Linear Discriminant Analysis

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May 22 2012
Class Presentation Statistics, RUG

Goals of this presentation

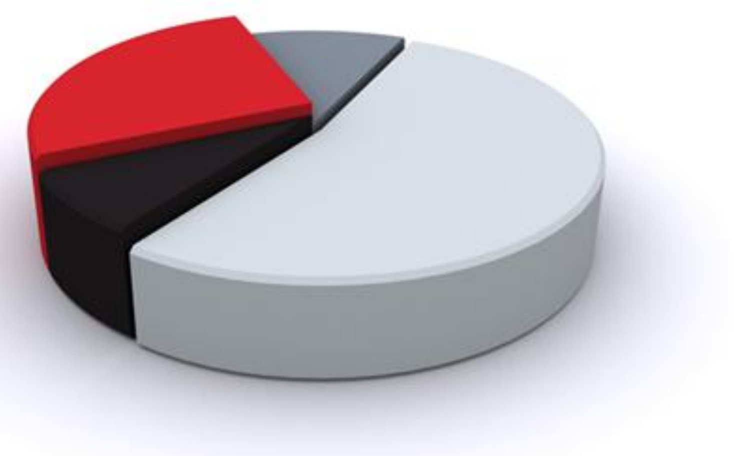
- Insight in Discriminant analysis
  - When to use it
  - How to use it
- Critical review of a dialectological method
  - Be careful with native raters!

Route map

- Swiss Standard German long <ä>
  - [ɛ:]~[e:] variation
- Methodology
  - Corpus
  - On line experiment: Level of Swiss accent
  - Categorical analysis
  - Acoustical
- Statistics: Discriminant Analysis
- Results

Standard German <ä>

- Träne 'Tear'
- Räd-chen 'wheel.Dim'
- Bäder 'bath.Plur'
- fähr-t 'drive.3Sg'



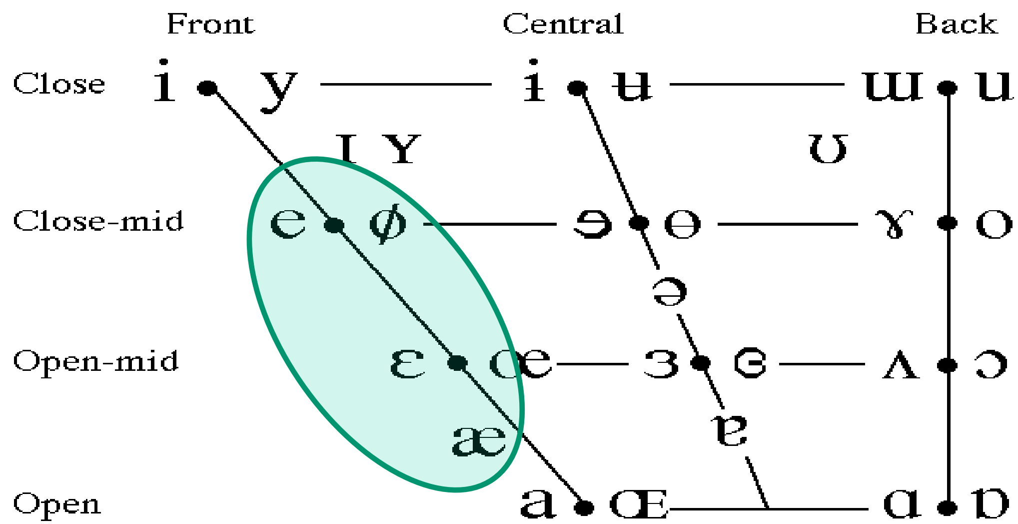
[ɛ:]~[e:] Variation

- Träne tr[e:]ne~tr[ɛ:]ne
- Räd-chen r[e:]dchen~ r[ɛ:]dchen
- Bäder b[e:]der~ b[ɛ:]der
- fähr-t f[e:]rt~ f[ɛ:]rt

[ɛ:]~[e:] Variation

- The [ɛ:]~[e:] variation is gradient

  any realization between [ɛ:]~[e:] is possible



Where symbols appear in pairs, the one to the right represents a rounded vowel.

