Vertical larynx actions and larynx-oral timing in ejectives and implosives

Phonetics and Phonology in Europe
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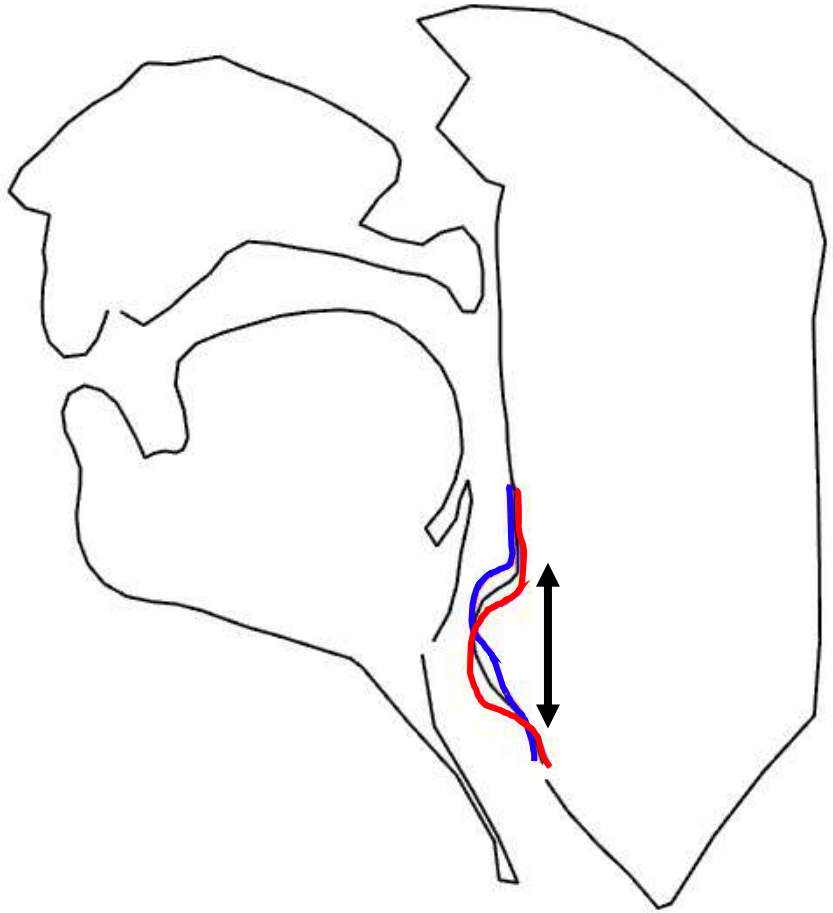
Goal

- Understand **the articulatory constellation** of ejectives and implosives in comparison with their pulmonic counterparts.



  - Vertical larynx activity
  - Timing of vertical larynx-oral gestures

Non-pulmonic vs. pulmonic consonants

- Manifested by the difference in "the mode of action of the larynx, or in the timing of laryngeal activity in relation to the oral articulation"

Maddieson & Ladefoged, 1996: 47

  - Raising/lowering of the larynx
  - Temporal coordination of oral-laryngeal activities

Ladefoged & Johnson, 2014

Implosives vs. voiced stops

- There is a gradient **continuum** between one form of voiced stops and true implosives
  - Implosives are produced with a comparatively greater amount of lowering and more rapid descent of the larynx than voiced stops.

Ladefoged 1971, Ladefoged & Maddieson 1996

- Does **the timing** of larynx movement vary to create phonological contrasts?

> "Larynx is at its highest [for ejectives] or lowest [for implosives] point near **the oral release**, since maneuvers which change the volume of the oral cavity have more profound effects on [oral air pressure] if they are initiated after the oral closure is made."

Kingston 1985: 17-18

Articulatory data

- Real-time MRI data of a midsagittal view of the vocal tract

Research Questions

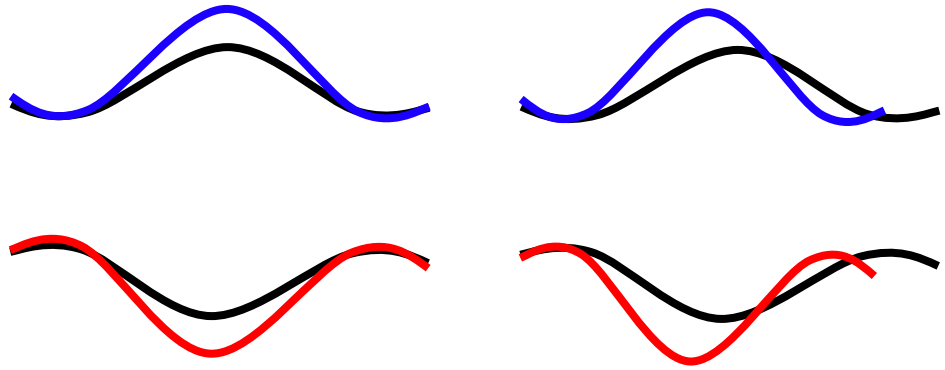
A. Do ejectives and implosives show distinctive raising and lowering of the larynx (compared to pulmonic consonants)?

Hypothesis A

- **Non-pulmonic consonants** show **larger** and **faster** vertical larynx movement than their **pulmonic counterparts.**

  i. Voiceless pulmonics < Voiceless ejectives

  ii. Voiced pulmonics < Voiced implosives



Clements & Osu 2002, Kingston 1985, Ladefoged 1968, 1971; Ladefoged & Maddieson 1996

Research Questions

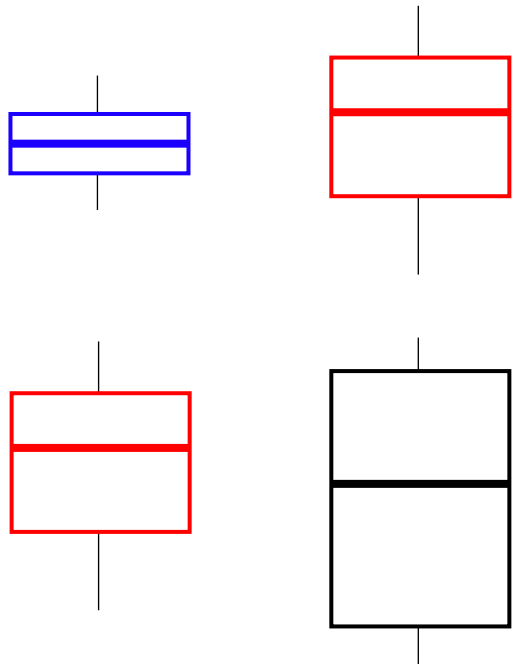
B. What are the timing relations between vertical larynx gestures and their coordinated oral gestures?

Hypothesis B

i. The temporal lag between oral closure and vertical larynx gestures is near zero and **highly stable** in ejectives and longer and **more variable** in implosives.

ii. The temporal lag between oral and vertical larynx gestures in **voiced pulmonics** that exhibit larynx lowering is **more variable** than that seen in non-pulmonic implosives.

