

# 2pSC36. The Pohnpeian stop contrast between laminal alveolars and apical dentals involves differences in VOT and F2 locus equation intercepts

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## Introduction

Pohnpeian (ISO639-3 pon) is a phonetically understudied Oceanic language spoken by about 34,000 people in the Federated States of Micronesia, and 12,000 in the US. Pohnpeian has a typologically uncommon contrast where the **laminal alveolar** stop /t̪/ contrasts with an **apical dental** stop /t̺/.

We explored the acoustic differences between the two stops via these analyses:

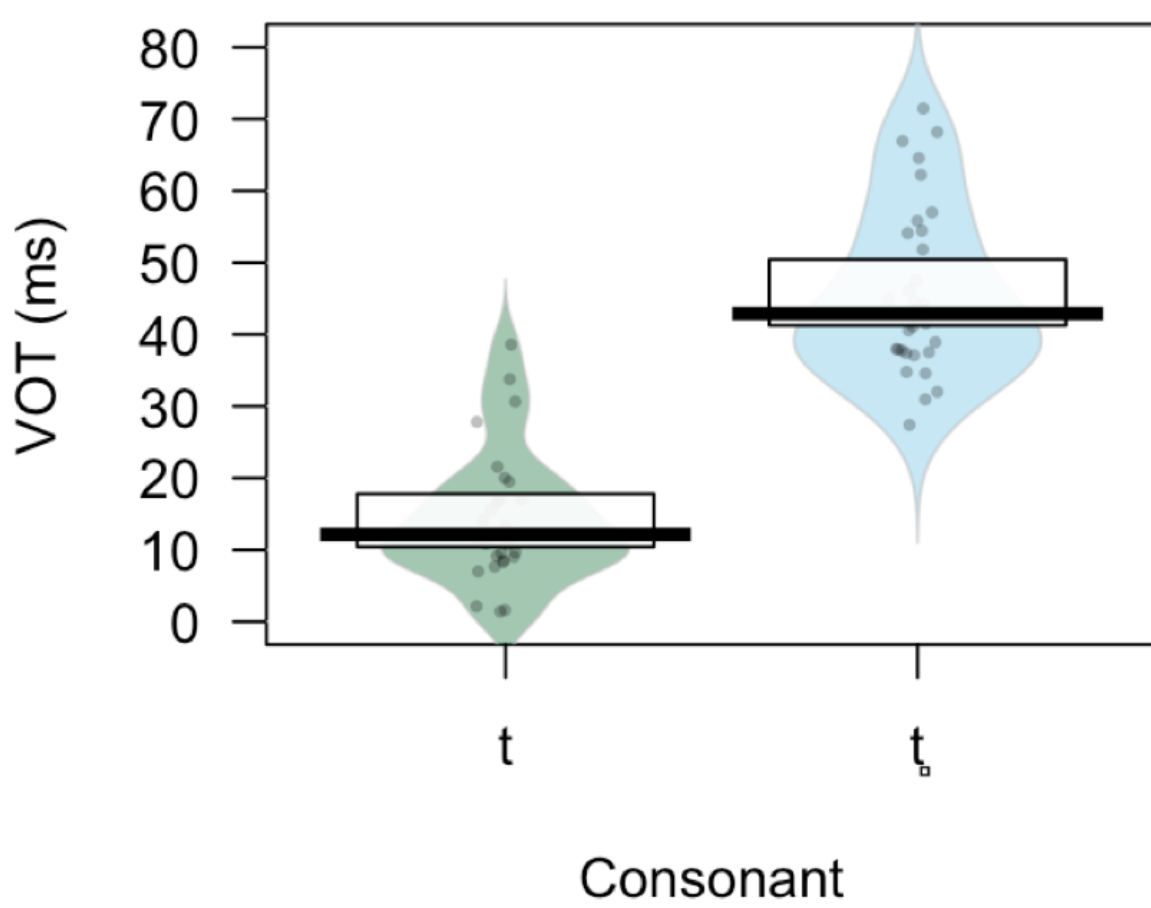
1. Voice Onset Time (VOT)
2. Locus equations
3. Burst spectral moments (center of gravity and skewness)

