BBN–ANG–243 Phonological analysis
Laryngeal contrast in English consonants

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lecture outline

- contrast among English obstruents consonants
- laryngeal (“voicing”) contrast
- phonological modelling and phonetic implementation of the contrast
- when contrast disappears: neutralization
the generative model of language

phonology is one of the **modules** of linguistic competence ("grammar")
the typical generative model of language
units in the mental lexicon

- the **lexicon** contains any information that needs to be memorized (no rules for them)
- e.g., it stores a **list** of the words, morphemes of a language
- what do you know when you “know” a word?
  1. the **elements** that the word is **built up from**
  2. their meaning
- these building blocks or **segments** are called **phonemes**
- the smallest units that can **distinguish** words from one another, responsible for the **contrast**
- words are represented in the lexicon as strings of phonemes = underlying representation (UR)
tasks of phonology

- it defines the **phoneme inventory** of a language
- it **maps** between phonemes and their surface realizations (allophones)
- it defines the **phonological rules** that are used to derive surface realizations when there are more than one possible realizations
not part of grammar

- **implements** the surface representations in speech (= the output of phonology)
- “translates” the output of phonology to actual speech gestures
what is it exactly that makes the difference between /ʃ/ and /s/, etc, possible?
- /ʃ/ and /s/ are phonemes because e.g., *shine* ⇐⇒ *sign*
- we can explicitly express why they contrast with the **distinctive features** they contain

<table>
<thead>
<tr>
<th>Feature</th>
<th>/ʃ/</th>
<th>/s/</th>
</tr>
</thead>
<tbody>
<tr>
<td>voicing</td>
<td>[–voice]</td>
<td>[–voice]</td>
</tr>
<tr>
<td>nasality</td>
<td>[–nasal]</td>
<td>[–nasal]</td>
</tr>
<tr>
<td>manner</td>
<td>[–stop]</td>
<td>[–stop]</td>
</tr>
<tr>
<td>place</td>
<td>[+palatal]</td>
<td>[–palatal]</td>
</tr>
</tbody>
</table>
features

- a phoneme = a sum of these features
- e.g., /ʃ/ = voiceless + oral + palatal + fricative
- features are usually defined based on articulation (phonetics)
- they can be thought of as the instructions the brain sends to the speech organs to implement sounds
phonetic implementation of distinctive features

you want to say the word *shine*:

<table>
<thead>
<tr>
<th>Phonological representation</th>
<th>Phonetic implementation</th>
</tr>
</thead>
<tbody>
<tr>
<td>[−voice]</td>
<td>‘do not vibrate vocal folds’ +</td>
</tr>
<tr>
<td>[−nasal]</td>
<td>‘do not lower the velum’ +</td>
</tr>
<tr>
<td>[+palatal]</td>
<td>‘raise tongue to hard palate’ +</td>
</tr>
<tr>
<td>[−stop]</td>
<td>‘do not create complete closure’</td>
</tr>
</tbody>
</table>
consonant contrasts in English
### Consonant Contrasts

#### The Consonant Inventory (Contrastive Consonants)

<table>
<thead>
<tr>
<th></th>
<th>Bil.</th>
<th>Lab-den.</th>
<th>Dental</th>
<th>Alveolar</th>
<th>Palatal</th>
<th>Velar</th>
<th>Glottal</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>O</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P</td>
<td>p</td>
<td>b</td>
<td>t</td>
<td>d</td>
<td>k</td>
<td>g</td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>f</td>
<td>v</td>
<td>θ</td>
<td>ð</td>
<td>s</td>
<td>z</td>
<td>f</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>g</td>
</tr>
<tr>
<td><strong>S</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N</td>
<td></td>
<td>m</td>
<td></td>
<td>n</td>
<td></td>
<td></td>
<td>η</td>
</tr>
<tr>
<td>L</td>
<td></td>
<td></td>
<td>l</td>
<td>r</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>G</td>
<td></td>
<td>w</td>
<td></td>
<td>j</td>
<td>h</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **Bil.** = bilabial, **Lab-den.** = labio-dental
- **P** = stop/plosive, **F** = fricative, **A** = affricate, **N** = nasal, **L** = liquid, **G** = glide
- **O** = obstruent, **S** = sonorant
- **|** = left of line: “voiceless”, right of line: “voiced”
obstruent contrasts

