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Comparing apples to oranges

- asynchrony in jaw & lip articulation of syllables

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Jaw and lip articulations have separate linguistic functions. This study reports on asynchronous patterns in displacement and peak velocity, which shows that jaw is the syllable articulator and the lips are the syllable onset/coda articulators.

Background

Jaw and lip coordination and variability in speech development: lip movements come later and are more variable [1-6]

Jaw and lip are strongly coordinated [7-9], but differences between

- opening and closing [10];
- upper lip more independent (lower lip follow jaw) [11]

Few studies report on syllable types, and using lip aperture

Syllable articulation is:

Two constriction cycles: closing and opening

One jaw cycle (opening + closing): shorter steady states [12]

Fitt's law: linear relationship between speed, distance, and accuracy (but not applicable to all speech movements [13])

This study examines (Fig 1):

- (1) the relationship between velocity and displacement of opening/closing of lips and jaw for syllable productions,
- (2) the difference between opening and closing velocity/displacement patterns, and
- (3) the relative timing of peak velocity of lip articulators compared with that of the jaw articulation.

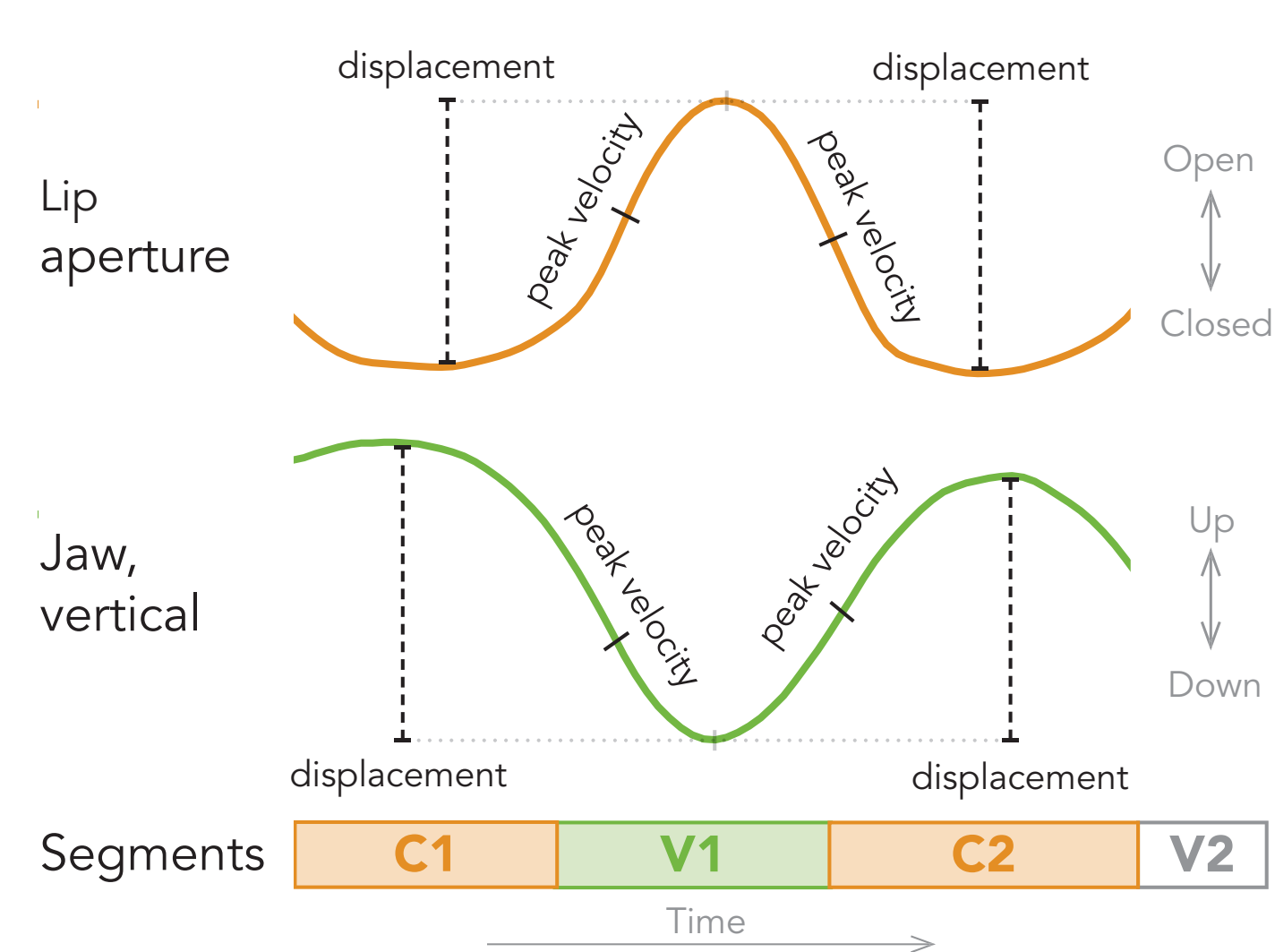


Fig 1. Articulatory measurements and calculations on lip aperture and jaw (example word /mama/ by one speaker).

