Why Adapt?
Phonotactic Learning as Non-Native Language Adaptation

Thomas Denby and Matt Goldrick
Northwestern University
Phonotactic Adaptation

• Phonotactics: Restrictions over sequences of speech sounds
  – e.g. English: sung but no ngus
  – Cross-linguistic variation: Vietnamese ngu ("sleep")

• Adults rapidly adapt to novel phonotactic constraints
  – After minimal exposure to lab-based constraints, speech error patterns rapidly shift, resembling error patterns based on native constraints (Dell et al., 2000)
Puzzle: Adaptation is Limited

• Constraints based on individual talkers difficult to learn (Onishi, Chambers, and Fisher, 2002)
  – E.g. “Frank never ends his syllables with /f/; Rebecca never ends her syllables with /t/”

• Unexpected, as the speech perception system is highly flexible
  – Listeners can learn talker-specific phonetic category boundaries (e.g., Kraljic & Samuel, 2007)
Clue: Variation is limited

• Talkers that share a language don’t differ in their phonotactic grammars
  – Communicative pressure for phonotactic grammars to be widely shared within communities (Pierrehumbert, 2001)

• Talkers that don’t share a language can have different phonotactic grammars
  – e.g., /ng/ English vs. Vietnamese
Hypothesis

Listeners integrate prior experience with information about talker background during adaptation
Hypothesis

Listeners integrate prior experience with information about talker background during adaptation

- Listeners make inferences about talkers during adaptation
  - Can include detailed information about talker background
  - Talker “modeling” occurs in other domains (e.g. phonetic adaptation; Kleinschmidt and Jaeger, 2015)

- Integrate prior experience when adapting
Hypothesis

*Listeners integrate prior experience with information about talker background during adaptation*

- Listeners make inferences about talkers during adaptation
- Integrate prior experience when adapting
  - Experience suggests languages, not individuals, vary in phonotactics
  - Listeners only adapt when prior experience suggests they should
When Should Phonotactic Adaptation Occur?

- Listeners assume they are being exposed to a ‘lab language’ different from English (Warker, 2013)

- Listeners’ prior experience strongly suggests individual talkers speaking a shared language do not differ
  - Talker-specific constraints should be difficult to learn

- Prior experience suggests talkers with different language backgrounds can have different phonotactics
  - Novel prediction: Listeners should adapt to talker-specific constraints when talkers differ in language background
Experiment Overview

• Listeners exposed to talker-specific constraints
  – E.g. “Speaker A does not end their syllables in fricatives; speaker B doesn’t end their syllables in stops”

• Experiment 1: Shared language background
  – Two native talkers (different genders)

• Experiments 2,3: Different language background
  – One native talker, one French talker (both female)
  – Strong (2) vs. weaker (3) cues to language difference
Recognition Memory Task

• Listeners hear a series of nonsense syllables without breaks
• Prompt: “Have you heard this sound before?”
• After stimulus plays: respond “YES” or “NO”

• Listeners asked to track nonsense syllables in memory
• Can probe learnability of constraints (Bernard, 2015; Steele, et al., 2015; Denby et al., under review)
Recognition Memory

“No fricatives in coda; stops unrestricted”

• Phase I: Familiarization
  – Expose listeners to repeated instances following constraint
    \textit{pak, sut, kut, shap, kut, pak, tap...}
Recognition Memory

“No fricatives in coda; stops unrestricted”

• Phase II: Generalization
  – Expose listeners to occasional **novel** generalization syllable
    tap, sut, pak, tus, kut, pik, shap...
Recognition Memory

“No fricatives in coda; stops unrestricted”

- Phase II: Generalization
  - Expose listeners to occasional novel generalization syllable tap, sut, pak, tus, kut, pik, shap...
  - Legal (follows constraint) or illegal (violates constraint)

Do participants incorrectly respond “yes” more often on legal syllables?
Methods

• 16 Participants (AMT; passed criteria for attending to task)

• Stimuli
  – 72 CVC nonsense syllables
  – 6 onsets {s,sh,f,t,k,p} * 2 vowels {i,u} * 6 codas
  – One speaker ends syllables in fricatives; other speaker in stops (counter-balanced)

