Leibniz-Zentrum Allgemeine Sprachwissenschaft

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# Changes and challenges in explaining speech variation: A review over half a century

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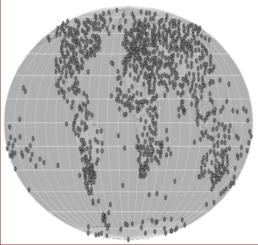
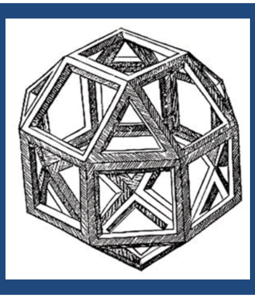
# Overview of my talk

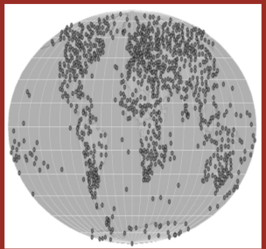


Explaining variability



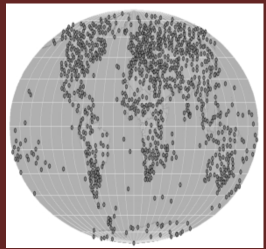
Challenges in explaining variability

Dealing with some of these challenges



# Explaining variability

- Dialectal, social, communicative factors
- Biological factors
- Nature of linguistic representations
- Relations between different levels



# 1952: Peterson & Barney

- Dialectal, social, communicative factors

33 men, 28 females, 15 children
recorded with 10 vowels in hVd words

a) huge variation in production
b) depends on dialectal background
c) variation is not random
d) corner vowels often better classified than central vowels

Peterson & Barney (1952) JASA *24*(2), 175-184.

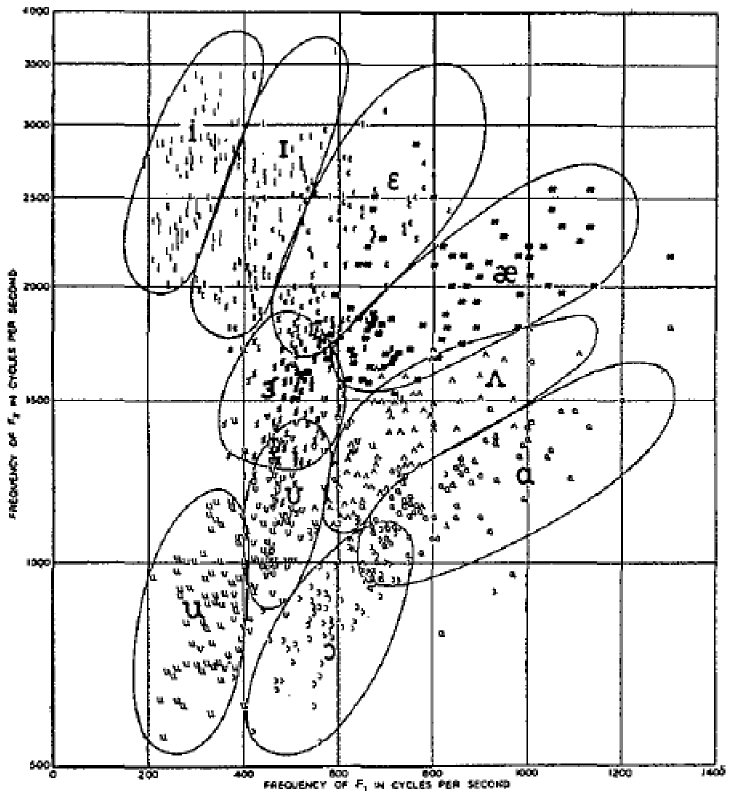
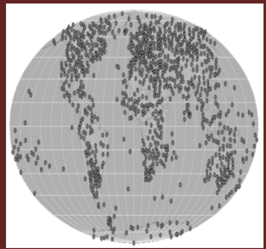



FIG. 8. Frequency of second formant *versus* frequency of first formant for ten vowels by 76 speakers.



# 1963: Labov

➢ Dialectal, social, communicative factors

Labov, W. (1963). *Word*, *19*(3), 273-309.

- Study at Martha's Vineyard, island, self-contained unit, diff. ethnic groups and 2 areas
- 69 interviews, diphthongs

  /ai/ -> [ɐɪ], [əɪ]

  /au/ -> [ɐʊ] , [əʊ]

- Centralisation of first low vowel in diphthongs:
  - with age
  - with the rural area (up island)
  - occupation (farmers in comparison to fisherman)
  - Portuguese (in contrast to English, Indian)
- No effects due to seasonal tourists

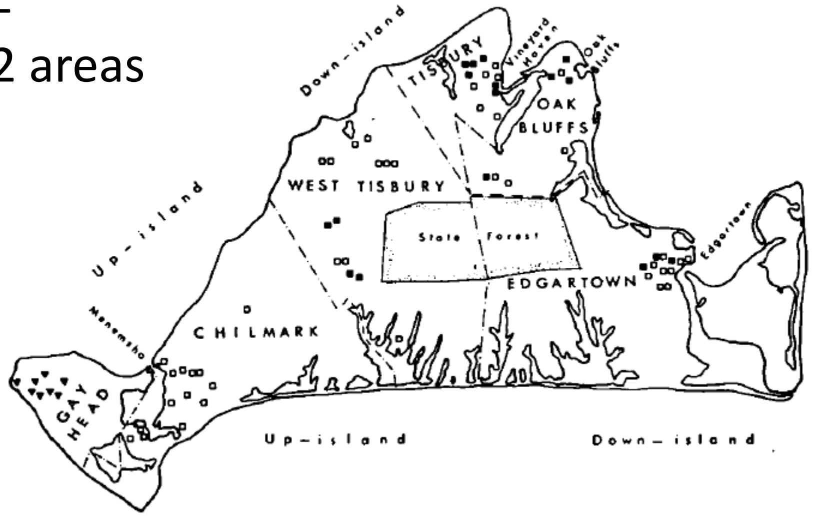
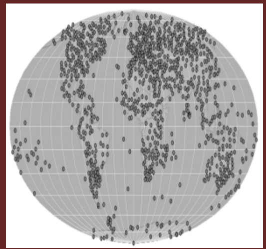



FIGURE 1. Location of the 69 informants on Martha's Vineyard. Ethnic origin of the informants indicated by the following symbols: □ English, ■ Portuguese, ▼ Indian. Symbols placed side by side indicate members of the same family.

**Correlation of social aspects with the actual pronunciation**



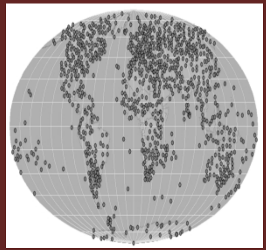
# 1991: Accommodation theory (Giles, Coupland & Coupland)

- Dialectal, social, communicative factors

Coupland, J., Coupland, N., & Giles, H. (1991). *Contexts of Accommodation. Cambridge University Press*, 1-68.

