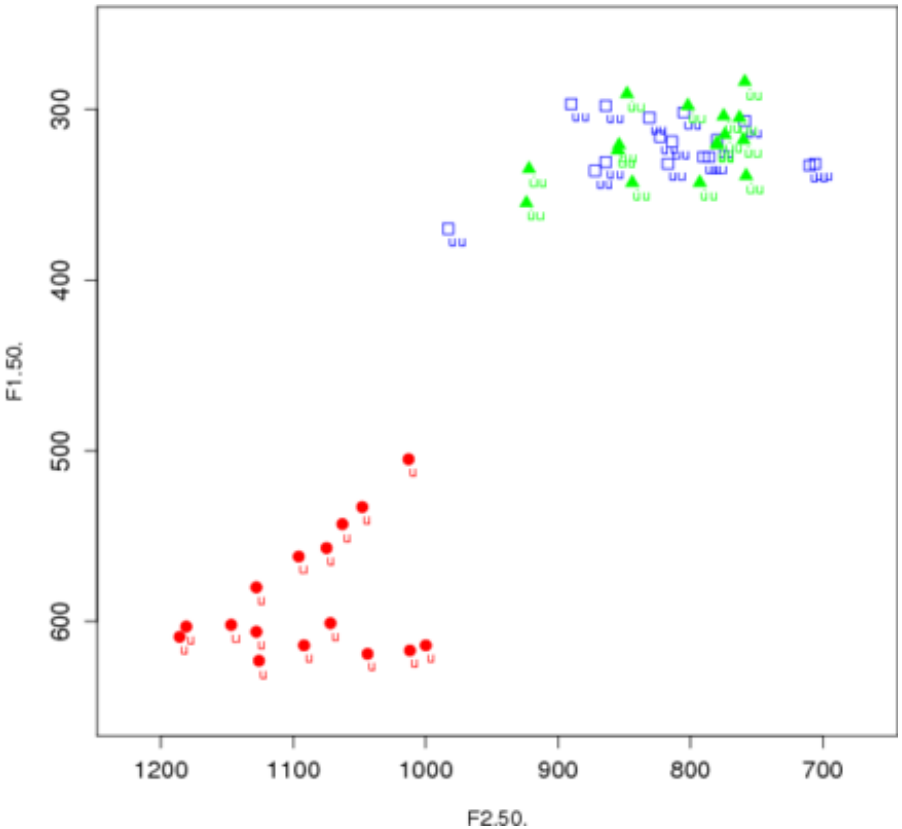
normal speech



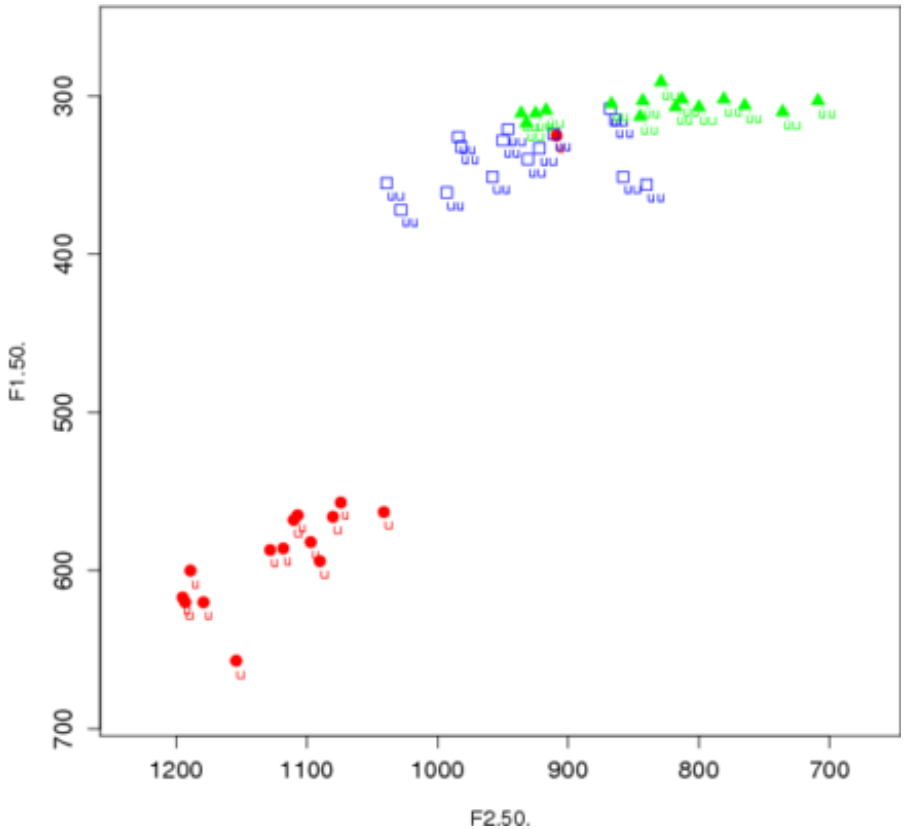
clear speech

Vowel plots

66 years old speaker

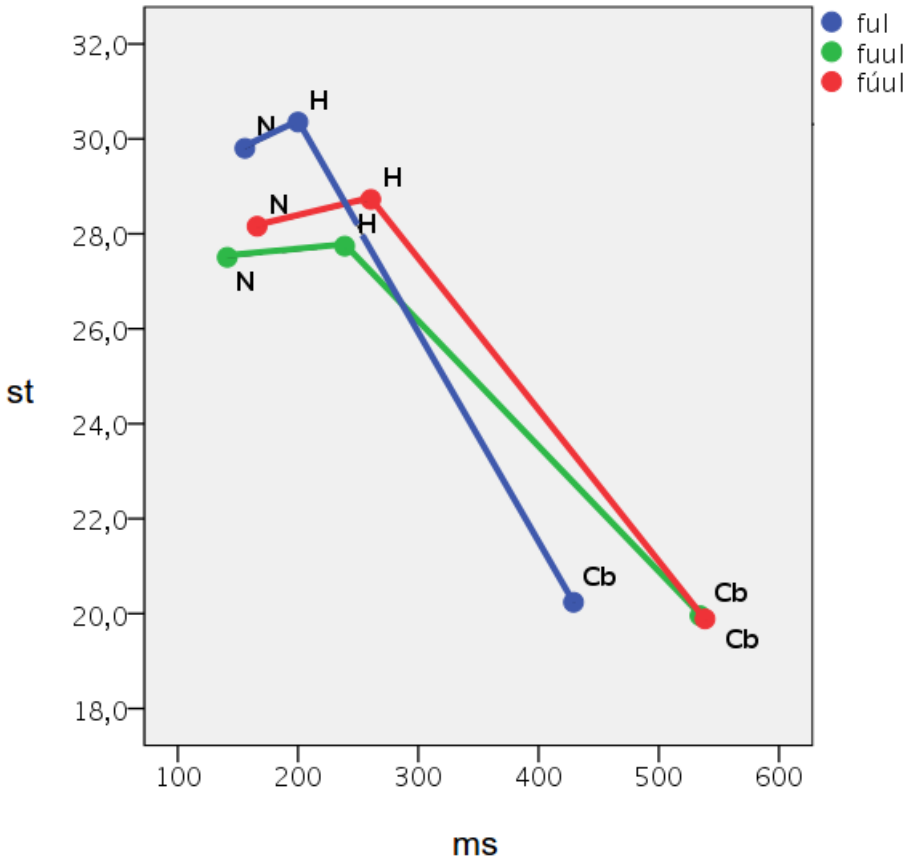


normal speech

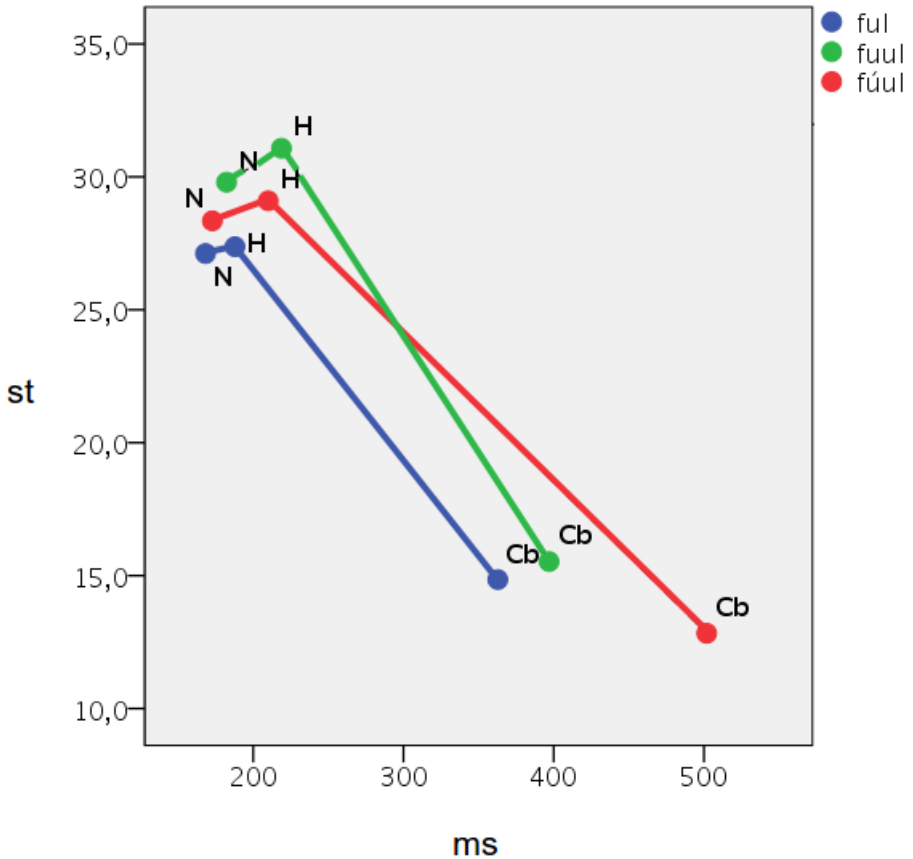


clear speech

Pitch contours



normal speech



clear speech

Distinction of words

	normal speech			
	sig.	sig. 1×2	sig. 1×3	sig. 2×3
duration /f/				
duration V	***	***	***	
duration /I/	***		**	
duration VC	***	***	***	
F1	***	***	***	
F2	***	***	***	
F3	**		*	
steepness1				
duration1				
size1				
steepness2	***	***	***	***
duration2				
size2				