Ladefoged & Johnsonn, 2014



Methods

- Subject: A female Hausa speaker in 20s
- Materials
  - Stimuli: target consonant placed word-initially in LH bi-syllabic words
  - 2 prosodic conditions X 2 vowel contexts X 5 repetitions

	Bilabial	Alveolar	Velar	Labio-velar
Plosive	b	d	k	k^w
Implosive	ɓ	ɗ		
Ejective		s’	k’	$k^{w'}$
Fricative		s		

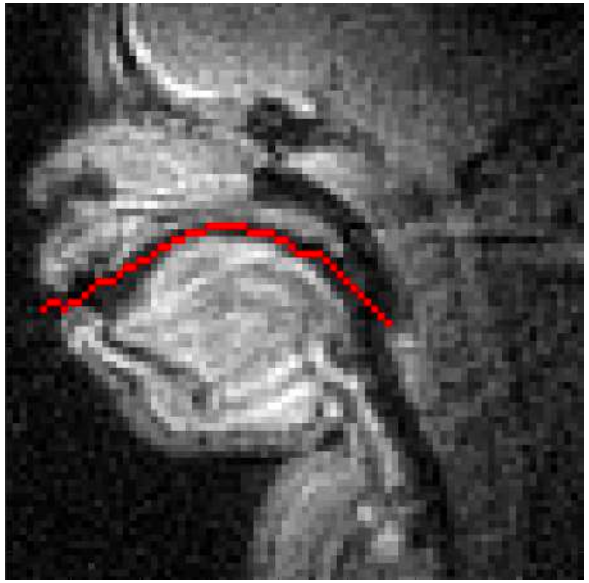
Examples

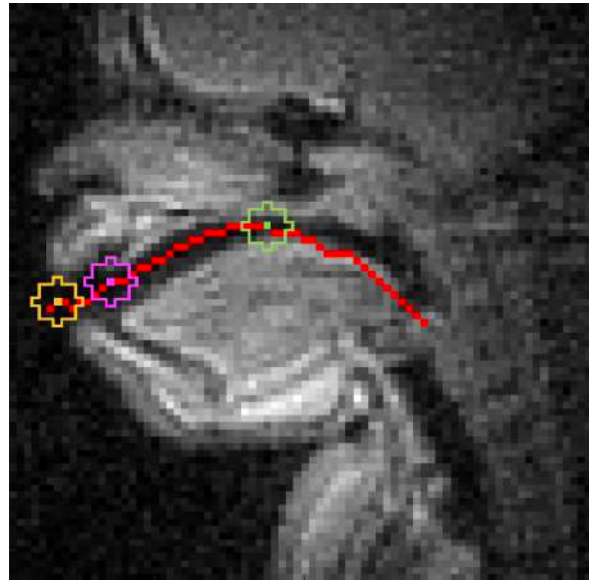
- Ejective
  - **ƙ**aho ya na da wahalan busawa.
  - *Trumpet is difficult to play.*

- Implosive
  - **ɓ**arna ya kawo kashe kudi.
  - *The loss has led to spending money.*