Method

- EMA. Sensors: Upper lip & lower lip, jaw incisors
- 18 Swedish speakers
- 566 stressed word initial syllables
- target words in a sentence context: /mama/, /papa/, /ma:lar/ and /ba:lar/

Results

Jaw velocity and displacement have a linear relationship - regardless of differences in syllable onset, i.e., /m/, /p/ and /b/ (Fig 2)

Larger distance = faster movement

Lip aperture linear relationship – but affected by syllable type (CVC vs CV:) and manner of consonant (Fig 2)

Opening – closing differences: /pap/ is fastest in opening. /mam/ is fastest in closing (inconclusive for jaw)

Closing of lips and jaw affected by syllable type (different active articulators) (Fig 3-4)

The **timing of peak velocity** is affected by syllable type and manner. In opening: jaw is before lips in open syllables (CV), but after in /pap/ (synchronized in /mam/)

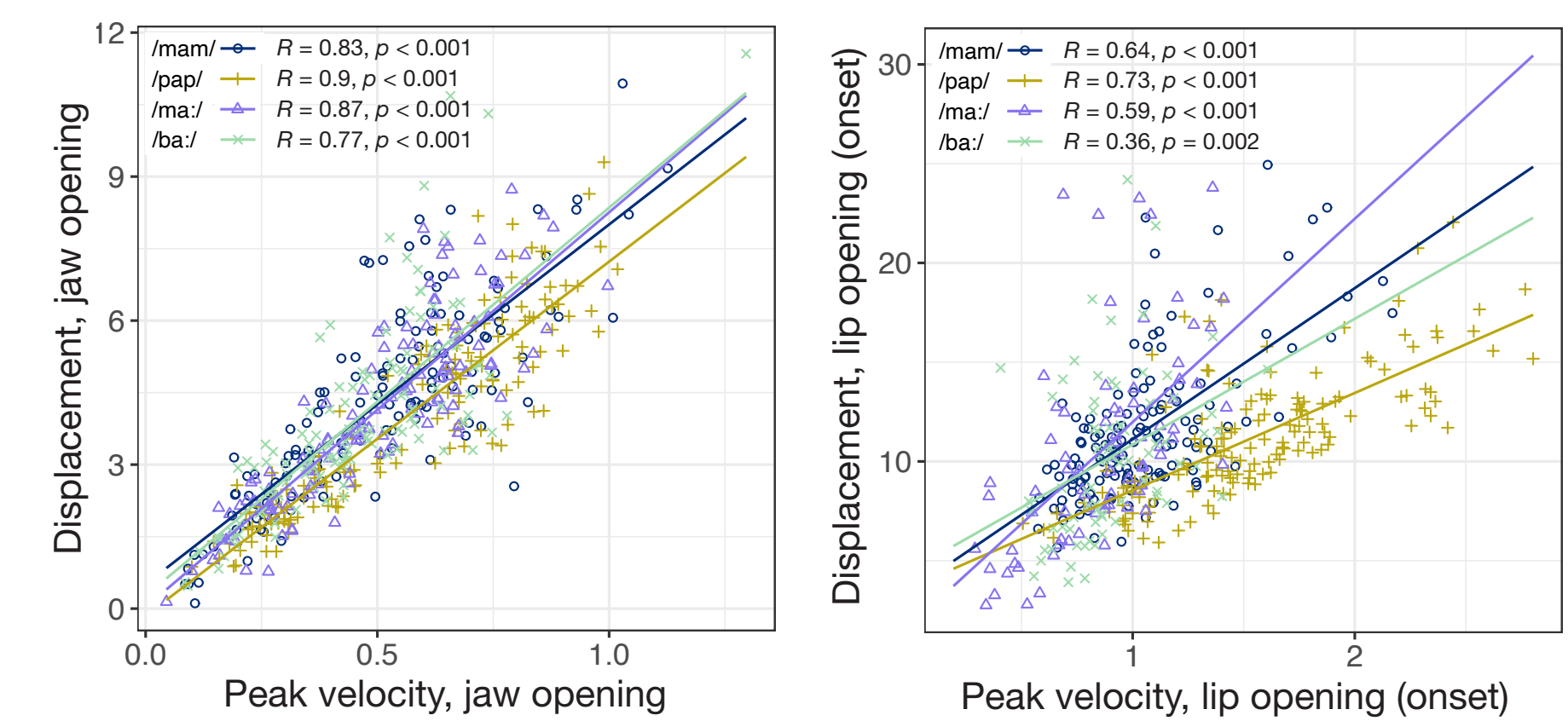


Fig 2. Jaw opening (left) and lip opening (right): displacement (mm) and peak velocity (cm/s).