- place contrast: e.g., /t/ vs. /p/: *tin–pin*; /t/ vs. /k/: *tan–can*
- manner contrast: e.g., /t/ vs. /s/: *tin–sin*
- “voicing” contrast: e.g., /t/ vs. /d/: *time–dime*
“voicing” contrast in obstruents

<table>
<thead>
<tr>
<th>OBSTRUENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>STOPS</strong></td>
</tr>
<tr>
<td>/t/</td>
</tr>
<tr>
<td>tie</td>
</tr>
<tr>
<td>writer</td>
</tr>
<tr>
<td>beat</td>
</tr>
<tr>
<td>‘voiceless’</td>
</tr>
</tbody>
</table>
laryngeal contrast in obstruents

- the phonological contrast of “voicing” is signalled (= cued) by a complex of features
- there are several correlates of this contrast = there are many “concomitant” features for the contrast
- vocal fold vibration is only one of them
laryngeal contrast in obstruents

- let’s call the **phonological** contrast between *tie–die, writer–rider, bus–buzz*, etc. **laryngeal contrast**
- **voicing** is a narrowly used **phonetic** term: vocal fold vibration (also called: **phonation**)

some phonetic correlates of laryngeal contrast in obstruents

- voicing/phonation: vocal fold vibration
- Voice Onset Time (VOT)
- relative length of preceding vowel
- glottalization
- release noise/burst: intensity & length
larynx: vocal folds + glottis
vocal folds: periodic vibration
states of the vocal folds

- widely open vocal folds
  - breathing
  - no voicing

- open vocal folds
  - aspiration
  - no voicing

- loosely closed vocal folds
  - voicing

- strongly closed vocal folds
  - glottalization
  - no voicing
cross-section of the larynx
vocal fold vibration: the Bernoulli effect
the aerodynamics of voicing: steps of vocal fold vibration

vocal fold vibration happens because of air pressure changes (aerodynamic reasons):

1. vocal folds loosely close
2. air pressure increases below vocal folds
3. air pressure blows vocal folds apart (glottis opens)
4. speed of air particles increases through narrow glottis
5. air pressure decreases below/within vocal folds ⇒ vocal folds sucked together (Bernoulli effect)
6. vocal folds are closed again, a cycle like this repeats itself approx. 100–300 times/second
7. the cycles last until the state of glottis changes (e.g., opens to produce a voiceless sound)

– phonation can start and can continue when air pressure is higher below the vocal folds than above it
1. spontaneous ("modal") voicing: open oral cavity – this helps to start and maintain voicing because air pressure will be low in the mouth but high below vocal folds ⇒ *vowels, sonorants*

2. passive devoicing: closure/constriction in mouth – this creates high air pressure above vocal folds, which inhibits vocal fold vibration ⇒ *obstruents*
voicing in obstruents

- obstruents easily get devoiced
- but there exist voiced obstruents, how?

- passive voicing
- active voicing
passive voicing

- when obstruents are **between two vowels or sonorants**, voicing from the preceding vowel/sonorant continues throughout the obstruent
- this is what we call **passive voicing**
voicing

VOWEL or SONORANT

OBSTRUENT

VOWEL or SONORANT
passive voicing

- English “voiced” obstruents are **passively voiced**
- examples: *rider*, *bandit*, *rabid*, *gamble*, *begin*, *English*, *gadget*, *nostalgia*, *fuzzy*, *palsy*, *Magda*, *exam /ɪɡˈzɑːm/...*
active voicing

- additional, “extra” voicing articulation-strategies are used to delay devoicing in obstruents
- e.g., lower the larynx, enlarge the oral cavity
- Hungarian, French, Russian, etc. obstruents are like this: actively voiced
active devoicing

▶ between vowels/sonorants, obstruents are passively voiced
▶ to produce voiceless obstruents in such positions, extra articulatory effort is needed
▶ this is called **active devoicing**
▶ examples from English: *city*, *lucky*, *tempo*, etc.
# types of phonetic voicing

<table>
<thead>
<tr>
<th>Type</th>
<th>Affected sounds</th>
</tr>
</thead>
<tbody>
<tr>
<td>spontaneous voicing</td>
<td>vowels, sonorant consonants</td>
</tr>
<tr>
<td>passive devoicing</td>
<td>obstruents</td>
</tr>
<tr>
<td>passive voicing</td>
<td>obstruents between Vs/son. (English, etc.)</td>
</tr>
<tr>
<td>active voicing</td>
<td>obstruents (Hungarian, etc.)</td>
</tr>
<tr>
<td>active devoicing</td>
<td>voiceless obstruents between Vs/son.</td>
</tr>
</tbody>
</table>
some consequences of voicing types