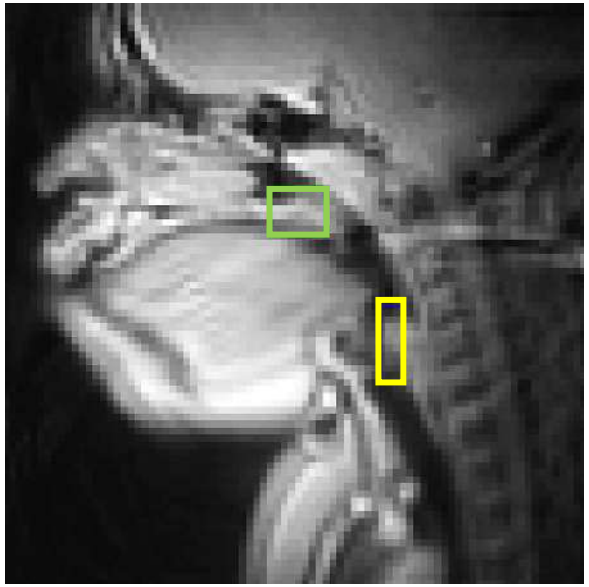
Data analysis

- Oral gestures (LAB, COR, DOR):
  - ROI analysis



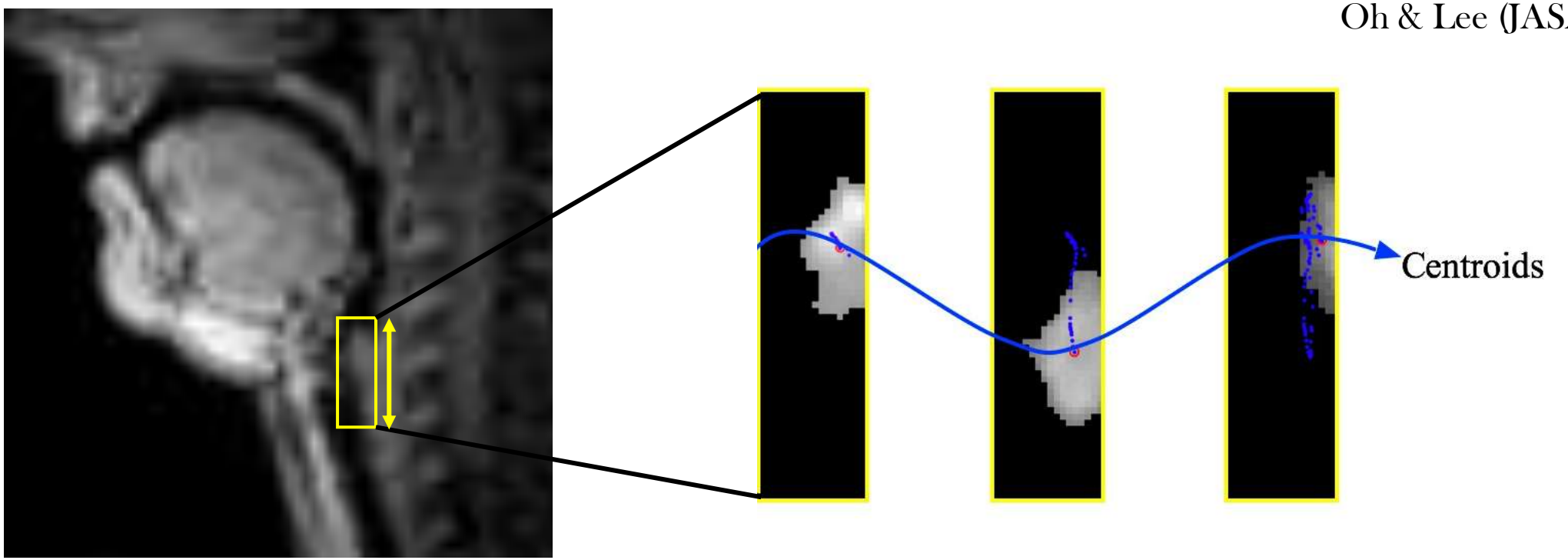


- Vertical laryngeal gesture (LX):
  - Centroid tracking analysis

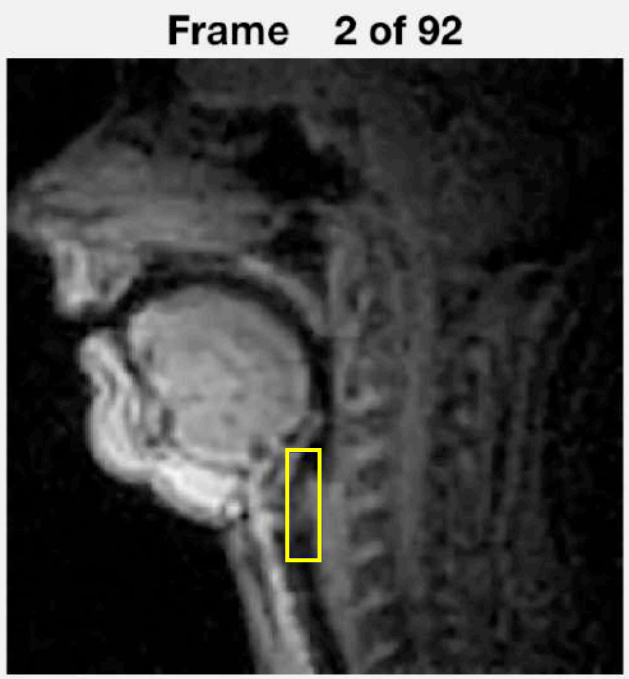


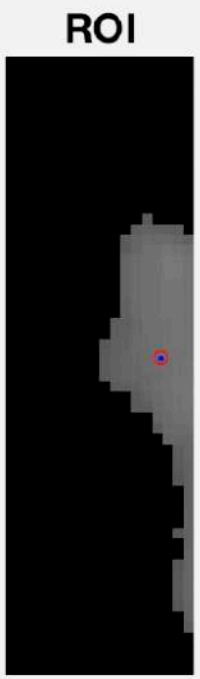
Larynx lowering (/aʤa/)

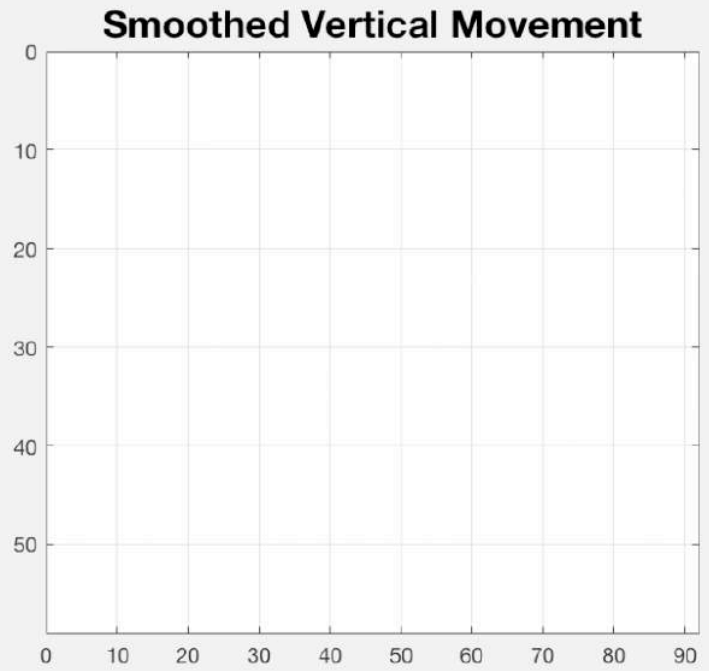
Oh & Lee (JASA-EL, 2018)



Larynx lowering (/ɑgɑ/)

