Acquisition of allophonic variation in second language speech: An acoustic and articulatory study of English laterals by Japanese speakers

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Acquisition of L2 allophonic variation

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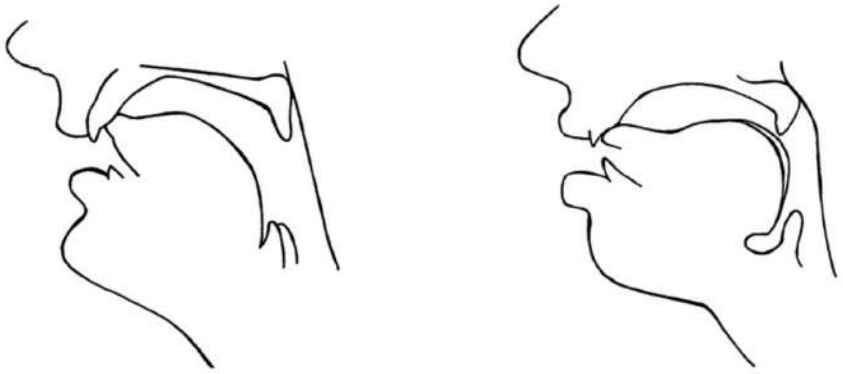
- Clear /l/: pre-vocalic, higher F2-F1, tongue body raising/fronting
- Dark /l/: post-vocalic, lower F2-F1, tongue dorsum lowering/retraction

(Sproat & Fujimura, 1993; Turton, 2017; Narayanan, Alwan, & Haker, 1997; Recasens, 2012)



Clear /l/ Dark /l/

Recasens (2012, p. 369)

Acquisition of L2 allophonic variation

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Do L2 speakers also employ similar articulatory strategies in distinguishing clear and dark /l/s?

L1 Japanese speakers often substitute English /l/ with Japanese /r/.

- Japanese /r/ lacks the specific TD gestural target (Yamane & Howson, 2015)
- L1 Japanese speakers use multiple articulatory strategies for English /r/ (Moore, Shaw, Kawahara & Arai, 2018)
- EPG data show L1 Japanese can learn the lateral allophony but show individual variations (Kochetov, 2022)

The current study

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What are the tongue shape properties in production of English lateral allophony by L1 Japanese speakers?

Key effects: **syllable position** (initial vs final)

vowel context (/i_a/, /i_i/, /a_i/, /a_a/)

Methods

Participants & Equipment

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Five participants

- L1 Japanese / L2 English
- Two females and three males
- Aged between 23 – 30 (*M* = 24.6)
- High L2 proficiency
- No speech//hearing impairment

Elicitation materials (cf. Gick et al., 2007)

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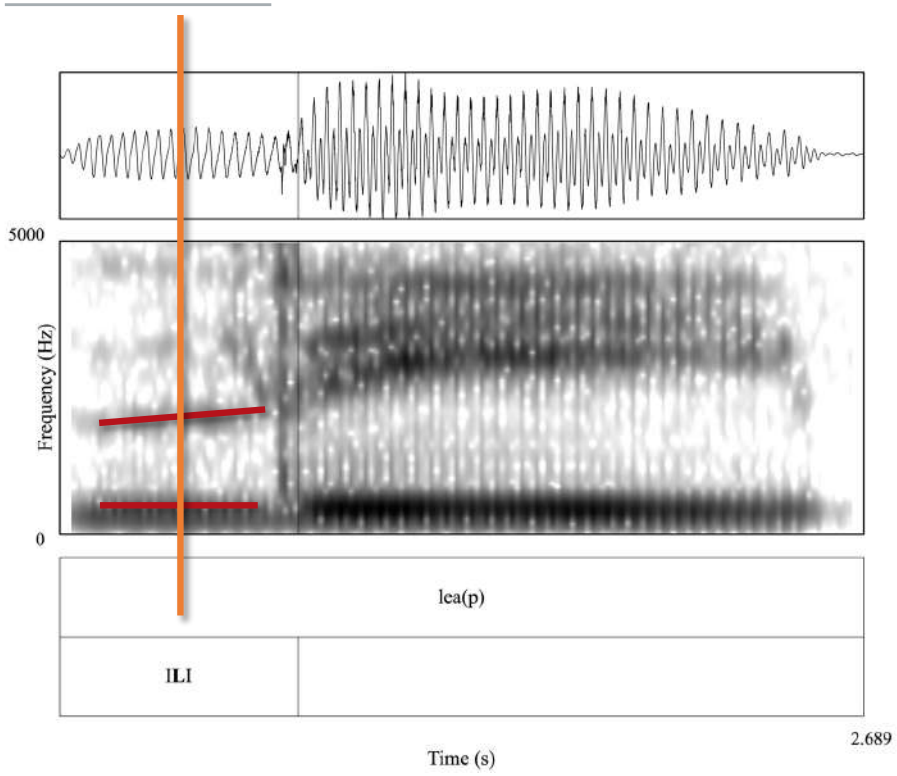
- **16** target words
  - 8 with word-initial /l/
  - 8 with word-final /l/
- **4** vowel environments
  - Pseudo phrases by adding another word before/after the target word
- Embedded in a carrier sentence
  - *'(Someone) said "X Y" to (someone's) boss.'*