Communication Accommodation Theory (CAT)

- Theory developed in the 70s
- Basic concept: During communication speakers **accommodate or adjust** their speaking style to others
- Done in two ways: **convergence (less variation) or divergence (more variation)**
- Both are **regulators of social distance** (e.g. to highlight group identity, in-group or out-group behaviour)



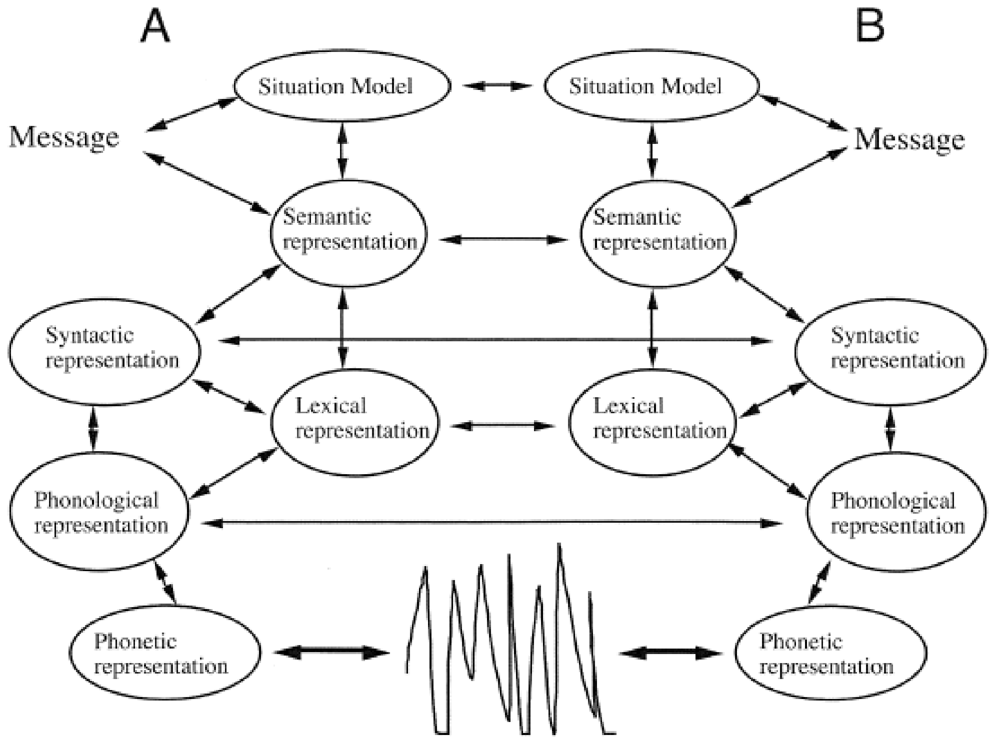
# 2004: Interactive alignment model (Pickering & Garrod)

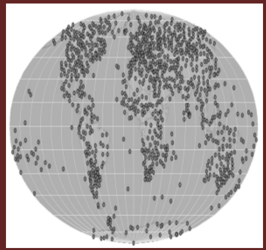
- Dialectal, social, communicative factors

Pickering, M. J., & Garrod, S. (2004). Toward a mechanistic psychology of dialogue. *BBS*, *27*(2), 169-190.

Adaptation between interlocutors seen as an **automatic priming process** (unconcious)

i.e. **communicative situations** are very **variable**, but a **reduction of variation** between interlocutors is found over the course of the dialogue due to priming





# 2012: Eckert's three waves of variation

## ➢ Dialectal, social, communicative factors

Eckert, P. (2012). Three waves of variation study: The emergence of meaning in the study of sociolinguistic variation. *Annual Review of Anthropology*, 41, 87-100.

**First wave:**

- Survey studies: Variation in speech is explained by socioeconomic status, gender and stylistic dynamics; greater variation at the lower end of the socioeconomic hierarchy & use of non-standard forms

**Second wave**

- Ethnographic methods. "that patterns of variation are not set in childhood but continue to develop along with social identity." (p.92)

**Third wave**

- "variation as a reflection of social identities and categories to the linguistic practice in which speakers place themselves in the social landscape through stylistic practice."
- "Variation constitutes a social semiotic system…." (p. 94)

# ➢ Dialectal, social, communicative factors

Paul Foulkes & Gerry Docherty
Stefanie Jannedy & Melanie Weirich
Jonathan Harrington
Jennifer Hay
Jim Scobbie
Rachel Smith
Jennifer Pardo
Benjamin Munson
Jane Stuart-Smith
Janet Pierrehumbert
Penelope Eckert
Cynthia Clopper & David Pisoni
Molly Babel
Chiara Celata & Silvia Calamai
and so many more

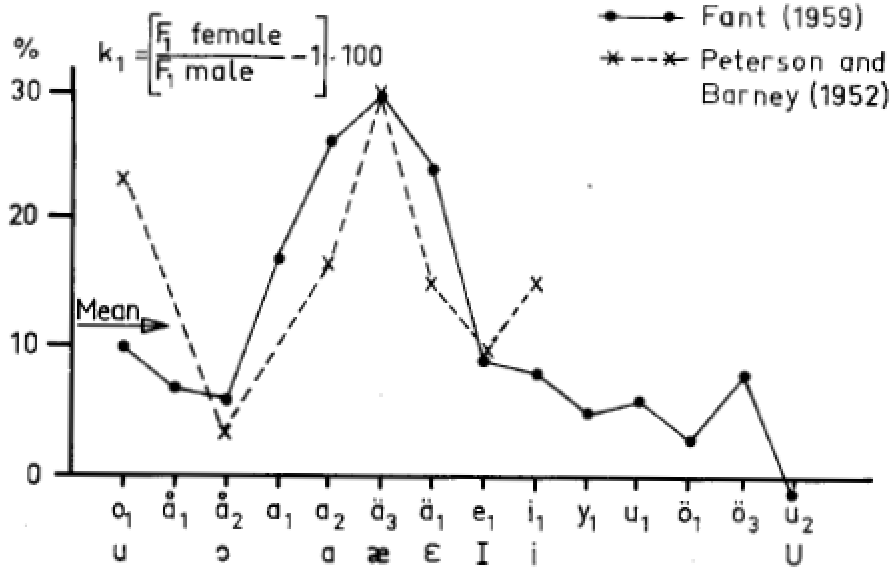
- Long term changes
  - Dialect
  - Age
  - Sex/Gender
  - Occupation…
- Short term changes
  - Flexible adaptations within a momentary communicative situation
  - From larger groups to a focus on changes in the individual

# 1966: Vocal tract size & formant patterns (Fant)

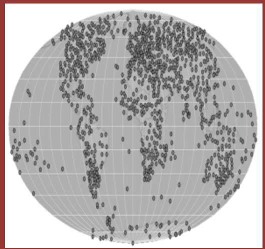
## ➢ Biological factors

Differences in vocal tract length (males longer than females)

- partially explain differences in the acoustic vowel space (larger for females than males)
- but non-uniform effects regarding different vowels




Fant, G. (1966). A note on vocal tract size factors and non-uniform F-pattern scalings. *STL-QPSR, 7*(4), 022-030.



# 1999: Body height & vocal tract length (Fitch & Giedd)

➢ Biological factors

Strong **positive correlation between body height/size and vocal tract length** in in 129 humans from 2-25 years based on MRI data

Fitch & Giedd (1999*) J. Acoust. Soc. Am.* 106 (3), Pt. 1, 1511-1522.

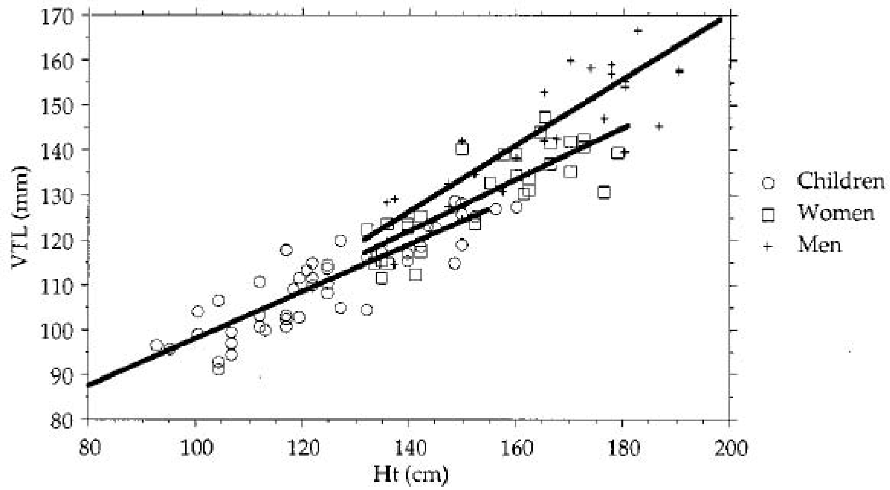
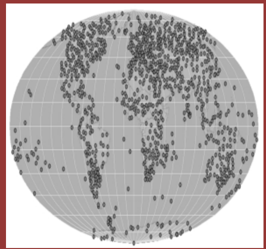



FIG. 5. Height (cm) versus vocal tract length (mm), with separate regression lines illustrating the difference between sexually mature male vocal tract allometry and that of women and children.

