Traversing the Phonology-Phonetics Interface

Wouter Jansen
wouter.jansen@kuvik.net

October 15, 2004

Overview

- Part I: general introduction

Overview

- Part I: general introduction
- Part II: Case study: Hungarian RVA

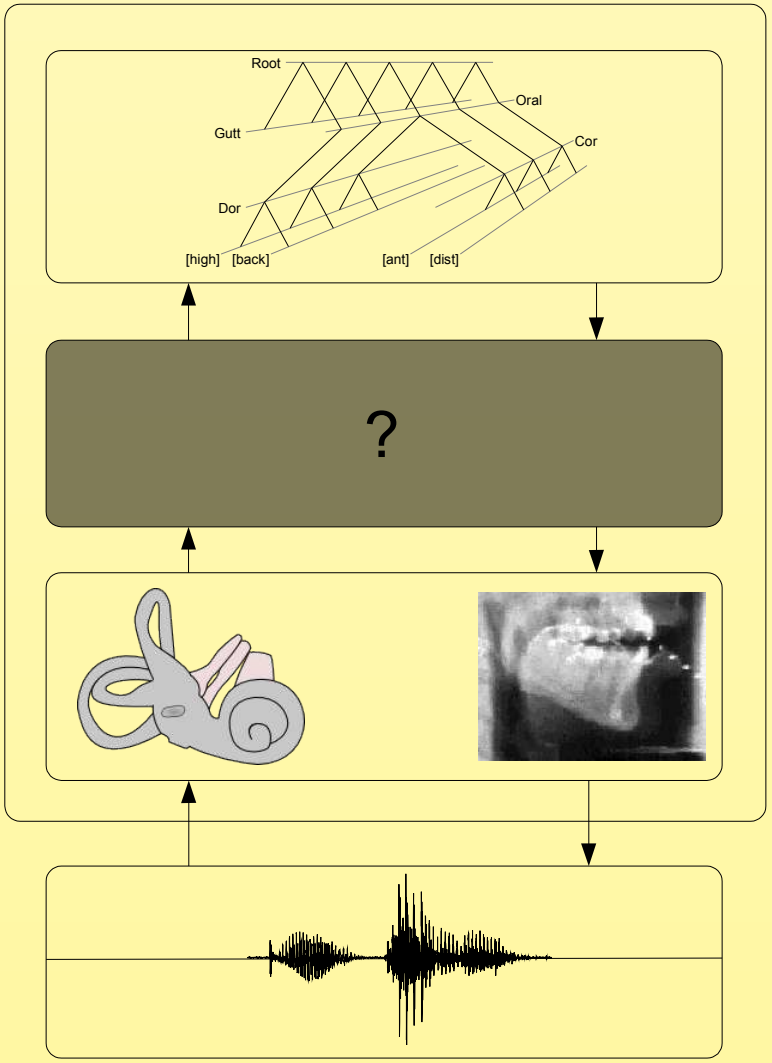
Traversing what?

Phonological representation

Processing

Cochlear/ articulatory mechanics

Speech sounds



Traversing what?

- But I’m a phonologist (morphologist, syntactician, . . .)! Why should I be interested in all that low-level stuff?

Traversing what?

- But I’m a phonologist (morphologist, syntactician, . . .)! Why should I be interested in all that low-level stuff?
- Phonology is/ought to be part of a larger model of human speech production and perception, and interface issues should be taken into account the design of any module

Traversing what?

- But I'm a phonologist (morphologist, syntactician, . . .)! Why should I be interested in all that low-level stuff?
- Phonology is/ought to be part of a larger model of human speech production and perception, and interface issues should be taken into account the design of any module
- Recent advances in instrumental phonetics. . .

Traversing what?

- But I'm a phonologist (morphologist, syntactician, . . .)! Why should I be interested in all that low-level stuff?
- Phonology is/ought to be part of a larger model of human speech production and perception, and interface issues should be taken into account the design of any module
- Recent advances in instrumental phonetics. . .
  - indicate that there is more low-level stuff than has sometimes been assumed

Traversing what?

- But I'm a phonologist (morphologist, syntactician, . . .)! Why should I be interested in all that low-level stuff?
- Phonology is/ought to be part of a larger model of human speech production and perception, and interface issues should be taken into account the design of any module
- Recent advances in instrumental phonetics. . .
  - indicate that there is more low-level stuff than has sometimes been assumed
  - suggest that much of phonology is ultimately grounded in phonetics

Extra-linguistic processing

- Some aspects of the phonology-to-sound mapping are outside the scope of linguistic control:

Extra-linguistic processing

- Some aspects of the phonology-to-sound mapping are outside the scope of linguistic control:
  - Individual pulses of the vocal folds (van den Berg, 1958)

Extra-linguistic processing

- Some aspects of the phonology-to-sound mapping are outside the scope of linguistic control:
  - Individual pulses of the vocal folds (van den Berg, 1958)
  - Cochlear mechanics (Lyons, 1982)

Extra-linguistic processing

- Some aspects of the phonology-to-sound mapping are outside the scope of linguistic control:
  - Individual pulses of the vocal folds (van den Berg, 1958)
  - Cochlear mechanics (Lyons, 1982)
  - Reflex adjustments of coordinated articulators (e.g., Saltzman & Munhall 1989)

Extra-linguistic processing

- The representations/instructions at the interface between the peripheral auditory/articulatory systems and linguistic processing are not discrete at anywhere near the phone level, since

Extra-linguistic processing

- The representations/instructions at the interface between the peripheral auditory/articulatory systems and linguistic processing are not discrete at anywhere near the phone level, since
  - Speakers have fine-grained control over phonetic parameters in online speech production (e.g. pitch, vowel reduction)

Extra-linguistic processing

- The representations/instructions at the interface between the peripheral auditory/articulatory systems and linguistic processing are not discrete at anywhere near the phone level, since
  - Speakers have fine-grained control over phonetic parameters in online speech production (e.g. pitch, vowel reduction)
  - Fine-grained crosslinguistic differences in the realisation of 'identical' phonological categories, e.g. English vs. Danish [i] (Disner, 1983; Bradlow, 1995)

Extra-linguistic processing

- The representations/instructions at the interface between the peripheral auditory/articulatory systems and linguistic processing are not discrete at anywhere near the phone level, since
  - Speakers have fine-grained control over phonetic parameters in online speech production (e.g. pitch, vowel reduction)
  - Fine-grained crosslinguistic differences in the realisation of 'identical' phonological categories, e.g. English vs. Danish [i] (Disner, 1983; Bradlow, 1995)
  - Phonological categories are usually more than 1 JND apart

Extra-linguistic processing

- Therefore linguistic competence includes knowledge of speech sounds that is best represented on continuous scales

Extra-linguistic processing

- Therefore linguistic competence includes knowledge of speech sounds that is best represented on continuous scales

- The need for scalar features is acknowledged in SPE (Chomsky & Halle, 1968); such features are also allowed postlexically in Lexical Phonology (Kaisse & Shaw, 1985; Mohanan, 1986)

Extra-linguistic processing

- Therefore linguistic competence includes knowledge of speech sounds that is best represented on continuous scales
- The need for scalar features is acknowledged in SPE (Chomsky & Halle, 1968); such features are also allowed postlexically in Lexical Phonology (Kaisse & Shaw, 1985; Mohanan, 1986)
- But be aware that an LP postlexical rule is not necessarily a gradient rule