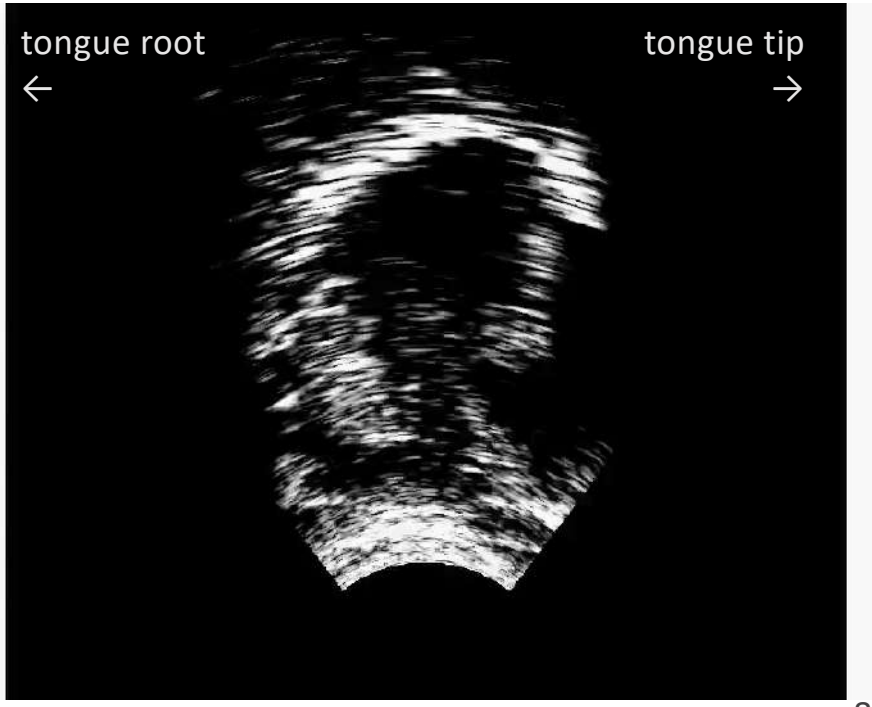
Vowel	Initial	Final	Example phrase
high	leap	peal	heap leap (i#li), peal heap (il#i)
	lead	deal	heap lead (i#li), deal heap (il#i)
	lean	kneel	hap lean (a#li), kneel hap (il#a)
	leave	veal	hap leave (a#li), veal hap (il#a)
low	lap	pal	heap lap (i#la), pal heap (al#i)
	lag	gal	heap lag (i#la), gal heap (al#i)
	lab	bal	hap lab (a#la), bal hap (al#a)
	lack	Cal	hap lack (a#la), Cal hap (al#a)

JP01F

JP03M

Acoustic / articulatory analysis





Statistical analysis: Mixed-effect models

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Acoustic: Linear mixed-effect model (LME)

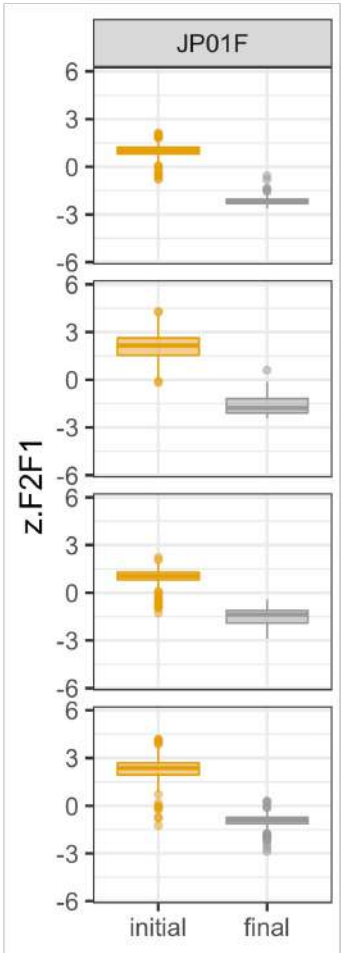
- Final model: *z.F2F1 ~* ***position*** *+* ***vowel*** *+ (1 + position + vowel | speaker) + position:vowel*

