Voicing Variability and Formal Phonology

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Variation, Gradiance and Frequency in Phonology

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Voicing Variability and Formal Phonology

- Final devoicing seems to pose two major problems for a categorical theory of phonology:
  - The output is gradient
  - The input is predictable on the basis of corpus distribution
- From this, people have drawn the conclusion that either the data are wrong or non-phonological, or that formal phonology is wrong
- We offer instead a refined, but classical phonological account of these experimental data
Voicing Variability and Formal Phonology

Incomplete final devoicing
The issue
Faithfulness
Turbidity Theory

Determining underlying voicing
The issue
Voicing in Dutch
Conclusions
Final Devoicing

- **Catalan:**
  - *gris* ‘grey (M)’ - *grizə* ‘grey (F)’
  - *gos* ‘dog (M)’ - *gosə* ‘dog (F)’

- **Dutch:**
  - *kwaa[t]* ‘angry (PRED.)’ - *kwadə* ‘angry (ATT)’
  - *laat* ‘late (PRED.)’ - *latə* ‘late (ATT)’

- **Polish:**
  - *klup* ‘club’ - *klubi* ‘clubs’
  - *trup* ‘corpse’ - *trupi* ‘corpses’
The issue

**Phonetic Timing**

![Graph showing the phonetic timing of different words](image)

- **bat**
- **Bad**
- **Alp**
- **Alb**

<table>
<thead>
<tr>
<th></th>
<th>Vowel (plus Glide)</th>
<th>Closure Voicing</th>
<th>Closure</th>
<th>Burst</th>
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<td><strong>bat</strong></td>
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Duration in msec

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The issue

Listening task

- if asked to randomly guess whether a given instance [bunt] corresponds to (German) /bund/ ‘league’ or /bunt/ ‘colourful’, speakers will guess correctly (60 to 70 per cent)

- “If [these words] were the same, then in a listening task you would expect 50 percent correct (pure guessing — like English too and two would show). If contrastive, one would expect at least 99 percent correct identification under good listening conditions with motivated subjects (just like Bunde and bunte would show).” (Port & Leary 2005)
The issue

Possible responses

1. *The data are wrong*, for instance because they have been acquired under suspicious laboratory conditions;
The issue

Possible responses

1. *The data are wrong*, for instance because they have been acquired under suspicious laboratory conditions; but they have now been replicated for many languages, and we need to account for laboratory behaviour as well
The issue

**Possible responses**

1. *The data are wrong*, for instance because they have been acquired under suspicious laboratory conditions; but they have now been replicated for many languages, and we need to account for laboratory behaviour as well.

2. *Phonology is wrong*;
The issue

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1. *The data are wrong*, for instance because they have been acquired under suspicious laboratory conditions; but they have now been replicated for many languages, and we need to account for laboratory behaviour as well.

2. *Phonology is wrong*; but this throws away decades of solid results.
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3. *This is all phonetics*;
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3. *This is all phonetics*; but that means direct access of phonetics to the lexicon

4. *We have to integrate these facts into a classical model*
The issue

Final devoicing is phonological

- *ik heb* ‘I have’ [ɪk hɛp]
- *hebben* ‘to have’ [hɛ.bən]
- *ik heb ’m* ‘I have him’ [ɪk hɛ.pəm]

(Booij 1995)
The issue

Formal analyses

- There is a phonetic paradigmatic effect; ‘Word-based phonetics’ (Pierrehumbert 2002) is a possible implementation of this.
- The laryngeal contrast between voiced and voiceless obstruents is ‘enhanced’ by other features (Avery and Rice 1989).
- Both of these complicate the relationship between phonology and phonetics
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Containment and Correspondence

1. Correspondence Theory: There are separate input and output representations, as well as correspondence constraints between elements of these (McCarthy and Prince 1995)

2. Containment Theory: The input is contained in the output, therefore all faithfulness constraints can be read off the surface representation (Prince and Smolensky 1993, Van Oostendorp 2005).
Correspondence