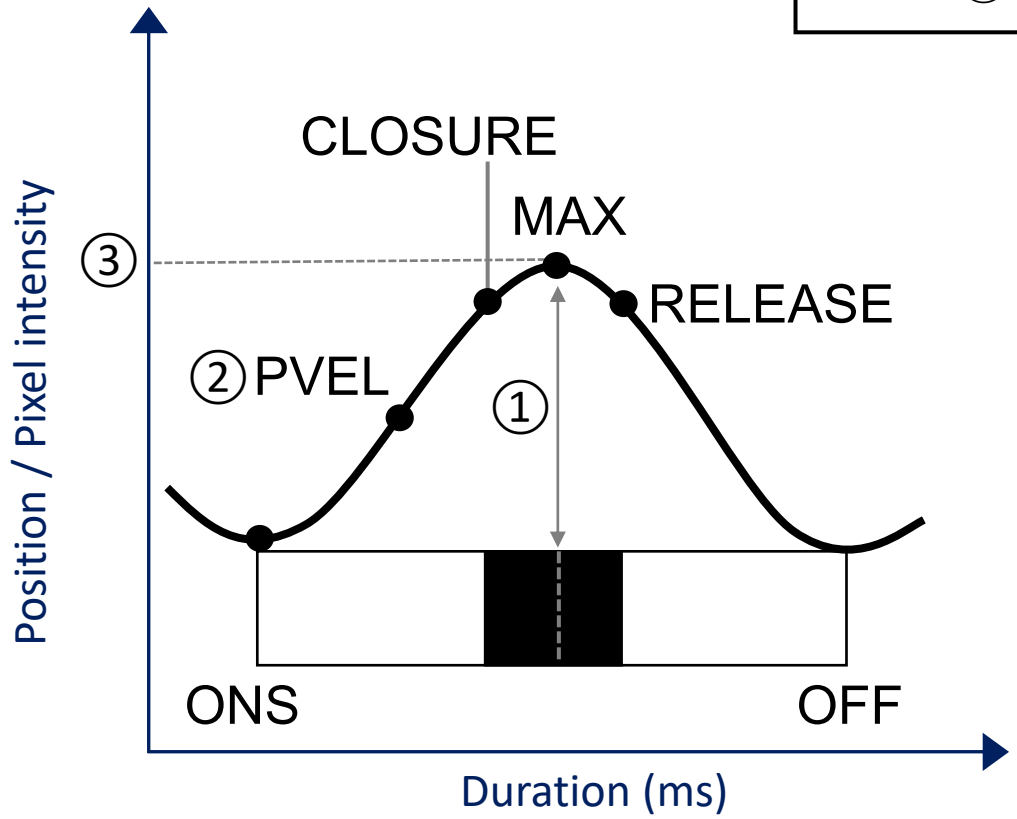






Measurements

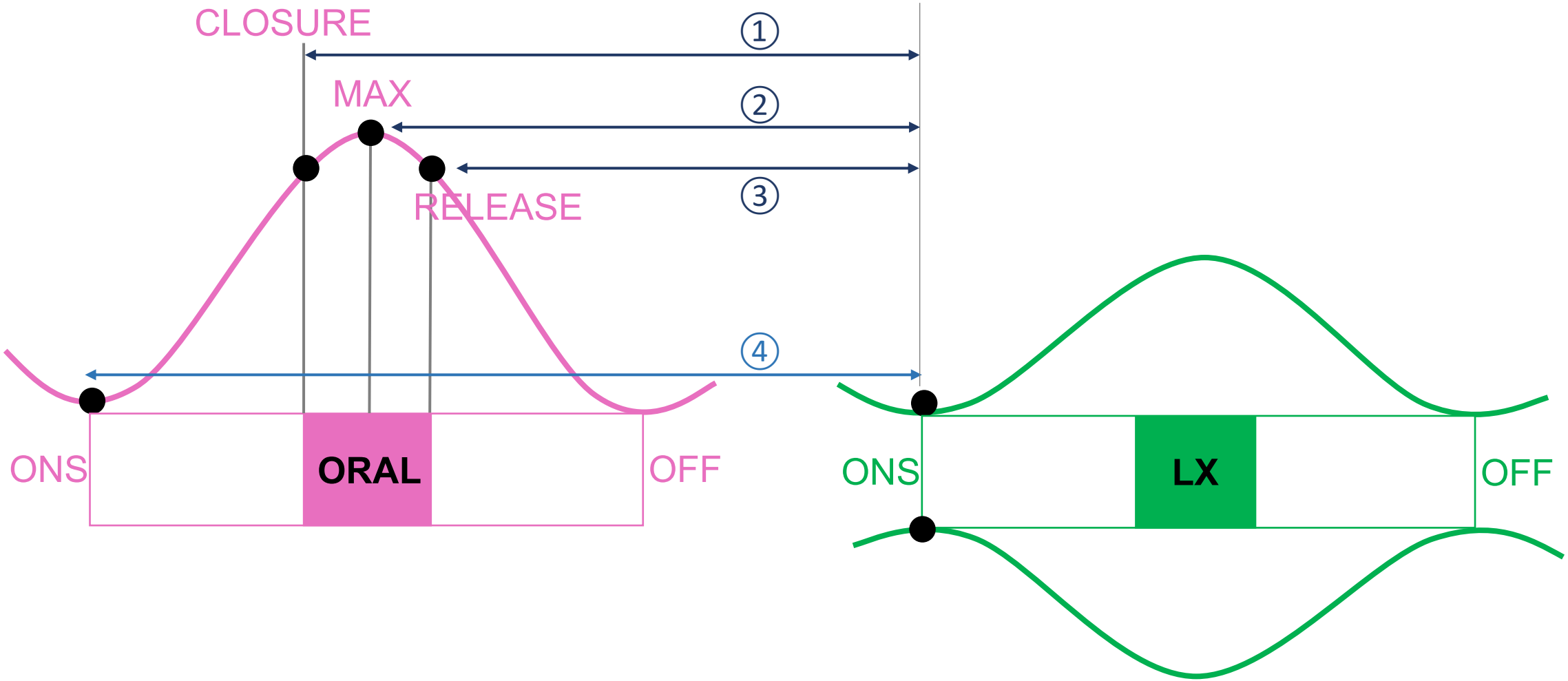
- Magnitude
  - ① Displacement (MAX-y − ONS-y)
  - ② Peak velocity (PVEL)
  - ③ Extremum (MAX-y)



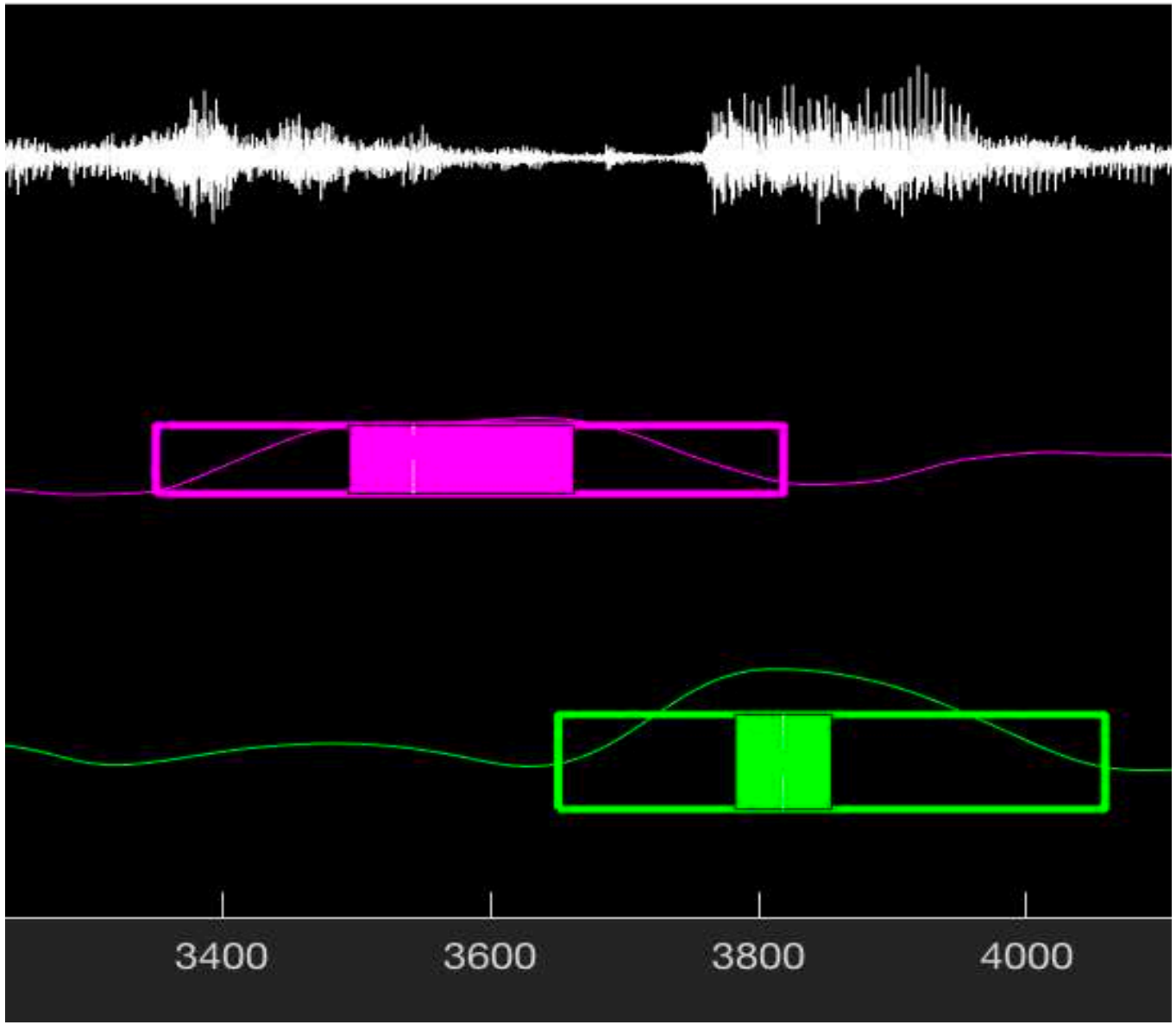
ONS/OFF: onset/offset of the movement
PVEL: peak velocity
MAX: maximum displacement of the gesture
CLOSURE/RELEASE: target of oral closure/onset of oral release

Measurements

- Timing
  - ① Oral closure
  - ② Oral maximum → to LX onset lag
  - ③ Oral release
  - ④ Onset to onset lag