Swiss Standard German (SSG)

- Swiss Standard German (SSG) differs from Standard German as spoken in Germany (NSG)
  - E.g. in NSG <ä> is more likely to be pronounced as [e:]
    - Neutralization with <e>

» Beeren	b[e:]ren	‘berry.Plur’
» Bären	b[e:]ren	‘bear.Plur’

  - SSG ‘Schriftsprache’
    - Close connection orthography and pronunciation

» Beeren	b[e:]ren	‘berry.Plur’
» Bären	b[ɛ:]ren	‘bear.Plur’

Swiss Standard German (SSG)

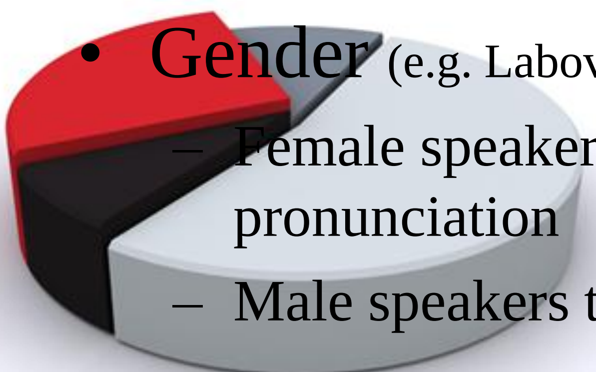
- Change?
  - Younger speakers tend to a more NSG pronunciation
  - Older speakers tend to a more SSG pronunciation
    - Ongoing change (Hove 2002)

Research Question (1)

- Which factors play a role in the realization of <ä> in Swiss Standard German?

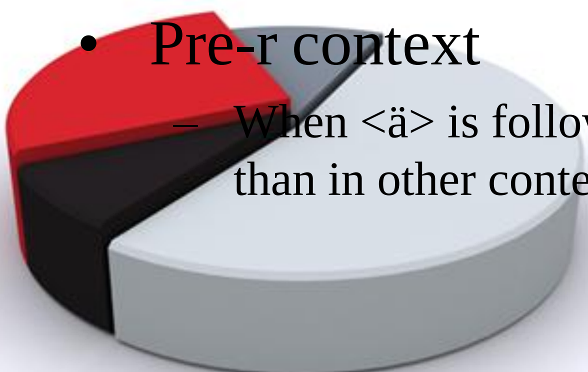
Hypotheses

- Swiss accent
  - The more Swiss accent a speaker has, the lower (i.e. [ɛ:]-like) the realization of <ä>
- Age (e.g. Labov 2001)
  - Younger speakers tend to a higher (i.e. [e:]-like) pronunciation
  - Older speakers tend to a lower (i.e. [ɛ:]-like) pronunciation
- Gender (e.g. Labov 2001)
  - Female speakers tend to a higher (i.e. [e:]-like) pronunciation
  - Male speakers tend to a lower (i.e. [ɛ:]-like) pronunciation



Hypotheses

- Umlaut
  - <ä> that is the result of umlaut of <a> has a lower (i.e. [ɛ:]-like) realization
- Frequency (Bybee 1999 et seq., Phillips 2006)
  - Words that are highly frequent are likely to be pronounced with a lower (i.e. [ɛ:]-like) pronunciation
  - Words that are lowly frequent are likely to be pronounced with a higher (i.e. [e:]-like) pronunciation
- Pre-r context
  - When <ä> is followed by a rhotic, pronunciation is lower (i.e. [ɛ:]-like), than in other contexts (Hall 1990)



Methodology

- Recordings of ‘native speakers’
- Categorical rating by two linguistically trained ‘native speakers’
- Logistic regression test on the factors
- ***Common method, but reliable?***

Psycholinguistics: Listeners reconstruct what they think they hear…..