- vowels and sonorants are usually **only voiced** (no voiceless pair)
- some languages only have voiceless obstruents ("voiceless obstruents are **unmarked**")
- if a language has a **voiced** obstruent, it must also have a **voiceless** obstruent
some consequences of voicing types

- if an obstruent is passively voiced (as in English), its voicing depends on its environment
  - passively voiced obstruents are only fully voiced between vowels/sonorants
  - elsewhere they are usually partially or fully devoiced, e.g.:
    - word-initial position: *back*, *demon*, *game*, *juice*…
    - word-final position: *rob*, *lead*, *vague*, *bridge*…
    - next to another obstruent: *anecdote*

- passively voiced obstruents are not predicted to cause regressive voicing assimilation
Hungarian obstruents contain the feature [±voice] in their underlying representation.

English obstruents do **not** contain the feature [±voice] in their underlying representation.

So what feature makes the contrast possible between English obstruents? For example: *tip* – *dip*?

VOT
Voice Onset Time, VOT

- voicing of stops can be characterized by the **timing between the release and the beginning ("onset") of voicing** of the next vowel/approximant
- we call this timing relationship **Voice Onset Time (VOT)**
three Voice Onset Time options

closure  release

vowel  hold  vowel

time

zero VOT  [t] voiceless unaspirated
positive VOT  [tʰ] voiceless aspirated
negative VOT  [d] fully voiced
voicing and aspirating languages

- **Voiced**
  - [d]
- **Voiceless unaspirated**
  - [t]
- **Voiceless aspirated**
  - [tʰ]

Hawaiian

Hungarian

English

Thai

Cl. Greek:

- βάς /bás/ – πάς /pás/ – φάς /pʰás/
voicing and aspirating languages

**voicing** (zero VOT ⇔ −VOT) languages

most Romance and Slavic languages (Spanish, Italian, French, Russian, Polish, Slovak, etc.) but also Dutch, Yiddish, Scottish English, and Hungarian

**aspirating** (+VOT ⇔ zero VOT) languages

most Germanic (English, German, Danish, Icelandic, Norwegian, Swedish, etc.) but also some Turkic languages
voicing and aspirating languages

**voicing** (zero VOT $\Leftrightarrow -VOT$) languages: $[\pm \text{voice}]$

- difference between obstruents is due to *voicing*
- e.g., $/p/$ = *voiceless*, $[-\text{voice}]$; $/b/$ = *voiced*, $[+\text{voice}]$

**aspirating** ($+VOT \Leftrightarrow $ zero VOT) languages: $[\pm \text{fortis}]$

- difference between obstruents is due to *fortisness*
- e.g., $/p/$ = *fortis*, $[+\text{fortis}]$; $/b/$ = *lenis*, $[-\text{fortis}]$
<table>
<thead>
<tr>
<th>Fortis [+fortis]</th>
<th>Lenis [−fortis]</th>
</tr>
</thead>
<tbody>
<tr>
<td>never voiced</td>
<td>have passive voicing, only voiced between Vs/sonorants/lenis obst.’s</td>
</tr>
<tr>
<td>can be aspirated</td>
<td>never aspirated</td>
</tr>
<tr>
<td>can shorten the preceding vowel</td>
<td>never shorten preceding vowel</td>
</tr>
<tr>
<td>(&quot;Pre-Fortis Clipping&quot;)</td>
<td></td>
</tr>
<tr>
<td>can be glottalized</td>
<td>can never be glottalized</td>
</tr>
</tbody>
</table>
fortis vs. lenis obstruent contrast in English

English obstruent phonemes

<table>
<thead>
<tr>
<th></th>
<th>Stops</th>
<th>Affr.</th>
<th>Fricatives</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fortis [+fortis]</td>
<td>/p t k/</td>
<td>/ʧ/</td>
<td>/ʃ θ s j/</td>
</tr>
<tr>
<td>Lenis [−fortis]</td>
<td>/b d g/</td>
<td>/ʤ/</td>
<td>/v ð z ʒ/</td>
</tr>
</tbody>
</table>

