Why Adapt?
Phonotactic Learning as Non-Native Language Adaptation

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Phonotactic Adaptation

- Phonotactics: Restrictions over sequences of speech sounds
  - e.g. English: *sung* but no ***ng**us*
  - Cross-linguistic variation: Vietnamese ***ng**u* ("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

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- 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

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- 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

    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*

	Speaker A: Fricative codas	Speaker B: Stop codas
Familiarization	fu**f**, ki**sh**, ti**s**, shu**f**	fu**t**, ki**p**, ti**k**, shu**k**
*Generalization - **legal***	fi**f**, ku**sh**, fi**t**, **kup**	
*Generalization - **illegal***	tu**s**, tu**f**, tu**k**, shi**p**	

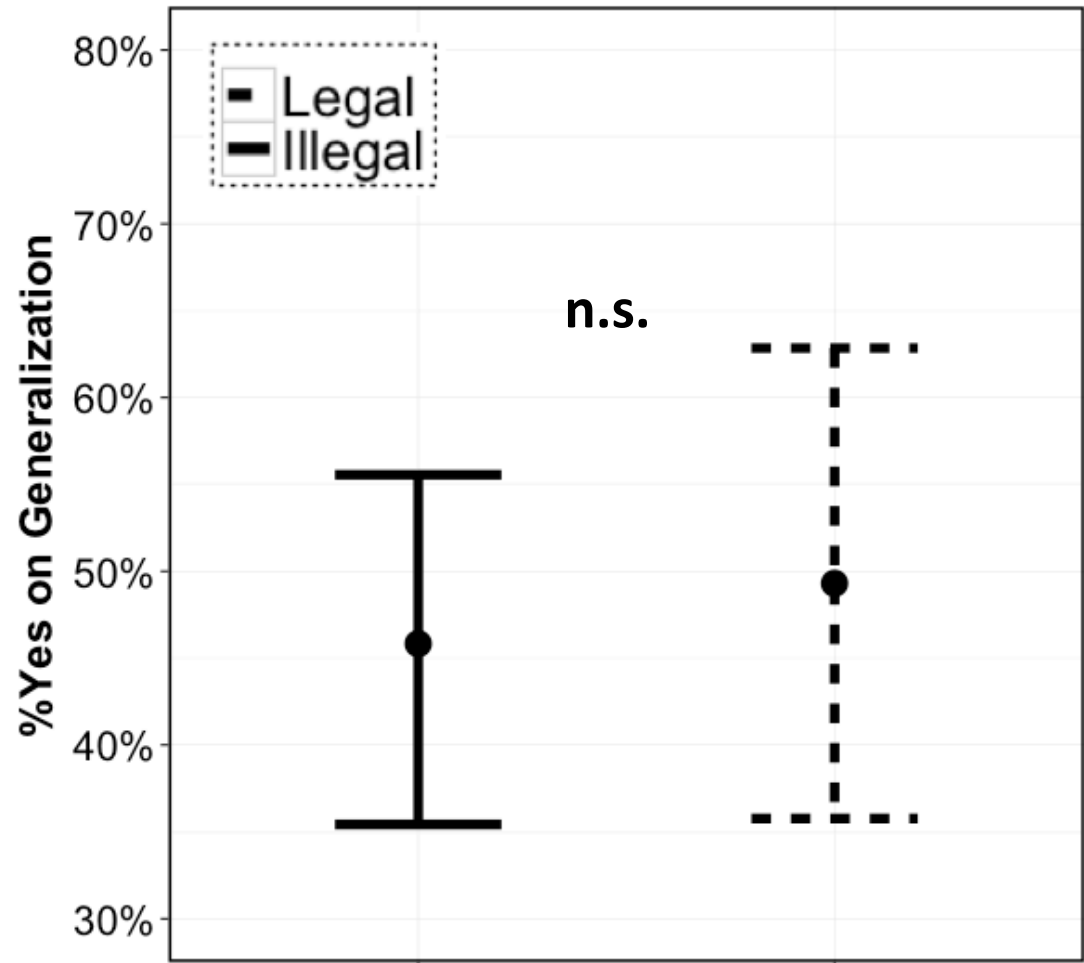*Learning: Greater "yes" responses on legal vs. illegal*