Distinction of words

	normal speech				clear speech			
	sig.	sig. 1×2	sig. 1×3	sig. 2×3	sig.	sig. 1×2	sig. 1×3	sig. 2×3
duration /f/								
duration V	***	***	***		***	***	***	***
duration /I/	***		**		***	***	*	**
duration VC	***	***	***		***	***	***	***
F1	***	***	***		***	***	***	***
F2	***	***	***		***	***	***	***
F3	**		*		**			*
steepness1					***		***	
duration1					***	***	***	
size1					***		***	
steepness2	***	***	***	***	***	**	***	***
duration2					***		***	***
size2					***	*	***	

Second research question

- How well do cues contribute to the discrimination of the three triplet words?

Prediction of words

	normal speech	
variable	sig.	% correct
duration /f/		45.2
duration V	***	62.9
duration /l/	***	41.9
duration VC	***	48.4
formant1	***	58.1
formant2	***	53.3
formant3	*	41.9
duration1	***	38.7
size1		41.9
steepness1		41.9
duration2		29.0
size2		41.9
steepness2	***	41.9

Prediction of words

	normal speech		clear speech	
variable	sig.	% correct	sig.	% correct
duration /f/		45.2		48.1
duration V	***	62.9	***	80.9
duration /l/	***	41.9	***	55.8
duration VC	***	48.4	***	77.0
formant1	***	58.1	***	71.2
formant2	***	53.3	***	77.0
formant3	*	41.9	***	46.1
duration1	***	38.7	**	48.0
size1		41.9		48.1
steepness1		41.9	***	48.1
duration2		29.0	***	75.0
size2		41.9	***	46.1
steepness2	***	41.9	***	51.9

Prediction of words

	normal speech
	% correct
duration V	62.9
duration V + F1	64.9
duration V + F1 + F2	69.3
duration V + F1 + F2 + steepness1	69.3
duration V + F1 + F2 + steepness1 + steepness 2	71.0

Prediction of words

	normal speech	clear speech
	% correct	% correct
duration V	62.9	80.9
duration V + F1	64.9	92.3
duration V + F1 + F2	69.3	92.3
duration V + F1 + F2 + steepness1	69.3	92.3
duration V + F1 + F2 + steepness1 + steepness 2	71.0	92.3

Conclusions

- Normal speech:
  - ful and fuul/fúul distinguished by duration VC, F1, F2 and steepness2;
  - fuul and fúul distinguished by steepness2.
- Clear speech:
  - ful and fuul/fúul distinguished by all acoustic variables, except for duration /f/, F3 and steepness1 (ful vs. fuul).
  - fuul and fúul distinguished not only by steepness2, but also by duration and formants.
- Clear speech contributes to better discrimination of fuul and fúul.

Thanks!

Literature

- Cumming, R. E. (2011). The effects of dynamic fundamental frequency on the perception of duration. *Journal of Phonetics*, 39, 375–387.
- Fort, M. C. (1980). *Saterfriesisches Wörterbuch mit einer grammatischen Übersicht*. Hamburg: Buske.
- Kramer, P. (1982). Kute Seelter Sproakleere – Kurze Grammatik des Saterfriesischen. Rhauderfehn: Ostendorp.
- Lehiste I. (1976). Influence of fundamental frequency pattern on the perception of duration. *Journal of Phonetics*, 4:113–117.
- Lehnert-LeHouillier, H. (2010). A cross-linguistic investigation of cues to vowel length perception. *Journal of Phonetics*, 38, 472–482.
- Siebs, Th. (1889). *Zur Geschichte der englisch-friesischen Sprache*. Halle am Saale: Max Niemeyer.
- Sjölin, B. (1969). *Einführung in das Friesische*. Stuttgart: Metzler.
- Tröster-Mutz, (1997). *Phonologie des Saterfriesischen*. Dissertation University of Osnabrück.
- Tröster-Mutz, (2002). *Untersuchungen zu Silbenschnitt und Vokallänge im Saterfriesischen*. Theorie des Lexikons Nr. 120. Düsseldorf: Heinrich-Heine-University.
- Yu, A. C. L. (2010). Tonal effects on perceived vowel duration. In C. Fougeron, B. Kühnert, M. D'Imperio and N. Vallée (Eds.), *Laboratory phonology 10*. Berlin etc.: de Gruyter, 151–168.