Articulatory Phonology: example studies

Phonology II
Swarthmore College

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Articulatory Phonology review
Coordinating gestures in time
Articulatory Phonology in one slide

• *Gesture*: dynamic movements in the vocal tract that unfold over time.

• Gestural coupling modes:
  
  • *In-phase coupling*: (synchronous) and *Anti-phase coupling* (sequential) are most stable
  
  • *Competitive coupling*: combination of in-phase and anti-phase coupling relations
  
  • *Eccentric coupling*: one coupling relation, just not intrinsically stable

*(Nam & Saltzman 2003, Nam et al. 2009, Goldstein 2011)*
Articulatory Imaging

- What does it do well?
- What does it not do well?
- When might you use it?

Optical + Ultrasound

Ultrasound

Nasal airflow

MRI

Electroglottography

a) Speech Signal

b) EGG Signal
Articulatory Imaging

Electromagnetic Articulography (EMA)

X-ray microbeam (XRMB)
Coordinating tone gestures

Articulatory Phonology in one slide

• *Tone gesture*: treat F0 targets similar to articulatory targets

• For lexical tone languages, C-V timing has a lag suggesting competitive coupling

  • difference between lexical tone and intonational tone...

(Gao 2008, Niemann et al. 2011, Karlin 2014)
Tibetan
A “Natural Laboratory”

- A language with variation across dialects & speakers:
  - lexical tone
  - onset consonant clusters
  - laryngeal phonology

- Tone gestures predicts that tone affects relative C-V timing. Observed in:
  - contextually-toneless syllables (Mandarin) (Zhang et al. 2019)
  - across speakers of the same language…
Tibetan

- "archaic"/"cluster"
- "innovative"/"non-cluster"
- dialect continuum
- post-1959 diaspora

Approx. extent of tone
**Dialects: Natural laboratory**

- tonogenesis
- laryngeal variation
- cluster simplification
- vowel shifts, spirantization, retroflexion, palatalization
- evidential, honorifics, modality, etc.

<table>
<thead>
<tr>
<th>Written (Classical)</th>
<th>Balti (Western)</th>
<th>Rebkong (Northeastern)</th>
<th>Tokpe Gola (Central)</th>
<th>Gloss</th>
</tr>
</thead>
<tbody>
<tr>
<td>khrag</td>
<td>[kʂʌk]</td>
<td>[ʈʂɤɣ]</td>
<td>[ʈʰɭk] ([ʈʰáɭk])</td>
<td>‘blood’</td>
</tr>
<tr>
<td>rtswa</td>
<td>[xstsoa]</td>
<td>[xtsa]</td>
<td>[t̚sá]</td>
<td>‘grass’</td>
</tr>
<tr>
<td>spyang ki</td>
<td>[spjaŋ.'ku]</td>
<td>[xtçan.'kʰɤ]</td>
<td>[ʈʃaŋ.gú]</td>
<td>‘wolf’</td>
</tr>
<tr>
<td>bcu bdun</td>
<td>[ʈɕub.'don]</td>
<td>[ʈɕəb.'dɤn]</td>
<td>[ʈʃúp.tǔ] ([ʈʃúp.tũ])</td>
<td>‘seventeen’</td>
</tr>
</tbody>
</table>

(Adapted from Caplow 2013)
Tonogenesis
(tonal dialects only)

• Voiceless onsets > high tone
• Voiced onsets > low tone
• Sonorants with pre-initial > high tone

• *pʰar ‘over there’ > H
  *sa ‘earth’ > H
• *bar ‘between’ > L
  *za ‘eat’ > L
  *mar ‘butter’ > L
• *sman ‘medicine’ > H
# Laryngeal contrasts

<table>
<thead>
<tr>
<th>Orthography</th>
<th>Etymological onsets</th>
<th>Innovative features</th>
</tr>
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<tbody>
<tr>
<td>Old Tibetan</td>
<td>spa pʰa ba sʰba sa za bʰza</td>
<td>aspiration allphonic</td>
</tr>
<tr>
<td>Northeastern and Western dialects</td>
<td>spa pʰa ba ~ wa bʰba sa za za</td>
<td>cluster simplification aspirated/unaspirated contrast</td>
</tr>
<tr>
<td>Eastern dialects</td>
<td>pᵃ pʰᵃ pᵃ bᵃ sᵃ zᵃ zᵃ</td>
<td>tonogenesis cluster simplification</td>
</tr>
<tr>
<td>Central dialects (Lhasa)</td>
<td>pᵃ pʰᵃ pʰᵃ pᵃ sᵃ sᵃ sᵃ</td>
<td>voiced clusters &gt; voiceless voiced simplex &gt; aspirated</td>
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</table>
The temporal basis of complex segments
Shaw et al. 2019
Shaw et al. (2019): predictions and how to test?

