Biomechanical Simulation of Lateral Asymmetry in Tongue Bracing

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Biomechanical Simulation of Lateral Asymmetry in Tongue Bracing (in speech!)

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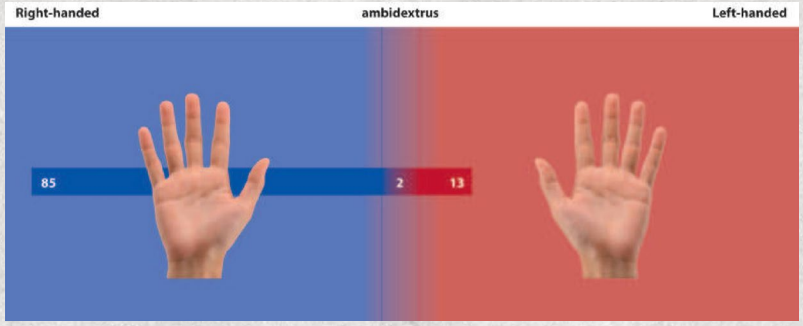
Lateral asymmetry (a.k.a. “ -edness”)

Images from:

Handedness



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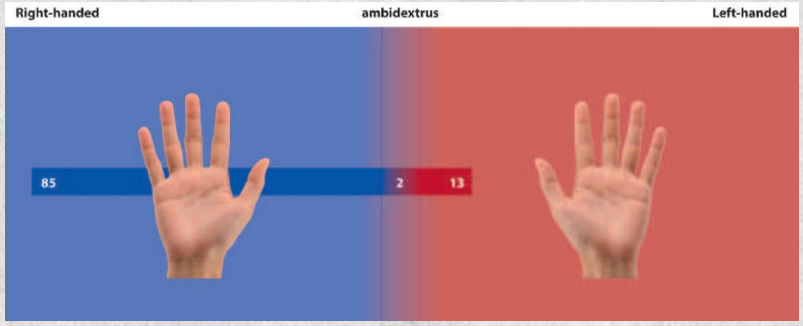

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Handedness may be the best-known *lateral asymmetry*, but...

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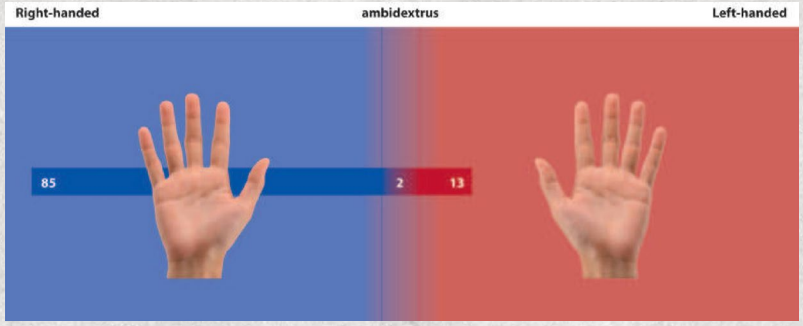

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Many lateral asymmetries are aligned…

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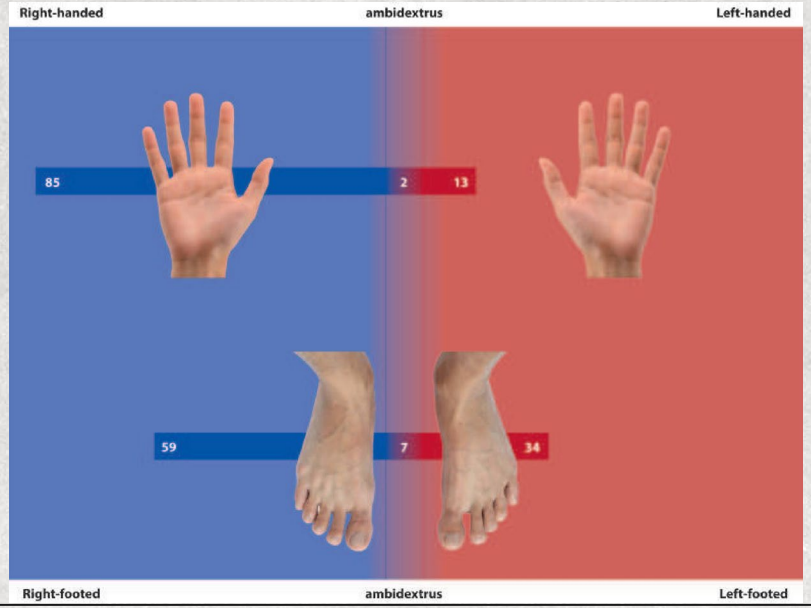