Linguistic phonetics and phonology

- According to a model associated with much (early) work in Laboratory Phonology, the ‘phonetic grammar’ consists of two distinct modules:

Linguistic phonetics and phonology

- According to a model associated with much (early) work in Laboratory Phonology, the 'phonetic grammar' consists of two distinct modules:

1. The phonology, which operates on discretely-valued (typically unary/binary) features[1];

Linguistic phonetics and phonology

- According to a model associated with much (early) work in Laboratory Phonology, the 'phonetic grammar' consists of two distinct modules:

1. The phonology, which operates on discretely-valued (typically unary/binary) features[1];
2. The (linguistic) phonetics, which operates on continuously valued features

Linguistic phonetics and phonology

- According to a model associated with much (early) work in Laboratory Phonology, the 'phonetic grammar' consists of two distinct modules:

1. The phonology, which operates on discretely-valued (typically unary/binary) features[1];
2. The (linguistic) phonetics, which operates on continuously valued features

[1]The term operate is not meant to imply that the algorithms in either of the two models are necessarily procedural; thus the MESM is fully consistent with declarative models such as Optimality Theory

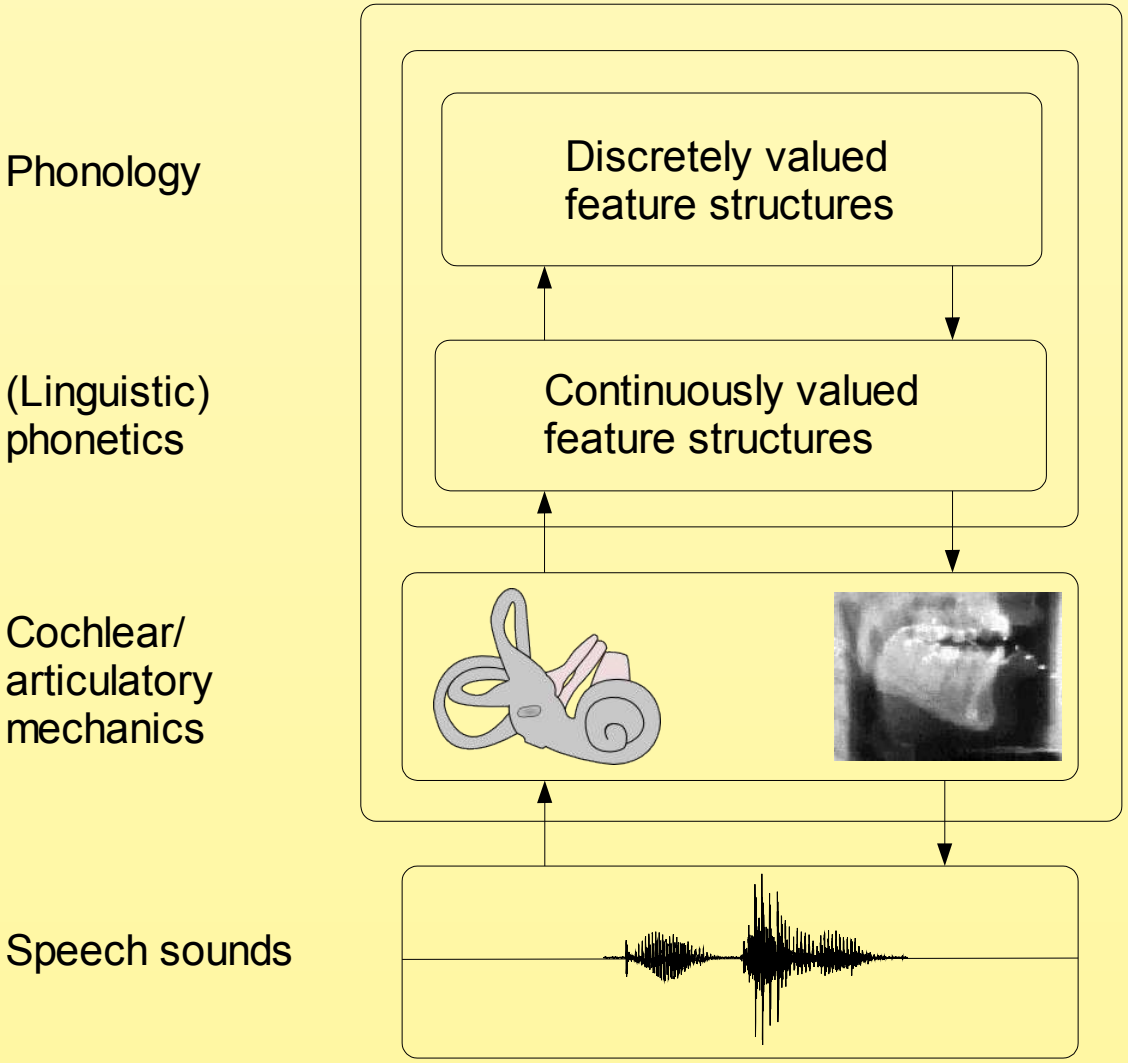
Linguistic phonetics and phonology

- The interface between these two modules is conceived as a mapping that translates phonological features into phonetic ones

Linguistic phonetics and phonology

- Pierrehumbert (1994) labels the core principle behind the model of the phonetic grammar sketched up to here Modified Extended Standard Modularization (MESM) (see also Pierrehumbert et al. 2000)

Linguistic phonetics and phonology



Linguistic phonetics and phonology

- Example 1: a rule mapping /i/ into the appropriate phonetic values for a Dutch [i] (male speaker; values in Bark):

Linguistic phonetics and phonology

- Example 1: a rule mapping /i/ into the appropriate phonetic values for a Dutch [i] (male speaker; values in Bark):
- $$\begin{bmatrix} +\text{high} \\ -\text{low} \\ -\text{back} \\ -\text{round} \end{bmatrix}$$

