

Phonotactic learning as adaptation to non-native speech

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MidPhon 21

Phonotactics

- Restrictions over sequences of speech sounds
 - e.g. English: */#ŋ/ vs. /ŋ#/
 - Cross-linguistic variation
 - E.g. Nenets: /#ŋ/ vs. */ŋ#/
- Part of the speaker's grammatical knowledge
 - Used in production and perception of novel items
 - E.g. Jusczyk et al. (1993); McQueen (1998); Vitevitch & Luce (1998); Munson (2001)

Phonotactic Adaptation

- Adults rapidly adapt to novel phonotactic constraints
 - Production
 - Lab-learned constraints result in speech error patterns resembling error patterns from native constraints (e.g. Dell et al., 2000)
 - Perception
 - Listeners rate words that violate lab-learned constraints as less “word-like” (e.g. Richtsmeier, 2011)

Puzzles

- Why doesn't adaptation occur across all contexts?
 - Constraints based on individual talker difficult to learn (Onishi, Chambers, and Fisher, 2002)
 - E.g. “Frank never ends his syllables with fricatives; Rebecca never ends her syllables with plosives”
 - Talker-specific information learnable in other domains (e.g. speech perception: Nygaard and Pisoni, 1998)

Puzzles

- Why do adults maintain the ability to adapt?
 - 18+ years of experience with their native language telling them otherwise

Clue

- When do we encounter phonotactic variability?
 - Talkers within a speech community likely don't differ in their phonotactic grammars
 - Pressure for phonotactic grammars to be widely shared within speech community (Pierrehumbert, 2001)
 - Talkers *between* speech communities (e.g. different languages) clearly differ

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

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
 - Listeners only adapt when prior experience suggests they should

Puzzles

- Individual talkers
 - Listeners' prior experience strongly suggests individuals do **not** differ
 - Predicts talker-specific constraints should be difficult to learn

Puzzles

- Why do adults adapt?
 - Prior experience suggests phonotactics differ across languages
 - Do experiments test adaptation to non-native speech?
 - All adaptation studies, by definition, expose participants to non-native distributions
 - Participants may be learning “lab language”
 - Retain lab-learned constraints for 1 week (Warker, 2013), despite huge amount of conflicting English in interim

Prediction

- Listeners should adapt to talker-specific constraints only when talkers differ in accent
 - Prior experience suggests two talkers with language backgrounds should produce different phonotactics

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 plosives”
- Native condition
 - Two native talkers; different genders
- Accent condition
 - One native talker, one French talker
 - Both female
- 16 participants/condition (AMT)

Prediction

- Adaptation to talker-specific constraints only when talkers differ in accent
 - Adaptation in accent condition
 - No adaptation in native condition (Chambers, Onishi, & Fisher, 2002)

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
- Listeners learn categorical (Bernard, 2015; Steele, et al., 2015) and gradient constraints (Denby et al., under review)

Recognition Memory

**coda fricatives*

- Familiarization: expose listeners to repeated instances that follow constraint

pak, sut, kut, shap, kut, pak, tap...

Recognition Memory

**coda fricatives*

- Generalization: after familiarization, expose listeners to occasional novel generalization syllable

tap, sut, pak, tus, kut, pik, shap...

Recognition Memory

**coda fricatives*

- Generalization: after familiarization, expose listeners to occasional **novel** generalization syllable

*tap, sut, pak, **tus**, kut, **pik**, shap...*

Recognition Memory

**coda fricatives*

- Generalization: after familiarization, 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

- Stimuli
 - 72 CVC nonsense syllables
 - 6 onset consonants {s,sh,f,t,k,p} * 2 vowels {i,u} * 6 coda consonants
 - Syllables split by **coda consonant**: fricatives vs. plosives
 - One speaker ends syllables in fricatives; other speaker in plosives (counter-balanced)
- Procedure
 - Familiarization: 4 reps of 36 syllables
 - Generalization: 9 more reps of familiarization syllables, intermixed with 36 novel generalization syllables (4/block)