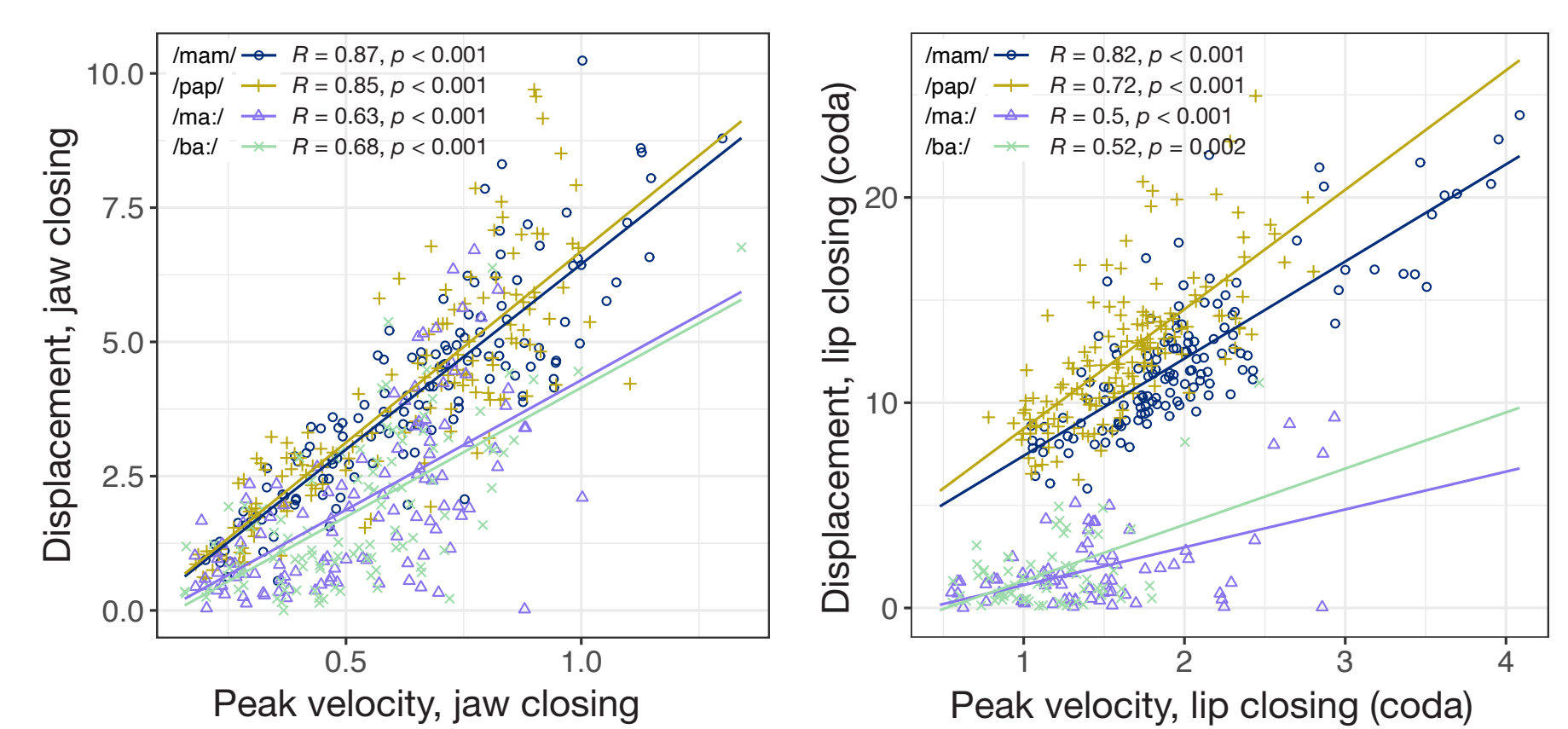


Fig 3. Jaw closing (left) and lip closing (right). Displacement (mm) and peak velocity (cm/s).