Linguistic phonetics and phonology

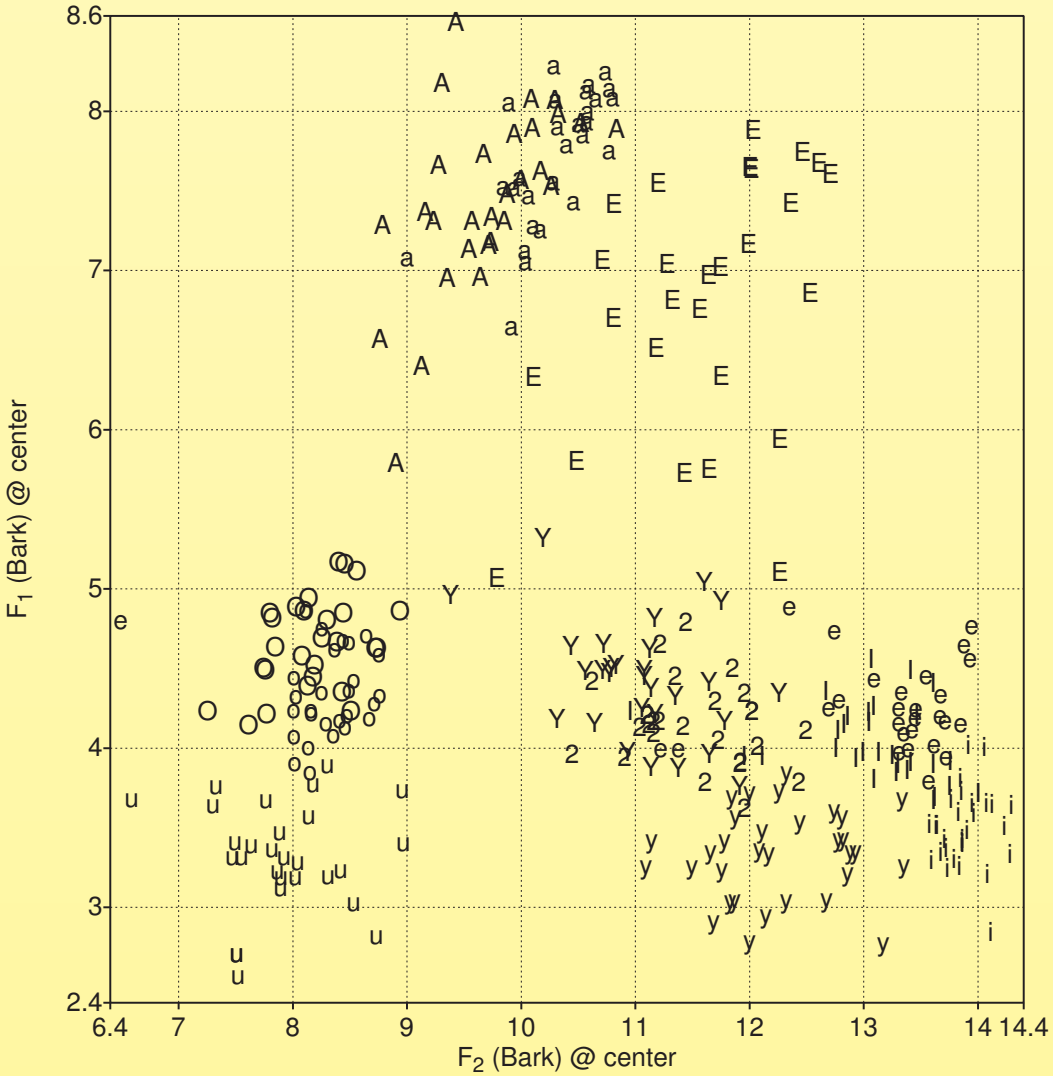
- Example 1: a rule mapping /i/ into the appropriate phonetic values for a Dutch [i] (male speaker; values in Bark):
- $$\begin{bmatrix} +\text{high} \\ \text{-low} \\ \text{-back} \\ \text{-round} \end{bmatrix} \rightarrow$$

Linguistic phonetics and phonology

- Example 1: a rule mapping /i/ into the appropriate phonetic values for a Dutch [i] (male speaker; values in Bark):

- $$\begin{bmatrix} +\text{high} \\ \text{-low} \\ \text{-back} \\ \text{-round} \end{bmatrix} \rightarrow \begin{bmatrix} \text{F}_1\text{: } 3.5 \\ \text{F}_2\text{: } 14 \\ \text{F}_3\text{: } \ldots \\ \ldots \end{bmatrix}$$

Linguistic phonetics and phonology



Linguistic phonetics and phonology

- Example 2: Phonological vowel harmony

Linguistic phonetics and phonology

- Example 2: Phonological vowel harmony
- Phonology:

$$\begin{bmatrix} +\text{high} \\ -\text{low} \\ -\text{back} \\ -\text{round} \end{bmatrix} \cdots \begin{bmatrix} +\text{high} \\ -\text{low} \\ +\text{back} \\ +\text{round} \end{bmatrix}$$

Linguistic phonetics and phonology

- Example 2: Phonological vowel harmony
- Phonology:

$$\begin{bmatrix} +\text{high} \\ -\text{low} \\ -\text{back} \\ -\text{round} \end{bmatrix} \cdots \begin{bmatrix} +\text{high} \\ -\text{low} \\ +\text{back} \\ +\text{round} \end{bmatrix} \rightarrow$$

Linguistic phonetics and phonology

- Example 2: Phonological vowel harmony
- Phonology:

$$\begin{bmatrix} +\text{high} \\ -\text{low} \\ -\text{back} \\ -\text{round} \end{bmatrix} \cdots \begin{bmatrix} +\text{high} \\ -\text{low} \\ +\text{back} \\ +\text{round} \end{bmatrix} \rightarrow \begin{bmatrix} +\text{high} \\ -\text{low} \\ -\text{back} \\ +\text{round} \end{bmatrix} \cdots \begin{bmatrix} +\text{high} \\ -\text{low} \\ +\text{back} \\ +\text{round} \end{bmatrix}$$

Linguistic phonetics and phonology

- Example 2: Phonological vowel harmony
- Phonology:

$$\begin{bmatrix} +\text{high} \\ -\text{low} \\ -\text{back} \\ -\text{round} \end{bmatrix} \cdots \begin{bmatrix} +\text{high} \\ -\text{low} \\ +\text{back} \\ +\text{round} \end{bmatrix} \rightarrow \begin{bmatrix} +\text{high} \\ -\text{low} \\ -\text{back} \\ +\text{round} \end{bmatrix} \cdots \begin{bmatrix} +\text{high} \\ -\text{low} \\ +\text{back} \\ +\text{round} \end{bmatrix}$$

- Phonology-phonetics interface:

$$\begin{bmatrix} +\text{high} \\ -\text{low} \\ -\text{back} \\ +\text{round} \end{bmatrix} \cdots \begin{bmatrix} +\text{high} \\ -\text{low} \\ +\text{back} \\ +\text{round} \end{bmatrix}$$

Linguistic phonetics and phonology

- Example 2: Phonological vowel harmony
- Phonology:

$$\begin{bmatrix} +\text{high} \\ -\text{low} \\ -\text{back} \\ -\text{round} \end{bmatrix} \cdots \begin{bmatrix} +\text{high} \\ -\text{low} \\ +\text{back} \\ +\text{round} \end{bmatrix} \rightarrow \begin{bmatrix} +\text{high} \\ -\text{low} \\ -\text{back} \\ +\text{round} \end{bmatrix} \cdots \begin{bmatrix} +\text{high} \\ -\text{low} \\ +\text{back} \\ +\text{round} \end{bmatrix}$$

- Phonology-phonetics interface:

$$\begin{bmatrix} +\text{high} \\ -\text{low} \\ -\text{back} \\ +\text{round} \end{bmatrix} \cdots \begin{bmatrix} +\text{high} \\ -\text{low} \\ +\text{back} \\ +\text{round} \end{bmatrix} \rightarrow$$

Linguistic phonetics and phonology

- Example 2: Phonological vowel harmony
- Phonology:

$$\begin{bmatrix} +\text{high} \\ -\text{low} \\ -\text{back} \\ -\text{round} \end{bmatrix} \cdots \begin{bmatrix} +\text{high} \\ -\text{low} \\ +\text{back} \\ +\text{round} \end{bmatrix} \rightarrow \begin{bmatrix} +\text{high} \\ -\text{low} \\ -\text{back} \\ +\text{round} \end{bmatrix} \cdots \begin{bmatrix} +\text{high} \\ -\text{low} \\ +\text{back} \\ +\text{round} \end{bmatrix}$$

