COARTICULATION IS MEDIATED BY “AUTISTIC TRAITS” IN NEUROTYPICALS

Alan Yu and Ian Calloway, University of Chicago
Coarticulation/coproduction in speech
Perceptual compensation for coarticulation

- Anticipatory coarticulatory lip-rounding causes spectral centre of gravity lowering in /s/
- Listeners *know* this and reverse its effect (= compensation for coarticulation*)

*Anticipatory coarticulatory lip-rounding causes spectral centre of gravity lowering in /s/

Listeners reverse the effects of coarticulation

*e.g. Fujisaki & Kunisaki, 1977; Mann & Repp 1980 etc.*
A classic demonstration

- Present listeners with CV stimuli, where C was one of 7 fricatives from an [s] – [ʃ] continuum and V was [a] or [u].

“Autistic” traits mediate perceptual compensation

Size of the shift

Yu 2010 PloSOne
Autistic-Spectrum Quotient (AQ)

- Assess certain social, communicative, and imaginative traits in neuro-(a)typical individuals

- Questions on
  - social skills;
  - attention switching;
  - attention to detail;
  - communication;
  - imagination

Baron-Cohen et al., 2001
Autistic-Spectrum Quotient (AQ)

- **Social skills**
  - “I would rather go to a library than a party”

- **Communication**
  - “I frequently find that I don’t know how to keep a conversation going”

- **Imagination**
  - “When I’m reading a story, I find it difficult to work out the characters’ intentions”

- **Attention to detail**
  - “I usually notice car number plates or similar strings of information”

- **Attention-switching**
  - “I frequently get so absorbed in one thing that I lose sight of other things”
“Autistic” traits, language, and cognition

- The “Ganong” Effect (Stewart & Ota 2008)
- Absolute pitch (Heaton, Hermelin, & Pring 1998)
- Use of semantic context to disambiguate homographs (Happe 1997) or sentences (Jolliffe & Baron-Cohen 1999)
- Scalar inference (Nieuwland et al. 2010)
- Inverted face recognition (Wyer et al 2012)
- Embedded Figure Task (Shah & Frith 1983)
- ...

...
Assuming that there exists a perception-production feedback loop, is coarticulated speech mediated by “autistic” traits as well?
Simple compensation scheme:

- Listener identifies speaker and vowel.
- Recodes cues relative to expectations for that speaker/vowel.
C-CuRE

Cole, Linebaugh, Munson & McMurray (2010, JPhon)
McMurray, Cole & Munson (2011?)
McMurray & Jongman (2011)
Predictions

**Allophony**

- **Low AQ**: More coarticulation (/su/ → [ʃu])
- **High AQ**: Less coarticulation (/su/ → [su])

Say What ???

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“I said ‘barium,’ not ‘bury him’!”
“… generally articulated by placing the tip of the tongue against the back of the lower front teeth. The area between the blade and the front of the tongue is raised against the region between the alveolar ridge and the hard palate. They have a sound value between apico-alveolars and fronto-prepalatals.” (Dow 1972:157)
Free variation in Cantonese /s/

- “Before the front vowel /i/, /c c’ s/ are articulated in dental-alveolar position; before /oe/ and especially before /oeʔ]/, in a position between alveolar and pre-palatal; before /y/, in the same position as before /oe/, but with lip rounding.” (Kao 1972: 62)

- /s/ has two allophones (Cheung 1986):
  - /s/ → [ʃ] / ____ [+round]
  - /s/ → [s] / elsewhere
Free variation in Cantonese /s/

- Different speakers show this allophony at different rates (Bauer & Benedict 1997, Cheung 2005, Cheng 2006,)
- What governs the variation?
A production study: Cantonese

- 詩 /si55/
- 書 /sy55/
- 沙 /sa55/
- ...