- lenis phonemes have two allophones: (partially) voiceless and voiced, the voiced allophone is the most limited
- for example:
  - /b/ phonetically: [b] or [p] elsewhere
  - bin /bɪn/ phonetically: [pɪn] or [bɪn]
  - Robin /rɒbɪn/ phonetically: [rɒbɪn]
- fortis phonemes have various allophones (aspirated, unaspirated, glottalized)
### Phonetic Implementation of \([\pm \text{fortis}]\) in English

**Example:** *tip* – *dip*:

<table>
<thead>
<tr>
<th>Phonological representation</th>
<th>(\Rightarrow)</th>
<th>Phonetic implementation</th>
</tr>
</thead>
<tbody>
<tr>
<td>([+\text{fortis}])</td>
<td>([-\text{nasal}])</td>
<td>‘aspirate/+VOT’ +</td>
</tr>
<tr>
<td>([-\text{nasal}])</td>
<td>([+\text{alveolar}])</td>
<td>‘don’t lower the velum’ +</td>
</tr>
<tr>
<td>([+\text{stop}])</td>
<td></td>
<td>‘raise tongue to alveolar ridge’ +</td>
</tr>
<tr>
<td>(/t/ = )</td>
<td></td>
<td>‘create complete closure’</td>
</tr>
</tbody>
</table>

\[ [t^h] \]

| \([-\text{fortis}]\)       | \([-\text{nasal}]\) | ‘don’t do anything/\(\emptyset\) VOT’ +       |
| \([-\text{nasal}]\)        | \([+\text{alveolar}]\) | ‘don’t lower the velum’ +       |
| \([+\text{stop}]\)         |               | ‘raise tongue to alveolar ridge’ +       |
| \(/d/ = \)               |               | ‘create complete closure’ |

\[ [d^\_] = [t] \]
phonetic implementation of $[\pm \text{voice}]$ in Hungarian

example: \textit{tél} ‘winter’ – \textit{dél} ‘noon’:

<table>
<thead>
<tr>
<th>Phonological representation</th>
<th>$\Rightarrow$</th>
<th>Phonetic implementation</th>
</tr>
</thead>
<tbody>
<tr>
<td>$[-\text{voice}]$</td>
<td></td>
<td>‘don’t vibrate vocal folds/∅VOT’ +</td>
</tr>
<tr>
<td>$[-\text{nasal}]$</td>
<td></td>
<td>‘do’nt lower the velum’ +</td>
</tr>
<tr>
<td>$[+\text{alveolar}]$</td>
<td></td>
<td>‘raise tongue to alveolar ridge’ +</td>
</tr>
<tr>
<td>$[+\text{stop}]$</td>
<td></td>
<td>‘create complete closure’</td>
</tr>
<tr>
<td>/t/ =</td>
<td></td>
<td>[t]</td>
</tr>
</tbody>
</table>

<table>
<thead>
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<th>Phonological representation</th>
<th>$\Rightarrow$</th>
<th>Phonetic implementation</th>
</tr>
</thead>
<tbody>
<tr>
<td>$[+\text{voice}]$</td>
<td></td>
<td>‘vibrate vocal folds/−VOT +</td>
</tr>
<tr>
<td>$[-\text{nasal}]$</td>
<td></td>
<td>‘do’nt lower the velum’ +</td>
</tr>
<tr>
<td>$[+\text{alveolar}]$</td>
<td></td>
<td>‘raise tongue to alveolar ridge’ +</td>
</tr>
<tr>
<td>$[+\text{stop}]$</td>
<td></td>
<td>‘create complete closure’</td>
</tr>
<tr>
<td>/d/ =</td>
<td></td>
<td>[d]</td>
</tr>
</tbody>
</table>
laryngeal contrast of English stops in various positions

- as we saw, there can be various phonetic implementations of [+fortis] and [−fortis]
- they depend on the position of the obstruent
  1. between sonorants, before a stressed vowel: repél – rebél
  2. word-initial, before a stressed or unstressed vowel: tíe – díe, políte – Bolívia
  3. between sonorants, before an unstressed vowel: wríter – ríder
1. between Vs/sonorants, before a stressed vowel

| Word in spelling: | repél | rebél |
| Underlying repr.: | /p/ | /b/ |
| [+fortis] | [−fortis] |