- Phonology-phonetics interface:

$$\begin{bmatrix} +\text{high} \\ -\text{low} \\ -\text{back} \\ +\text{round} \end{bmatrix} \cdots \begin{bmatrix} +\text{high} \\ -\text{low} \\ +\text{back} \\ +\text{round} \end{bmatrix} \rightarrow \begin{bmatrix} \text{F}_1\text{: } 3.5 \\ \text{F}_2\text{: } 12.5 \\ \text{F}_3\text{: } \ldots \\ \ldots \end{bmatrix} \cdots \begin{bmatrix} \text{F}_1\text{: } 3.5 \\ \text{F}_2\text{: } 8 \\ \text{F}_3\text{: } \ldots \\ \ldots \end{bmatrix}$$

Linguistic phonetics and phonology

- Example 2: Vowel-to-vowel coarticulation

Linguistic phonetics and phonology

- Example 2: Vowel-to-vowel coarticulation
- Subtle variations in the place of articulation of /ə/ in /bV$_1$b_bV$_2$/ frames

Linguistic phonetics and phonology

- Example 2: Vowel-to-vowel coarticulation
- Subtle variations in the place of articulation of /ə/ in /bV$_1$b_bV$_2$/ frames
- where V = /i/, /a/, /u/

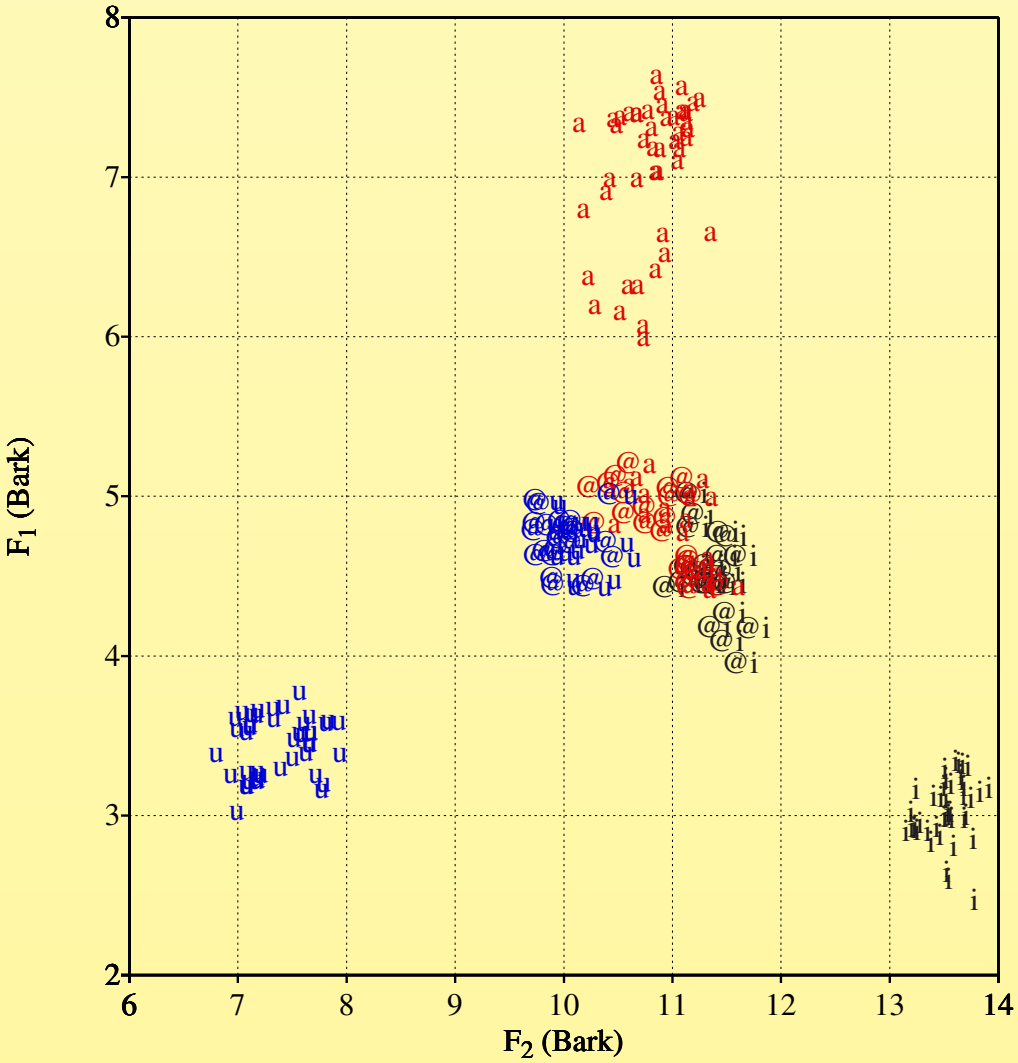
Linguistic phonetics and phonology

- Example 2: Vowel-to-vowel coarticulation
- Subtle variations in the place of articulation of /ə/ in /bV$_1$b_bV$_2$/ frames
- where V = /i/, /a/, /u/
- Measured center F$_1$, F$_2$ of V$_1$, V$_2$ and target /ə/

Linguistic phonetics and phonology

- Example 2: Vowel-to-vowel coarticulation
- Subtle variations in the place of articulation of /ə/ in /bV$_1$b_bV$_2$/ frames
- where V = /i/, /a/, /u/
- Measured center F$_1$, F$_2$ of V$_1$, V$_2$ and target /ə/
- Example utterance

Linguistic phonetics and phonology



Linguistic phonetics and phonology

- Phonology (no change):

$$\begin{bmatrix} \text{-high} \\ \text{-low} \\ \text{+back} \\ \text{-round} \end{bmatrix} \cdots \begin{bmatrix} \text{+high} \\ \text{-low} \\ \text{-back} \\ \text{-round} \end{bmatrix}$$

Linguistic phonetics and phonology

- Phonology (no change):

$$\begin{bmatrix} \text{-high} \\ \text{-low} \\ \text{+back} \\ \text{-round} \end{bmatrix} \cdots \begin{bmatrix} \text{+high} \\ \text{-low} \\ \text{-back} \\ \text{-round} \end{bmatrix} \rightarrow$$

Linguistic phonetics and phonology

- Phonology (no change):

$$\begin{bmatrix} \text{-high} \\ \text{-low} \\ \text{+back} \\ \text{-round} \end{bmatrix} \cdots \begin{bmatrix} \text{+high} \\ \text{-low} \\ \text{-back} \\ \text{-round} \end{bmatrix} \rightarrow \begin{bmatrix} \text{-high} \\ \text{-low} \\ \text{+back} \\ \text{-round} \end{bmatrix} \cdots \begin{bmatrix} \text{+high} \\ \text{-low} \\ \text{-back} \\ \text{-round} \end{bmatrix}$$

Linguistic phonetics and phonology

- Phonology (no change):

$$\begin{bmatrix} \text{-high} \\ \text{-low} \\ \text{+back} \\ \text{-round} \end{bmatrix} \cdots \begin{bmatrix} \text{+high} \\ \text{-low} \\ \text{-back} \\ \text{-round} \end{bmatrix} \rightarrow \begin{bmatrix} \text{-high} \\ \text{-low} \\ \text{+back} \\ \text{-round} \end{bmatrix} \cdots \begin{bmatrix} \text{+high} \\ \text{-low} \\ \text{-back} \\ \text{-round} \end{bmatrix}$$