**In-phase**

1

2

1

2

**Antiphase**

1 ————> 2

1 2

**In-phase + lag**

1

2

1 1

2

**Antiphase - lag**

1 ————> 2

1 1 2

**Figure 1:** Hypothesized gestural coordination patterns for complex segments (a), (c) and segment sequences (b), (d)
Shaw et al. (2019): results

**Figure 2:** Correlations for the Russian data

**Figure 4:** Correlations for the data from the English experiment
Interpreting LMMs
Shaw et al (2019)

- Predicting: lag
- Random effects: speaker, item
- Fixed effects (R): gesture duration, sequence ([pʲ], [br]), interaction
- Fixed effects (E): gesture duration, segment: [m b p v]
- no interaction because effect of duration on lag is uniform across segments

| Fixed Eff. | Est. | Std. Err. | t-val | p(>|t|)) |
|------------|------|-----------|-------|----------|
| Inter.     | -9.2 | 33.2      | -0.3  | 0.78     |
| G.D.       | 0.09 | 0.2       | 0.6   | 0.54     |
| Seq        | -72.8| 49.3      | -1.5  | 0.15     |
| G.D.:Seq (br) | 0.82 | 0.2       | 3.6   | <0.001   |

Table 2: Mixed effects model for the English TB gestures in palatal consonants [G.D. = gesture duration, FirstSeg = first segment]

| Fixed Eff. | Est. | Std. Err. | t-val | p(>|t|)) |
|------------|------|-----------|-------|----------|
| Inter.     | -128.3| 20.1      | -6.4  | <0.001   |
| G.D.       | 0.64 | 0.09      | 7.4   | <0.001   |
| FirstSeg (b) | 51.5 | 13.1      | 3.9   | <0.001   |
| FirstSeg (p) | 39.6 | 13.1      | 3.0   | 0.003    |
| FirstSeg (v) | 25.8 | 12.4      | 2.1   | 0.04     |
An acoustic and articulatory study of Drenjonke fricatives

Guillemot et al. 2019
Drenjonke (Sikkimese) fricatives & tones

- Acoustic study to confirm
- F0 → tone? yes
- spectrogram, EGG → voicing?
  - yes for 1 female speaker
  - no voicing for 4 male speakers

### Previous descriptions

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<td></td>
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### Results: female speaker

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Drenjonke (Sikkimese) fricatives & tones

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Corpus study
Geissler (2021)
Goals

• Establish facts about consonant-al and tonal contrasts
  • Interspeaker variation?
  • How to tone and laryngeal contrasts co-occur?

• Inform hypotheses for controlled articulatory study
Methods

- Word list presented in Tibetan orthography
  - 22 items * 2 repetitions (from 64-item wordlist)
- Data presented from 19 speakers raised in diaspora (30s or younger)
- Part of a larger study:
  - speakers from other dialects
  - sociolinguistic interviews with other tasks
F0-tone
F0 at onset of voicing

• H > L significant for 11/19 speakers
• no significant difference for 7/19 speakers
VOT and tone categories

- Unaspirated vs. aspirated

- Unaspirated vs. aspirated... plus tone
Summary of corpus study

• Confirmed:
  • no clusters in diaspora speakers

• Novel findings:
  • some speakers lack tone contrast (production)
  • effect of tone on aspiration duration
  • effect of tone on prevoicing
Articulatory study

Geissler (2021)
Hypotheses

- H1: variation in timing conditioned by presence/absence of lexical tone
  - speakers with tone contrast will have competitive coupling (pos. C-V lag)
  - speakers without tone contrast will have in-phase C-V timing (no C-V lag)
- H2: timing convergence:
  - all speakers will have similar coordination patterns despite interspeaker variation in presence/absence of tone
- What kind of tone contrast is there?
  - If H-∅, then difference will be visible in high vs. low tone words
  - If H-L, then no difference in timing by tone.
EMA data
articulatory trajectories

• Tracks movement of sensors over time
• \([p \ p^{\text{h}} \ m]\): distance between lip sensors
• \([i] \rightarrow [u \ o \ a]\): tongue dorsum retraction

(Mview software: Tiede 2005)
Results: tone contrast

- 4 speakers produce a tone contrast, two do not (on /mV/)
Results: C-V lag

- There is a positive C-V lag… for speakers with and without the tone contrast
- No significant difference between the tones
Two systems of laryngeal contrasts

- Both conditioned by tone:
  - Left speaker:
    - no prevoicing
    - long VOT only with H tone
  - Right speaker:
    - prevoicing with L tone
    - long VOT with both tones
EMA Study conclusions

- **H1**: variation in timing conditioned by presence/absence of lexical tone
  - speakers with tone contrast will have competitive coupling (pos. C-V lag)
  - speakers without tone contrast will have in-phase C-V timing (no C-V lag)

- ✔ **H2**: timing convergence:
  - all speakers have similar coordination patterns despite interspeaker variation in presence/absence of tone

- What kind of tone contrast is there?
  - If H-∅, then difference will be visible in high vs. low tone words
  - ✔ If H-L, then no difference in timing by tone.
Summary of Findings

• Tibetan speakers in diaspora..
• ... vary in their phonology
  • presence/absence of tone
  • two laryngeal contrast systems
• ... preserve lexical contrasts
  • tone-conditioned VOT categories persist even when speakers don’t have tone contrast
• ... maintain temporal stability in articulation
Implications

• Members of a speech community can have different phonologies.
• Multi-lingual, multi-dialectal situations are helpful for linguistic research.
• C-V lag related to tone, but not always through competitive coupling.
  • at least not for non-tonal speakers.
• Stable C-V timing amid variation.
  • this is something we can learn.
  • even the “mechanical” is social.
General summary

- What is AP useful for?
- What is AP *not* useful for?
- What are some challenges in AP?
- What do you want to learn more about?
Thank you!