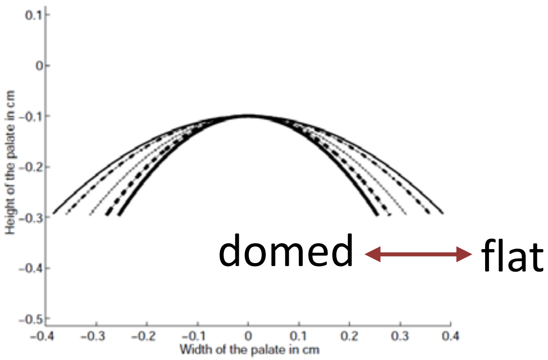


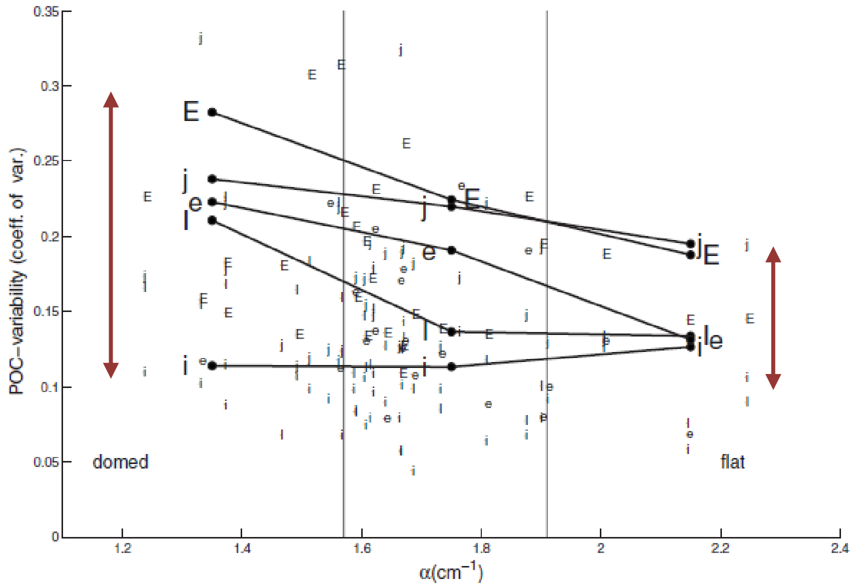
# 2009: Palate shape (Brunner et al.)

## ➢ Biological factors

### Individuals' morphology constraints articulatory precision

- Domed versus flat palates
- 32 speakers measured with EPG

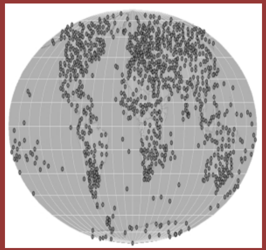



ıtionship between α (abscissa) and POC-variability (ordinate). Small letters show results of single measurements. The lines connecting big letters ıally observed POC-variability. Vertical lines show borders between palate groups.

- Coronal plane

Brunner et al. (2009) *J. Acoust. Soc. Am*. 125, 3936-3949



# 2011: Brain plasticity (Golestani et al.)

## ➢ Biological factors

Structural plasticity in the expert phonetician brain

17 Phoneticians

16 Normal controls

- **Size of the left pars opercularis** (constitutes the anterior Broca's speech region) **~ with years of phonetic training**
- Morphological differences in left auditory cortex (**greater gyrification in the expert**)
- Gyrification at birth predicts functional outcome in later life

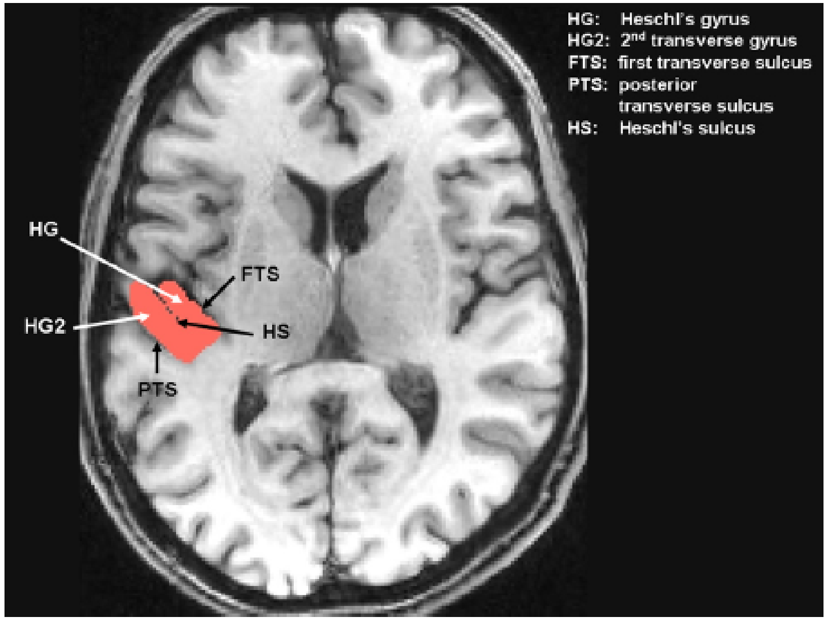
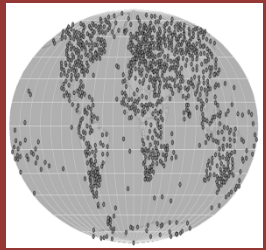



**Figure 1.** Transverse gyrus landmarks and boundaries shown on left hemisphere with two transverse gyri.

Golestani, Price & Scott (2011) *The Journal of Neuroscience 16*, 31(11): 4213– 4220



# 2016: Modern genetics (Dediu & Christiansen)

➢ Biological factors

Dediu & Christiansen (2016) *Topics in Cognitive Science*, *8*(2), 361-370.

Variation also exists at the genetic level, e.g.

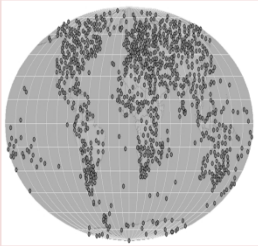
- Mutations of the TECTA gene (chromosome 11) can result in dominant form of hearing loss (100% pathology)
- Other mutations of the same gene can result in recessive form of hearing loss (25% chances pathology)

➢ **i.e. same gene and same phenotype, but different inheritance patterns**

# ➢ Biological factors

Houri Vorperian
Melanie Weirich
Adrian Simpson
Yana Yunusova
Ralf Winkler
Pascal Perrier
Yohan Payan
John Ohala
Björn Lindblom
Johan Liljencrants
Peter MacNeilage
Natalie Vallee
Kiyoshi Honda
Maureen Stone
Jianwu Dang
Lawrence Barsalou
and so many more

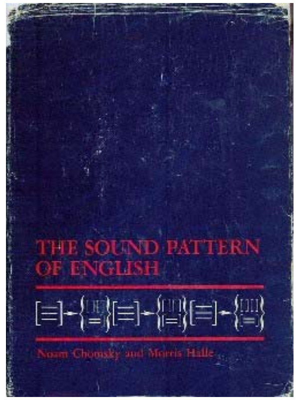
- Variation is everywhere !
- Visible and audible changes
  - Body height, weight
  - Vocal tract differences
- Structures behind the surface
  - Chromosomes, genes, their regulation
  - Brain areas
  - Biomechanics
- Use of big data, advanced models & statistics
- From binary categories to more continuous ones



# 1968: Sound pattern of English (Chomsky & Halle)

➢ Nature of linguistic representations

Chomsky & Halle (1968). *The Sound Pattern of English*. New York: Harper & Row.