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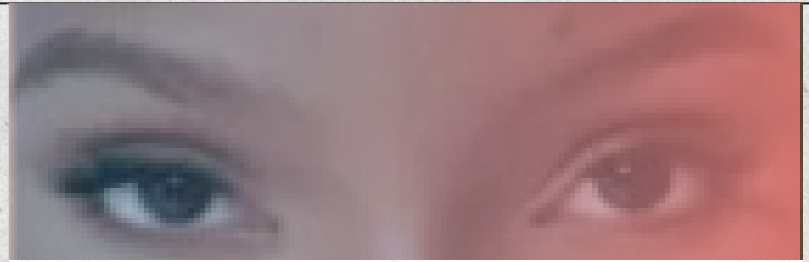

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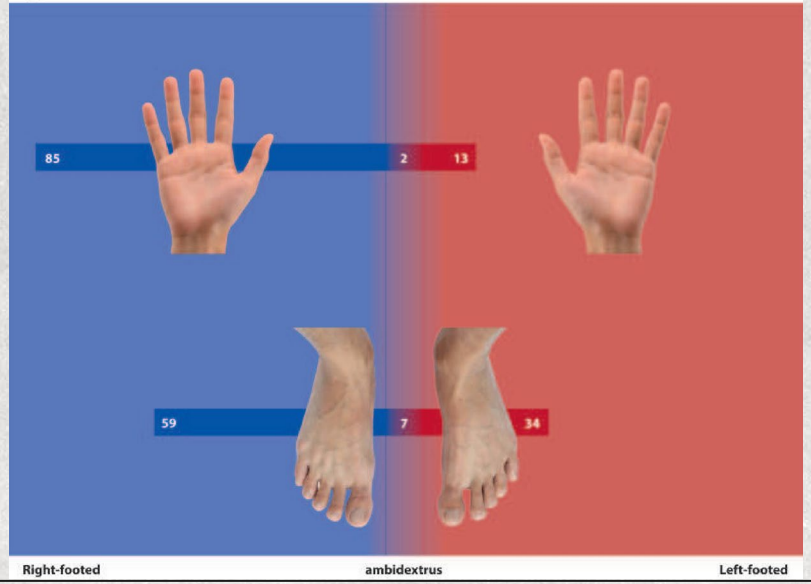
Handedness

Footedness



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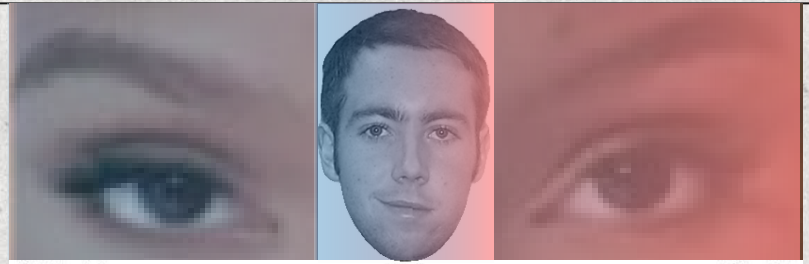

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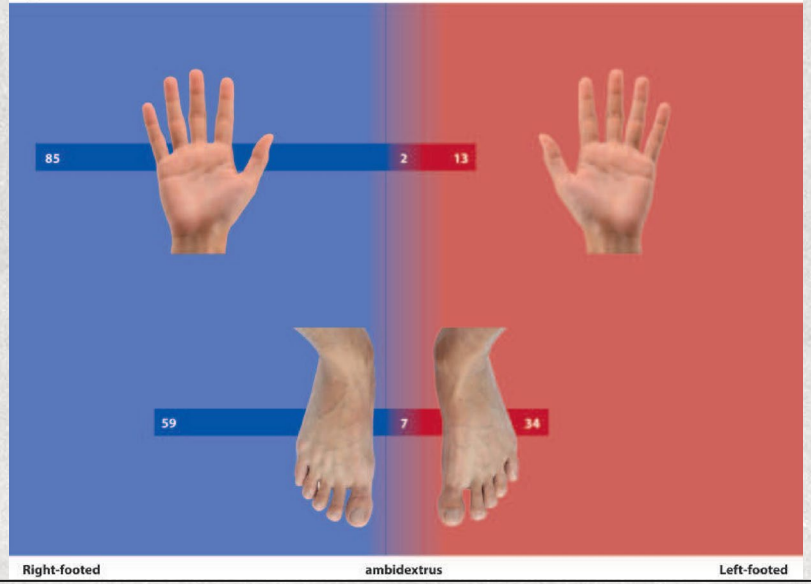