Articulation: Generalised additive mixed effect models (GAMMs)

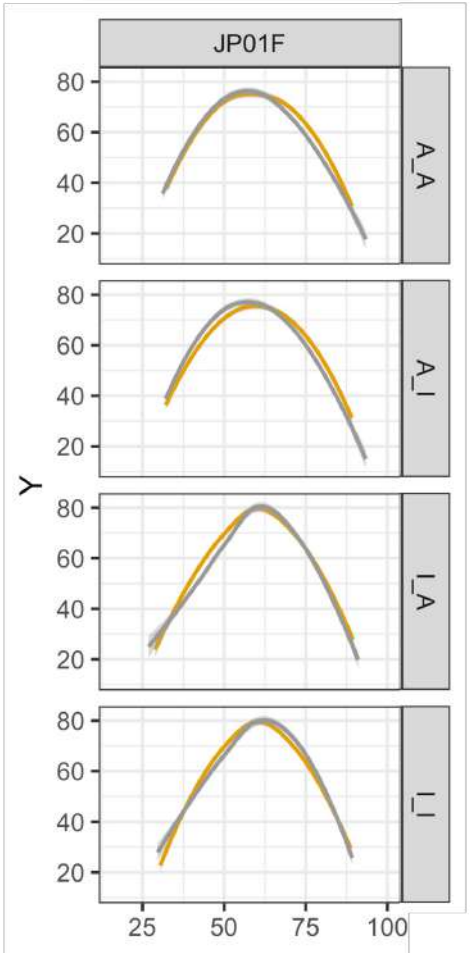
- Focussing only on within-speaker variations
- Full model: *Y ~* ***position*** *+* ***vowel*** *+ s(X, by = position) + s(X, by = vowel)*
- Position model: *Y ~* ***position*** *+ s(X, by = position)*
- Vowel-context model: *Y ~* ***vowel*** *+ s(X, by = vowel)*

Results & Discussion

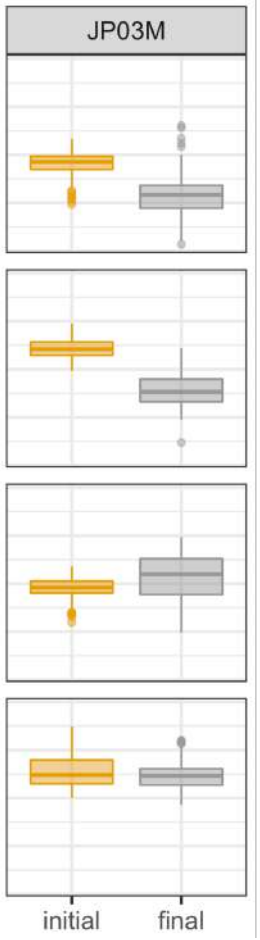
Acoustics



Articulation



Acoustics



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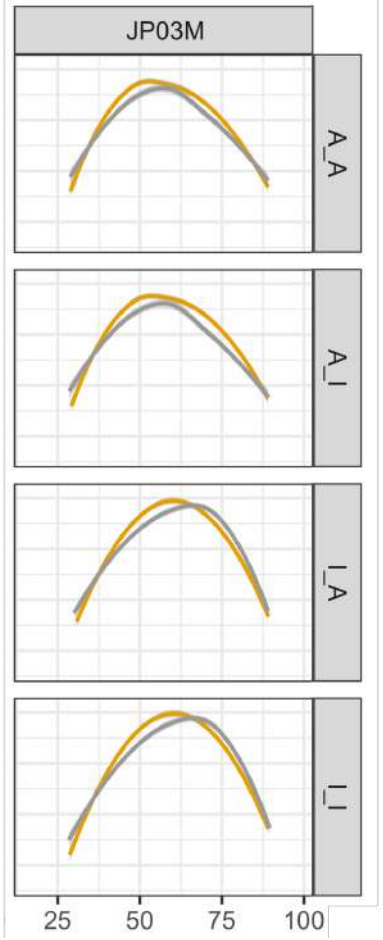