**Input**

```
  k l u k
  |   |   |
  k u k u
```

**Output**

```
  k l u k
  |   |   |
  k u k u
```

**Universe**

\( \{ k_1, l_2, u_3, k_4 \} \cup \{ k_a, u_b, k_c, u_d \} \)

**Relations**

\( \mathcal{C}(k_1, k_a) \land \mathcal{C}(u_3, u_b) \land \mathcal{C}(k_4, k_c) \)
Containment

- **Containment.** Every element of the phonological input representation is contained in the output. (There is no deletion.)
Faithfulness

**Containment: Prince and Smolensky 1993**

- **PARSE**: All elements should be ‘parsed’ in the phonological structure (no deletion.)
- **FILL**: Do not allow empty elements. (No insertion.)
Containment Representation

\[\Phi\]

Universe \(\{k_1, l_2, u_3, k_4, \emptyset_5\}\)

Relations \(\mathcal{D}_\phi(\Phi, k_1) \land \mathcal{D}_\phi(\Phi, u_3) \land \mathcal{D}_\phi(\Phi, k_k) \land \mathcal{D}_\phi(\Phi, \emptyset_5)\)
Occam’s Razor and Containment

- **PARSE-C**: Every consonant needs to be affiliated to prosodic structure.
- **FILL-V**: (Nuclear) syllable slots need features.
Problems with the Prince & Smolensky Interpretation

- features should also not be allowed to ever spread to an epenthetic vowel
- how do we prevent spreading from happening everywhere in every language?
"No changes in the exponence of a phonologically-specified morpheme are permitted." (McCarthy and Prince 1993, 1994)
Explanation

“[Consistency of Exponence] means that the lexical specifications of a morpheme (segments, prosody, or whatever) can never be affected by Gen. In particular, epenthetic elements posited by Gen will have no morphological affiliation, even when they lie within or between strings with morphemic identity. Similarly, underparsing of segments — failure to endow them with syllable structure — will not change the make-up of a morpheme, though it will surely change how that morpheme is realized phonetically. Thus, any given morpheme’s phonological exponents must be identical in underlying and surface form.”
CoE Representation

\[ \Phi \]

\[ k \downarrow l \downarrow u \downarrow k \downarrow u \downarrow \]

\[ M \]

\textit{Universe:} \{ k_1, l_2, u_3, k_4, u_5 \}

\textit{Relations:}

\[ \mathcal{D}_M(M, k_1) \land \mathcal{D}_M(M, l_2) \land \mathcal{D}_M(M, u_3) \land \mathcal{D}_M(M, k_4) \]

\[ \mathcal{D}_\phi(\Phi, k_1) \land \mathcal{D}_\phi(\Phi, u_3) \land \mathcal{D}_\phi(\Phi, k_k) \land \mathcal{D}_\phi(\Phi, u_5) \]
Faithfulness constraints (coloured versions)

- **PARSE-$\phi(x)$**: The morphological element $x$ must be incorporated into the phonological structure. (No deletion.)
- **PARSE-$\mu(x)$**: The phonological element $x$ must be incorporated into the morphological structure. (No insertion.)
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The trouble with features

input

\[ x \ x \]

F

\[ \quad \quad \quad \quad \quad \]

output

\[ x \ x \]