## Project Design

- Recorded 5 Pohnpeian L1 speakers on O'ahu (3 men, 2 women: mean age=42, range=27–51)
- Each speaker read phonetically controlled words in 3 sentence frames (each test word was repeated three times)
  1. \_\_\_ **irail kin inda**. '\_\_\_ they always say'
  2. **Irail kin inda** \_\_\_. 'They always say \_\_\_.'
  3. **Irail kin inda** \_\_\_ **nimenseng**. 'They always say \_\_\_ in the morning.'
- Test words: For /t̪/: /e:ten/ 'having a strong current' and /iti/ 'boundary'. For /t̺/: /e:te/ '1DU.INCL.POSS.CLF' and /it̪ik/ 'to shake'
- Results were analyzed using Bayesian Hierarchical Linear Modelling (BHLM)

## VOT

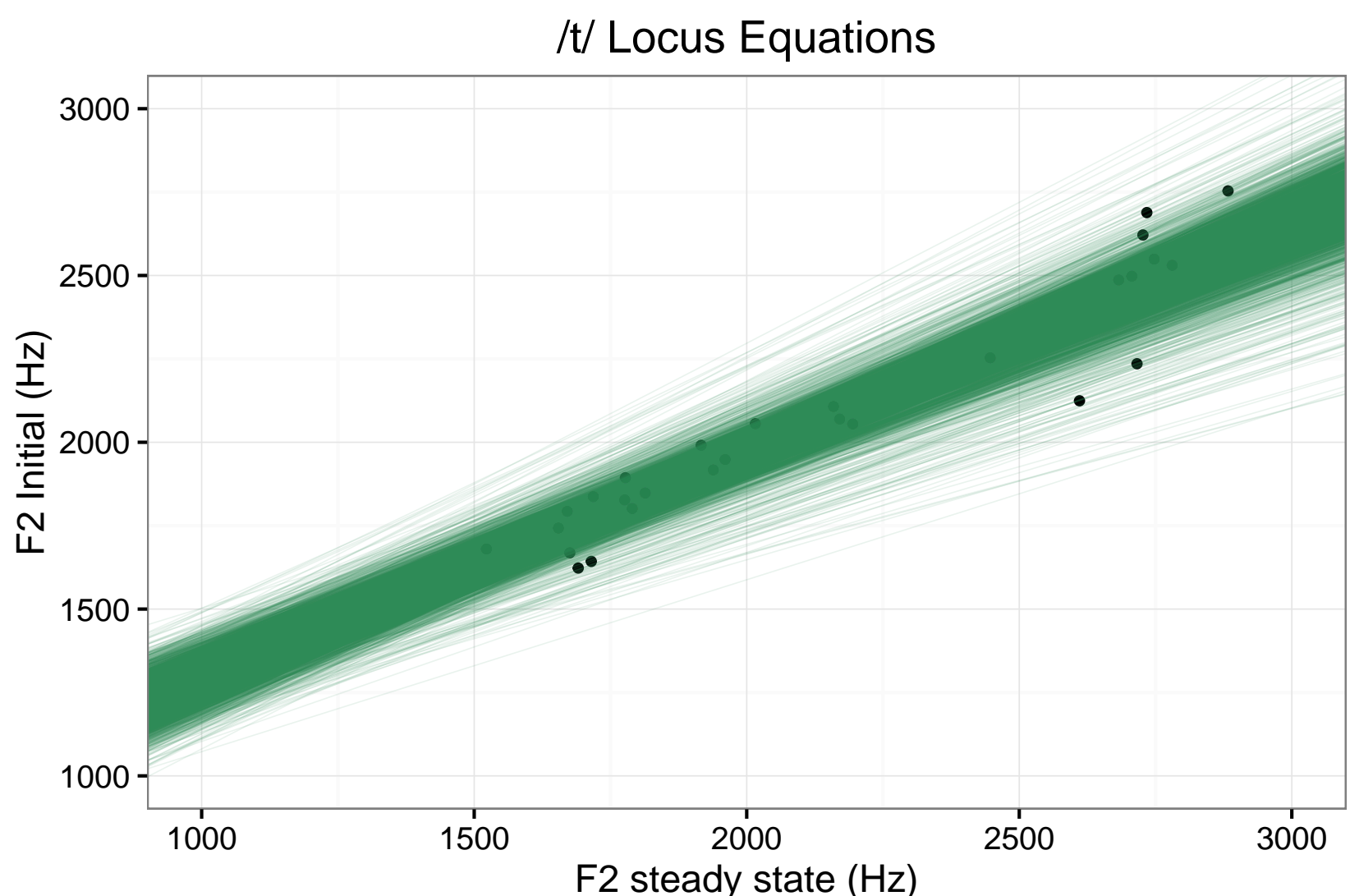
- For BHLM fixed effect: consonant; random effects: word and participant with random intercepts and slopes by consonant
- Laminal alveolar /t̪/ had a **longer** VOT than dental /t̺/ by average of 31.6ms (95% CrI = [6.7, 44.9])