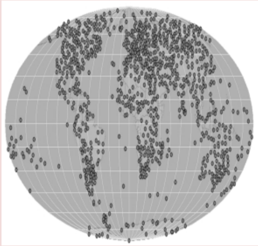



Distinction between **language competence and performance**

- Competence = **innate capacity** for language
- Performance = **individual realisation** (can be variable)

Describes phonology and smallest meaningful units (phonemes) with **binary +/- features** and **phonological rules**

- **Features are invariant, abstract, timeless entities**
- **Variability** in a phoneme's realization is rather treated as **random noise than being meaningful**



# 1979: Acoustic invariance (Blumstein & Stevens)

## ➢ Nature of linguistic representations

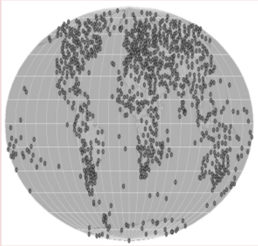
Blumstein, S.E. & Stevens, K.N. (1979). *JASA, 66 (4)*, 1001-1017.

Blumstein, S.E. (1986). In J.S. Perkell & D.H. Klatt (Eds.), *Invariance and Variability in Speech Processes* (pp. 178-193). Hillsdale N.J.: Erlbaum.

Distinctive features are based on **invariant acoustic properties**

" [...] That is, it is hypothesized that the speech signal is highly structured in that it contains **invariant acoustic patterns for phonetic features**, and **these patterns remain invariant across speakers, phonetic contexts, languages.** [...] the perceptual system is sensitive to these invariant properties. That is, it is hypothesized that the perceptual system can use these invariant patterns [...] to process the sounds of speech in ongoing perception" (Blumstein, 1986, p.178)."

- Invariant acoustic patterns could be formants (for vowels) and spectral shapes of bursts for stops



# 1985: Motor theory (Liberman 1967; L&M 1985)

➢ Nature of linguistic representations

Liberman, A.M., Cooper, F., Shankweiler, D. & Studdert-Kennedy, M. (1967). *Psychological Review, 74,* 431-461; Liberman, A.M. & Mattingly, I.G. (1985). *Cognition, 21*, 1-36.; see also Perrier (2005) ZASPiL 40, 109-132.

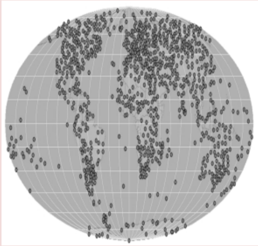
**Denies the importance of acoustic properties**

– E.g. in speech acquisition: How can children imitate invariant acoustic properties with their shorter vocal tract (larger acoustic vowel space)?

" there is typically a lack of correspondence between acoustic cue and perceived phoneme, and in all cases it appears that **perception mirrors articulation more closely than sound**" (Liberman et al., 1967, p. 453)

– **Acoustics is** "a **basis for finding his way back to the articulatory gestures**" (p.463)

**Invariants are the motor commands in the brain** that correspond to the intended articulatory gestures

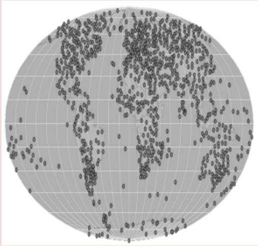


# 2003: Fine phonetic details (Hawkins)

## ➢ Nature of linguistic representations

Hawkins, S. (2003) *Journal of Phonetics*, 31, 373–405.

- **Systematic, non-random variation in phonetic detail** which cannot be explained by linguistic categories, but are due to speaker's identity, attitudes, and current state of mind
- E.g. different meanings of: I ….do…..not….know. I do not know.
  I don't know. I dunno.
- "**formal linguistic analysis of speech into abstract phonological units** like features, allophones, phonemes …. **neglect information that is available in the speech signal alone** that enables **broad connotative meaning to be understood**" (p. 376)
- Connects very well to work in other disciplines (psychology and neuroscience) on episodic memory



# Episodic memory (Goldinger, Pierrehumbert)

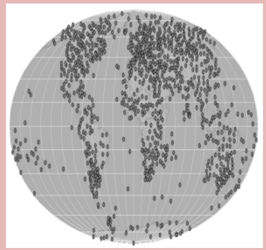
- Remember "pub"
- Rather concrete than abstract -> there will be traces in memory for my last visit  (i.e. name of the pub, the friends I went with, the beer, the discussions..)
- **Rich multisensory representation stored in episodic memory**
- Role of sleep for memory consolidation has been emphasized


e.g. Pierrehumbert, J. (2016) Phonological representation: beyond abstract versus episodic. *Annu. Rev. Linguist.* 2:33–52.

# Nature of linguistic representations

LabPhon community
MIT and Haskins group
Louis Goldstein
Dani Byrd
David Ostry
Osamu Fujimura
Jelena Krivokapic
Caterina Petrone
Jana Brunner
Joe Perkell
Frank Guenther
John Houde
Sven Öhman
Peter Ladefoged
Bernd Möbius
Sarah Hawkins
Noel Nguyen
and so many more

- Changes from a phonemic level
  - Features, minimal pairs, allophonic variation
- to a subphonemic one
  - Speaker-specific behaviour
  - Situational context etc.
- From linguistics
  - Abstract linguistic representations
- to psychology, neuroscience…
  - Enriched representations
  - Including sensorimotor representations, memory, sleep
  - Embodied cognition



# 1989: Quantal nature of speech (Stevens)

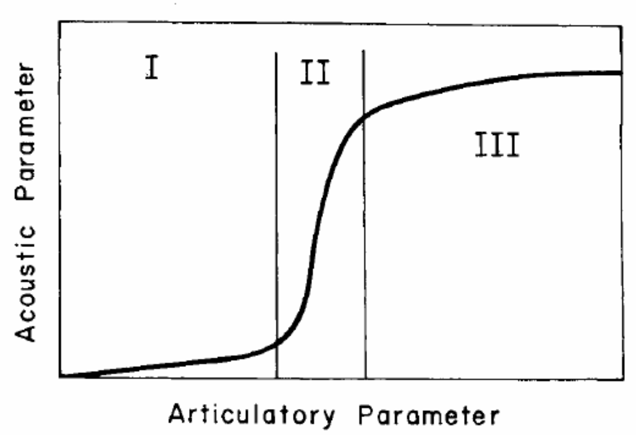
➢ Relations between different levels

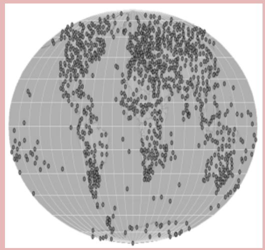
Stevens, K.N. (1989). *J. Phonetics, 17*, 3-45.

**Nonlinearities** between:

- Acoustics-articulation
- Acoustics-perception

**Sounds of the world's languages prefer stable acoustic regions** where **articulators can still move (are variable)**, but have no huge consequence on the acoustic output (following the idea of acoustic invariant properties)





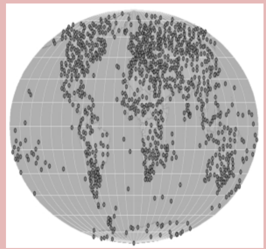
# 1993: Motor equivalence (e.g. Perkell et al.)

➢ Relations between different levels

For a summary: Perrier & Fuchs (2015) In Redford, M. (ed.): *Handbook of Speech Production*. Blackwell.

**Capacity of the motor system to achieve the same goal differently**

– **offers freedom** (possibility to vary)
– one can "**achieve the same goal through a variety of kinematic trajectories**, with **different muscle groups** and in the face of **ever-changing postural and biomechanical requirements**" (Kelso & Tuller, 1983)
– e.g. reaching an object with the arm
– e.g. speaking with a pencil in the mouth, with a bite block in the jaw
– In the case of Perkell et al. (1993): reaching similar acoustic properties (F2 values) to produce an /u/ with an adjustment of the constrictions at the lips and the tongue



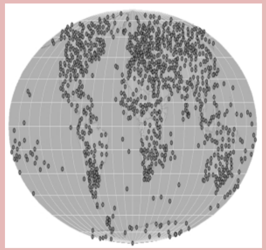
# 1990: H&H model (Lindblom)

## ➢ Relations between different levels

Lindblom (1990) Explaining phonetic variation: A sketch of the H&H theory. In *Speech production and speech modelling* (pp. 403-439). Springer Netherlands.

