Crosslinguistic comparison of phonotactic repair in onset clusters

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Background.

Non-native sound sequences are often misheard such that they conform to listeners' native language (called ***phonotactic repair***) [1-4, 7, 8, 11]

- Typologically common repair, commonly produced by English & French listeners:

Actual		Reported [7-9]
*[tl-]	⇨	"KL"
*[dl-]	⇨	"GL"

  - Accurately identified by listeners of languages where [tl-] & [dl-] onsets attested [7,8]
- When hearing *gated* stimuli (see *Methods*), French & English listeners were most accurate in shorter gates, before vowel [7,9]

Debate over whether this represents a *direct* or *indirect* phonotactic effect

- **Direct:** phonological knowledge utilized to 'filter' segments/strings [4,12]
  - Phonotactic system performs online constraint evaluation
  - Either innate or learned phonotactic bias against [tl-]
- **Indirect:** phonological knowledge probabilistically influences cue mapping [1,10]
  - Spectral similarity of pre-lateral [t] & [k] release bursts
  - Asymmetrical repair due to relative frequency, token goodness for pre-lateral [t]

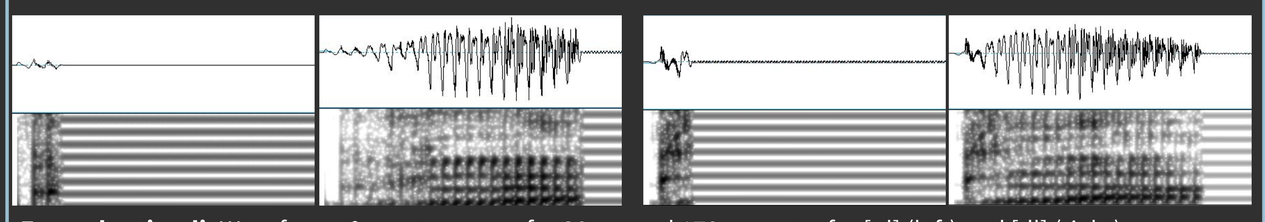
The present study compares English to Mexican Spanish

- Mexican Spanish: **[tl-] attested, but not *[dl-] (voiced counterpart)**
- Variability in [tl-] onsets (e.g., 'tlayuda' ~ 'clayuda') suggests [tl-] vs. [kl-] may not be reliably perceived; no prior systematic perceptual study
- Will Mex. Span. listeners extend auditory cue mapping to unfamiliar environment?

Sequence grammaticality			
Language	[kl-] & [gl-]	[tl-]	[dl-]
Polish, Hebrew	✓	✓	✓
Mexican Spanish	✓	✓	✗
English, French	✓	✗	✗
Mandarin Chinese	✗	✗	✗

Methods.

- Native English (N = 19) and Mexican Spanish (N = 28) listeners
- **Stimuli**: lateral **[tla]**, **[dla]**, **[kla]**, **[gla]** and glide [twa], [dwa], [kwa], [gwa] (from [2])
  - 2 base tokens each
  - **Gating:** stimuli included 30-170 ms (20 ms intervals) following release burst
    - 8 gate lengths per base token → 64 total stimulus conditions
  - Speech followed by 500 Hz square wave tone



Example stimuli. Waveforms & spectrograms for 30 ms and 170 ms gates for [gl] (left) and [dl] (right).

- **PsychoPy-based experiment**
  - Eng. listeners completed in lab, Mex. Spanish listeners completed online via Pavlovia
- **Forced-choice task**
  - Single auditory stimulus per trial, blocked by onset cluster type /Cw/ or /Cl/
  - Response via keyboard button without feedback
  - 5 randomized test blocks for each of the two onset cluster types
    - All stimuli (4 onsets x 2 tokens x 8 gates = 64) presented once per block
    - Total of 640 trials; 10 observations per stimulus condition, per participant

Hypotheses.