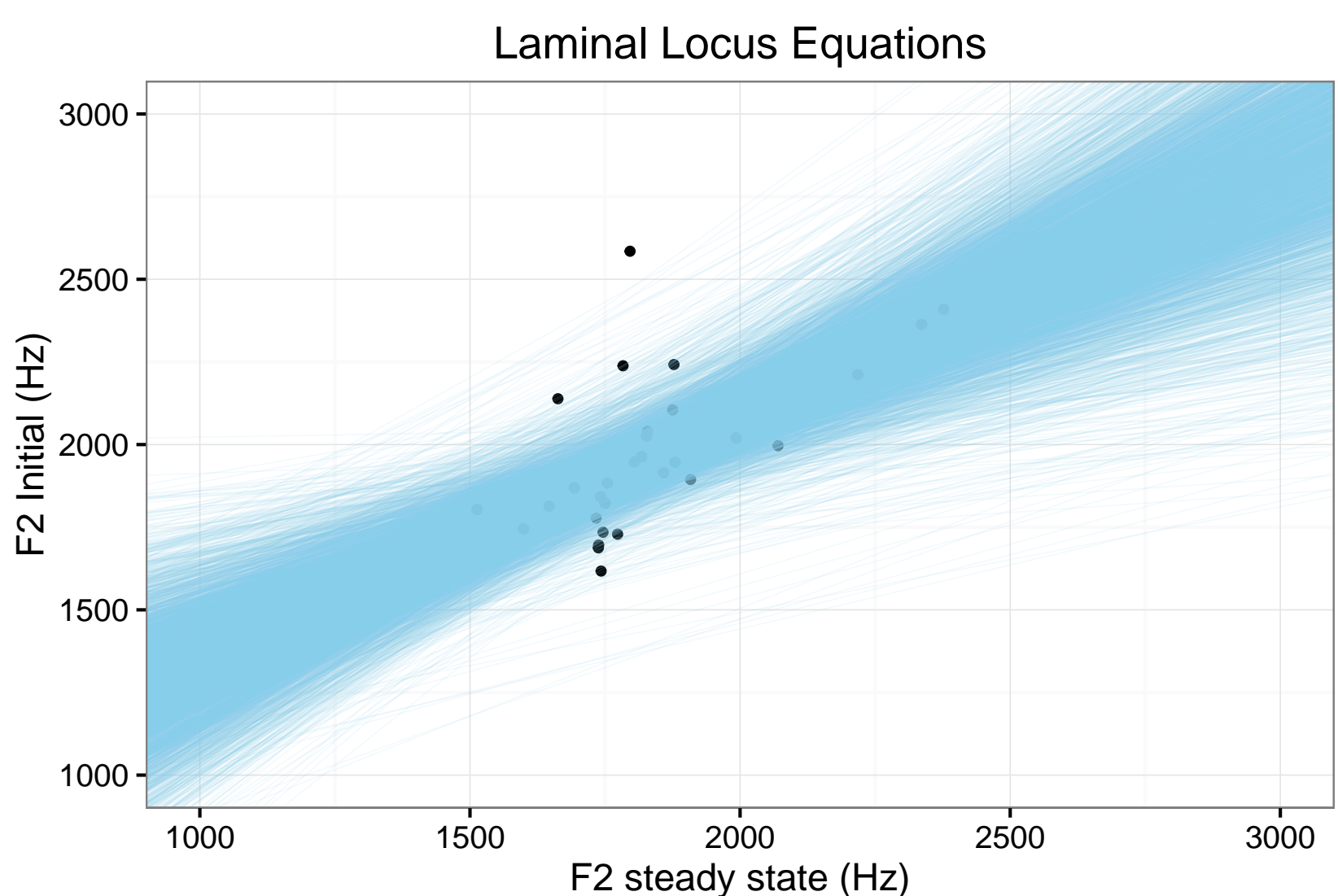
**Figure 1:** Pirate plot of VOT (box is Bayesian 95% Highest Density Interval with median line; 'bean' is density plot)