- Phonology-phonetics interface:

$$\begin{bmatrix} \text{-high} \\ \text{-low} \\ \text{+back} \\ \text{-round} \end{bmatrix} \cdots \begin{bmatrix} \text{+high} \\ \text{-low} \\ \text{-back} \\ \text{-round} \end{bmatrix}$$

Linguistic phonetics and phonology

- Phonology (no change):

$$\begin{bmatrix} \text{-high} \\ \text{-low} \\ \text{+back} \\ \text{-round} \end{bmatrix} \cdots \begin{bmatrix} \text{+high} \\ \text{-low} \\ \text{-back} \\ \text{-round} \end{bmatrix} \rightarrow \begin{bmatrix} \text{-high} \\ \text{-low} \\ \text{+back} \\ \text{-round} \end{bmatrix} \cdots \begin{bmatrix} \text{+high} \\ \text{-low} \\ \text{-back} \\ \text{-round} \end{bmatrix}$$

- Phonology-phonetics interface:

$$\begin{bmatrix} \text{-high} \\ \text{-low} \\ \text{+back} \\ \text{-round} \end{bmatrix} \cdots \begin{bmatrix} \text{+high} \\ \text{-low} \\ \text{-back} \\ \text{-round} \end{bmatrix} \rightarrow$$

Linguistic phonetics and phonology

- Phonology (no change):

$$\begin{bmatrix} \text{-high} \\ \text{-low} \\ \text{+back} \\ \text{-round} \end{bmatrix} \cdots \begin{bmatrix} \text{+high} \\ \text{-low} \\ \text{-back} \\ \text{-round} \end{bmatrix} \rightarrow \begin{bmatrix} \text{-high} \\ \text{-low} \\ \text{+back} \\ \text{-round} \end{bmatrix} \cdots \begin{bmatrix} \text{+high} \\ \text{-low} \\ \text{-back} \\ \text{-round} \end{bmatrix}$$

- Phonology-phonetics interface:

$$\begin{bmatrix} \text{-high} \\ \text{-low} \\ \text{+back} \\ \text{-round} \end{bmatrix} \cdots \begin{bmatrix} \text{+high} \\ \text{-low} \\ \text{-back} \\ \text{-round} \end{bmatrix} \rightarrow \begin{bmatrix} \text{F}_1\text{: } 4.5 \\ \text{F}_2\text{: } 10.5 \\ \text{F}_3\text{: } \ldots \\ \ldots \end{bmatrix} \cdots \begin{bmatrix} \text{F}_1\text{: } 3.5 \\ \text{F}_2\text{: } 14 \\ \text{F}_3\text{: } \ldots \\ \ldots \end{bmatrix}$$

Linguistic phonetics and phonology

- Linguistic phonetics (coarticulation):

$$\begin{bmatrix} \mathrm{F}_1\colon\ 4.5 \\ \mathrm{F}_2\colon\ 10.5 \\ \mathrm{F}_3\colon\ \ldots \\ \ldots \end{bmatrix} \ldots \begin{bmatrix} \mathrm{F}_1\colon\ 3.5 \\ \mathrm{F}_2\colon\ 14 \\ \mathrm{F}_3\colon\ \ldots \\ \ldots \end{bmatrix}$$

Linguistic phonetics and phonology

- Linguistic phonetics (coarticulation):

$$\begin{bmatrix} \mathrm{F}_1\colon\ 4.5 \\ \mathrm{F}_2\colon\ 10.5 \\ \mathrm{F}_3\colon\ \ldots \\ \ldots \end{bmatrix} \ldots \begin{bmatrix} \mathrm{F}_1\colon\ 3.5 \\ \mathrm{F}_2\colon\ 14 \\ \mathrm{F}_3\colon\ \ldots \\ \ldots \end{bmatrix} \rightarrow$$

Linguistic phonetics and phonology

- Linguistic phonetics (coarticulation):

$$\begin{bmatrix} \mathrm{F}_1\colon\ 4.5 \\ \mathrm{F}_2\colon\ 10.5 \\ \mathrm{F}_3\colon\ \ldots \\ \ldots \end{bmatrix} \ldots \begin{bmatrix} \mathrm{F}_1\colon\ 3.5 \\ \mathrm{F}_2\colon\ 14 \\ \mathrm{F}_3\colon\ \ldots \\ \ldots \end{bmatrix} \rightarrow \begin{bmatrix} \mathrm{F}_1\colon\ 4.2 \\ \mathrm{F}_2\colon\ 11.5 \\ \mathrm{F}_3\colon\ \ldots \\ \ldots \end{bmatrix} \ldots \begin{bmatrix} \mathrm{F}_1\colon\ 3.5 \\ \mathrm{F}_2\colon\ 14 \\ \mathrm{F}_3\colon\ \ldots \\ \ldots \end{bmatrix}$$

Linguistic phonetics and phonology

- Linguistic phonetics (coarticulation):

$$\begin{bmatrix} \mathrm{F}_1\colon\ 4.5 \\ \mathrm{F}_2\colon\ 10.5 \\ \mathrm{F}_3\colon\ \ldots \\ \ldots \end{bmatrix} \ldots \begin{bmatrix} \mathrm{F}_1\colon\ 3.5 \\ \mathrm{F}_2\colon\ 14 \\ \mathrm{F}_3\colon\ \ldots \\ \ldots \end{bmatrix} \rightarrow \begin{bmatrix} \mathrm{F}_1\colon\ 4.2 \\ \mathrm{F}_2\colon\ 11.5 \\ \mathrm{F}_3\colon\ \ldots \\ \ldots \end{bmatrix} \ldots \begin{bmatrix} \mathrm{F}_1\colon\ 3.5 \\ \mathrm{F}_2\colon\ 14 \\ \mathrm{F}_3\colon\ \ldots \\ \ldots \end{bmatrix}$$

- For a real-life example of the distinction between VH and V-V coarticulation, see Zsiga (1997)

Linguistic phonetics and phonology

- The phonology processes

Linguistic phonetics and phonology

- The phonology processes
  - representations containing lexically contrastive information (includes intonational tunes)

Linguistic phonetics and phonology

- The phonology processes
  - representations containing lexically contrastive information (includes intonational tunes)
- The linguistic phonetics is responsible for:

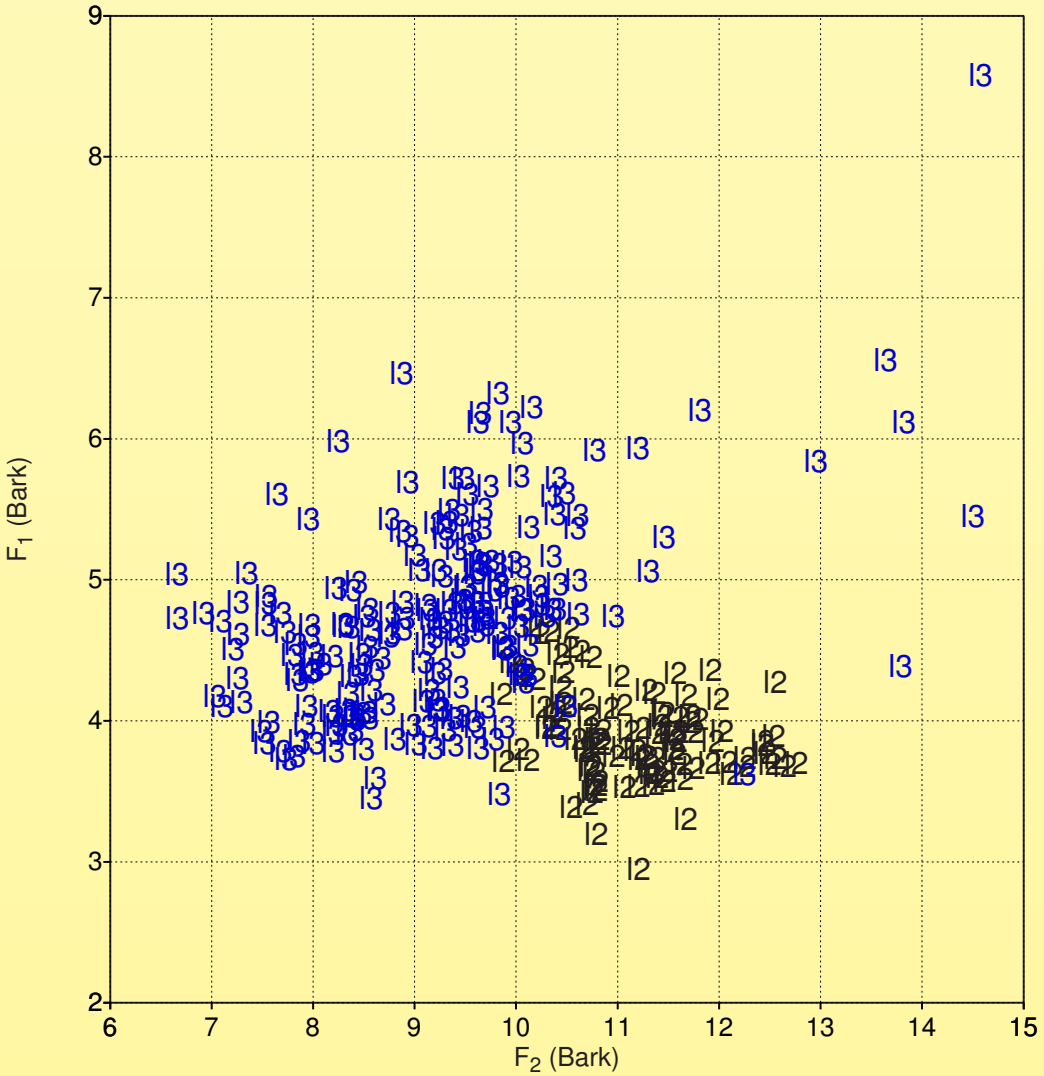
Linguistic phonetics and phonology

- The phonology processes
  - representations containing lexically contrastive information (includes intonational tunes)
- The linguistic phonetics is responsible for:
  - gradient processes (which vary with e.g., style, rate, physical pauses)

Linguistic phonetics and phonology

- The phonology processes
  - representations containing lexically contrastive information (includes intonational tunes)
- The linguistic phonetics is responsible for:
  - gradient processes (which vary with e.g., style, rate, physical pauses)
- But how about subphonemic but phonetically categorical (and clearly perceptible) phenomena, such as English [l]∼[ɬ]?

Linguistic phonetics and phonology



An alternative to MESM

- Lexical items/underlying forms consist of scalar phonetic features

An alternative to MESM

- Lexical items/underlying forms consist of scalar phonetic features
- and contain both lexically contrastive and redundant information

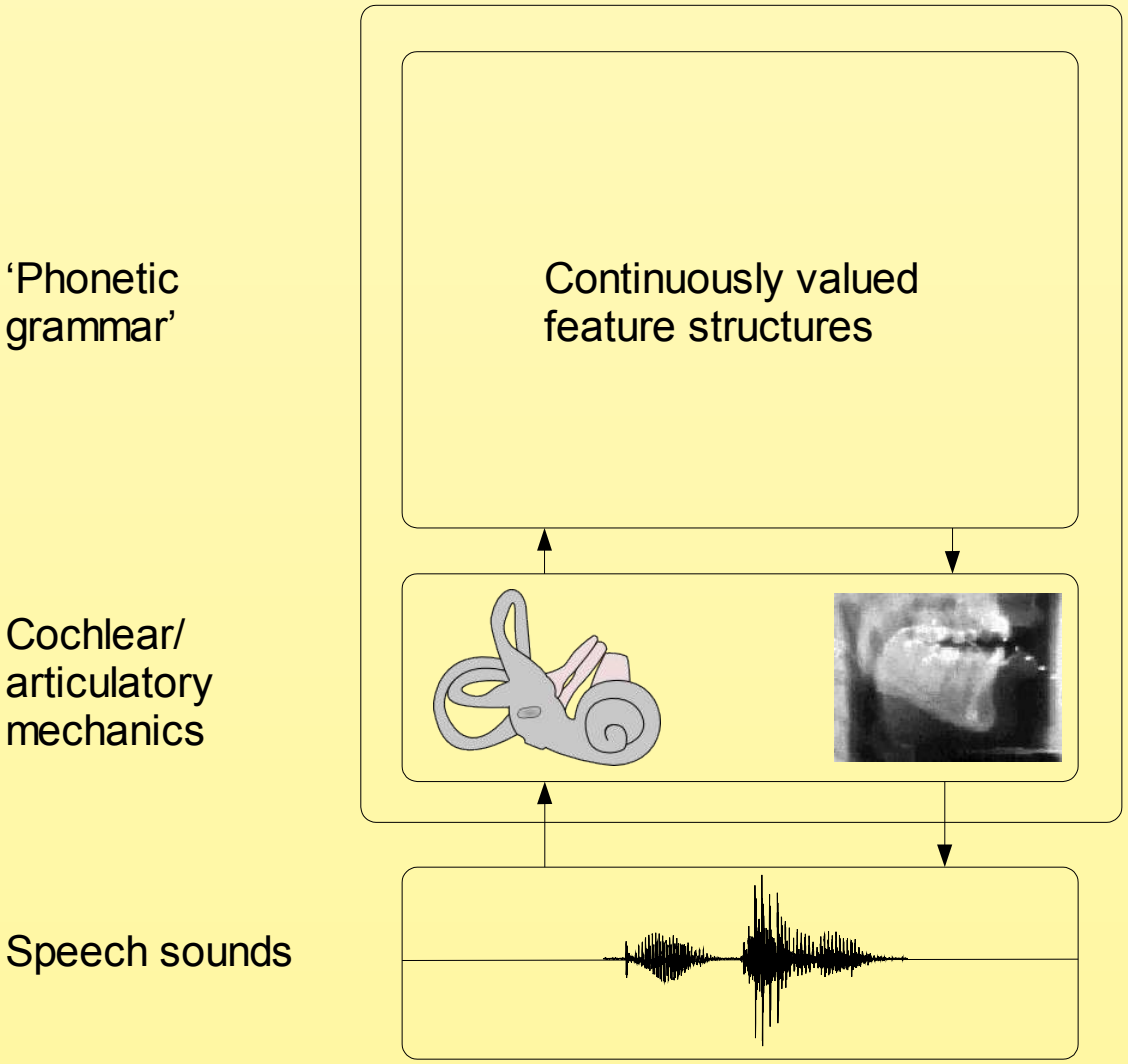
An alternative to MESM

- Lexical items/underlying forms consist of scalar phonetic features
- and contain both lexically contrastive and redundant information
- categorical (neutralising) processes are stated over scalar features, just as ‘low-level’ phonetic rules

An alternative to MESM

- Lexical items/underlying forms consist of scalar phonetic features
- and contain both lexically contrastive and redundant information
- categorical (neutralising) processes are stated over scalar features, just as ‘low-level’ phonetic rules
- Example: Articulatory Phonology (Browman & Goldstein 1986 et seq.)