Phonetic implem.:

- repél:
  - aspirated/+VOT
  - plus: passive voicing
  - = [pʰ]

- rebél:
  - unaspirated/ØVOT
  - = [b]

– on the surface, both aspiration and phonetic voicing make the contrast possible, we can call it a strong position for the obstruent contrast
2. word-initial, before vowel (stressed or unstressed)

Word in spelling:  
Underlying repr.:  
Phonetic implem.:  

<table>
<thead>
<tr>
<th>Word in spelling:</th>
<th>tie</th>
<th>die</th>
</tr>
</thead>
<tbody>
<tr>
<td>Underlying repr.:</td>
<td>/t/</td>
<td>/d/</td>
</tr>
<tr>
<td>[+fortis]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>[-fortis]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phonetic implem.:</td>
<td>aspirated/+VOT</td>
<td>unaspirated/ØVOT</td>
</tr>
<tr>
<td></td>
<td>$[t^h]$</td>
<td>$[d]$ or $[t]$</td>
</tr>
</tbody>
</table>

– only aspiration is active in this position for the contrast on the surface
3. between sonorants, before an unstressed vowel

<table>
<thead>
<tr>
<th>Word in spelling:</th>
<th>writer</th>
<th>rider</th>
</tr>
</thead>
<tbody>
<tr>
<td>Underlying repr.:</td>
<td>/t/</td>
<td>/d/</td>
</tr>
<tr>
<td>[±fortis]</td>
<td></td>
<td>[-fortis]</td>
</tr>
</tbody>
</table>

Phonetic implem.:

- unaspirated/∅VOT
- plus: passive voicing

= [t]  
= [d]

- only voicing is active in this position for the contrast on the surface
- note: 1. fortis stops may be weakly aspirated in this position, too
- 2. length of stops is relatively short here, and voicing may continue throughout the stop: /t/ and /d/ may become a flap [ɾ] in American English, but not /p/–/b/ or /k/–/g/: rápido – rábid still contrast
absolute word final position: *beat* – *bead*

- in this position, voicing is difficult to maintain
- since nothing follows the stop, **aspiration is also impossible**
no contrast in *beat* – *bead*?

<table>
<thead>
<tr>
<th>Word in spelling:</th>
<th>beat</th>
<th>bead</th>
</tr>
</thead>
<tbody>
<tr>
<td>Underlying repr.:</td>
<td>/t/</td>
<td>/d/</td>
</tr>
<tr>
<td></td>
<td>[+fortis]</td>
<td>[−fortis]</td>
</tr>
<tr>
<td>Phonetic implem.:</td>
<td>unaspirated/∅VOT</td>
<td>unaspirated/∅VOT</td>
</tr>
<tr>
<td></td>
<td>= [t]</td>
<td>= [d] or [t]</td>
</tr>
</tbody>
</table>

- has English given up contrast in word-final position? = **neutralization**
- or maybe there are features other than aspiration or voicing that get activated here to maintain the contrast...
neutralization: the beer goggle effect
neutralization

The disappearance of contrast under a given condition.

= The local suspension of a phonological opposition between two or more contrastive sound segments; only one segment can appear in that position (but not its contrastive counterpart(s)).
neutralization: the beer goggle effect

- **opposition**: the attractiveness of people is perceived differently
- **condition**: being drunk
- **output**: the difference in attractiveness disappears (all people are perceived as attractive)
neutralization example: vowel reduction

- a wide range of vowels can appear in a stressed syllable but in unstressed syllables, vowel contrast is reduced to a handful of vowels (primarily the schwa)

- senténtial ~ sénentence ε ∼ ə
  systémic ~ sýstém ɛ ∼ ə
  morálity ~ mórál a ∼ ə
  symbólic ~ sýmbol ɔ ∼ ə
  atómic ~ átom ɔ ∼ ə
  harmónious ~ hármony əw ∼ ə
  mystérious ~ mýstery ɪ ∼ ə
  dráma ~ dramática ɑː ∼ ə
  sulphúrious ~ súlphur ʒuː ∼ ə

- opposition: full vowels, condition: unstressed syllable, output: /ə/
laryngeal neutralization for word-final obstruents?