## Locus Equations

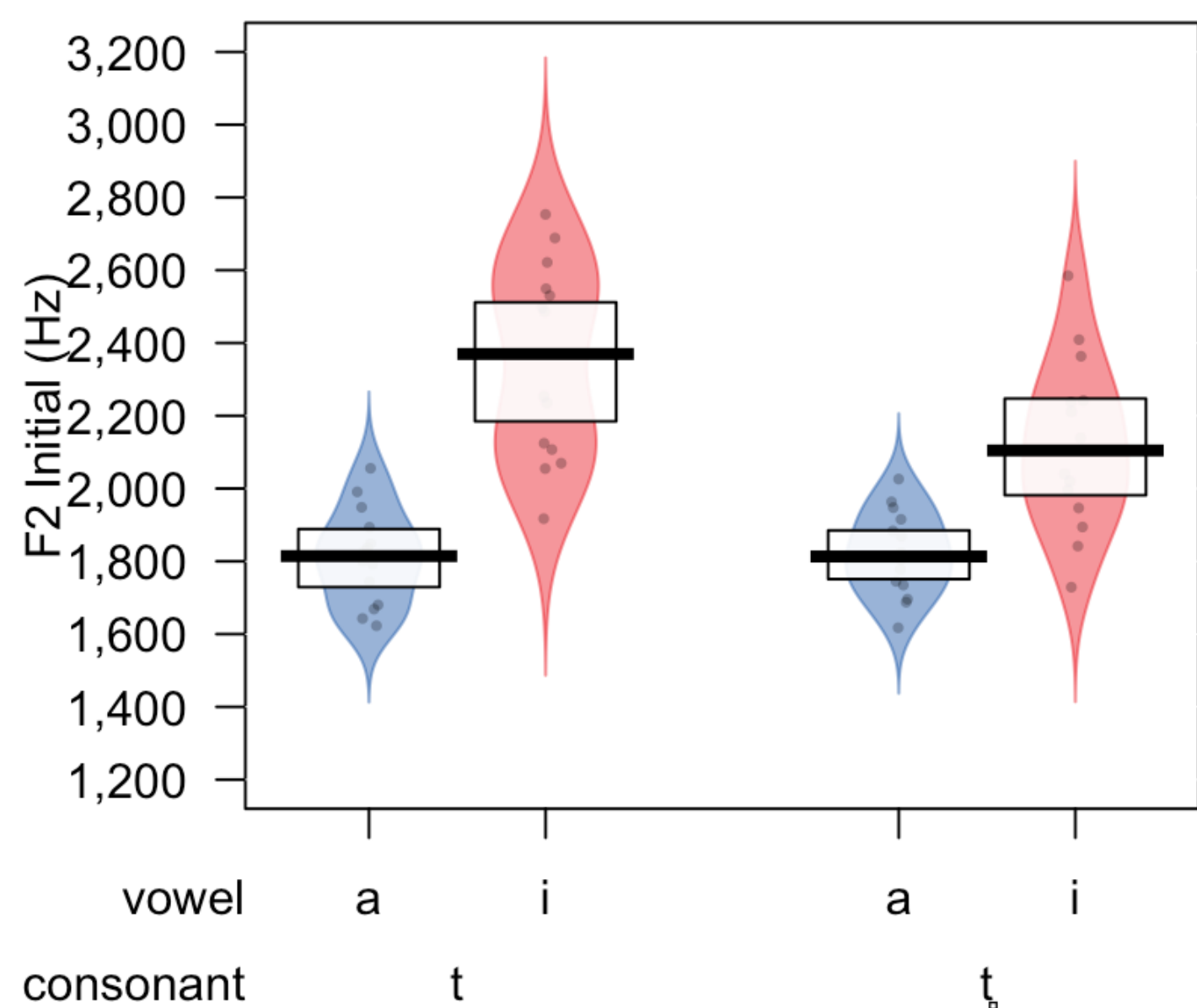
- Measured F2 initial and F2 steady state for each vowel
- BHLM of F2 initial ~ F2 steady state with random effects of participant with random intercepts and slopes by F2 steady state