Acoustics – articulatory comparisons

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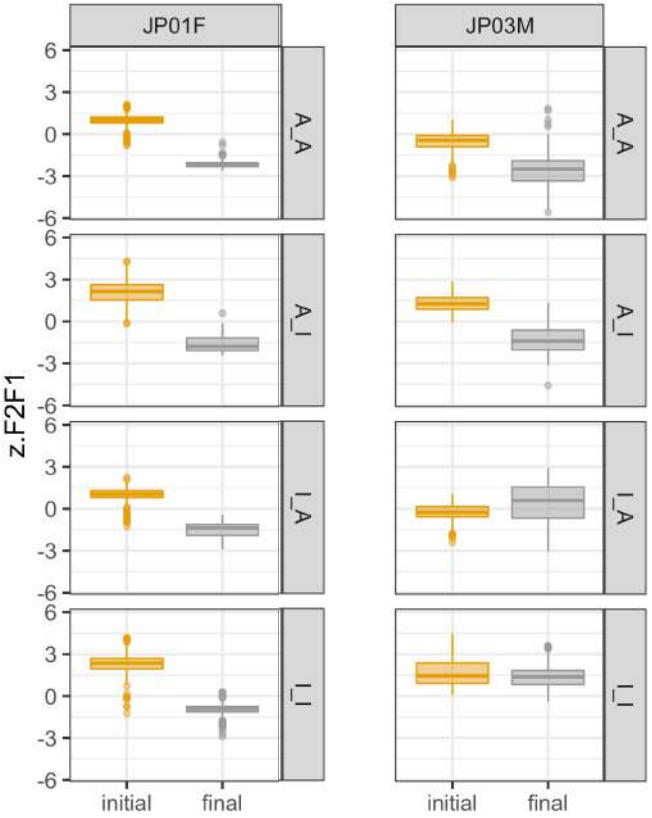
Acoustics

- **expected clear-dark patterns**
  - Higher F2-F1 word-initially
  - Lower F2-F1 word-finally
- **Significant effects of:**
  - ***Position*** ($\chi^2(1) = 8.801$, $p = .003$)
  - ***Vowel*** ($\chi^2(3) = 10.727$, $p = .013$)
  - ***Position-vowel*** **i**nteraction

    ($\chi^2(3) = 171.800$, $p < .001$)

Japanese speakers acquire the clear-dark allophony of laterals



Acoustics – articulatory comparisons

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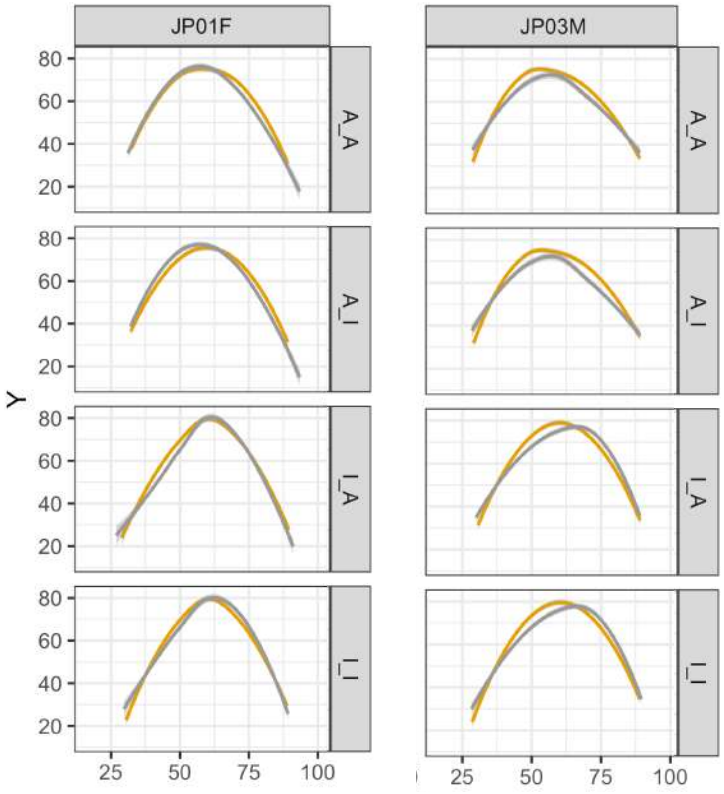
Articulation

- **Vowel context > syllable position**
  - Vowel context (sig.)
  - Position (n/s)
- The degree of contrast in articulation doesn't match that in acoustics.