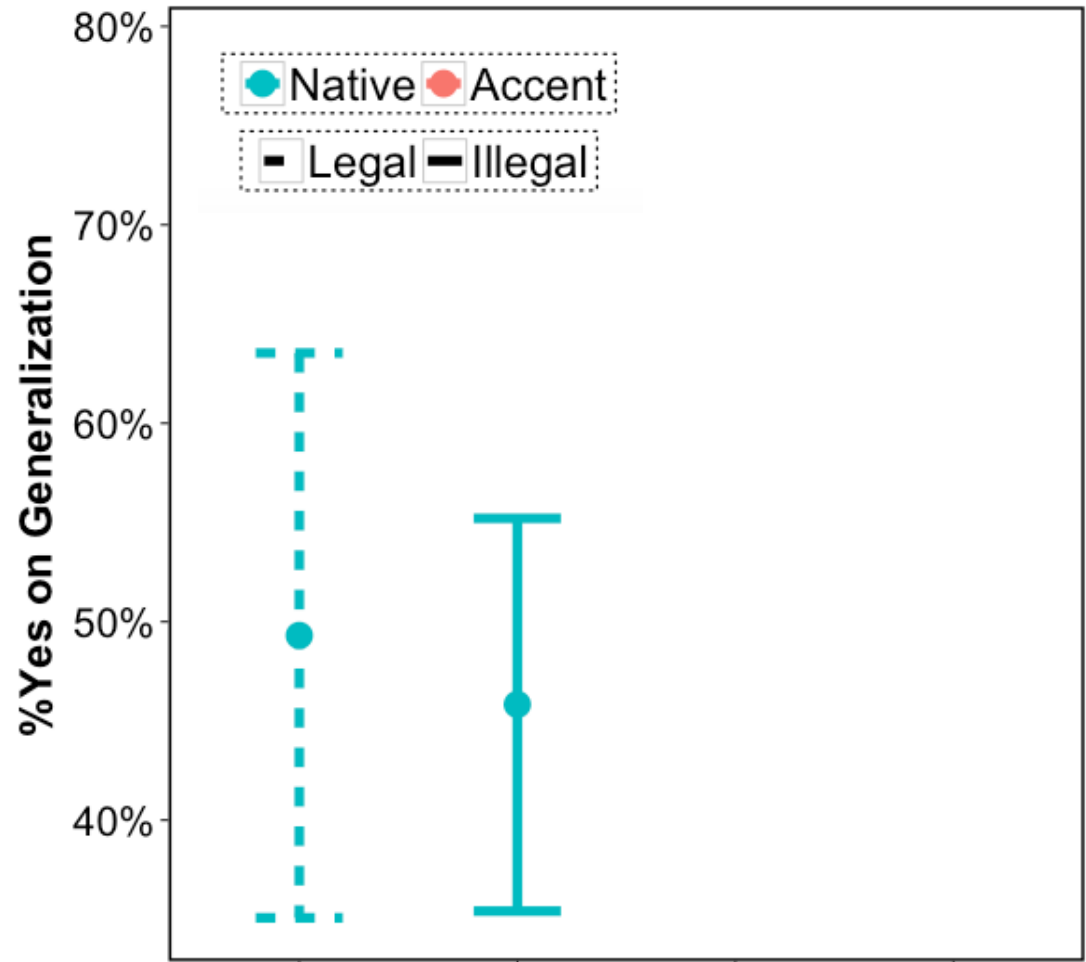
Generalization syllables following familiarization pattern/speaker combination are **legal**, those that don't are **illegal**

	Speaker A	Speaker B
<i>Familiarization</i>	fuf, kish, tis, shuf	fut, kip, tik, shuk
<i>Generalization - legal</i>	fif, kush, fit, kup	
<i>Generalization - illegal</i>	tus, tuf, tuk, ship	