• Procedure
  – Familiarization: 4 reps of 36 syllables
  – Generalization: 9 more reps of familiarization syllables, intermixed with 36 novel generalization syllables (4/block)
Generalization syllables following familiarization pattern are *legal*, those that don’t are *illegal*

<table>
<thead>
<tr>
<th></th>
<th><strong>Speaker A:</strong> Fricative codas</th>
<th><strong>Speaker B:</strong> Stop codas</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Familiarization</strong></td>
<td><strong>fuf, kish, tis, shuf</strong></td>
<td><strong>fut, kip, tik, shuk</strong></td>
</tr>
<tr>
<td><strong>Generalization - legal</strong></td>
<td><strong>fif, kush, fit, kup</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Generalization - illegal</strong></td>
<td><strong>tus, tuf, tuk, ship</strong></td>
<td></td>
</tr>
</tbody>
</table>

*Learning: Greater “yes” responses on legal vs. illegal*
Shared Language Background

• Two native English talkers
  – Male + Female
Results: Shared Language Background

- 3.5% legality advantage
- No significant effect of legality
- Difficult to learn talker-specific phonotactics
  - Replicates previous results using a new paradigm

![Graph showing %Yes on Generalization vs. Legality]

n.s.
Different Language Background I: Strong Cue to Language

• Replace male talker with a female French talker

• Vowels for French productions: [i, y]
  – [y] perceived as an (unusual) token of [u] by native English speakers (Levy, 2009)
Different Language Background I: Strong Cue to Language

• 13.9% legality advantage

• **Significant legality effect** ($\beta = 0.73$, s.e. $\beta = 0.19$, $\chi^2(1) = 13.1$, $p < 0.001$)

• Learners can acquire talker-specific constraints when talkers have different language backgrounds
Different Language Background II: Weaker Cue to Language

• Same French female talker.

• Vowels for French productions: [i, u]
  – Less distinct than French [y] and English [u]
  – (but not identical: Flege, 1987)
Different Language Background II: Weaker Cue to Language

- 9.4% legality advantage

- **Significant legality effect** ($\beta = 0.46$, s.e. $\beta = 0.19$, $\chi^2(1) = 6.14$, $p < 0.05$)

- Learners can acquire talker-specific constraints when talkers have different language backgrounds
Cross-Experiment Comparison

![Graph showing the comparison of Legality Advantage across Shared, Weak-Diff, and Strong-Diff categories, with no data points.]
Results

• Listeners adapt to talker-specific constraints only if talkers differ in language background
  – Differing language background serves as evidence that talkers should have different underlying phonotactic grammars

• Adaptation is a function of cue strength
  – Stronger evidence for difference in language background leads to stronger adaptation
  – Current work: Higher-powered replication
Extensions: Production

• Talkers model their interlocutors (e.g. phonetic imitation: Babel, 2012)

• Assuming production adaptation relies on similar mechanisms, effect should extend to production.
  – Adaptation to interlocutor-specific constraints when the talker has evidence interlocutors have different language backgrounds.
Phonotactic Adaptation: Inference Using Past Experience

• Puzzle
  – Listeners are highly adaptive; why no adaptation to talker-specific phonotactics?

• Hypothesis
  – Listeners use past experience when making inferences about talkers
  – Past experience suggests only languages, not individuals, differ

• Results
  – Listeners only adapt when there are cues that talkers have different language backgrounds
Thank you!

NU Linguistics Department for funding
Thanks to Melissa Baese-Berk, Chun Chan, and the NU SoundLab for their help and feedback!

tdenby [at] u.northwestern.edu
sites.northwestern.edu/denby 
Northwestern University
Future Directions

• Talker inference
  – Are listeners truly making inferences about talkers?
  – Or does accented speech intrinsically lead to adaptation?
  – Control experiment
    • Expose participants to two talkers of the same (non-native) accent
    • If this is about inference over talkers, listeners should not adapt

1 Thanks to Melissa Baese-Berk for this question/suggestion