H&H theory: **speaking and listening are shaped by general biological processes**

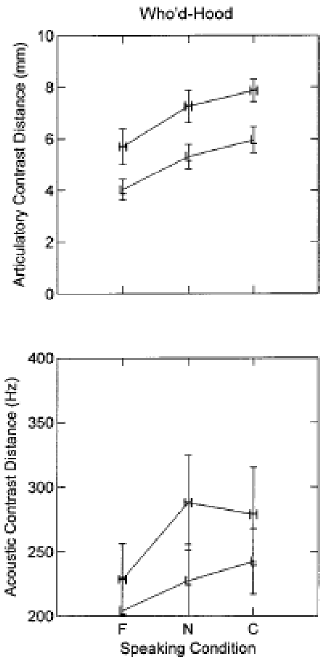
- Balance between **production-oriented** and **out-put oriented factors**
- **Hypospeech:** driven by the motor system, low cost, save energy
- **Hyperspeech**: driven by the need to be understood, perceptual discrimination
- Speakers vary along a **hypo-hyperspeech continuum which explains variation**



# 2004: Speaker-specific accuracy and perceptual acuity (Perkell)

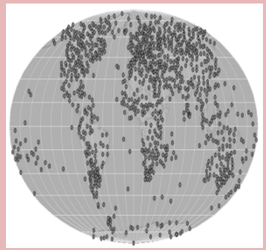
➢ Relations between different levels

Perkell et al. (2004) J. Acoust. Soc. Am., Vol. 116, No. 4, Pt. 1, 2338–2344




The more accurately a speaker discriminates a phonemic contrast perceptually, the more distinctive s/he produces that contrast

**Individual distinctiveness of a contrast will be visible both, in production and perception**



# 2014: Dyad dependent accuracy and acuity (Cangemi)

➢ Relations between different levels

Cangemi et al. (2015) In Fuchs et al. (eds.) Individual Differences in Speech Production and Perception. Peter Lang Publisher.

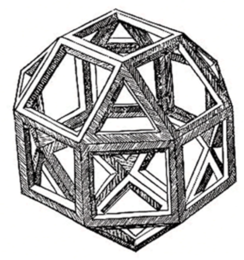
**Listener-specific perception of speaker-specific productions in intonation**

– There is no perfect speaker or listener.
– Same speaker can be involved in both very beneficial and very detrimental interactions, depending on the listener.

# Relation between levels

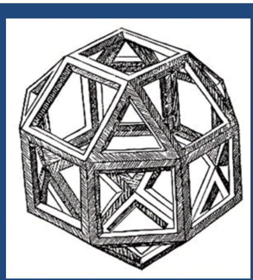
Gunnar Fant
MIT and Haskins group
David Ostry
Lucie Menard
Osamu Fujimura
Jonathan Harrington
Frank Guenther
John Houde
Peter Ladefoged
and many more

- From stable (non)linearities between all levels
  - Quantal regions
  - Speaker acuity and perceptual discriminability
- To more flexible behaviour
  - Dyad dependent behaviour
  - Role of the situation: Continuum between hypo- and hyper-speech



# Challenges in explaining variability

- Nonlinearities between different levels
- Intra- and inter-speaker variability
- Single time point analyses versus time series analyses
- Teasing apart all influences

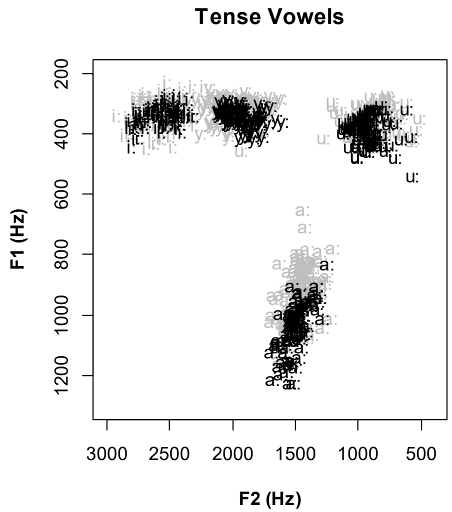


# Nonlinearities between different levels

1. If we investigate variability at the **acoustic level**, our knowledge may be **limited to generalize to articulation** (see quantal theory, principles of motor equivalence) **and perception**. Thus, it is advisable to **examine variability at different levels to draw conclusions**.

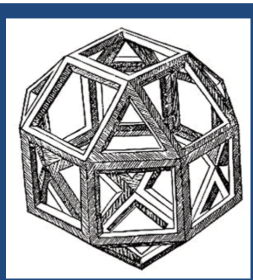
2. **Variability is**, among others, **phoneme-, speaker-, context-specific**. For example, if we know the acoustic variability of /i/ and its articulatory correlates, we cannot generalize it to /a/. Hence, it is better to base generalizations (if something consistent occurs) on several linguistic structures than on a single one.

**Black: loud**, **grey: normal**




Frequently vowel expansion reported for loud speech,
Studies almost exclusively on /a/

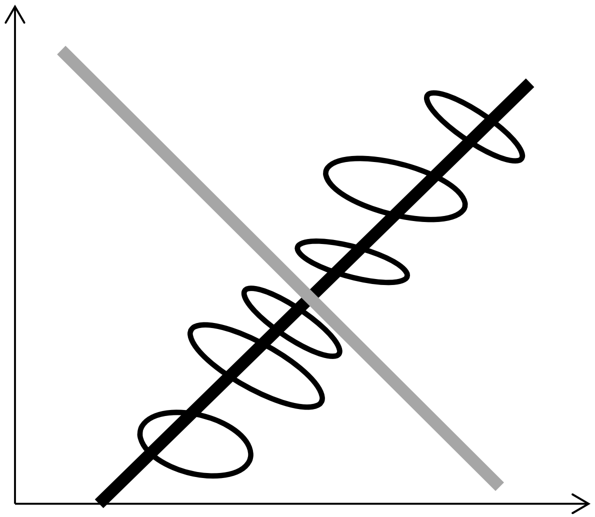
Koenig, L. L., & Fuchs, S. (2019).
Vowel formants in normal and loud speech.
JSLHR, 62(5), 1278-1295.

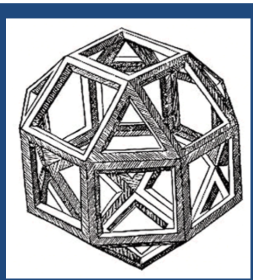


# Intra- and inter-speaker variability

1. **Intra- and interspeaker variability may not always go in the same direction** (Be aware of this in your statistical models). They can even go in opposite directions.

2. Even if one can find a significant correlation, **interpretations about the underlying mechanisms concerning the relation between X and Y are subjective,** X and Y may be unrelated in real life.

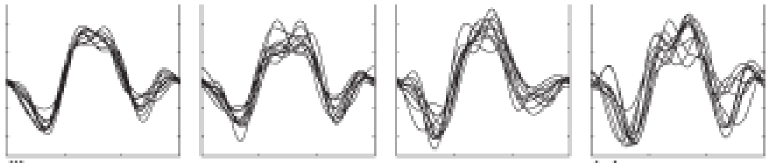




# Single time point analyses versus time series analyses

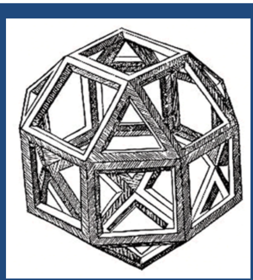
1. We need to question ourselves **at what point in time do we calculate variability** (single point analysis – do we assume speakers move from one target to the next?) and **which conclusions can we draw** from it?