- **opposition:** laryngeal contrast of obstruents,
  **condition:** word-final position,
  **output:** only voiceless-unaspirated obstruents
- based on this, *beat* and *bead* are supposed to be pronounced the same way:
- BUT this does **not** seem to be the case!
“redundant” features to the help

- correlates of laryngeal contrast so far: voicing and aspiration
  - but they are not active in word-final position
- however, there are other correlates of the laryngeal contrast
- they do not seem to play a role in other positions (e.g., word-medially), they are “redundant”
- but they seem to emerge more saliently when contrast is in danger (as in word-final position):
  - relative length of preceding vowel
  - glottalization
  - other features: release noise, articulatory strength/effort/force
relative length of preceding vowel

- experimental evidence: relative length of vowel to the length of the obstruent is an important factor for categorizing the obstruent as ‘fortis/voiceless’ or ‘lenis/voiced’, especially in word-final position

- generally: short vowel + longer obstr. ⇒ ‘fortis/voiceless’
  long vowel + shorter obstr. ⇒ ‘lenis/voiced’
experiments: manipulating voicing & length

vowel : obstruent

voicing (%)

vowel:obstr. length ratio
relation of voicing categorization and voicing amount + vowel length in word-final position

![Graph showing the relationship between vowel length and voicing in obstruents]
conclusions

- if there is little or no voicing in the obstruent, the preceding vowel has to be around twice as long as the obstruent for it to be categorized as ‘lenis/voiced’

- if this vowel is not this long, the obstruent is categorized as ‘fortis/voiceless’ = **Pre-Fortis Clipping**
Pre-Fortis Clipping in English in word-final position

- In English vowels (+ sonorants) are significantly **shorter** (clipped) before fortis obstruents than before lenis obstruents, where they are significantly **longer**

- Vowel (+ son.) is **shorter** before **fortis** obstr.
  - mate
  - rope
  - write
  - root
  - cap
  - speak
  - loose
  - leaf
  - font
  - dense

- Vowel (+ son.) is **longer** before **lenis** obstr.
  - made
  - robe
  - ride
  - rude
  - cab
  - speed
  - lose
  - leave
  - fond
  - dens
contrast in *beat* – *bead*

<table>
<thead>
<tr>
<th>Word in spelling:</th>
<th><em>beat</em></th>
<th><em>bead</em></th>
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<tbody>
<tr>
<td>Underlying repr.:</td>
<td>/t/</td>
<td>/d/</td>
</tr>
<tr>
<td>[+fortis]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>[−fortis]</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Phonetic implem.:  

- *beat*: unaspirated/∅VOT + shorter/clipped vowel  
  \[ = [V_{clipped}t] \]

- *bead*: unaspirated/∅VOT + longer vowel  
  \[ = [V_{longer}d] \]
  or \[ = [V_{longer}t] \]

z. g. kiss (elte|delg)  
analysis | laryngeal contrast
pre-glottalization/glottal reinforcement

- glottal closure quickly closes down the voicing of the vowel, followed by the oral closure of the fortis stops & affricate
- happens word-finally or when they are followed by another consonant
- it only happens for the fortis consonants: 
  mate [mæj?t] – made [mæjt],
  seat [sɪj?t] – seed [sɪjt]
- it is another indicator of the fortis – lenis contrast!
- it happens where the contrast between fortis & lenis stops could potentially disappear (word-finally)
- note: glottalization may well be just a more salient/forceful version of pre-fortis clipping: the vowel is cut by glottal closure
contrast in *beat* – *bead*

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<td>unaspirated/∅VOT</td>
</tr>
<tr>
<td>+ shorter/clipped vowel</td>
<td>+ longer vowel</td>
<td></td>
</tr>
<tr>
<td>+ glottalization</td>
<td>+ no glottalization</td>
<td></td>
</tr>
<tr>
<td>= [V\text{clipped}t]</td>
<td>= [V\text{longer}d] or [V\text{longer}t]</td>
<td></td>
</tr>
</tbody>
</table>
### Phonetic Implementation of [+Fortis] in Stops

<table>
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<tr>
<th>Phonetic Implementation</th>
<th>In Which Position?</th>
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</thead>
<tbody>
<tr>
<td>[+fortis] =⇒ (strong) aspiration</td>
<td>word-initially or before a stressed vowel</td>
</tr>
<tr>
<td>=⇒ vowel clipping</td>
<td>word-finally</td>
</tr>
<tr>
<td>=⇒ glottalization</td>
<td>word-finally</td>
</tr>
<tr>
<td>=⇒ weak/no aspiration</td>
<td>word-medially before an unstressed vowel</td>
</tr>
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</table>