Research Question (2)

- Do raters rely on just acoustic features?

  = are raters objective and unbiased?

Methodology

- Raters' judgements compared with the acoustical measurements
  - Are the [e:] and [ɛ:] ratings clear-cut categories?

Level of SSG accent

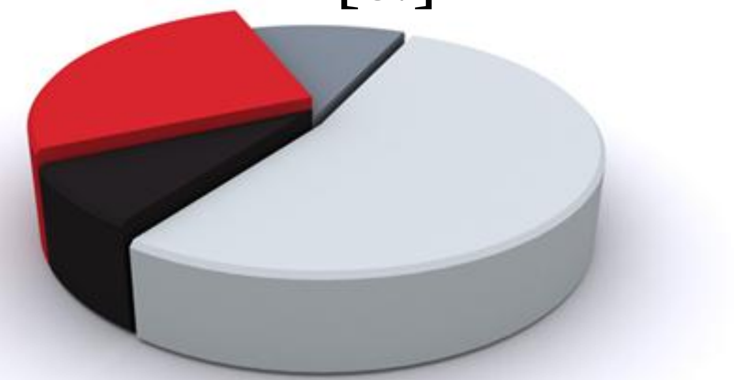
- Corpus data
  - Institut für deutsche Sprache Mannheim (Brinckmann et al. 2008)
  - 40 speakers
  - Average 15 <ä> per speaker
  - 22 males 18 females
  - 7 locations

Level of SSG accent

- Online elicitation of the level of Swiss accent of all speakers in the corpus
  - 40 respondents: 20 German 20 Swiss
  - Estimation of the SSG accent on a four-point scale
  - http://wievielstandardsprachainderschweizb.yolasite.com/

Raters judgements

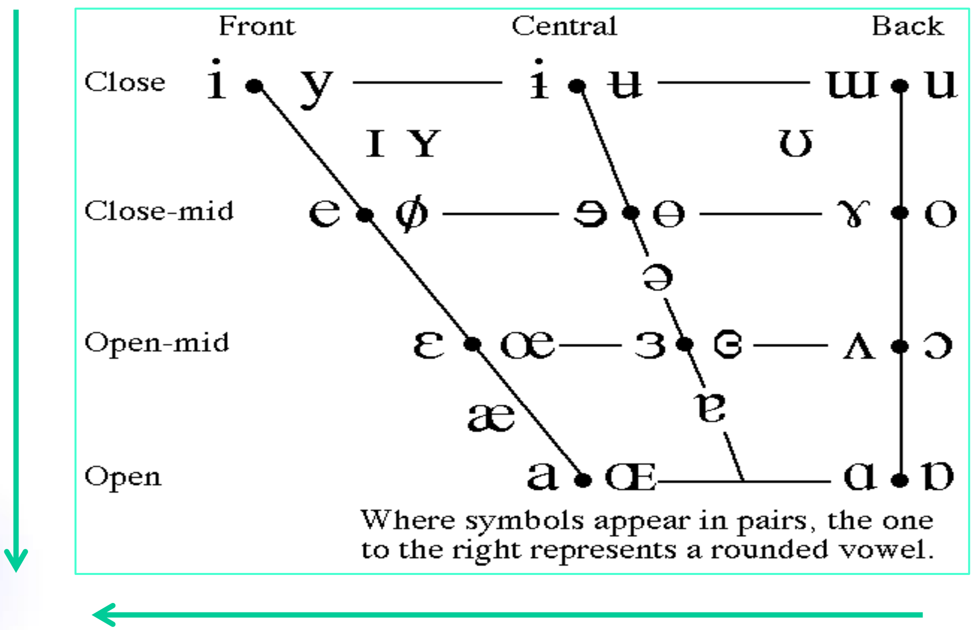
- Two raters
  - Both female
  - 24 and 27 years old
  - Linguistically trained
  - Judged long <ä> to be pronounced as either [e:] or [ɛ:]