Japanese speakers do not differentiate clear-dark /l/s in articulation?



Findings and discussion

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- **Acoustics: Position + Vowel**
- **Tongue shape: Vowel**
- **Acoustic-articulatory correspondence is not clear.**
  - JP01F: A **clear** contrast in **acoustics** but a **small** contrast in **articulation**
  - JP03M: A **small** contrast in **acoustics** but a **clear** contrast in **articulation**

Findings and discussion

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What could account for the acoustic-articulatory mismatch?

1. **Gestural complexity** (Sproat & Fujimura, 1993)
   - Clear and dark /l/s differ in the relative timing between lingual gestures.
   - Lateral midpoint may not represent the broad phonetic quality of /l/
   - Articulatory changes precede changes in acoustics (Ying, Shaw, Kroos & Best, 2012)

2. **Tongue lateralisation on the coronal plane**
   - Speakers may have an active control over the lateral gestures
     (Ying, Shaw, Carignan, Proctor, Derrick, & Best, 2021)
   - However, tongue lateralisation strategy is not always positively transferred from L1 to L2
     (Morimoto, 2021)

Conclusion

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- L1 Japanese speakers could acquire lateral allophony in English.
- The specific ways they demonstrate the contrast in articulation is still unknown.
- Future L2 research should take into **account the complex spatiotemporal coordination between articulatory gestures** in English /l/ (and /r/)
  - Tongue tip and tongue dorsum gestures for /l/ (e.g., Sproat & Fujimura, 1993)
  - Labial, tongue anterior and tongue posterior gestures for /r/

(e.g., Campbell, Gick, Wilson & Vatikiotis-Bateson, 2010)

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Key references (1)

Campbell, F., Gick, B., Wilson, I., & Vatikiotis-Bateson, E. (2010). Spatial and Temporal Properties of Gestures in North American English /r/. *Language and Speech*, *53*(1), 49–69. https://doi.org/10.1177/0023830909351209

Carter, P., & Local, J. (2007). F2 variation in Newcastle and Leeds English liquid systems. *Journal of the International Phonetic Association*, *37*(2), 183–199. https://doi.org/10.1017/S0025100307002939

Flege, J. E., & Bohn, O.-S. (2021). The Revised Speech Learning Model (SLM-r). In R. Wayland (Ed.), *Second Language Speech Learning: Theoretical and Empirical Progress* (1st ed., pp. 3–83). Cambridge University Press. https://doi.org/10.1017/9781108886901.002

Gick, B., Campbell, F., Oh, S., & Tamburri-Watt, L. (2006). Toward universals in the gestural organization of syllables: A cross-linguistic study of liquids. *Journal of Phonetics*, *34*(1), 49–72. https://doi.org/10.1016/j.wocn.2005.03.005

Kochetov, A. (2020). Research methods in articulatory phonetics I: Introduction and studying oral gestures. *Language and Linguistics Compass*, *14*(4), 1–1. https://doi.org/10.1111/lnc3.12368

Kochetov, A. (2022). *Production of English phonemic contrasts and allophony by Japanese learners: Electropalatographic evidence*. 43.

Moore, J., Shaw, J., Kawahara, S., & Arai, T. (2018). Articulation strategies for English liquids used by Japanese speakers. *Acoustical Science and Technology*, *39*(2), 75–83. https://doi.org/10.1250/ast.39.75

Morimoto, M. (2021). Articulatory Preference in Japanese Liquids and F3 in English: A Preliminary Report. *ICU Working Papers in Linguistics: Selected Papers from the 5th Asian Junior Linguists Conference (AJL5)*, *15*, 1–6.

Key references (2)

Narayanan, S. S., Alwan, A. A., & Haker, K. (1997). Toward articulatory-acoustic models for liquid approximants based on MRI and EPG data. Part I. The laterals. *The Journal of the Acoustical Society of America*, *101*(2), 1064–1077. https://doi.org/10.1121/1.418030

Recasens, D. (2012). A cross-language acoustic study of initial and final allophones of /l/. *Speech Communication*, *54*(3), 368–383. https://doi.org/10.1016/j.specom.2011.10.001

Sproat, R., & Fujimura, O. (1993). Allophonic variation in English /l/ and its implications for phonetic implementation. *Journal of Phonetics*, *21*(3), 291–311. https://doi.org/10.1016/S0095-4470(19)31340-3