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

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
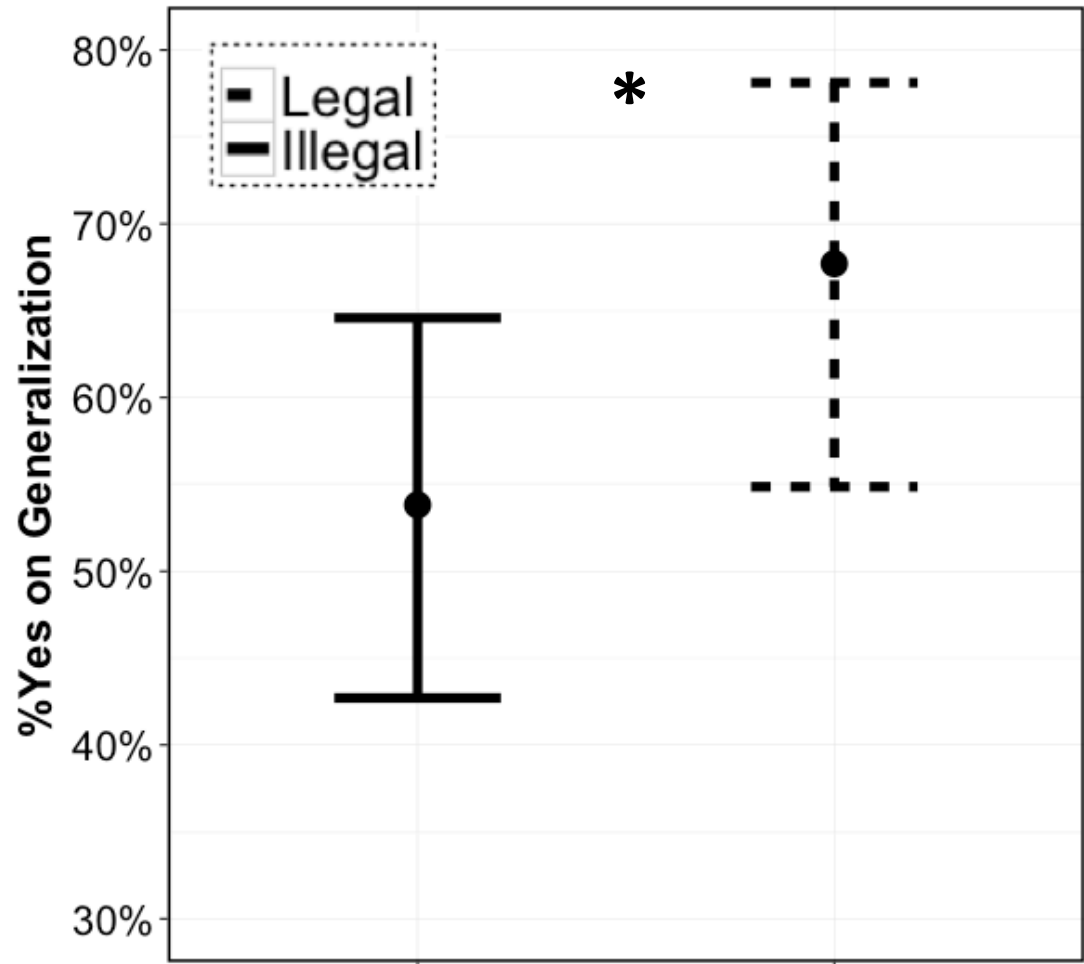
Different Language Background II: Weaker Cue to Language

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

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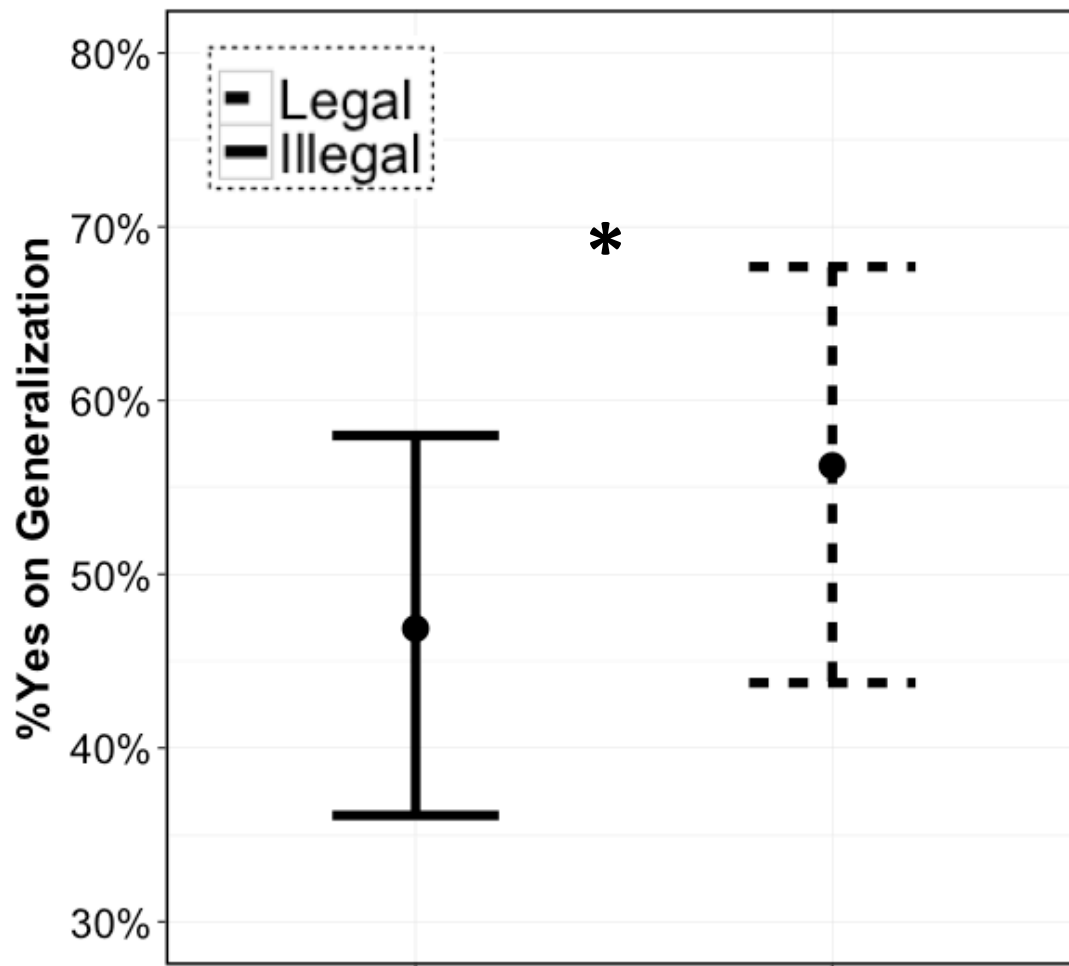
Cross-Experiment Comparison

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!

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Future Directions

- Talker inference[1]
  - 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