F
The trouble with PARSE-F

```
<table>
<thead>
<tr>
<th>input</th>
<th>output</th>
</tr>
</thead>
<tbody>
<tr>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>F</td>
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</tr>
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```
Two relations instead of one

- **projection**: an abstract, structural relationship holding between a segment and the feature (roughly equivalent to notions of ‘Licensing’).
- **pronunciation**: an output relationship that holds between the feature and the segment and describes the output realization of structure.
Turbidity in Goldrick’s work

- /ka+tiko/ → [katiko] ‘mushroom’
- /ka+oto/ → [ko:to] ‘fireplace (DIM)’
- /ka+ezi/ → [ke:zi] ‘moon (DIM)’

(Luganda)
Turbidity Theory

Turbid representation

\[ \mu \rightarrow a \rightarrow o \]

Turbidity presupposes Containment.
Stray Erasure (Turbid version)

- The phonetics only interprets features that stand in a pronunciation relation to a segment in the phonology.
we take projection lines to represent the lexical state of affairs, that is, to be part of the lexical representation of a morpheme [...]. In conformity with [Consistency of Exponence], therefore, they cannot be altered by Gen.
Reciprocity

\[ \text{RECIPROCITY}^V_F (\mathcal{R}^V_F) : \text{If a vowel } V \text{ entertains a } projection \text{ relation with a feature } F, \text{ then } F \text{ must entertain a pronunciation relation with the vowel } V. \]
[voice] cannot entertain a pronunciation relation with an obstruent in the coda.
Candidates

a. [kwaːd]  

\[
\begin{array}{ccc}
\text{k} & \text{w} & \text{aːd} \\
\text{voice} & & \\
\end{array}
\]

b. [kwaːd]  

\[
\begin{array}{ccc}
\text{k} & \text{w} & \text{aːd} \\
\text{voice} & & \\
\end{array}
\]
# Miniature Typology

**FINDEV** $\gg$ **RECIROCITY** $^V_F$: Final Devoicing (Catalan, Dutch, etc.)

<table>
<thead>
<tr>
<th>/kwaːd/</th>
<th>FINDEV</th>
<th>RECIROCITY $^V_F$</th>
</tr>
</thead>
<tbody>
<tr>
<td>kwaːd</td>
<td>*!</td>
<td></td>
</tr>
<tr>
<td>ɪkwaːd</td>
<td></td>
<td>*</td>
</tr>
</tbody>
</table>

**RECIROCITY** $^V_F$ $\gg$ **FINDEV**: Final Devoicing (Spanish, English, etc.)

<table>
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<th>/kwaːd/</th>
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<th>FINDEV</th>
</tr>
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<tr>
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<td></td>
<td>*</td>
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(Weak) past tense formation

- /tə/ after roots ending in underlyingly voiceless obstruents: kook-te ‘cooked’, raap-te ‘gathered’, praat-te ‘talked’
- /də/ after all other stems: leev-de ‘lived’, meld-de ‘mentioned’, ren-de ‘ran’

Past-tense formation thus reveals the underlying voicing of obstruents.
The issue

What happens with new (nonsense) verbs

- First person singular does not have any overt suffix, hence final devoicing (*ik leef* ‘I live’, *ik kook* ‘I cook’, *ik kam* ‘I live’, *ik ren* ‘I run’)
- This allows for a straightforward Wug test:
  - ‘What is the past tense of *ik le*[p], *ik sta*[x], *ik draa*[s]?’
Baayen and Ernestus (2003)

Responses ending in -de and -te, by type of stem-final obstruent (CV:C words)

<table>
<thead>
<tr>
<th>TYPE</th>
<th>de</th>
<th>te</th>
</tr>
</thead>
<tbody>
<tr>
<td>P</td>
<td>3</td>
<td>97</td>
</tr>
<tr>
<td>T</td>
<td>4</td>
<td>96</td>
</tr>
<tr>
<td>S</td>
<td>55</td>
<td>45</td>
</tr>
<tr>
<td>F</td>
<td>64</td>
<td>36</td>
</tr>
<tr>
<td>X</td>
<td>81</td>
<td>13</td>
</tr>
</tbody>
</table>
Correspondence to corpus data

The issue
The issue

The puzzle

- From these facts, Baayen and Ernestus (2003) conclude that speakers have knowledge of the statistical distribution in the corpus
- However, it is unclear that we can establish a direct causal relation here
- and it is left unexplained why the statistical distribution is the way it is
The hierarchy and its surprises

- P > T > F > S > X
- "[T]he type of the final obstruent itself is an important predictor of voicing. Surprisingly, a mirror image of the hierarchy of phonological strength emerges from the data [...] Dutch shows a preference for words to use final obstruents with a high cue validity. More research is clearly required here." (B&E 2003:30)
The issue

Possible responses