Turton, D. (2017). Categorical or gradient? An ultrasound investigation of /l/-darkening and vocalization in varieties of English. *Laboratory Phonology: Journal of the Association for Laboratory Phonology*, *8*(1), 13. https://doi.org/10.5334/labphon.35

Yamane, N., & Howson, P. (2015). An ultrasound examination of taps in Japanese. *Proceedings of the 18th International Congress of Phonetic Sciences*, 5. https://www.internationalphoneticassociation.org/icphs-proceedings/ICPhS2015/Papers/ICPHS0815.pdf

Ying, J., Shaw, J. A., Carignan, C., Proctor, M., Derrick, D., & Best, C. T. (2021). Evidence for active control of tongue lateralization in Australian English /l/. *Journal of Phonetics*, *86*, 101039. https://doi.org/10.1016/j.wocn.2021.101039

Ying, J., Shaw, J. A., Kroos, C., & Best, C. T. (2012). Relations Between Acoustic and Articulatory Measurements of /l/. *Proceedings of the 14th Australasian International Conference on Speech Science and Technology*, 109–112.

Thank you!

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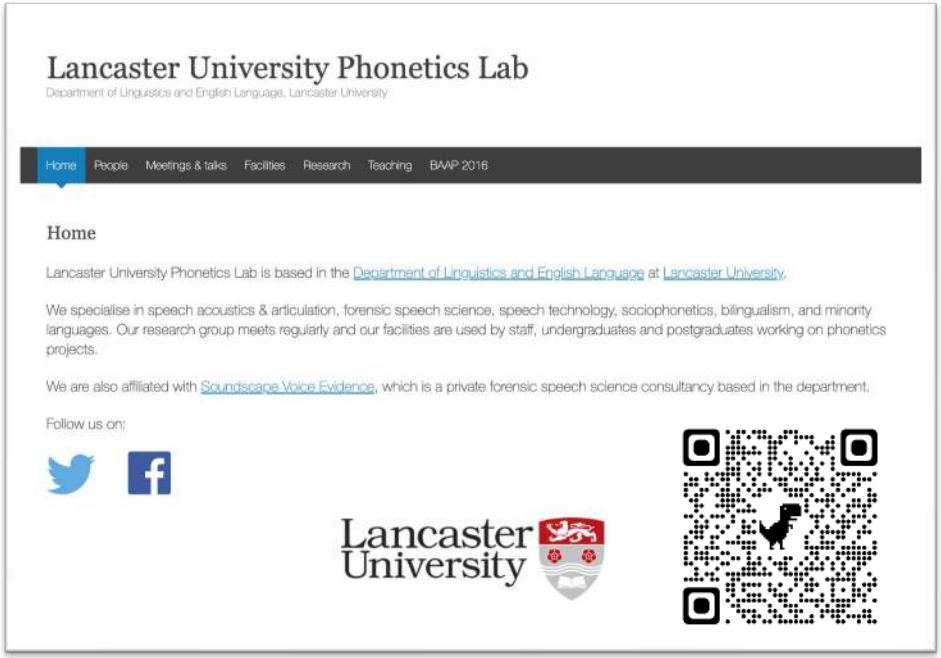

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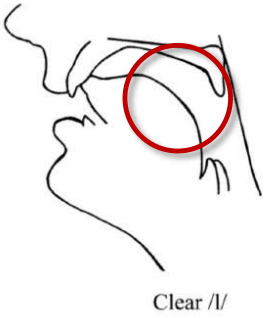
Unused slides

Acquisition of L2 allophonic variation

- Acquisition of position-sensitive allophones is **the fundamental mechanisms of second language (L2) speech learning**
  (Flege & Bohn, 2021)
- English laterals have two canonical allophonic variants:
  - Clear /l/: Syllable-initial, higher F2 and greater F2-F1 distance
  - Dark /l/: Syllable-final, lower F2 and smaller F2-F1 distance

  (Carter & Local, 2007)
- L1 English speakers employ **tongue tip (TT)** and **tongue dorsum (TD)** gestures to distinguish the two allophones in English laterals:
  - Clear /l/: tongue body raising/fronting
  - Dark /l/: pre-dorsum lowering, postdorsum retraction

  (Sproat & Fujimura, 1993; Turton, 2017; Narayanan, Alwan, & Haker, 1997; Recasens, 2012)



Recasens (2012, p. 369)