2. **Time Series Analyses**:
   - e.g., Functional Data Analysis
   - Time Warping
   - Cross-Recurrence Analysis
   - Cross-correlation analysis



**Many of these techniques require specific knowledge**
- we need to know the basic constraints, assumptions
- avoid automatically pushing a button

3. **Statistics:**
   - e.g. nonlinear time series: Generalized Additive Modelling (GAMMs)



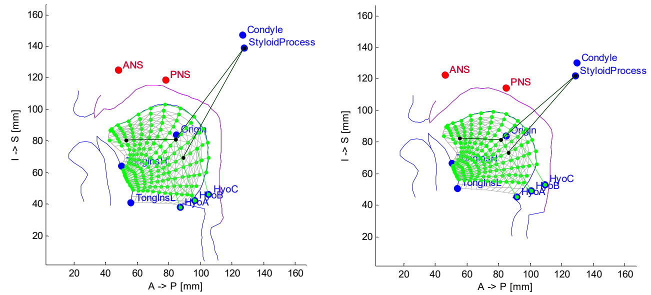
# Teasing apart all influences

1. Should be aware of own theoretical and conceptual thinking. **At which level do we expect variability?** (Examples from Labov 1963, Peterson & Barney 1952… if you intent to study sociophonetic features, don't ignore the biological ones and vice versa)

2. **Should be aware of potential influences** (and exploit the internet to search for the unknown)

3. **Modelling** biological factors with **speaker-specific physically realistic models** may help us to better understand the relations between articulatory, acoustic and perceptual variability (but time consuming, computationally expensive).

4. **Comprehensive data collection**, whenever possible (sharing data)

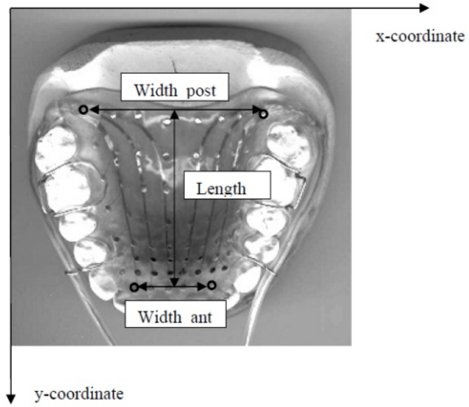


# Dealing with some of these challenges

# Linking individual anatomy – acoustics - articulation

➢ Dealing with some of these challenges

- **Differences in /s/ production between ♀ & ♂** frequently reported, higher frequencies for ♀ (acoustics)
- **Biological** and **social explanations** have been offered
- Underlying articulation and palatal morphology unclear



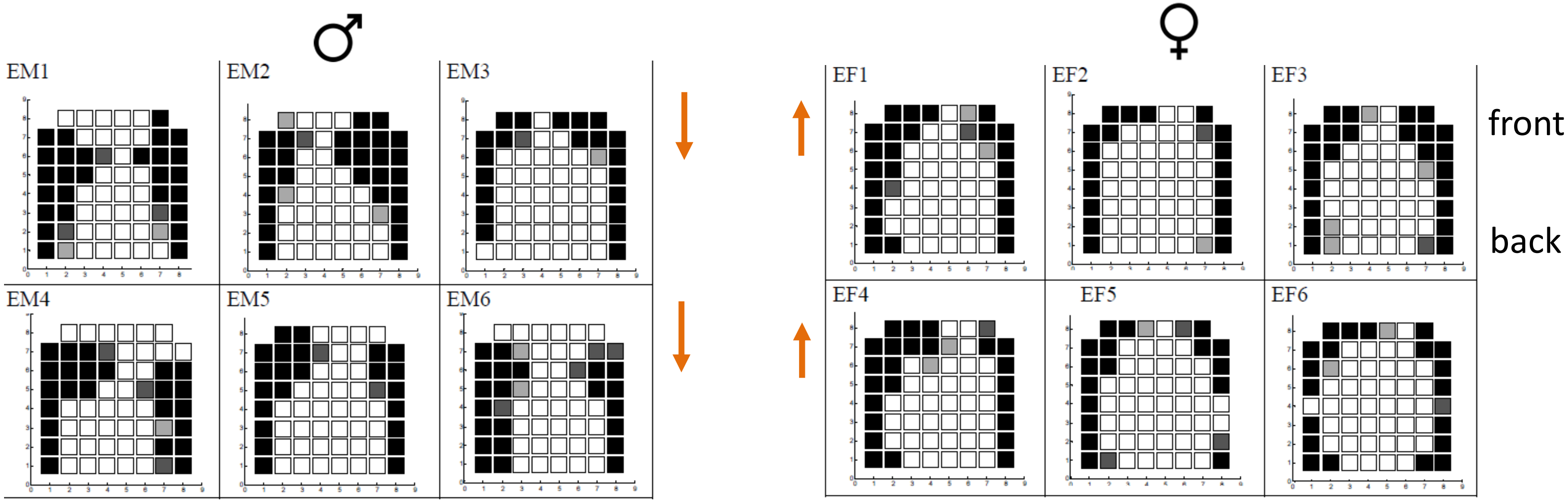

## Methodology

– Morphological data of the palate shape (based on EPG palates)
– Articulation (tongue-palatal contacts)
– Acoustics
– 12 English & 12 German speakers (6 females per group)

Fuchs, S. & Toda, M. (2010) In *Turbulent sounds. An interdisciplinary guide*, 281-302. Berlin: Mouton de Gruyter.

# Linking individual anatomy – acoustics - articulation

➢ Dealing with some of these challenges




More back articulation for males in comparison to females
in both languages

# Linking individual anatomy – acoustics - articulation

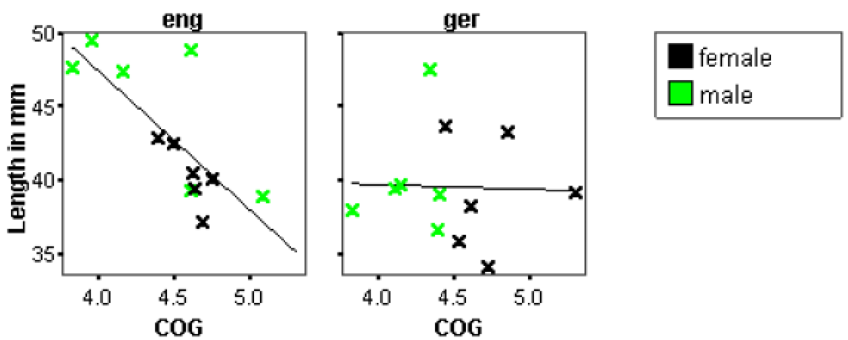
## Dealing with some of these challenges

- No differences in palatal parameters between males and females, but between English (longer, narrower in the front) and German speakers

- Negative correlation with palatal morphology for English speakers ($r^2$=0.58):

  -> the longer the palate, the further back the articulation
- 2 males with shorter palates do behave like females

  -> no compensation for anatomy (biological explanation)
- German speakers consistently show more front articulation for the females




**Statistical tests with palatal parameters as covariates** to rule out the anatomical differences

**-> differences in place of articulation pertain**

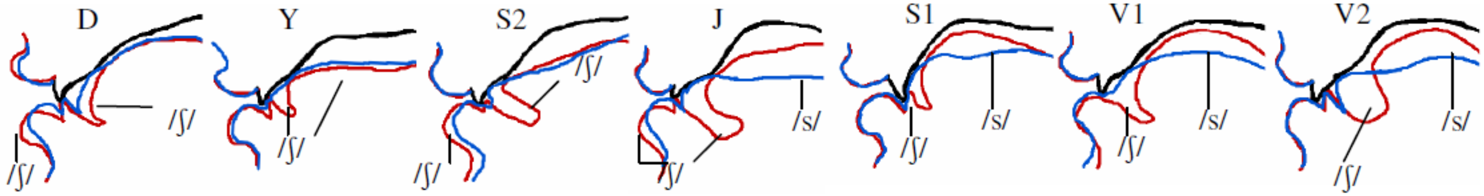
**-> i.e. mixture of effects for English**