Rate of repair** will reflect **listener experience** with **contextual place cues

a. Mexican Spanish listeners will outperform Eng. place identification of **[tla]**
b. Mexican Spanish listeners will identify place of unattested **[dla]** with similar accuracy (i.e., despite phonotactics)
c. Timecourse will not affect Mexican Spanish listeners' accuracy

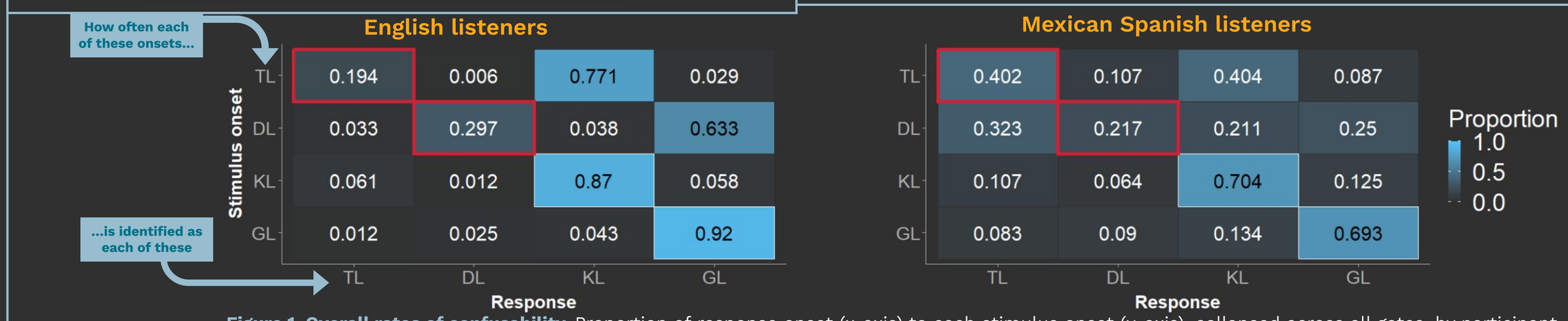


Figure 1. Overall rates of confusability. Proportion of response onset (x-axis) to each stimulus onset (y-axis), collapsed across all gates, by participant language. The cells outlined in red represent correct identification of [tl] and [dl].

Results.

✔ **Mex. Spanish listeners outperformed English listeners** in [tl] stimuli (Welch's t = -30.71, p < 0.001)

✔ **Mex. Span. listeners identify place equally well in [dl] & [tl]**

✗ Both groups **less accurate at later gates**; more so in English (z = 10.66, p < 0.0001)

	Estimate	Std. Error	z value	Pr(>|z|)	Odds Ratio
(Intercept)	0.2290	0.3301	0.6938	0.488	1.2573
Lang: Spanish	0.2373	0.3928	0.6042	0.546	1.2678
Gate	**-0.3641**	**0.0190**	**-19.1749**	**5.99e-82	**0.6948**
Lang(Sp)*Gate	**0.2760**	**0.0241**	**11.4337**	**2.84e-30	**1.3178**

Output of mixed effects logistic regression. Response accuracy for C1 place in [tl] & [dl] trials predicted by listener **language**, **gate**, and their **interaction**. Reference levels are English, 30 ms gate.