### Phonetic Implementation of [−Fortis] in Stops

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<td>[−fortis] =⇒ voicing</td>
<td>between vowels/son.</td>
</tr>
<tr>
<td>=⇒ no aspiration, no voicing</td>
<td>elsewhere</td>
</tr>
</tbody>
</table>
so far we have not seen neutralization of the laryngeal contrast for either stops or fricatives

- fortis fricative + stop clusters:
  - /s/ + stop: *speak, sport, spring, stéreo, stúpid, string, school, scheme, sketch, discover, display, explain...*
  - /ʃ/ + stop: *kaftán, áfter*
  - /ʒ/ + stop: *gestált*

the laryngeal contrast is **completely neutralized** in this position: only an **unvoiced-unaspirated** stop may occur here
the traditional analysis: exception!

- spelling suggests that the stop in *speak*, *discover*, etc. is *fortis*, just like in *peak*, *recover*, etc.
- but then all stops after fortis fricatives and before a (stressed) vowel are *exceptionally unaspirated*

<table>
<thead>
<tr>
<th>Aspirated</th>
<th>Not aspirated</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>péak</em></td>
<td><em>spéak</em></td>
</tr>
<tr>
<td><em>rećóver</em></td>
<td><em>discóver</em></td>
</tr>
<tr>
<td><em>atttáin</em></td>
<td><em>susttáin</em></td>
</tr>
<tr>
<td><em>máttter</em></td>
<td><em>ástter</em></td>
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- why?
syllable-based analysis

- ‘fortis stops are only aspirated at the beginning of a syllable’
- so: /p/ in *peak* is aspirated but not in *speak*, and /k/ in *re.co.ver* is aspirated but not in *di.sco.ver* (\* signals syllable boundary)
- problem: what is special about the syllable-initial position? why in only this “special” position can there be aspiration?
- problem: putting the fricative and the stop in the same syllable is questionable: *a.fter, ka.ftan, ge.stalt*...
perception of stops after fortis fricatives

– what do native speakers hear when the /s/ of school is deleted?

S

kuwl

cool ?

ghoul ?
stops after /s/ are perceived as lenis

– what do native speakers hear when the /s/ of school is deleted?
alternative analysis: the stop is lenis, not fortis

- stops after fortis fricatives seem to be **lenis** and NOT fortis
- they are not aspirated because they are never aspirated
- they are not voiced either because they are only (passively) voiced between vowels/sonorants/other lenis obstruents but not next to fortis obstruents
- if transcription was following this phonological fact, then: 
  \( \text{stop} = /\text{sdp}/ \), \( \text{dis} \text{cover} = /\text{dsg\'v}\text{\'}/ \), etc.
- why don’t we use this transcription then? – probably because it would be very misleading for language learners coming from voicing languages...
  \( /\text{sbo:t}/ \), \( /\text{s\'sd\'jn}/ \), \( /\text{\'s\'b\'\'g\'\'z}/ \)...
- = sport, sustain, Asperger’s...
- note Welsh spelling: \( \text{s\'b\'ecto} \) ‘spectacles’, \( \text{s\'gyrt} \) ‘skirt’, \( \text{S\'baen} \) ‘Spain’, \( \text{s\bl asio} \) ‘splash’...
laryngeal contrast of English fricatives/affricates

- similar analysis for fricatives/affricates
- realization of the laryngeal contrast depends on the position
- difference: aspiration (VOT) and glottalization do not play a role
correlates of laryngeal contrast of fricatives/affricates

- word-medial position, before vowels: absence/presence of voicing/phonation
  - *féction* – *féction*, *defied* – *divíde*; *míssle* – *mízzle*, *ríle* – *ríval*, *Confúcián* – *confúsion*

- word-initial position: **acoustic intensity** is the main correlate of the contrast

- fortis fricatives/affricates: more intense; lenis: relatively less intense

- absolute word-final position: **duration & intensity** is the main correlate

- *leaf* – *leave*, *bus* – *buzz*, *race* – *raise*, *ruche* /ruːʃ/ – *rouge* /ruːʒ/, *teeth* /tɪʃθ/ – *teethe* /tɪʃð/, *loath* – *loathe*