Results

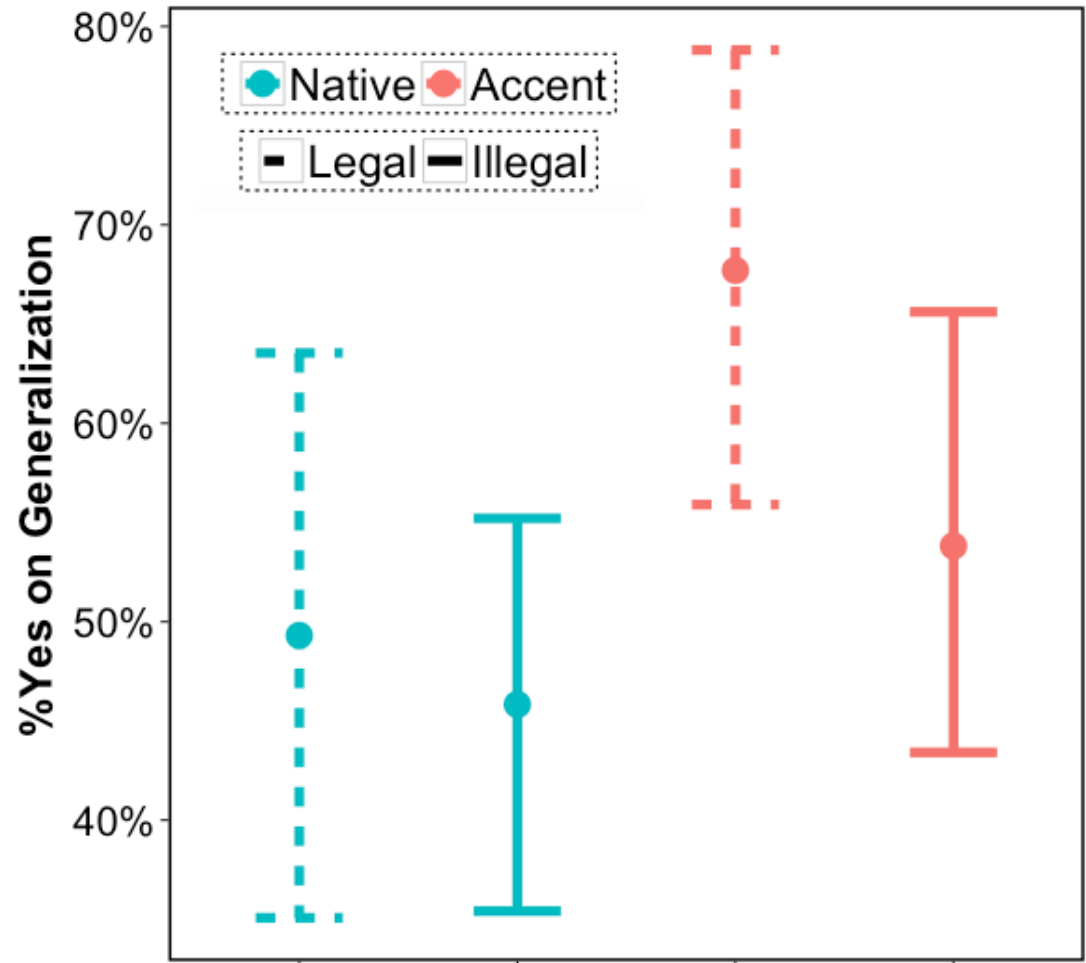
Results

- Native condition
 - 3.5% legality advantage



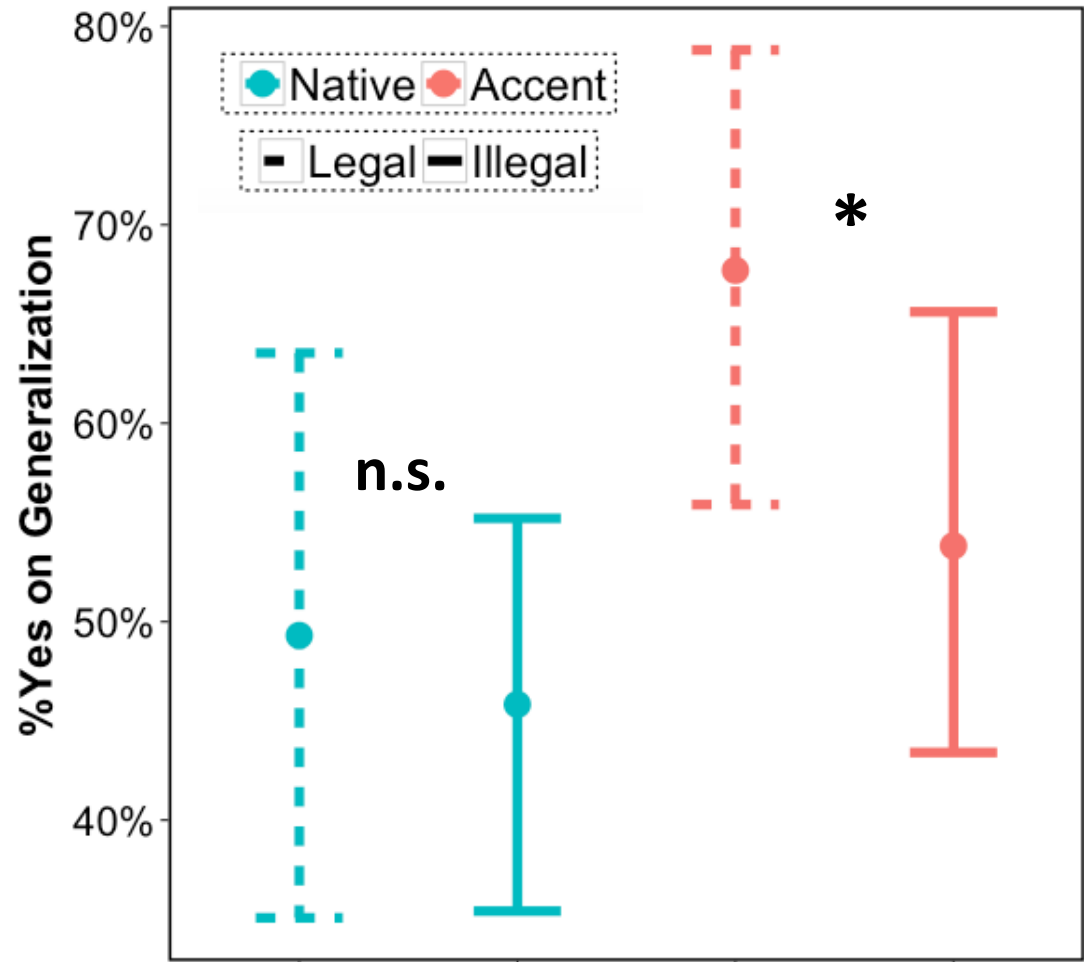
Results

- **Native condition**
 - 3.5% legality advantage
- **Accent condition**
 - 13.9% legality advantage