**-> sociophonetic for German**

# Linking anatomy, articulation and phonemic contrasts

## ➢ Dealing with some of these challenges

Toda, M. (2006) *Proc. of JEP*




MRI data for French speakers

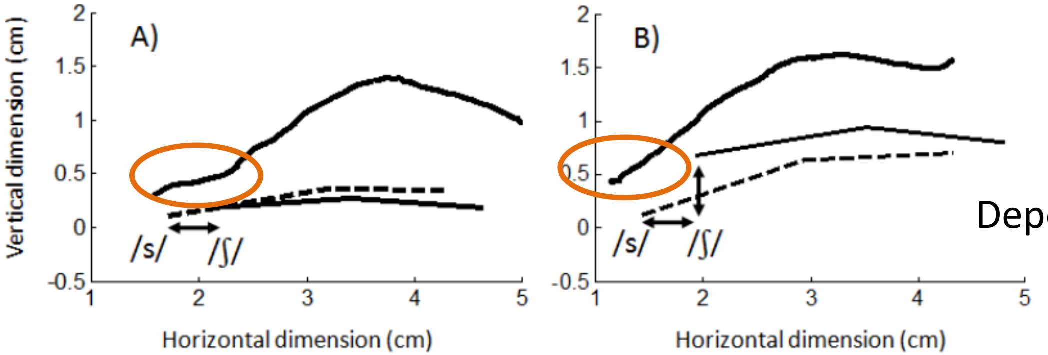
Position adjustment strategy

Pure tongue retraction

Tongue adjustment strategy

Tongue retraction and elevation

Weirich & Fuchs (2013) *JSLHR 56*, 1894-1908




Depends on inclination angle

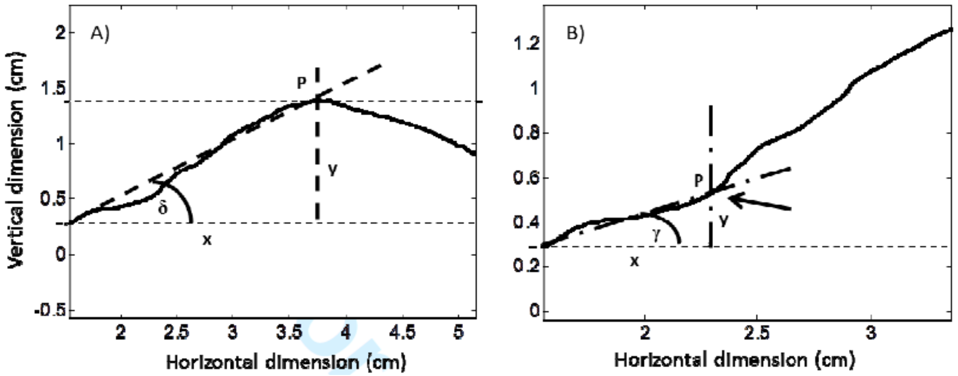
# Linking anatomy, articulation and phonemic contrasts

## ➢ Dealing with some of these challenges

Weirich & Fuchs (2013) *JSLHR 56*, 1894-1908

### 1. Experiment

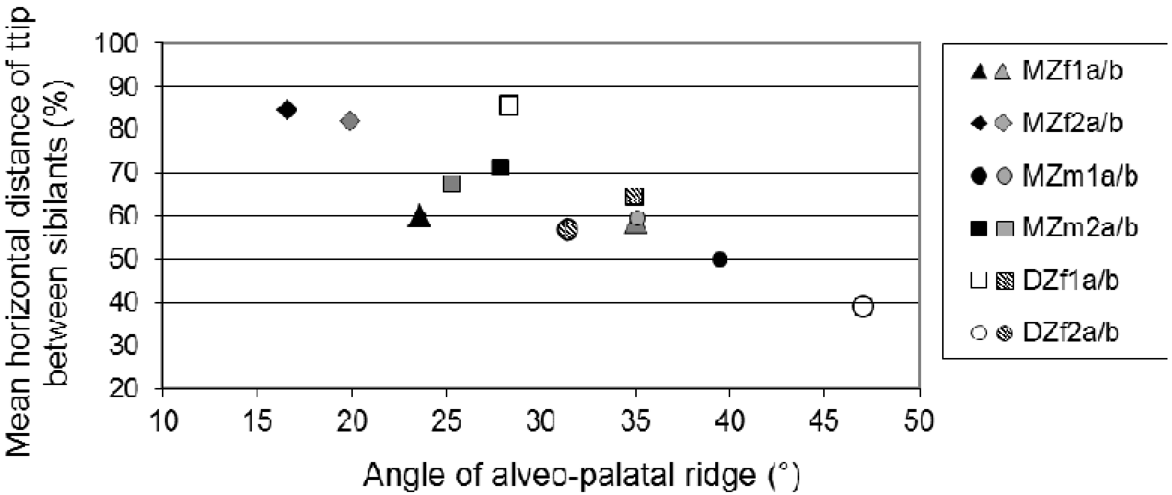
- 4 monozygotic and 2 dizygotic twin pairs (German)
- Palatal casts (to control for speaker morphology)
- Relation between tongue elevation and retraction of the tongue tip sensor using EMA
- Palatal trace to measure the inclination angle (at the alveolar ridge (B) and up to highest point (A))



# Linking anatomy, articulation and phonemic contrasts

## ➢ Dealing with some of these challenges

Weirich & Fuchs (2013) *JSLHR 56*, 1894-1908

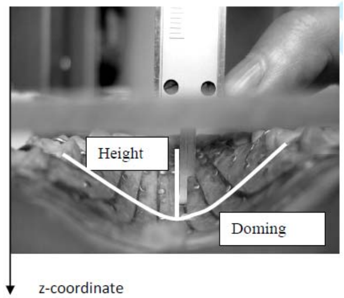



Smaller inclination angle -> tongue is only retracted (position adjustment)
Larger inclination angle -> tongue is retracted and elevated (tongue adjustment)

# Linking anatomy, articulation and phonemic contrasts

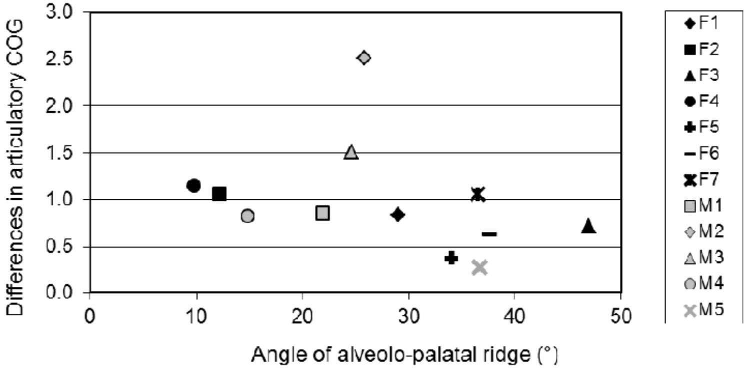
## ➢ Dealing with some of these challenges

Weirich & Fuchs (2013) *JSLHR 56*, 1894-1908




### Experiment 2

- Heterogenous sample
- 12 speakers of German, EPG palate
- Palatal cast and different measures of individual morphology
- Measures of tongue retraction and elevation impossible, but distance in place of articulation between both phonemes possible (difference in COG) in relation to inclination angle




**Similar effects than in Experiment 1**
**-> alveolo-palatal ridge morphology explains differences in phonemic contrast production**
**-> focus on phonemic contrasts (!)**

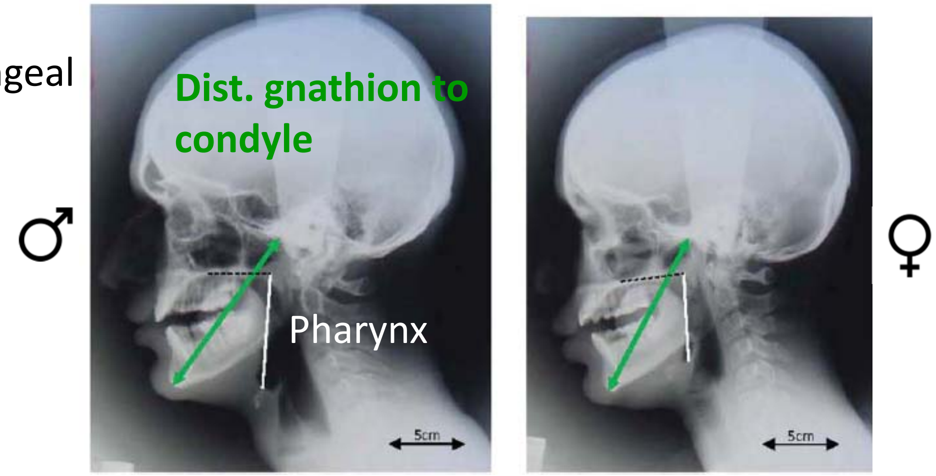
# Using physical models

## ➢ Dealing with some of these challenges

Weirich et al. (2016) *JSLHR 59,* S1587-S1595

Mumbling: Macho or morphology? (i.e. sociophonetic or biological)