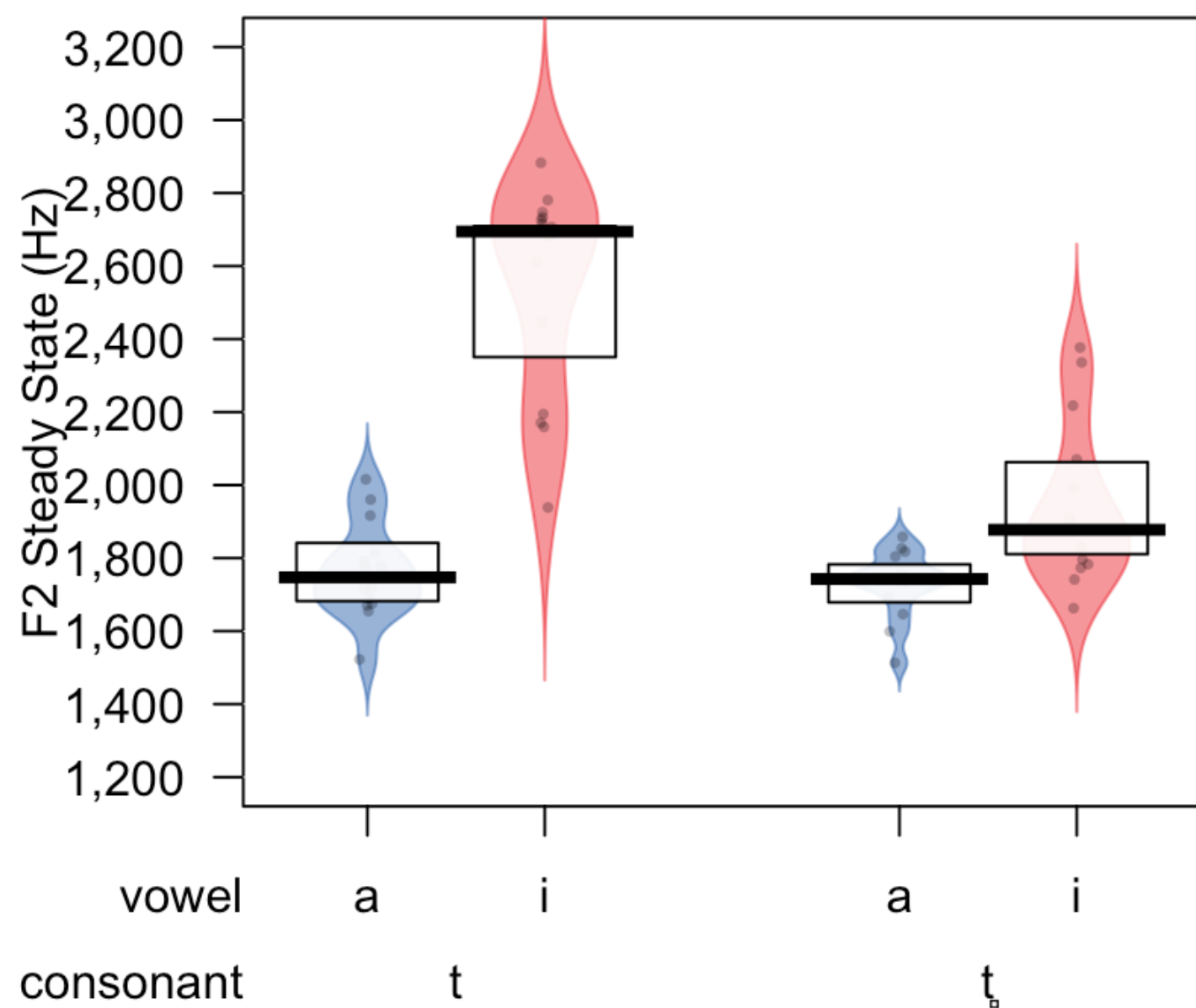
**Figure 2:** Apical dental /t̺/ locus equations