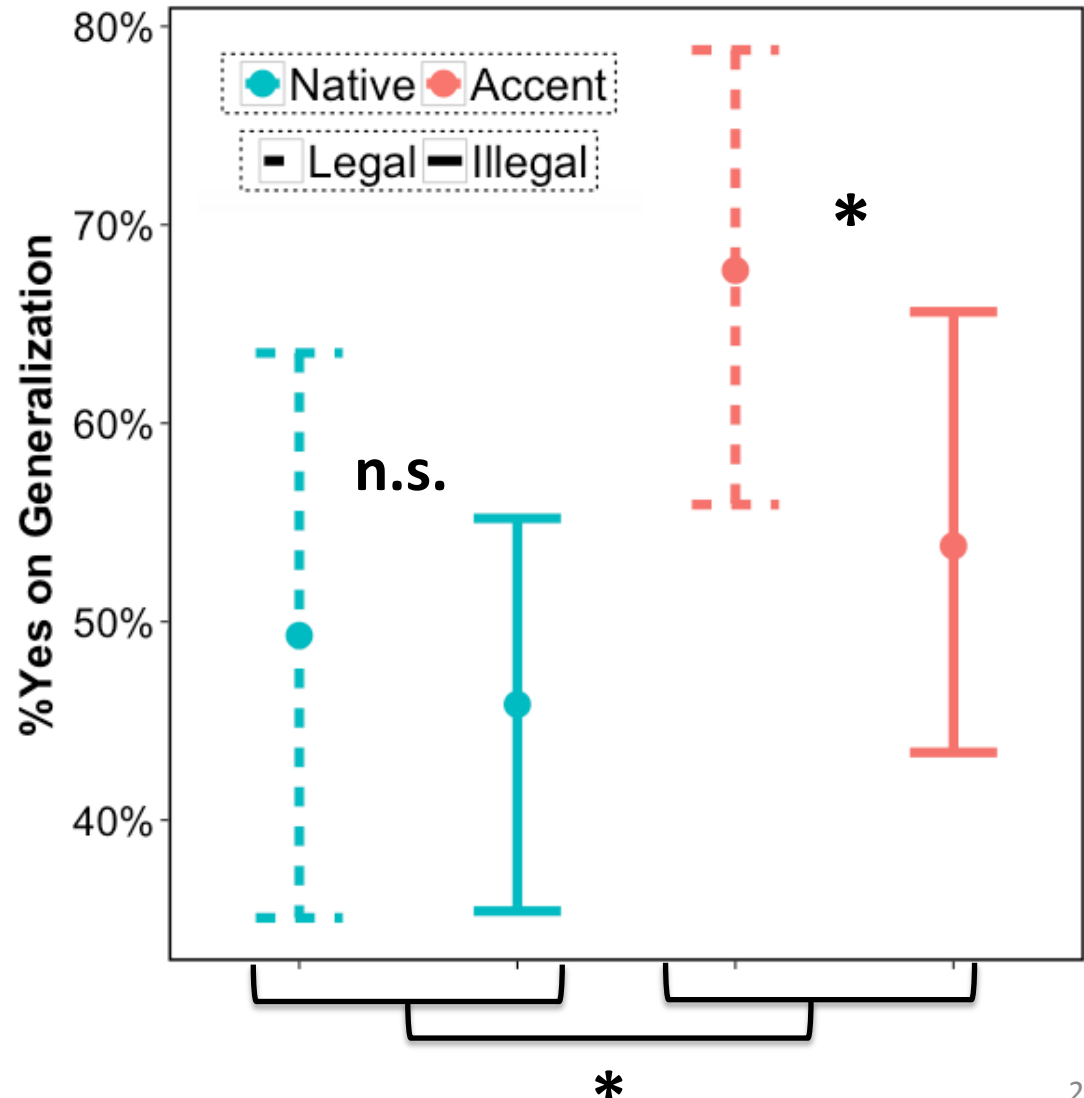
Results

- **Native condition**
 - 3.5% legality advantage
 - **No significant effect of legality**
- **Accent condition**
 - 13.9% legality advantage
 - **Significant legality effect** ($\beta = 0.73$, s.e. $\beta = 0.19$, $\chi^2(1) = 13.1$, $p < 0.001$)



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 - **Significant legality effect** ($\beta = 0.73$, s.e. $\beta = 0.19$, $\chi^2(1) = 13.1$, $p < 0.001$)
- **Significant legality * condition interaction** ($\beta = 0.58$, s.e. $\beta = 0.28$, $\chi^2(1) = 4.3$, $p < 0.05$)



Results

- Listeners adapt to talker-specific constraints only if talkers differ in accent
 - Listeners can learn language-level phonotactics, but not individual-level phonotactics
 - Differing accent is evidence that talkers should have different underlying grammars

CONCLUSION

Future Directions

- Talker inference¹
 - 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

Future Directions

- Production
 - Talkers model their listeners (e.g. phonetic imitation: Babel, 2012)
 - Effect should be independent of modality
 - We predict stronger adaptation when talker has evidence interlocutor is non-native

Future Directions

- Dialects
 - Dialects may provide intermediate case
 - Do speakers adapt when talkers differ in dialect?
 - Strength of adaptation should be weaker than language-level differences

Conclusion

- Two puzzles
 - Why no adaptation to individuals?
 - Why is there adaptation at all?
- Hypothesis
 - Listeners integrate past experience with inferences about talkers
 - Past experience suggests only languages, not individuals, differ
- Results
 - Listeners only adapt to individual talkers of different language backgrounds
 - Phonotactic learning may be motivated by adaptation to non-native speech

Thank you!

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