- The data are wrong
The issue

Possible responses

- *The data are wrong* but again there is no indication for this
Possible responses

- The data are wrong but again there is no indication for this
- The data are non-phonological
The issue

Possible responses

- *The data are wrong* but again there is no indication for this

- *The data are non-phonological* but there is a clear interaction with ‘real’ phonology
The issue

Possible responses

- *The data are wrong* but again there is no indication for this
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- *Phonology is wrong*
The issue

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A number of authors (Avery 1996, Iverson and Salmons 2003, Van Oostendorp 2002, fc) have argued on synchronic and diachronic phonological grounds that there is a split in the voicing system of Dutch:

- Stops have a ‘Romance’ system of \([\pm \text{voice}]\)
- Fricatives have ‘Germanic’ system of \([\pm \text{spread glottis}]\) and/or length
Voicing in Dutch

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  - Stops have a ‘Romance’ system of $[\pm \text{voice}]$
  - Fricatives have ‘Germanic’ system of $[\pm \text{spread glottis}]$ and/or length
Arguments in favour of a stop/fricative split (1)


  a. \(\sigma \quad \sigma\)  
  b. \(\sigma \quad \sigma\)  
  c. \(*\sigma \quad \sigma\)  
  d. \(*\sigma \quad \sigma\)
Voicing in Dutch

Arguments in favour of a stop/fricative split (2)

- **Voicing assimilation.** In obstruent clusters $C_1C_2$:
  - If $C_2$ is a stop, the cluster gets the underlying voicing of $C_2$:
    
    ```
    /hœyz/+dœ:r/ → [hœzdœ:r] ('house+door' = 'front door')
    ```
  
  - If $C_1$ is a fricative, the cluster gets devoiced:
    
    ```
    /hœyz/+vœyl/ → [hœsfœyl] ('house+dirt' = 'garbage')
    ```

- **Exceptions.** Some dialects have exceptions to final devoicing. If these exceptions are lexical, they always involve stops only; if they are grammatical they always involve fricatives only.

- **Spelling.** Final devoicing is reflected in traditional Dutch orthography for fricatives (*huis-huizen* ‘house(s)’) but not stops (*bord-borden* ‘plate(s)’)}
Arguments in favour of a stop/fricative split (3)

- *Phonetics.* “The problem is that fricative geminates are always realized as voiceless, independently of their context, exact duration, etc.” (Ernestus 2000:177)
Voiceless fricatives as long/spread glottis typologically

- **VAUX**: Fricative $\supset$ [spread glottis]. ‘Fricatives preferably have the feature [spread glottis]’ (Vaux 1998, Avery 2001)
- **MULTILINK**: [spread glottis] $\supset$ $\mu\mu$ ‘The feature [+spread glottis] has to be linked to two positions.’ (Ringen 1999)
Different representations for stops and fricatives

/t/
  [-cont]
   [coronal]

/d/
  [-cont]
   [coronal] [voice]

/s/
  [+cont]
   [coronal]
   [sp.gl.]

/z/
  [+cont]
   [coronal]
Different representations for stops and fricatives

/t/ \(\text{-cont}\) \([\text{coronal}]\)

/d/ \(\text{-cont}\) \([\text{coronal}]\) \([\text{voice}]\)

/s/ \(\mu\) \(\text{+cont}\) \([\text{coronal}]\)

/z/ \(\text{+cont}\) \([\text{coronal}]\)
Proposal about Lexicon Optimisation

- Choose the lexical representation which is least marked (contains the smallest amount of structure) and compatible with the data
- In case of stops, this will be the voiceless variant; in the case of fricatives, this will be the variant which is short/not [spr.gl]
- Notice that this makes predictions about e.g. German, in which plosives are also characterized by [sp.gl]
Baayen and Ernestus (2003)

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The length of place

- This accounts for the split between plosives and obstruents. What about place?
- At least for velarity, we know that there is an intimate connection to length as well.
- Velars sometimes behave as if they were long. E.g. velarisation in codas triggers shortening of preceding vowels.
  - [sxuːnə] ~ [sxuŋ] ‘shoe(s)’ (Antwerp Dutch)
  - [ziːt] → [zik] ‘time’ (Cologne German)
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- At first sight, Final Devoicing is a very simple and straightforward phonological process.
- Recent empirical study has shown that FD is more complicated than was hitherto assumed.
- However, this is a reason to refine our models rather than reject them.