**Figure 3:** Laminal alveolar /t̪/ locus equations



**Figure 4:** Pirate plot of F2 initial by vowel by consonant



**Figure 5:** Pirate plot of F2 steady state by vowel by consonant

## Locus (con't)

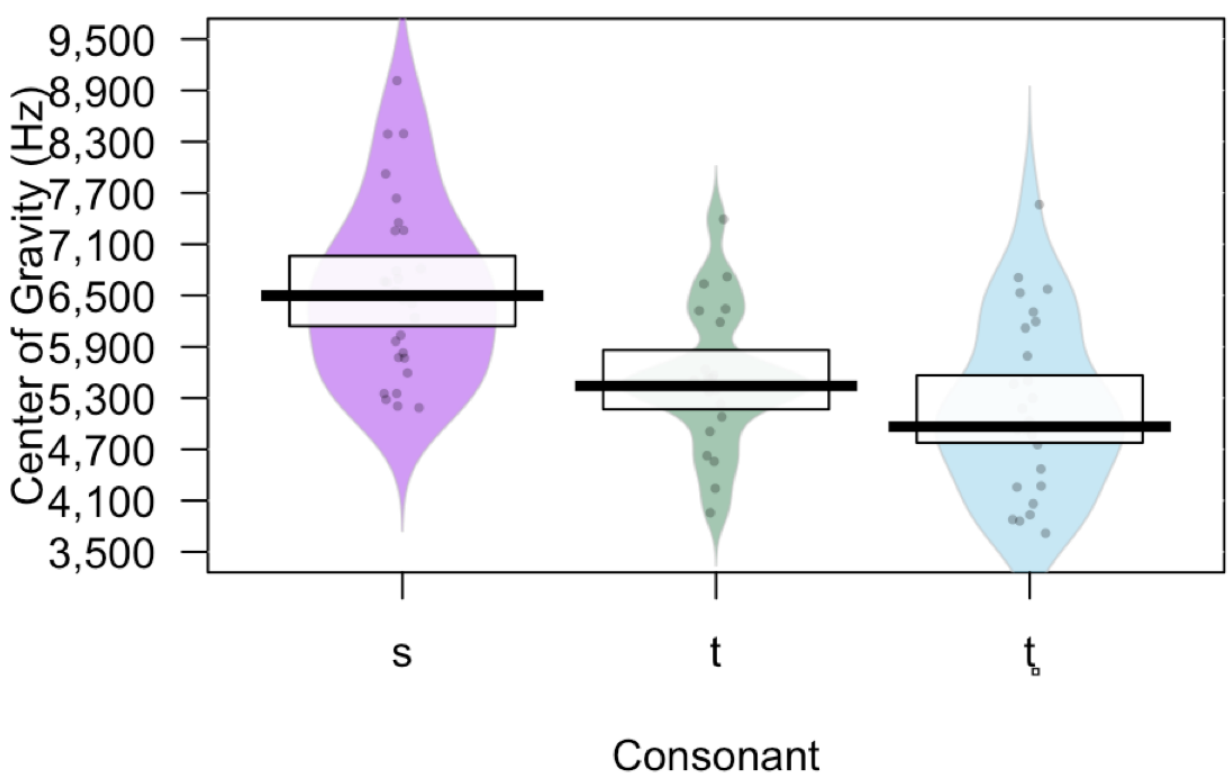
Measure	Mean	CrI	
		2.5%	97.5%
/t̺/			
Intercept	618.39	425.26	806.38
Slope	0.68	0.57	0.77
/t̪/			
Intercept	604.00	−88.39	1272.94
Slope	0.74	0.36	1.14