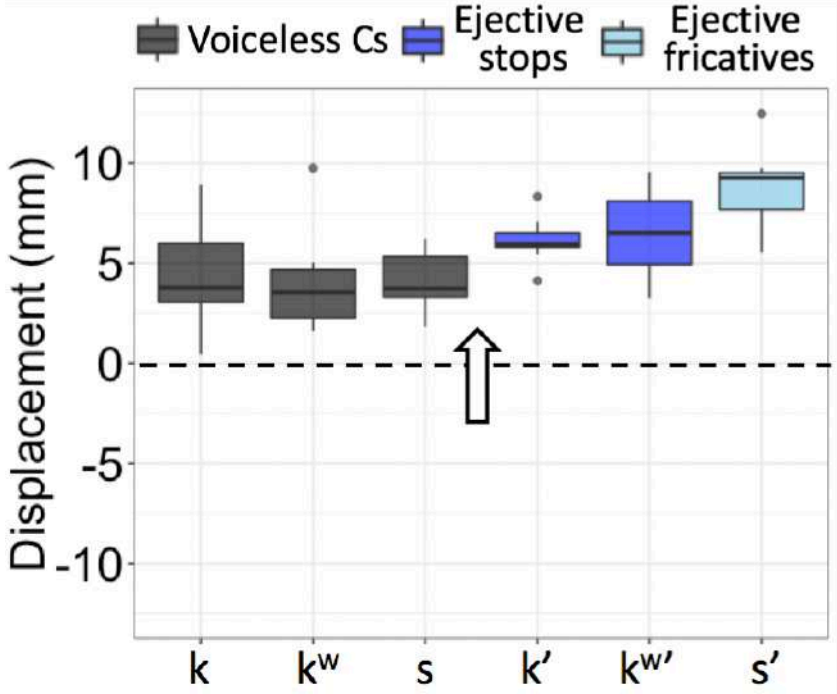
Velar ejective (/k’/)



Results (displacement)

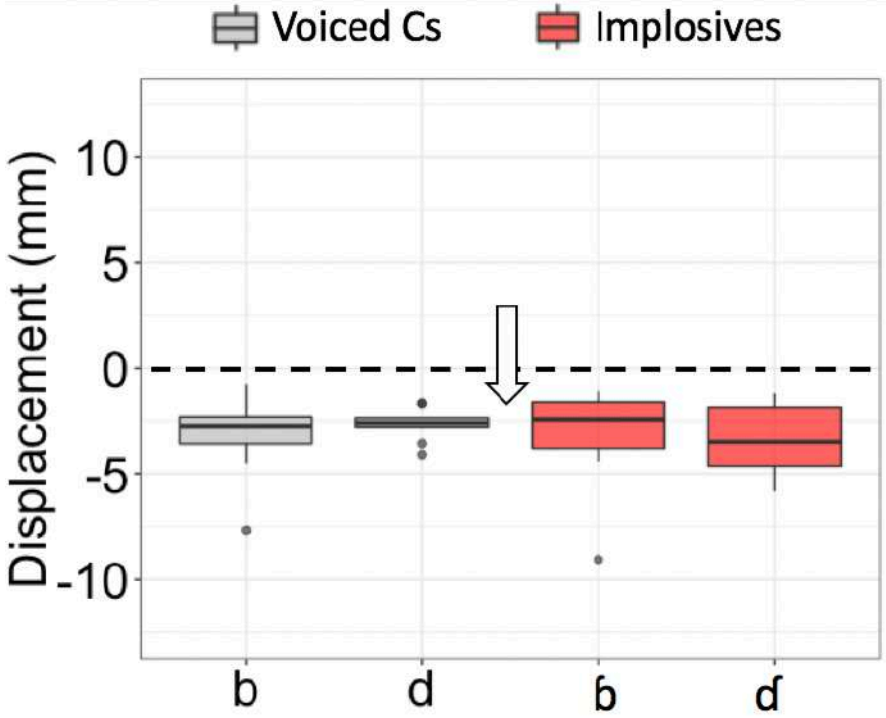
Hypothesis A: Ejectives ✓ and implosives ✗ show **larger** and **faster** vertical larynx movement than their pulmonic counterparts.

Larynx raising



Voicelesss pulmonics < Ejectives

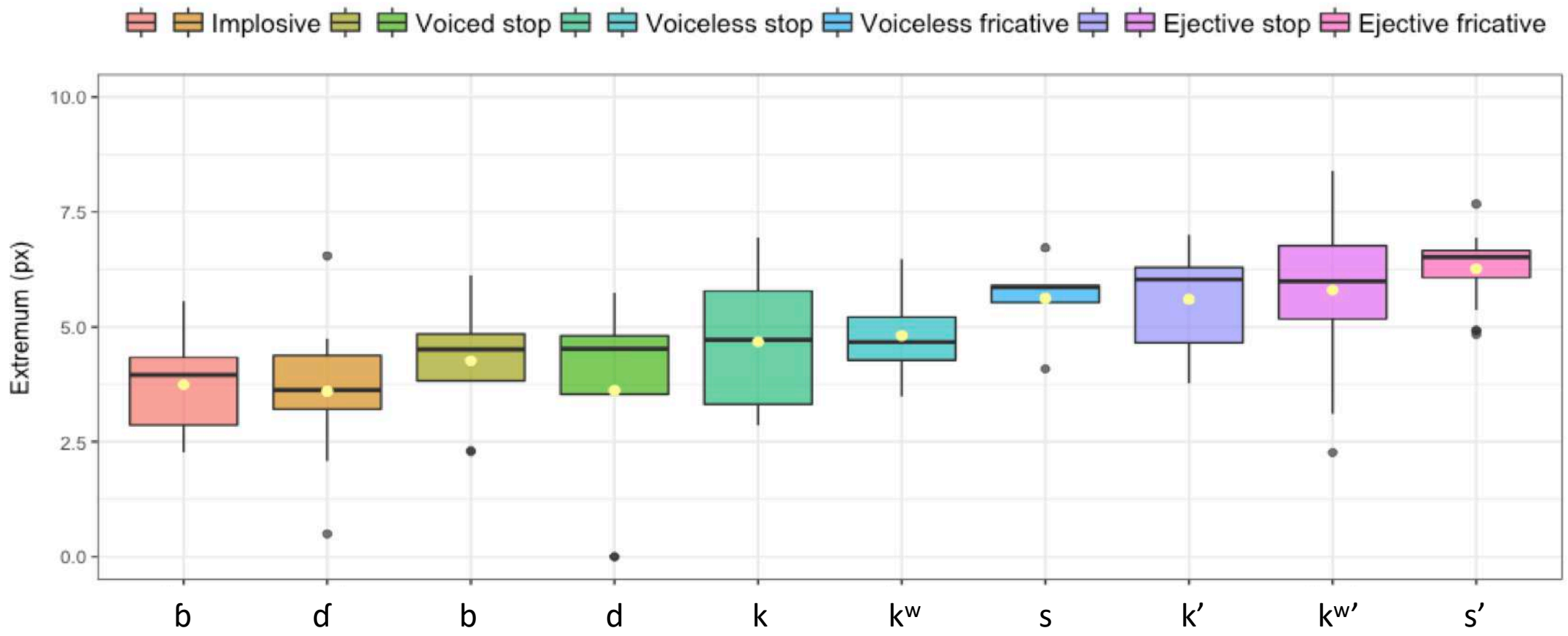
Larynx lowering



Voiced pulmonics ≈ Implosives

Results (Extremum)