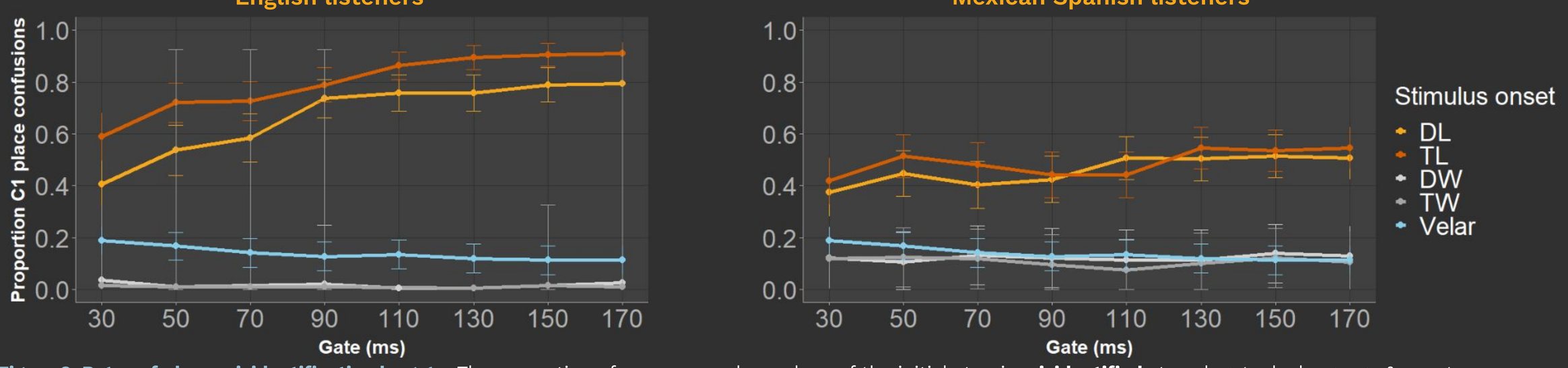


Figure 2. Rates of place misidentification by gate. The proportion of responses where place of the initial stop is **misidentified** at each gate, by language & onset.

Discussion.

Overall accuracy & rates of confusion support a probabilistic view

- Mx. Span. [tl-] appears to be more marginal than in, e.g., Polish & Hebrew
- Listeners equally able to **identify place cues correctly in [dl-] stimuli**
  - ➨ **Repair is independent of phonotactics *per se***
- Rate of voicing confusion for [dl-] in Mex. Span. listeners likely due to insufficient prevoicing in these stimuli; conducting follow-up with ~75 ms prevoicing [6]

Accuracy by gate

- Suggests that English listeners are more affected by later-arriving information
- Mexican Spanish listeners may be better able to extract (and thus have stronger weighting for) C1 place cues within the following lateral

Future directions.

Perceptual typology

- Currently extending this paradigm to Mandarin Chinese, where all onset clusters are unattested; phonetic experience limited
  - ➢ Better identification of [kl-, gl-] than [tl-, dl-] would suggest latent bias

Language dominance and mode

- Correlating identification with Bilingual Language Profile index of language dominance (compared to English) for both Mex. Spanish and Mandarin listeners [5]
- Testing bilinguals while manipulating language mode (as in [13])

Selected references. [1] Blevins & Grawunder, 2009. *KL> TL sound change in Germanic and elsewhere. [2] Breen, Kingston, & Sanders, 2013. Perceptual representations of phonotactically illegal syllables. [3] Brown & Hildum, 1958. Expectancy and the perception of syllables. [4] Dupoux, et al., 1999. Epenthetic vowels in Japanese: A perceptual illusion? [5] Gertken, Amengual & Birdsong, 2014. Assessing language dominance with the bilingual language profile. [6] Gorba & Cebrian, 2023. The acquisition of L2 voiced stops by English learners of Spanish and Spanish learners of English. [7] Hallé, et al., 1998. Processing of illegal consonant clusters: A case of perceptual assimilation?[8] Hallé & Best, 2007. Dental-to-velar perceptual assimilation: A cross-linguistic study of the perception of dental stop+/l/ clusters. [9] Kaplan, 2023. Is phonotactic repair of onset clusters modulated by listener expectations? [10] Kawasaki-Fukumori, 1992. An acoustical basis for universal phonotactic constraints. [11] Massaro & Cohen, 1983. Phonological context in speech perception. [12] Moreton, 2002. Structural constraints in the perception of English stop-sonorant clusters. [13] Simonet & Amengual, 2020. Increased language co-activation leads to enhanced cross-linguistic phonetic convergence.