- "mumbling" associated with sounding "macho" (Heffernan, 2010)
- mumbling = typical male characteristic in speech, consequence of a small jaw opening
- Our motivation: Jaw opening might also be affected by differences in vocal tract morphology
- Large jaw opening may lead to pharyngeal constriction/closure



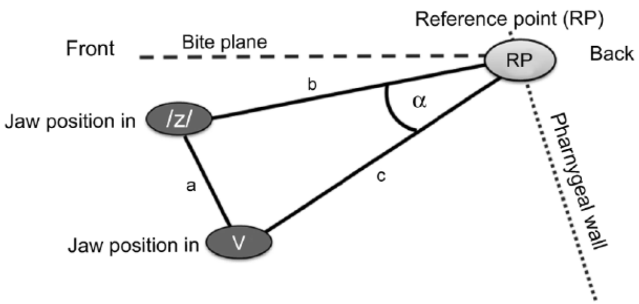
# Using physical models

## ➢ Dealing with some of these challenges

Weirich et al. (2016) *JSLHR 59,* S1587-S1595

1. Study: Wisconsin x-ray microbeam database (American English)
2. Study: EMA experiment with German speakers

**Figure 3.** Schematic visualization of jaw angle α measurement between /z/ and vowel (/oʊ/ in the Wisconsin data, /aː/ in the EMA data). For the English Wisconsin database, the reference point was determined by the intersection of the bite plane and the pharyngeal wall; for the German EMA data, it was determined by an EMA coil glued behind the speaker's left ear.




$$\alpha = \arccos\left(\left(\mathbf{b}^2 + \mathbf{c}^2 - \mathbf{a}^2\right)/\left(2\mathbf{bc}\right)\right)$$

American English (40 speakers):

The coat h**as** a blend of both light and dark fibers.

German (9 speakers):

Ich **sah** GVbi an. (I looked at Gvbi)

Question- answer paradigm with accent on verb or name.

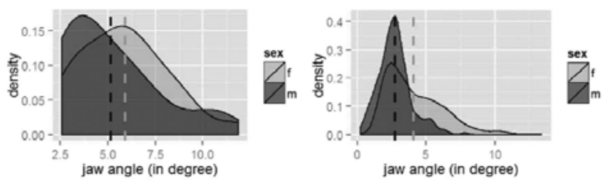
# Using physical models

## ➢ Dealing with some of these challenges

Weirich et al. (2016) *JSLHR 59,* S1587-S1595

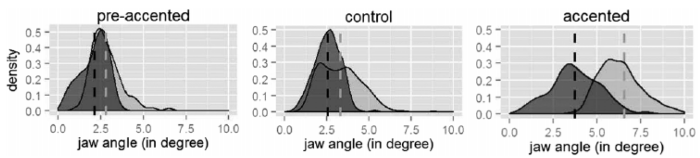
Pooling all data together – no significant effects, only some trends

**Figure 4.** Distribution of jaw angles by sex (male speakers: dark gray, female speakers: light gray) for low vowels. The dashed lines represent the mean angle per sex. The English Wisconsin data, containing one repetition for 40 speakers, are shown in the left plot; the German EMA data, containing 1,853 tokens from nine speakers, are shown in the right plot.




For more controlled dataset (German) significantly larger opening in accented speech only

**Figure 5.** Distribution of jaw angles of the German EMA data (nine speakers) separated by accent condition and sex (male speakers: dark gray, female speakers: light gray). Number of tokens per speaker was 71.7 (*SD* = 18.3) for the preaccented condition, 75.8 (*SD* = 22.6) for the control condition, and 58.4 (*SD* = 22.6) for the accented condition. The dashed lines show the average jaw angle per group.



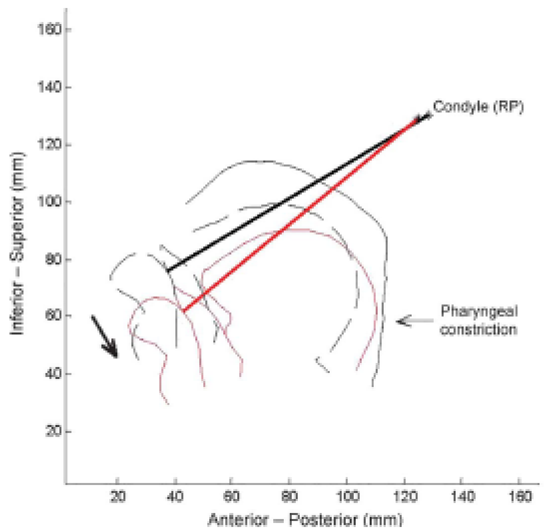
# Using physical models

- Dealing with some of these challenges

Weirich et al. (2016) *JSLHR 59,* S1587-S1595

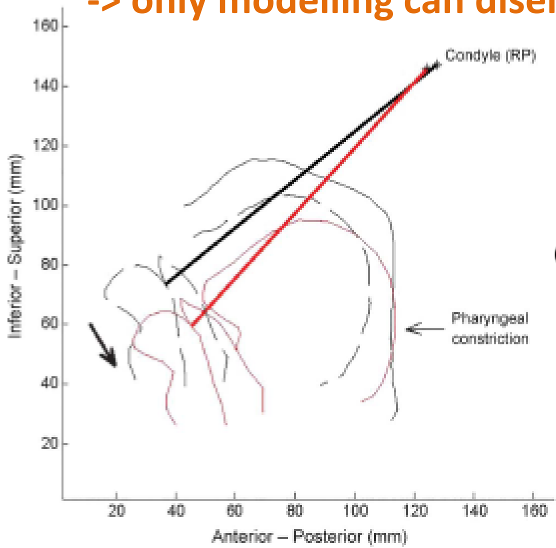
**Figure 8.** Modeling jaw opening 9° from rest position for the female model (upper panel) and the male model (lower panel). The rest position is displayed in black dashed lines, while the tongue, lower lip, and teeth position at 9° are marked in red. Jaw angle α is the angle between the black and the red line.

♀




In real life, trade-offs between tongue and jaw motion -> speakers may compensate for their anatomical properties

**-> only modelling can disentangle the different effects**




♂

**9° jaw opening**
**-> pharyngeal closure in male model, if the tongue does not compensate**

# Conclusions

Georg Meyer:

**“Variability is not the enemy, variability is our friend.”**

1. Concepts of variability and invariance have been integrated in major theoretical concepts of speech communication and continuously changed. We should be aware of our own conceptual thinking in interpreting variability.

2. Variability covers a huge variety of biological, social, speaker-, listener- and dyad-specific mechanisms which can be better understood through a detailed analysis. The challenge arises, how we can disentangle all effects.

# General remarks

## Theoretical plurality

(e.g. Dale & Duran, 2013, Eco. Psy. 25:248–255;
Fuchs & Lancia, 2016, JSLHR, S1555-S1557)

## Multidisciplinarity

- Working in interdisciplinary teams
- Exploit the potential of the internet
- Critical thinking

## Methodology

- Replication of results, publish negative results
- From lab speech to natural setting to gather ecological validity

# General remarks

## Theoretical plurality

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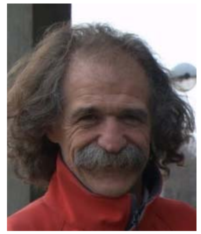



**My colleagues at ZAS**

Marzena Zygis, Stefanie Jannedy, Jörg Dreyer



Thank you for your attention!