Vertical larynx position at movement maximum (Extremum)

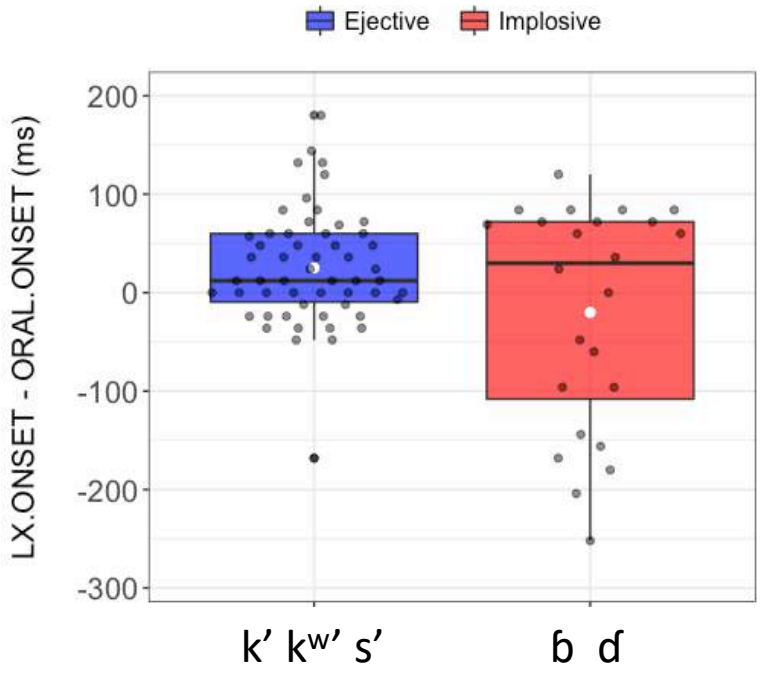


Results (Timing)

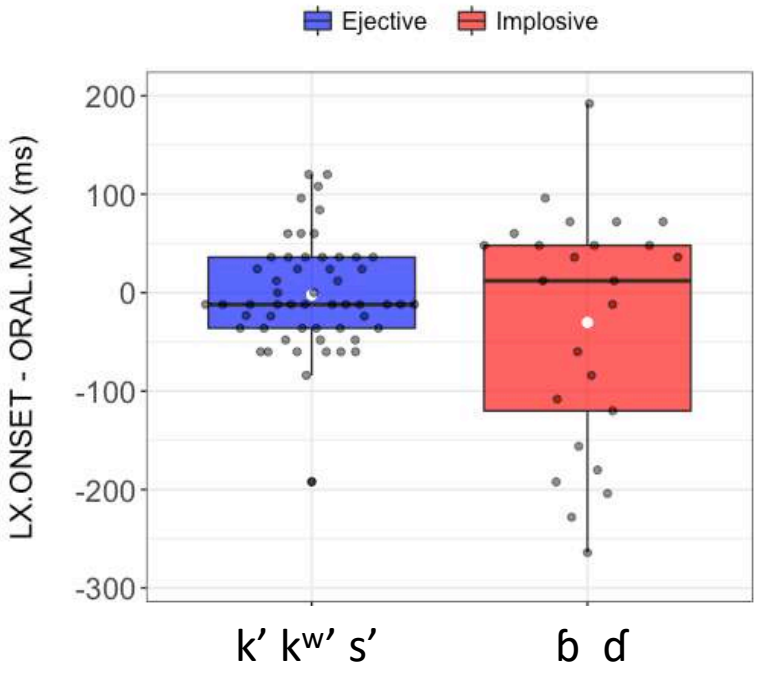
Hypothesis B-i: The temporal lag between oral and larynx gestures is near zero and **highly stable** in ejectives and longer and **more variable** in implosives. ✔

- Ejectives vs. Implosives

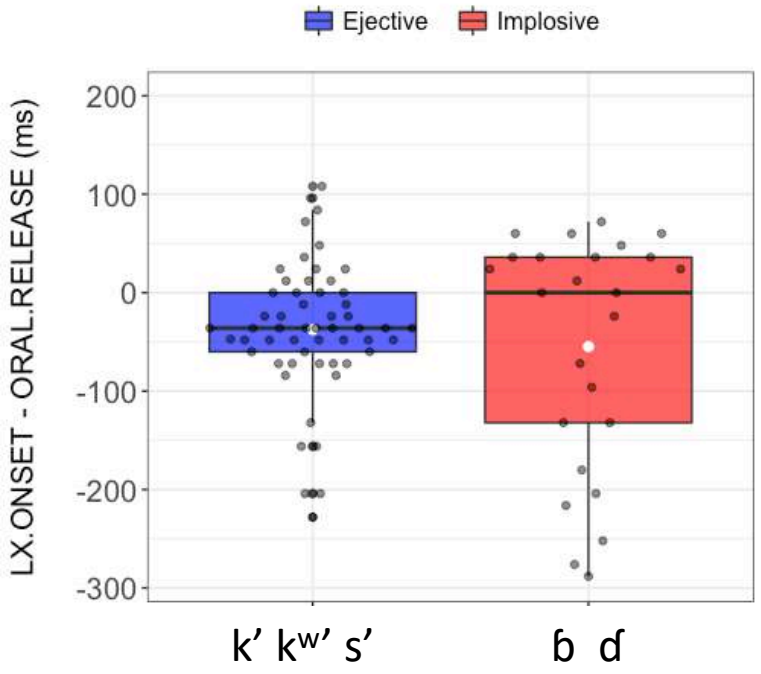
Oral closure to Larynx onset Lag



Oral MAX to Larynx onset Lag



Oral release to Larynx onset Lag

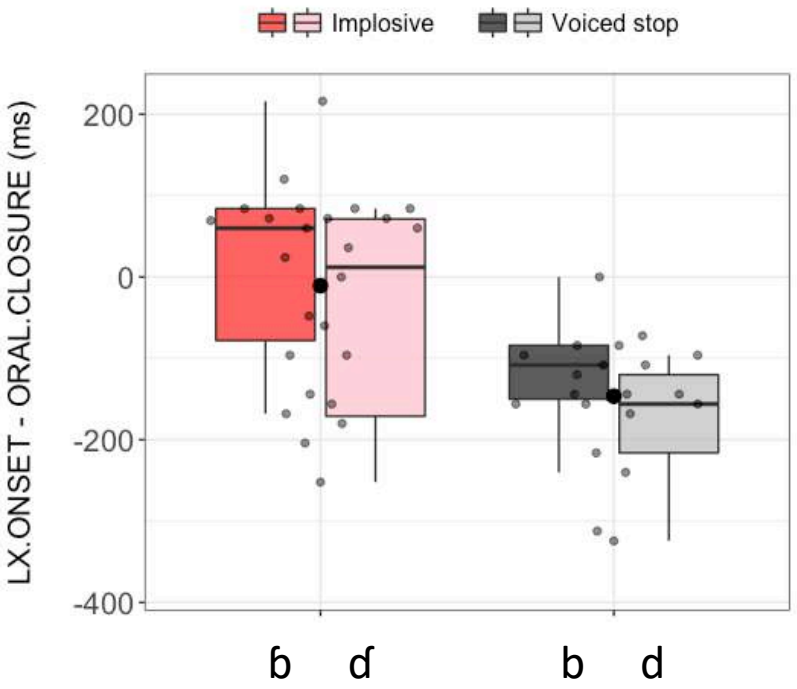


Results (Timing)