An alternative to MESM



An alternative to MESM

- Example 1: neutralising vowel harmony: /i/ → [y]/_/u/
- $\begin{bmatrix} \mathrm{F}_1\text{: } 3.5 \\ \mathrm{F}_2\text{: } 14 \\ \mathrm{F}_3\text{: } \ldots \\ \ldots \end{bmatrix} \ldots \begin{bmatrix} \mathrm{F}_1\text{: } 3.5 \\ \mathrm{F}_2\text{: } 8 \\ \mathrm{F}_3\text{: } \ldots \\ \ldots \end{bmatrix}$

An alternative to MESM

- Example 1: neutralising vowel harmony: /i/ → [y]/_/u/
- $\begin{bmatrix} \mathrm{F}_1\text{: } 3.5 \\ \mathrm{F}_2\text{: } 14 \\ \mathrm{F}_3\text{: } \ldots \\ \ldots \end{bmatrix} \ldots \begin{bmatrix} \mathrm{F}_1\text{: } 3.5 \\ \mathrm{F}_2\text{: } 8 \\ \mathrm{F}_3\text{: } \ldots \\ \ldots \end{bmatrix} \rightarrow$

An alternative to MESM

- Example 1: neutralising vowel harmony: /i/ → [y]/_/u/
- $$\begin{bmatrix} F_1\text{: } 3.5 \\ F_2\text{: } 14 \\ F_3\text{: } \dots \\ \dots \end{bmatrix} \dots \begin{bmatrix} F_1\text{: } 3.5 \\ F_2\text{: } 8 \\ F_3\text{: } \dots \\ \dots \end{bmatrix} \rightarrow \begin{bmatrix} F_1\text{: } 3.5 \\ F_2\text{: } 12.5 \\ F_3\text{: } \dots \\ \dots \end{bmatrix} \dots \begin{bmatrix} F_1\text{: } 3.5 \\ F_2\text{: } 8 \\ F_3\text{: } \dots \\ \dots \end{bmatrix}$$

An alternative to MESM

- Example 2: Vowel-to-vowel coarticulation
  - N.B.: a proper formulation of the mechanism is much more general

An alternative to MESM

- Example 2: Vowel-to-vowel coarticulation
  - N.B.: a proper formulation of the mechanism is much more general
- $$\begin{bmatrix} F_1\text{: } 4.5 \\ F_2\text{: } 10.5 \\ F_3\text{: } \dots \\ \dots \end{bmatrix} \dots \begin{bmatrix} F_1\text{: } 3.5 \\ F_2\text{: } 14 \\ F_3\text{: } \dots \\ \dots \end{bmatrix}$$

An alternative to MESM

- Example 2: Vowel-to-vowel coarticulation
  - N.B.: a proper formulation of the mechanism is much more general
- $\begin{bmatrix} F_1\text{: } 4.5 \\ F_2\text{: } 10.5 \\ F_3\text{: } \ldots \\ \ldots \end{bmatrix} \ldots \begin{bmatrix} F_1\text{: } 3.5 \\ F_2\text{: } 14 \\ F_3\text{: } \ldots \\ \ldots \end{bmatrix} \rightarrow$

An alternative to MESM

- Example 2: Vowel-to-vowel coarticulation
  - N.B.: a proper formulation of the mechanism is much more general
- $$\begin{bmatrix} F_1\colon\ 4.5 \\ F_2\colon\ 10.5 \\ F_3\colon\ \ldots \\ \ldots \end{bmatrix} \ldots \begin{bmatrix} F_1\colon\ 3.5 \\ F_2\colon\ 14 \\ F_3\colon\ \ldots \\ \ldots \end{bmatrix} \rightarrow \begin{bmatrix} F_1\colon\ 4.2 \\ F_2\colon\ 11.5 \\ F_3\colon\ \ldots \\ \ldots \end{bmatrix} \ldots \begin{bmatrix} F_1\colon\ 3.5 \\ F_2\colon\ 14 \\ F_3\colon\ \ldots \\ \ldots \end{bmatrix}$$

An alternative to MESM

- Example 2: Vowel-to-vowel coarticulation
  - N.B.: a proper formulation of the mechanism is much more general
- $$\begin{bmatrix} \mathrm{F}_1\colon\ 4.5 \\ \mathrm{F}_2\colon\ 10.5 \\ \mathrm{F}_3\colon\ \ldots \\ \ldots \end{bmatrix} \ldots \begin{bmatrix} \mathrm{F}_1\colon\ 3.5 \\ \mathrm{F}_2\colon\ 14 \\ \mathrm{F}_3\colon\ \ldots \\ \ldots \end{bmatrix} \rightarrow \begin{bmatrix} \mathrm{F}_1\colon\ 4.2 \\ \mathrm{F}_2\colon\ 11.5 \\ \mathrm{F}_3\colon\ \ldots \\ \ldots \end{bmatrix} \ldots \begin{bmatrix} \mathrm{F}_1\colon\ 3.5 \\ \mathrm{F}_2\colon\ 14 \\ \mathrm{F}_3\colon\ \ldots \\ \ldots \end{bmatrix}$$

An alternative to MESM

- Advantages of the alternative model:

An alternative to MESM

- Advantages of the alternative model:
  - No more duplication of (contrastive) information

An alternative to MESM

- Advantages of the alternative model:
  - No more duplication of (contrastive) information
  - Problems surrounding delimitation of phonology and phonetics dissolve

An alternative to MESM

- Advantages of the alternative model:
  - No more duplication of (contrastive) information
  - Problems surrounding delimitation of phonology and phonetics dissolve
  - Accounts for data indicating that lexical representation contains detailed phonetic information (Frisch, 1996; Bybee, 2000)

An alternative to MESM

- However, to avoid overgeneration, the alternative model needs to invoke functional constraints on phonological processes:

An alternative to MESM

- However, to avoid overgeneration, the alternative model needs to invoke functional constraints on phonological processes:
  - Perceptibility/contrast maintenance

An alternative to MESM

- However, to avoid overgeneration, the alternative model needs to invoke functional constraints on phonological processes:
  - Perceptibility/contrast maintenance
  - Effort minimisation

Incomplete Neutralisation

- The phenomenon of incomplete neutralisation calls for a further revision of the nature of the interface between phonology and phonetics