Acoustical analysis

- First formant F1 and second formant F2 were measured in Praat (Weenink & Boersma 2010)

F1



F2

Linear Discriminant Analysis

- Analyses whether the value of the dependent variable can be predicted on the basis of the independent variable
- Parametric test
- Dependent variable is nominal
- Independent variable is rational

Linear Discriminant Analysis

- Aims:
  - Investigate the differences between groups
  - Predicting the category to which a value belongs
  - To determine the best way to distinguish between groups
  - Classify cases into groups

Data

Item	Rater RB	Rater MS	F1	F2
3412	E	E	4.79	11.84
3413	E	E	4.76	11.82
3414	E	E	4.70	11.74
3415	E	E	4.31	12.56
3416	e	e	5.12	11.66
3417	E	E	4.62	13.12
3418	E	E	4.85	12.12
3419	e	E	3.72	12.35
3420	E	E	4.97	12.29
3421	E	E	4.55	11.32
3422	E	E	5.49	11.63
3423	E	E	4.73	11.82
3424	E	E	4.13	12.74
3412	E	E	4.79	11.84

LDA rater 1

Call: lda(RealRB ~ F1 + F2, data = CH)

Prior probabilities of groups:

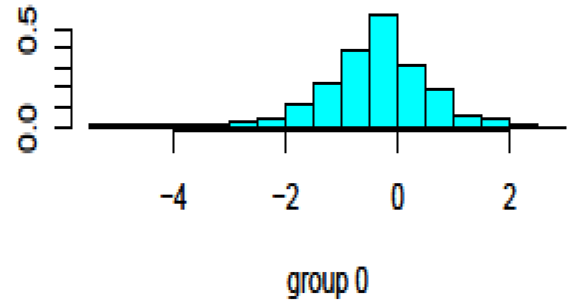
0	1
0.685567	0.314433

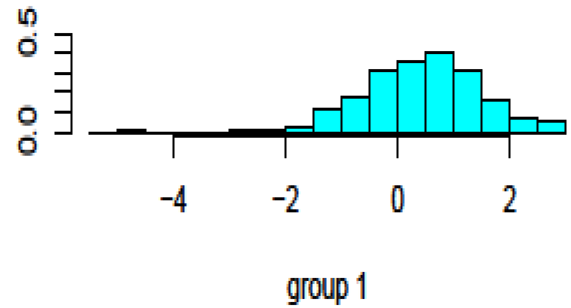
Group means:

	F1	**F2**
E	**5.23**	**12.55**
e	**4.73**	**13.11**

Coefficients of linear discriminants:

	LD1
F1	-0.82
F2	0.77





LDA rater 2

Call: lda(RealMS ~ F1 + F2, data = CH)

Prior probabilities of groups:

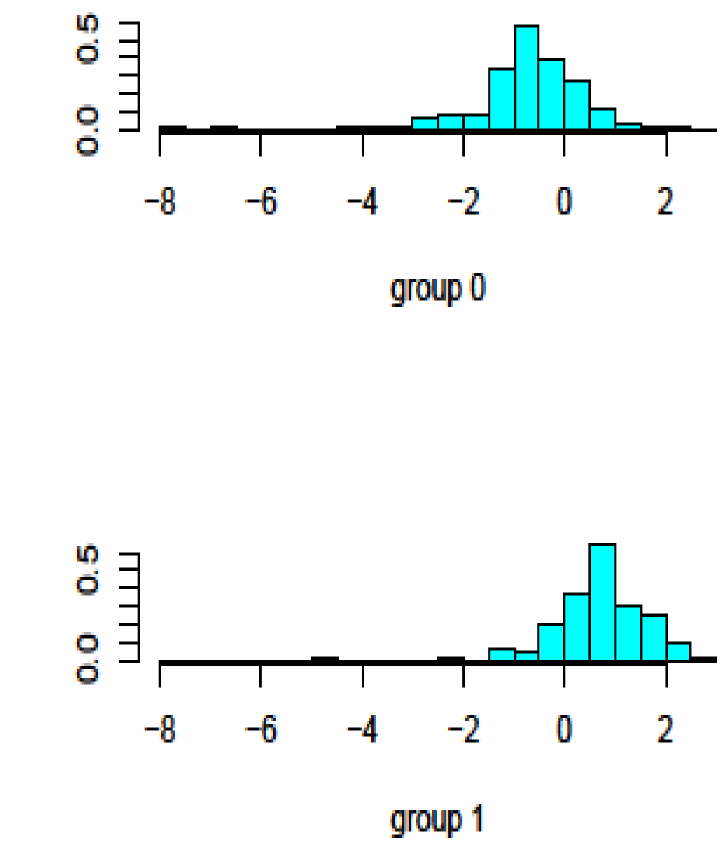
0	1
0.806563	0.193437

Group means:

	F1	F2
E	**5.28**	**12.65**
e	**4.23**	**13.06**

Coefficients of linear discriminants:

	LD1
F1	-1.0583420
F2	0.5133036



LDA pairs of ratings

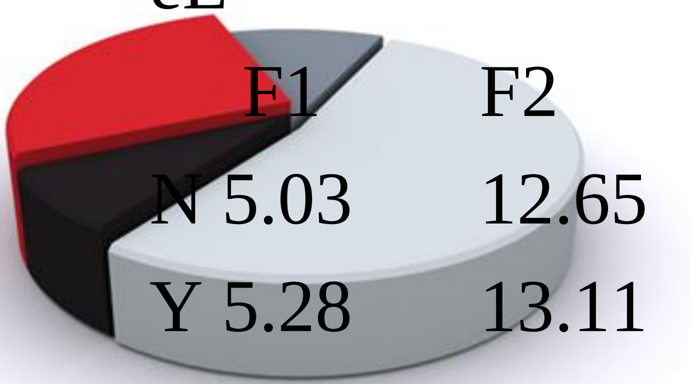
ee

	F1	F2
N	5.24	12.66
Y	4.17	13.09

EE

	F1	F2
N	4.70	13.07
Y	5.28	12.53

eE

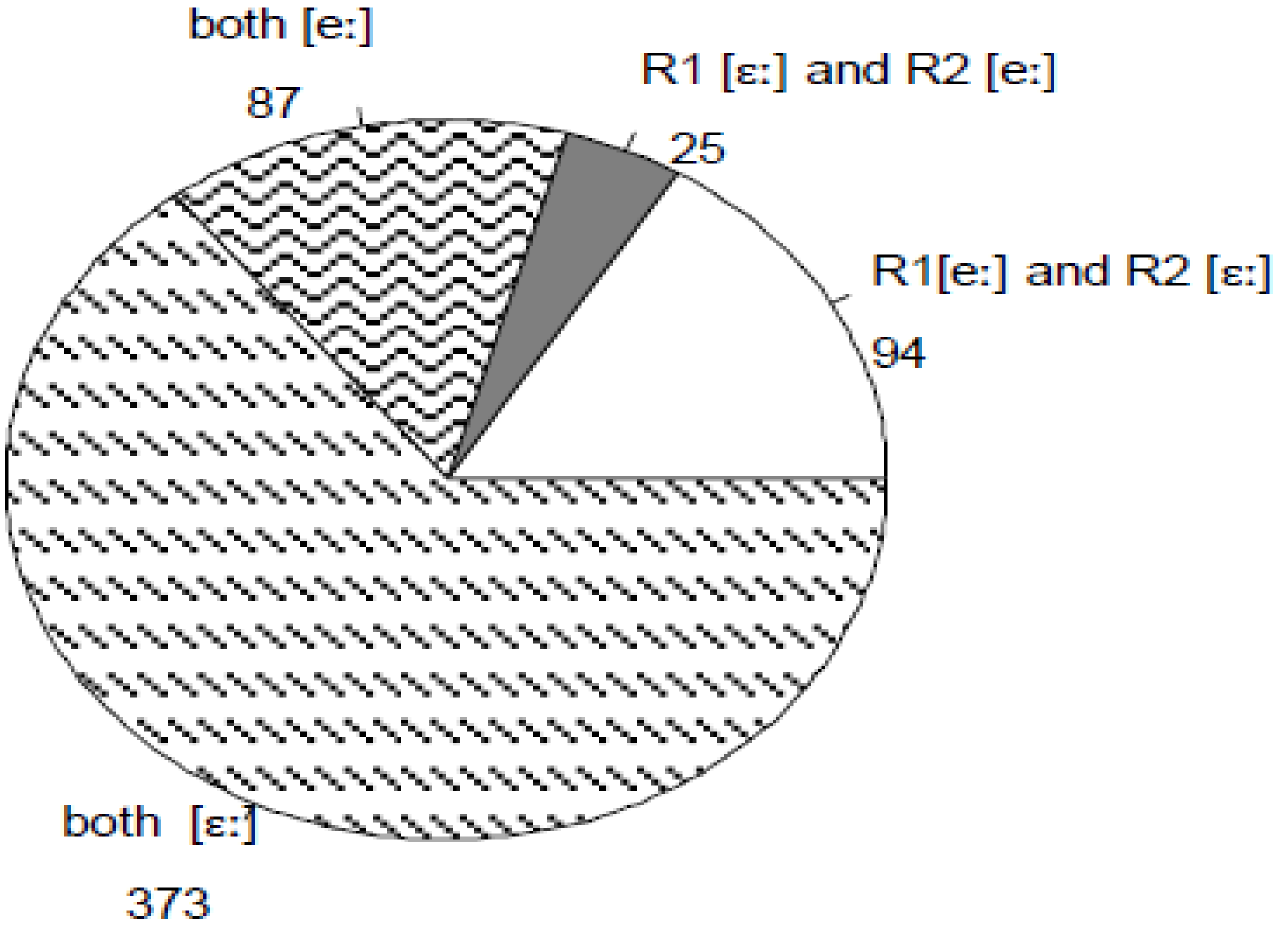


	F1	F2
N	5.03	12.65
Y	5.28	13.11

Ee

	F1	F2
N	5.10	12.72
Y	4.50	12.85

LDA pairs of ratings



Further….

- Comparison
  - Logistic regression on the raters data
  - Linear regression on the acoustic measurements

→ Totally different analysis!

Further….

- Raters’ judgements are predictable by SSG accent level and pre-r context
- Acoustic measurements are predictable by other factors……….

Further….

	Estimate	Std. Error	t value	*p*-value
(Intercept)	64.51	3.588	17.98	< .001*
Age young	-7.63	1.342	-5.69	< .001*
Gender male	5.70	1.247	4.57	< .001*
LogLemmaFrequency	0.03	1.382	0.03	0.978
Pre-r context	5.03	5.497	0.92	0.361
LogLemmaFrequency : Pre-r context	-5.78	2.080	-2.78	0.006*

Residual standard error: 14.55 on 568 degrees of freedom
(2 observations deleted due to missingness)
Multiple R-squared: 0.2686, Adjusted R-squared: 0.2544
F-statistic: 18.96 on 11 and 568 DF, p-value: < 0.001

Take home message

- Don’t trust the native speaker!
- Don’t rely only on LDA!

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Discussion?

Thank you!

Acoustical analysis

- Vowels are normalized
  - [i] = 100
  - [a] = 0
- Euclidean distance

$$\text{Interpol} = \frac{\delta(<\text{ä}>-a)}{\delta\ (i-a)} * 100$$

prototypical [ɛ] = 56

prototypical [e] = 72