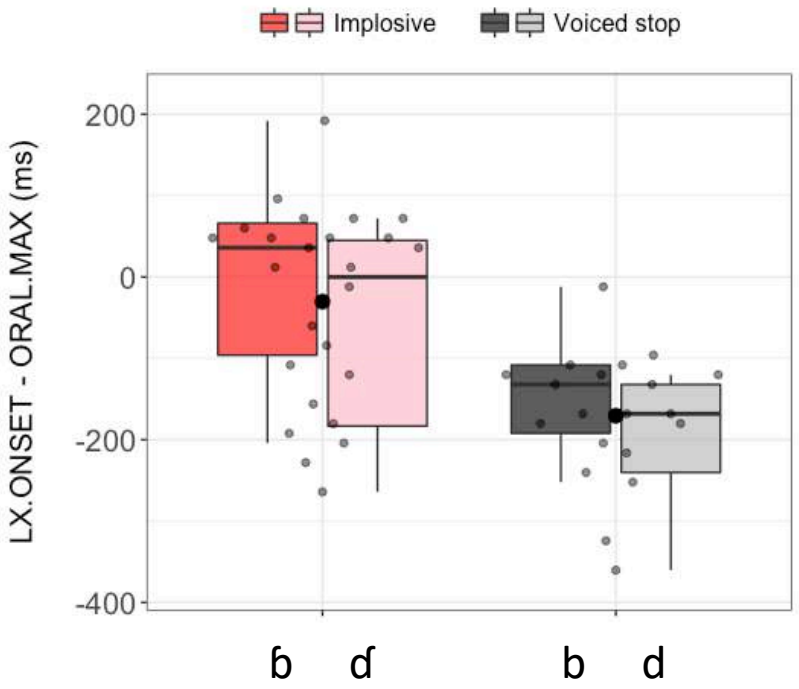
Hypothesis B-ii: The temporal lag between oral and larynx gestures in **voiced pulmonics** that exhibit larynx lowering is **more variable** than that seen in non-pulmonic implosives.

- Implosives vs. Voiced stops

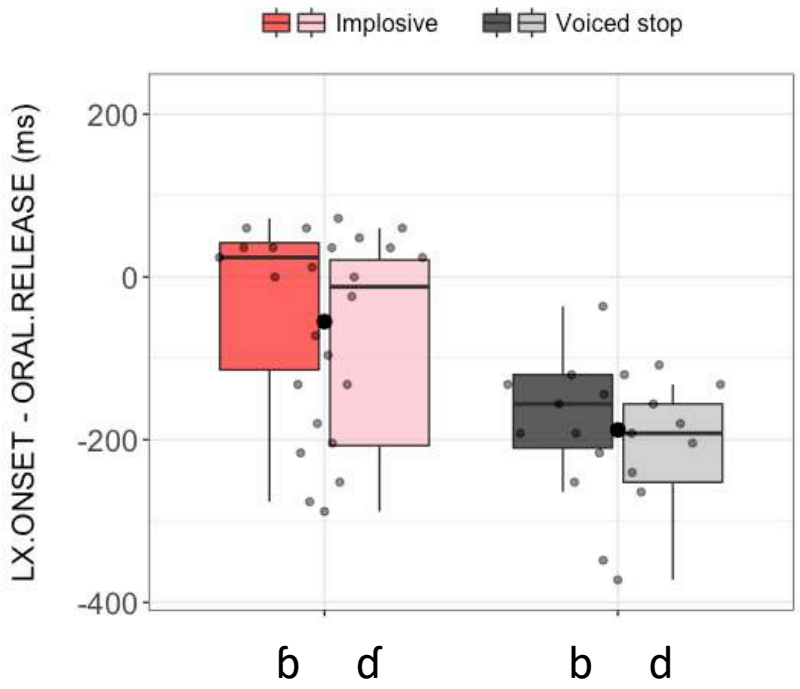
Oral closure to Larynx onset Lag



Oral MAX to Larynx onset Lag



Oral release to Larynx onset Lag



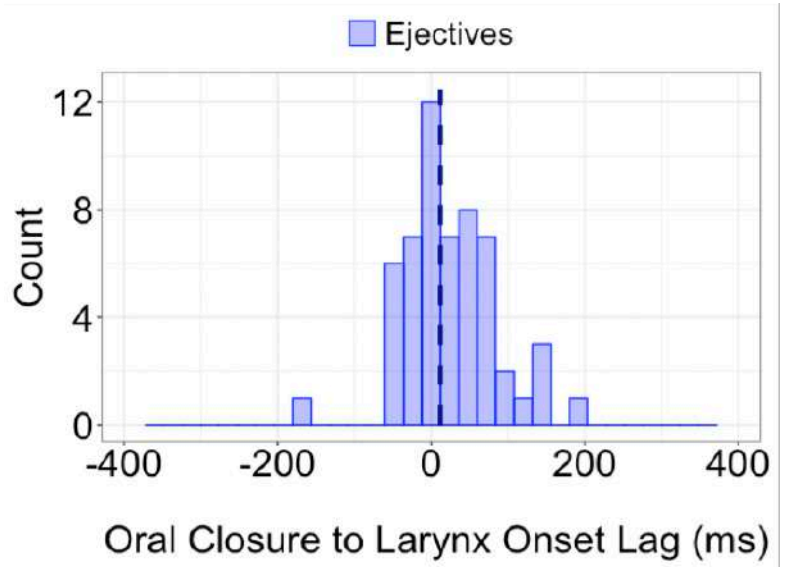
Results (Timing)

