5aSC12. Flap articulation and lowered fourth formant

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Q: Do some variants of North American English [ɾ] lower F4?

AmEng [ɾ] as allophone of /t, d/ is actually at least four covertly different **flap/tap events** (**FTEs**: see below)

- Vary by whether the **tongue tip/blade** taps from a **low** or raised/retroflexed position (henceforth **raised**), or flaps between the two
- Conditioned by a number of factors including surrounding segments [3]

FTEs reported to lower or raise F4 [8, 4], but which FTE is responsible for what F4 change is unclear

Hypothesis: **raised tongue tip/blade positions cause lowered F4** during transition into or out of FTEs

- **Why?** F4 lowering has been observed before and after **retroflex stops** [7]; **raised** transitions should be similar

Materials, method

- **Participants:** 6 North American English speakers (3 F)
- Synchronized **ultrasound/audio** recordings
- **Stimuli** varied vowels/rhotics before and after [ɾ] to induce all four FTEs:

Before	After			
	ə	ɚ	i	l̩
ɑ	oughtta	otter	body	bottle
ɑɹ	Sparta	harder	hearty	Bart'll
ɚ	heard of	murder	birdie	hurdle

  - Not all FTEs expected to occur in all words, or in the same words for all speakers
- **Forced alignment** to audio [6] to obtain time points of interest
- **F4 change (ΔF4)** calculated: F4 immediately before/after FTE minus F4 at preceding/following midpoint, using Parselmouth [5]
- **FTE type coded** from **ultrasound videos** of FTE by human annotators (example videos below)

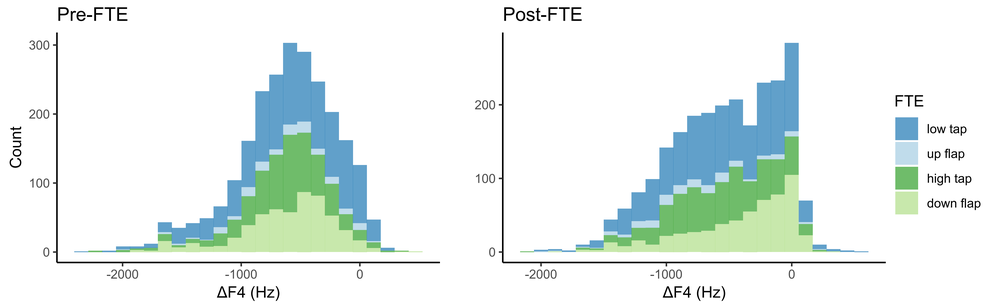
Flap/tap event (FTE) coding after Derrick and Gick [3]

We expect **raised** tongue position immediately before or after FTE to **lower F4**:

Name	Spectrogram	Ultrasound frames (right = anterior)			Video
		Before FTE	FTE closure	After FTE	
Low tap ɾ↕	'oughtta'	Starts low		Ends low	
High tap ɾ↔	'murder'	Starts **raised**		Ends **raised**	
Up flap ɾ↖	'otter'	Starts low		Ends **raised**	
Down flap ɾ↘	'heard of'	Starts **raised**		Ends low	

Raw ΔF4 by FTE label

- ***All*** FTEs have **F4 lowering** effect, both before and after FTE

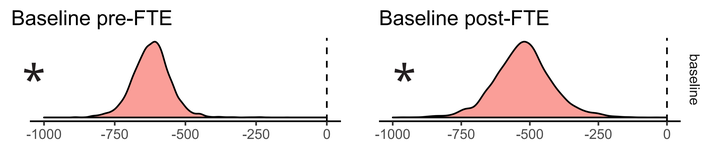


- Consistent with [8] but unexpected given [4]
- Note very low number of up flaps

Bayesian models using [2]; ask us about our priors

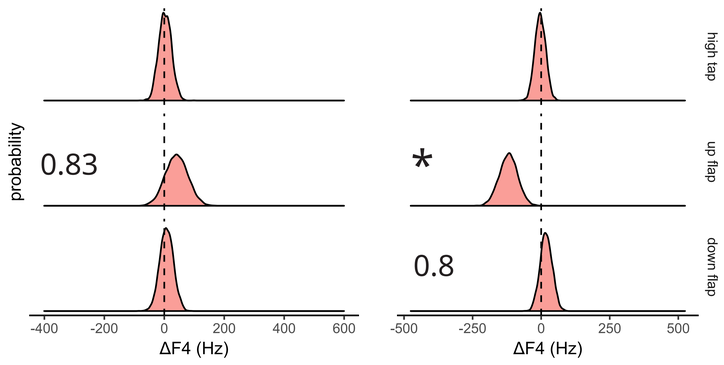
- **Two models** for before and after contexts: ΔF4 ~ FTE label + (1 | subject) + (1 | segment : stim)
- Posterior probability estimates of **baseline (low tap)'s difference from zero**:
  - Credible ($P > 0.95$) ΔF4 difference from zero gets *; trends ($P > 0.8$) also shown

- Baseline (**low tap, and FTEs overall**) has **strong lowering** effect on F4



- Posterior probability estimates of **difference from baseline** for **other FTEs**:

- No additional effects for **high tap** (unexpected)
- **Up flap** has further F4-lowering post-FTE; may raise F4 pre-FTE
- **Down flap** may raise F4 after FTE (unexpected)



A: They all do.

Strong lowering effect on F4 for **all FTEs**, in line with [8] (and not [4]):

- About -500 Hz drop immediately adjacent to FTE
- Effect is observed both **before and after** FTE
- Additional F4 lowering **after up flaps**

Unexpectedly, **all FTEs** show this magnitude of effect, and not only those using **raised tongue configurations**

- F4-lowering effect of retroflexes, North American English /ɹ/ thought to be due to brief appearance of **sublingual cavity** or other small side cavities during blade/tip raising [7, 9]
- In spite of intuitive similarity to these segments, **non-raised** FTEs also lower F4 to a similar degree
- Leaves unclear the **specific cause** for F4 lowering

One possibility to explore in future work: the four FTE categories used here [ɾ↕, ɾ↔, ɾ↖, ɾ↘] do not map well to the relevant articulations for all speakers

- **Speaker-specific articulations** may be washed out by coding
- Interspeaker variation in F4-lowering effect may be partly determined by speaker-specific articulations [7, 8] or differences in palate shape [1]
- A **data-driven approach** might allow categories better suited to individual speakers to emerge

Acknowledgements

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Poster PDF

Or visit the repo at **github.com/mfaytak/flaps-f4-asa**

References

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