Incomplete Neutralisation

- The phenomenon of incomplete neutralisation calls for a further revision of the nature of the interface between phonology and phonetics
- Incomplete neutralisation effects have been observed for a number of phenomena that were previously thought to be neutralising phonological rules

Incomplete Neutralisation

- The phenomenon of incomplete neutralisation calls for a further revision of the nature of the interface between phonology and phonetics
- Incomplete neutralisation effects have been observed for a number of phenomena that were previously thought to be neutralising phonological rules
- final devoicing is a particularly well-investigated topic in this area, e.g., (Baumann, 1995; Charles-Luce, 1985, 1993; Port, 1996; Port & Crawford, 1989; Fourakis & Iverson, 1984)

Incomplete Neutralisation

- Some studies of this phenomenon show clear intraparadigmatic effects in the production and perception of neutralisation targets (e.g., Ernestus & Baayen 2003)

Incomplete Neutralisation

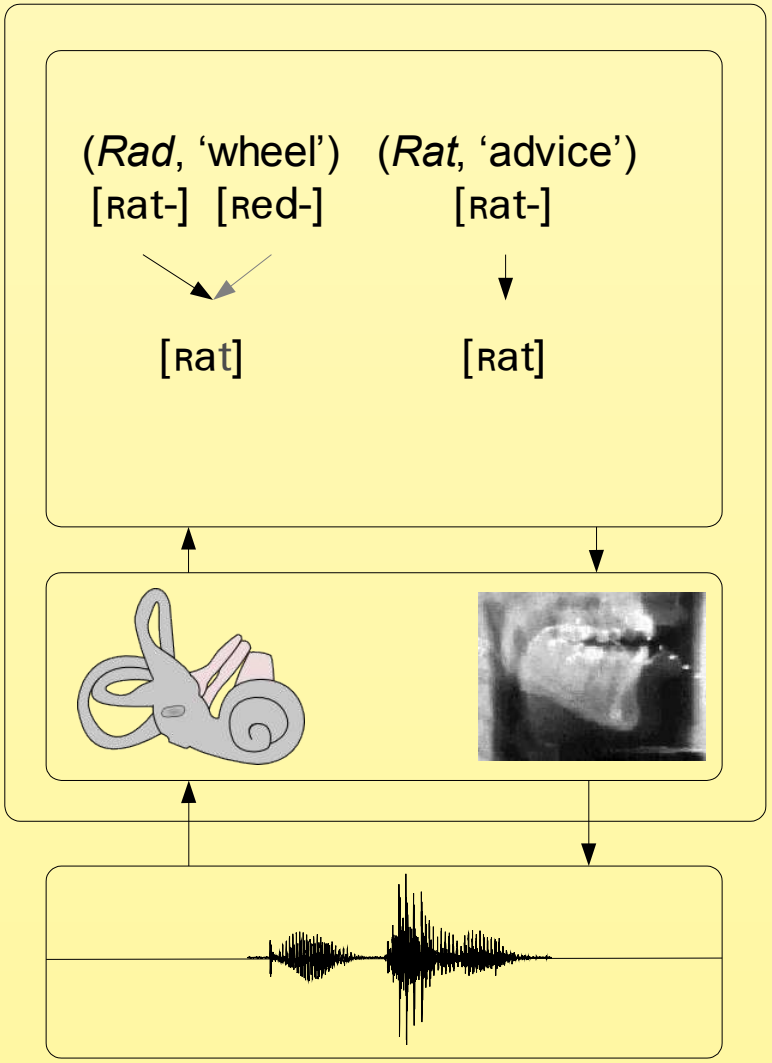
- Some studies of this phenomenon show clear intraparadigmatic effects in the production and perception of neutralisation targets (e.g., Ernestus & Baayen 2003)
- This suggests that multiple forms of the same root are stored in the lexicon and interfere in the production of words containing them

Incomplete Neutralisation

‘Phonetic grammar’

Cochlear/ articulatory mechanics

Speech sounds



References

Baumann, M. (1995) *The production of syllables in connected speech.* PhD dissertation, University of Nijmegen.

Bradlow, A. (1995) A comparative study of English and Spanish vowels. *Journal of the Acoustical Society of America* 97: 1916-1924.F

Towards an articulatory phonology. *Phonology Yearbook* 3: 219-252.

Bybee, J. (2000) The phonology of the lexicon: evidence from lexical diffusion. In M. Barlow & S. Kemmer (eds.)

Proceedings of the Rice Symposium on Usage-Based Models of Language. Stanford, CA: CSLI.

Charles-Luce, J. (1985) Word final devoicing in German: effects of phonetic and sentential contexts. *Journal of Phonetics* 13: 309-324.

Charles-Luce, J. (1993) The effects of semantic context on voicing neutralisation. *Phonetica* 50: 28-43.

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

Disner, S. (1983) Vowel quality: The relation between universal and language-specificfactors. *UCLA Working Papers in Phonetics* 58.

Ernestus, M. & H. Baayen (2003) Intraparadigmatic effects on the perception of voice. Ms., Max Planck Institute for Psycholinguistics, Nijmegen.

Fourakis, M. & G. Iverson (1984) On the 'incomplete neutralization' of German final obstruents *Phonetica* 41: 140-149.

Frisch, S. (1996) *Similarity and Frequency in phonology.* PhD Dissertation, Northwestern University.

Kaisse, E. & P. Shaw (1985) On the theory of lexical phonology. *Phonology Yearbook* 2: 1-30.

Lyons, R. (1982) A computational model of filtering, detectio, and compression in the cochlea. *Proceedings of*

the IEEE International Conference on Acoustics, Speech and Signal Processing.

Mohanan, K. (1986) *The Theory of Lexical Phonology.* Dordrecht: Reidel.

Pierrehumbert, J. (1994) Knowledge of variation. In K. Beals, J. Denton, R. Knippen, L. mielmar, H. Suzuki & E. Zeinfeld (eds.) *Papers from the 30th Meeting of the Chicago Linguistics Society* Vol 2, *Papers from the Parasession in Variation* Chicago: Chicago Linguistics Society.

Pierrehumbert, J., M. Beckman & D. Ladd (2000) Conceptual foundations of phonology as a laboratory

science. In N. Burton-Roberts, P. Carr & G. Docherty (eds.) *Phonological Knowledge. Conceptual and Empirical Issues.* Oxford: OUP, 273-304.

Port, R. (1996) The discreteness of phonetic elements: response to A. Manaster-Ramer. *Journal of Phonetics* 24: 491-511.

Port, R. & Crawford, P. (1989) Pragmatic effects on neutralization rules. *Journal of Phonetics* 16: 257-282.

Port, R. & M. O'Dell (1985) Neutralization of syllable-final voicing in German. *Journal of Phonetics* 13:455-471.

Port, R. F. Mitleb, M. O'Dell (1981) Neutralization of

obstruent voicing in German is incomplete. *Journal of the Acoustical Society of America* 70(suppl.1):13-[...].

Saltzman, E. & K. Munhall (1989) A dynamical approach to gestural patterning in speech production. *Ecological Psychology* 1: 333-382.

van den Berg, J. (1958) Myoelastic-aerodynamic theory of voice production. *Journal of Speech and Hearing Research* 1: 227-244.

Zsiga, E. (1997) Features, gestures, and Igbo vowels: an approach to the phonetics-phonology interface. *Language* 73: 227-274.