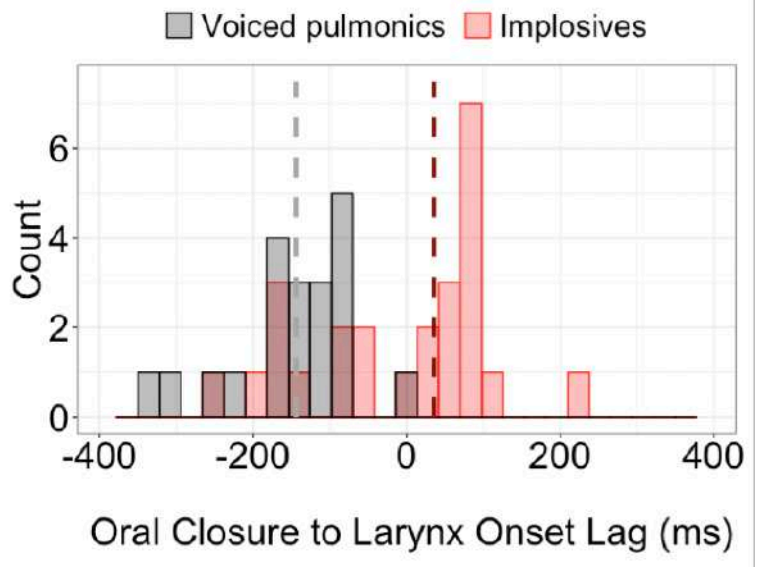
- Ejectives
- Implosives
- Voiced stops

Near zero in ejectives & implosives

Negative lag in voiced pulmonics

Oral closure to Larynx onset Lag





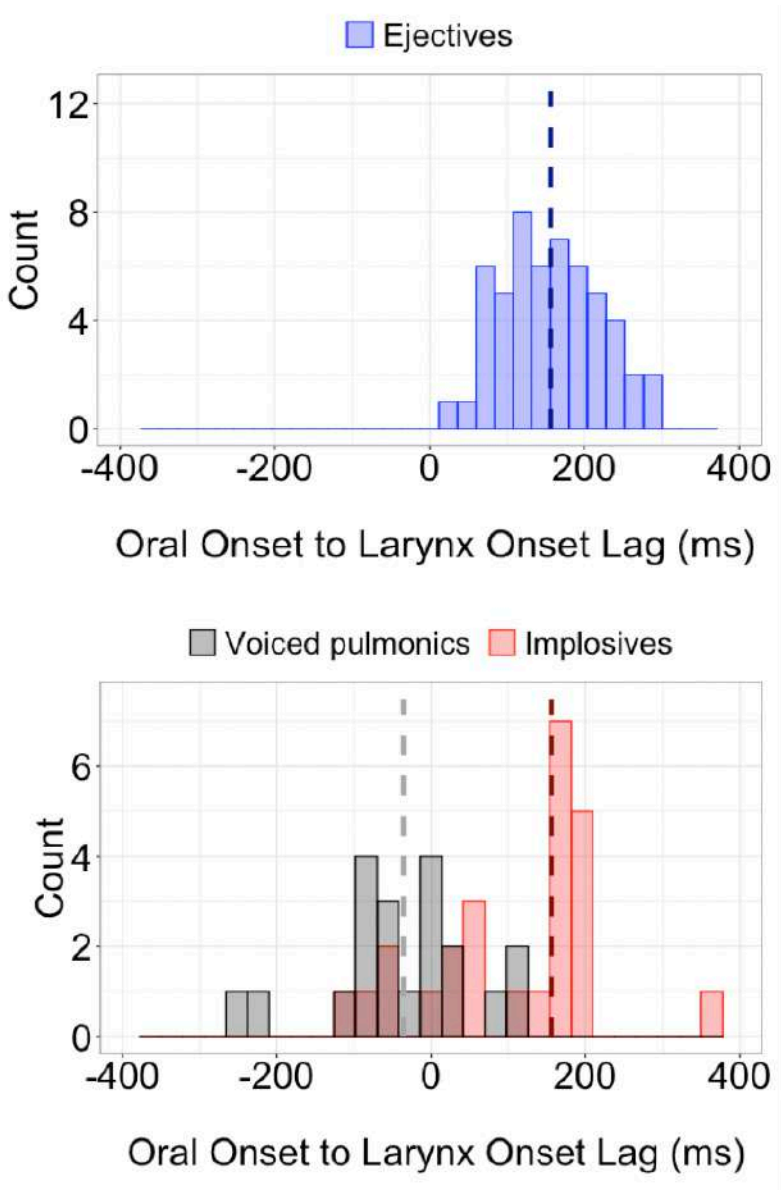
Results (Timing)

- Ejectives
- Implosives
- Voiced stops

Near zero in voiced pulmonics

Positive lag in ejectives & implosives

Oral onset to Larynx onset Lag



Summary

A. Larynx actions

- Ejectives show **more upward** larynx movement than pulmonic consonants.
  - Ejective fricatives show **more upward** larynx movement than ejective stops.

B. Oral-vertical larynx timing

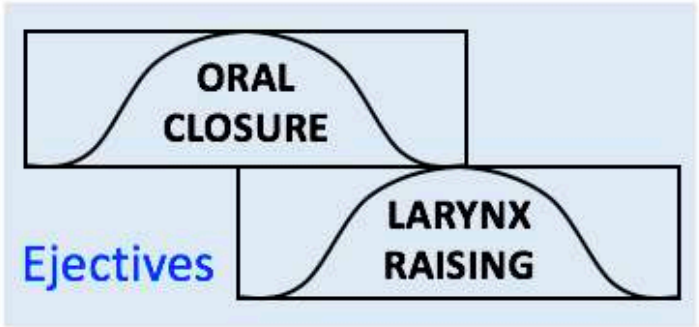
i. The timing between oral-larynx gestures is **less variable** in ejectives than in implosives.

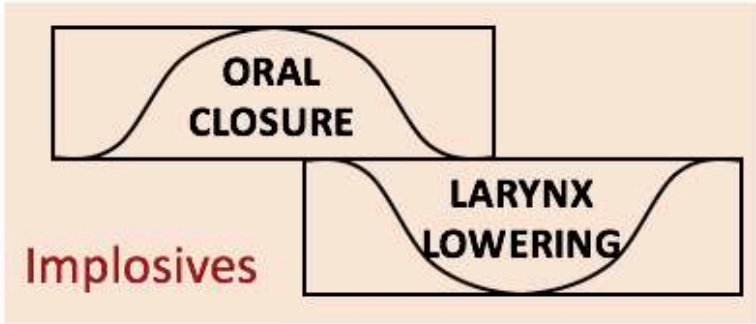
ii. The timing between oral-larynx gestures is **more variable** in implosives than in voiced stops.
  - Larynx lowering is **synchronous** to oral constriction formation in voiced stops and **sequential** to oral gesture in implosives.

Conclusion

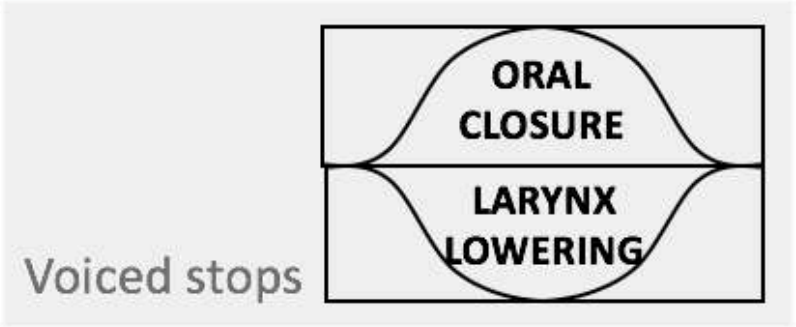
- Gestural organization of glottalic Cs

Glottalic consonants (anti-phase)





Pulmonic consonants (in-phase)



Conclusion

- Non-pulmonic consonants are in fact articulatorily distinct from pulmonic consonants, in the phasing between **larynx-oral timing**.

Ejectives
- Greater gestural magnitude (larynx raising), more stable timing, gestural sequencing

vs.

Implosives
- No magnitude difference (larynx lowering), more variable, gestural sequencing

Voiced stops
- larynx lowering, gestural synchrony

Future directions

- Collected three native Hausa speakers' data with revised stimuli

- Prosodic variation: phrase-initial & phrase-medial
  - Influence of prosodic effects on **the timing relations** and **gestural stiffness**
    - Prosodic stability/variability

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SAIL

THANK YOU

Acknowledgement

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