- 30 tokens
  - 5 vowels (i e a o y) x 2
    tones x 3 repetitions
  - Part of a larger study of Cantonese sound change in progress.
A production study: Cantonese

- **Measurements:**
  - Spectral peak and centroid frequencies at three positions
    - Negatively correlates with the length of the front resonating cavity
  - Duration

![Graph showing spectral analysis](image-url)
Model: Peak Frequency

Fixed effects:

<table>
<thead>
<tr>
<th>Term</th>
<th>Estimate</th>
<th>Std. Error</th>
<th>t value</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Intercept)</td>
<td>6129.38</td>
<td>296.79</td>
<td>20.652</td>
</tr>
<tr>
<td>cAGE</td>
<td>-242.51</td>
<td>218.58</td>
<td>-1.109</td>
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<tr>
<td>cDur</td>
<td>267.73</td>
<td>103.92</td>
<td>2.576</td>
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<td>round1</td>
<td>-877.67</td>
<td>133.45</td>
<td>-6.577</td>
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<tr>
<td>Position2</td>
<td>395.51</td>
<td>89.37</td>
<td>4.425</td>
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<tr>
<td>Position3</td>
<td>89.81</td>
<td>96.75</td>
<td>0.928</td>
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<tr>
<td>SEX1</td>
<td>524.12</td>
<td>237.06</td>
<td>2.211</td>
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<tr>
<td>cAQ</td>
<td>135.47</td>
<td>242.59</td>
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<td>cDur:round1</td>
<td>46.14</td>
<td>95.88</td>
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<td>round1:Position2</td>
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<td>round1:Position3</td>
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<td>108.64</td>
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<tr>
<td>round1:SEX1</td>
<td>-345.05</td>
<td>81.38</td>
<td>-4.240</td>
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<tr>
<td>cDur:cAQ</td>
<td>-10.76</td>
<td>51.04</td>
<td>-0.211</td>
</tr>
<tr>
<td>round1:cAQ</td>
<td>261.87</td>
<td>79.87</td>
<td>3.279</td>
</tr>
</tbody>
</table>

`lmer(Peak ~ cAGE + cDur * round + round * Position + SEX * round + cAQ * cDur + cAQ * round + (1|Label) + (1+cDur*round+round*Position|Subject), data=x)`
Effects of rounding and sex

- Left: Box plot showing the effect of rounding on peak frequency, comparing 'round' vs 'unround' categories.
- Right: Box plot showing the effect of sex (Female vs Male) on peak frequency.
Effects of measurement position
Female vs. male

beta = -345.05, p < 0.001
Round x AQ

Individuals with more autistic traits (high AQ) exhibit lesser rounding effects from the following vowel.
A production study: English

- 24 target words begin with CV sequences where 
  \( C = \{s, \text{ʃ} \} \) and 
  \( V = \{i, æ, u\} \).

- Two conditions
  - Target words embedded in a standard carrier phrase
    (i.e., “Say ‘sheet’ again”)
  - Target words embedded in a question/answer pair
    - What is the difference between a balance sheet and a bed sheet?
    - The difference between a balance sheet and a bed sheet is …
      [where you keep it in your house]
Preliminary results
Summary

Low AQ

High AQ
Implications and conclusions

- More subjects are needed to ascertain the robustness of the individual-difference effects observed here.

- To the extent that the patterns reported here are robust, we may hypothesize that...
Implications and conclusions

- Linguistic variants may not be distributed randomly in the population.
  - Individual differences in speech processing may result in competing perceptual and production norms within a speech community (i.e., linguistic variation).
## Predictions

### Allophony

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  - Individual differences in speech processing may result in competing perceptual and production norms within a speech community (i.e. linguistic variation).
  - This variation is associated with individual differences in cognitive processing style, such as “autistic” traits, which are associated with particular social-personality traits.
Social skills and personality traits

Yu 2013
Implications and conclusions

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  - Individual differences in speech processing may result in competing perceptual and production norms within a speech community (i.e. linguistic variation).
  - This variation is associated with individual differences in cognitive processing style, such as “autistic” traits, which are associated with particular social-personality traits.
  - **Individual differences in cognitive processing style**, when differentiated in socially relevant ways, may lead variation in perceptual and production norms to structure along the similar social dimensions.
Thanks!

Lab members
- James Grove
- Julian Grove
- Alison Thumel

Funding sources