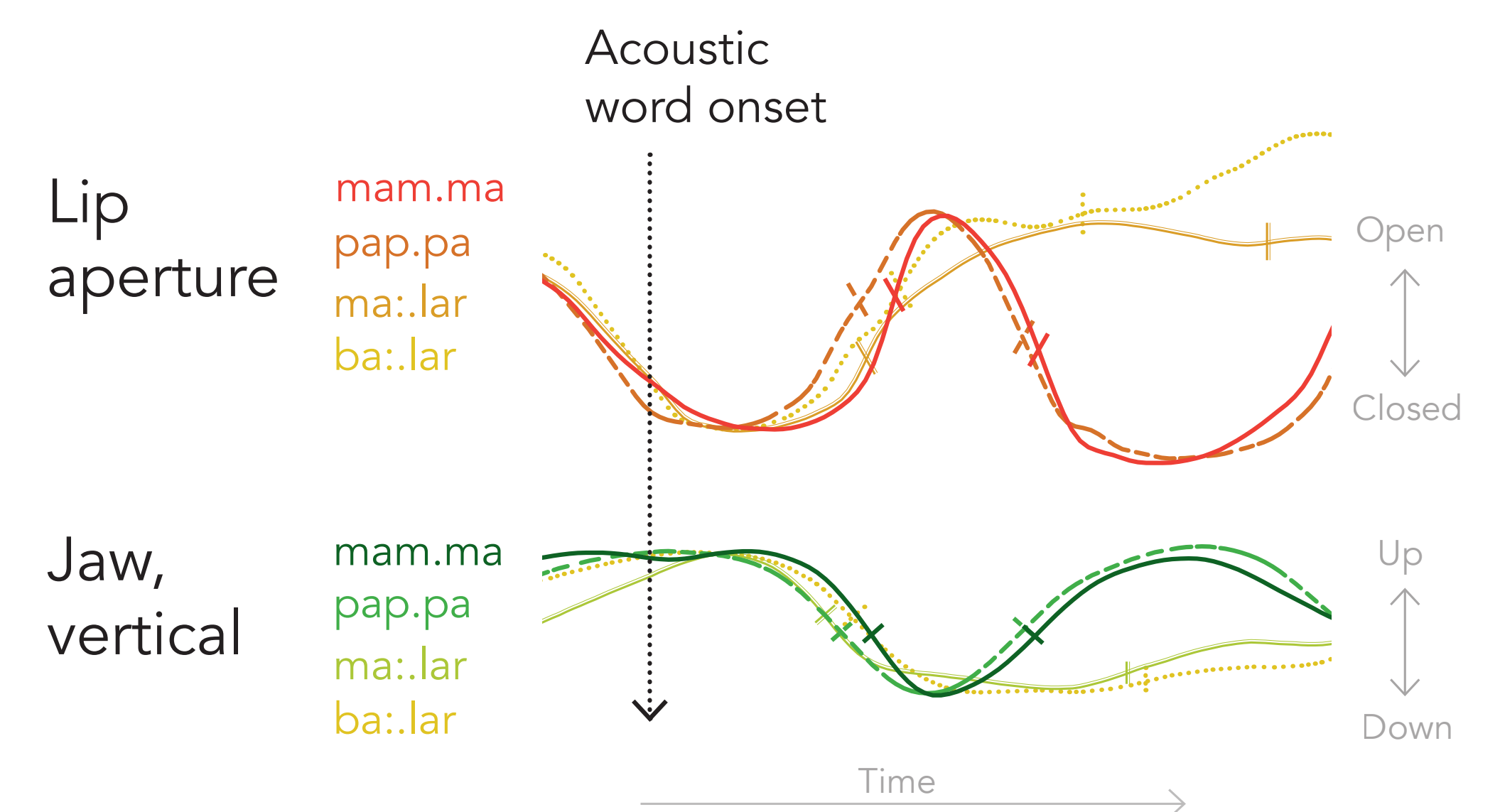


Fig 4. Visualizing the results: jaw below (green) lips above (red). Kinematic trajectories of all four words by one speaker. Reference point: the acoustic word onset. Peak velocity is marked.

Conclusions and outlook

Velocity/displacement relationship for both lip aperture & jaw—but Fitt's law more conclusive for the jaw across all words

We found effects on velocity measurements of (a) position in syllable (opening or closing), (b) syllable type (CVC vs CV:) and (c) consonant features (manner and voicing). More overall effects found on lips than on jaw.

Also differences found in timing between segmental articulation and syllabic articulation. This is what leads us to say that jaw opening and lip aperture are like apples and oranges.

They are both fruit but have different functions in a fruit salad

The role of the jaw in speech is still largely understudied

	Lip aperture		Jaw	
	Opening	Closing	Opening	Closing
Correlation peak velocity + displacement	Opening diff between words: strongest /pap/, weakest /ba:/	Closing Strong correlation in /mam/ and /pap/	Opening Very strong correlation in all words = linear relationship	Closing Very strong correlation in /mam/ and /pap/
Peak velocity	Opening sign diff between words: /pap/ is fastest. No diff between /ba:/ - /ma:/	Closing sign diff between all words: /mam/ is fastest	Opening /pap/ is fastest	Closing sign diff between syllable types
Displacement	Opening No diff between words	Closing sign diff between syllable types	Opening No diff between words	Closing sign diff between syllable types
Relative timing of peak velocity (jaw vs lips)	Opening Diff between /mam/ and /pap/, and between syllable types Closing No sign diff between words			

Table. Summary of results

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