**Table 1:** Locus equation results

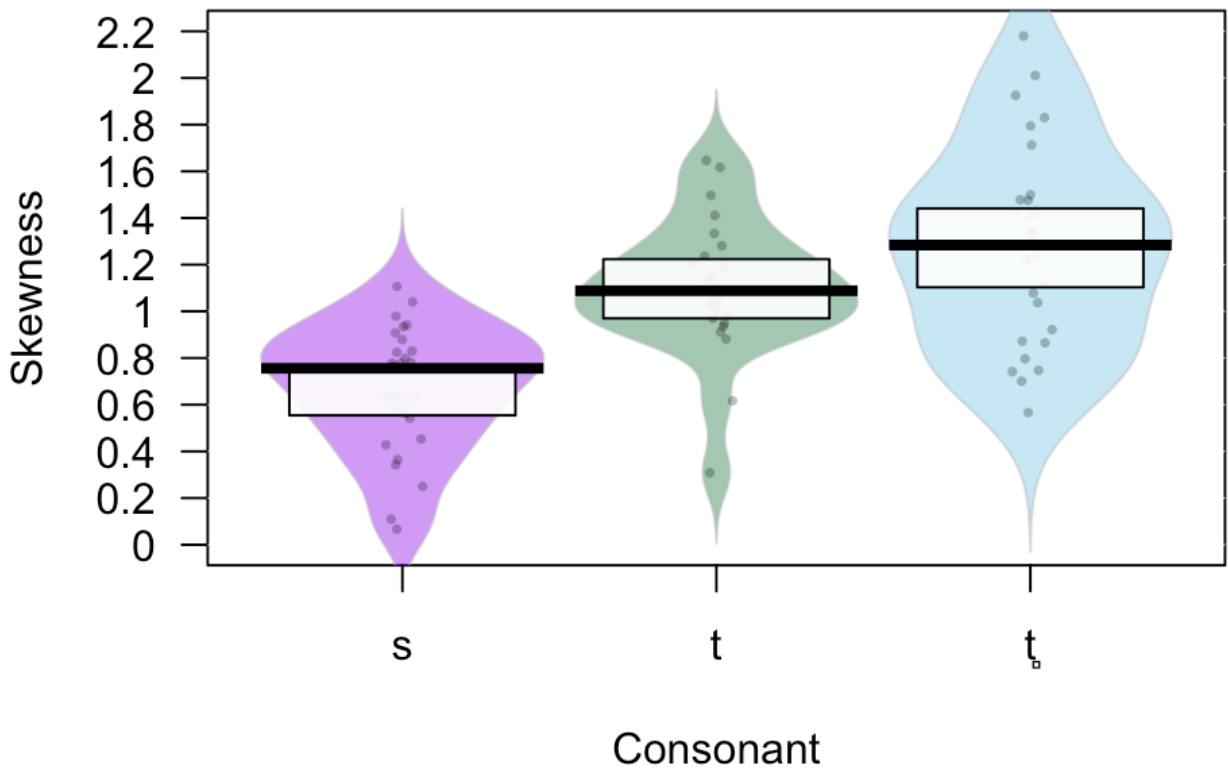
- Both stops have **similar** intercepts and slopes with much overlap of credible intervals (Tab. 1)
- Apical dental /t̺/ has **less variation** for both slopes and intercepts (Fig. 2)
- Laminal alveolar /t̪/ has (1) **significant variation** in intercepts (Fig. 3), (2) **lower and higher** probable intercepts and slopes than /t̺/ (Tab. 1), and (3) **lower** F2 steady states values causing model variation (Fig. 5)

## Burst Spectral Moments

- Measured COG and Skewness at onset of stop burst with 10 ms window
- For each BHLM, fixed effect: consonant; random effects: word and participant with random intercepts and slopes by consonant
- Much overlap in credible intervals of /t̺/ and /t̪/ for both COG and skewness (probable **equal**)
- Probable too that apical dental /t̺/ is (1) **higher** in COG than laminal alveolar /t̪/ (Fig. 6) & (2) **lower** in skewness than laminal alveolar /t̪/ (Fig. 7)



**Figure 6:** Pirate plot of Center of Gravity



**Figure 7:** Pirate plot of Skewness

## Spectral Moments (con't)

		CrI	
Measure	Mean	2.5%	97.5%
/t̺/			
COG	5582.5	4526.3	6634.7
Skewness	1.05	0.73	1.35
/t̪/			
COG	5139.0	4067.9	6239.4
Skewness	1.26	0.87	1.64

**Table 2:** Spectral moments results

## Conclusions

- VOT** difference and **Locus Equations** were clearest differences
- /t̺/ had **longer** VOT than /t̪/ (agrees with Ladefoged & Maddieson (1996) and Dart (1993))
- /t̺/ had lower F2 steady state values which caused greater variation in locus equations
  - Example of C-to-V carryover coarticulation (Iskarous et al. 2010)
  - The following vowel carries meaningful information about laminal apical consonant contrast
- 'Tight' vs. 'loose' fit of locus equations may be an additional component of what listeners pay attention to
- Uncertain if slight difference in skewness and center of gravity are meaningful

## References

- Dart, Sarah N. 1993. Phonetic properties of O'dham stop and fricative contrasts. *International Journal of American Linguistics* 59(1). 16–37. <http://www.jstor.org/stable/1265467>.
- Iskarous, Khalil, Carol A. Fowler & D.H. Whalen. 2010. Locus equations are an acoustic expression of articulator synergy. *Journal of the Acoustical Society of America* 128(4). 2021–2032. doi: 10.1121/1.3479538.
- Ladefoged, Peter & Ian Maddieson. 1996. *The sounds of the world's languages*. Oxford: Blackwell Publishing.

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**Data & Code**

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