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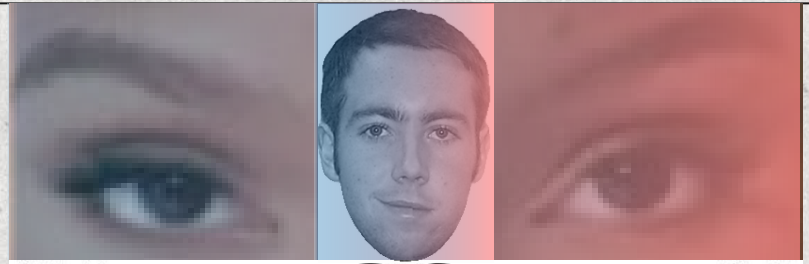

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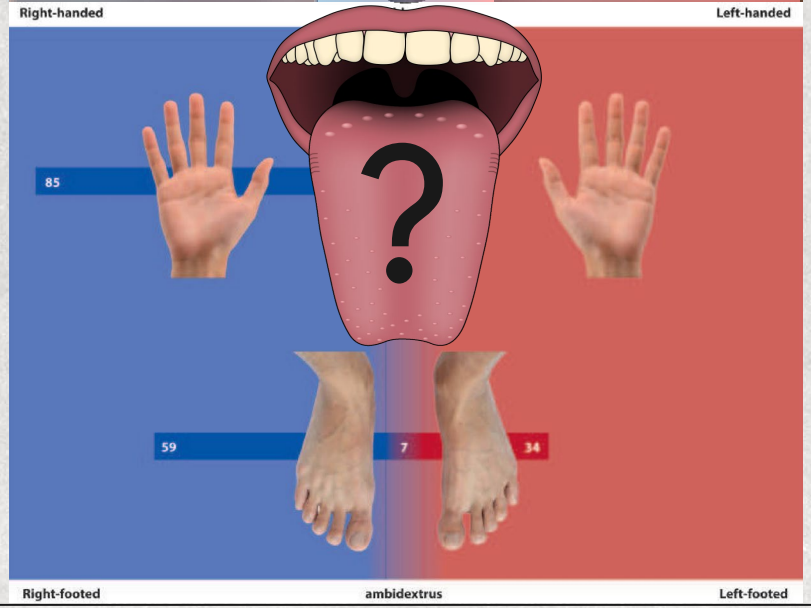

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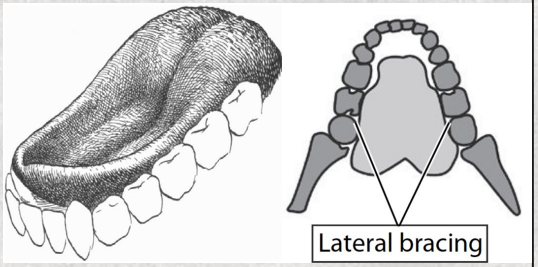
What about tonguedness?

Tongue Bracing



Speaking Tongues Are Actively Braced (Gick et al., 2017)

- Lateral bracing:
  - sides of tongue held against palate & upper molars
- Bracing maintained for 97.5% of running speech
- Lateral bias/asymmetry observed (more releases on one side than the other)

Q: Like other "–ednesses"! ...but which side is dominant?

Robustness of lateral tongue bracing under bite block perturbation (Liu et al. 2022)

- Perturbation study
  - Found lateral bracing is *necessary* for speech
- Biomechanical simulations
  - Identified bracing *agonist/antagonist* muscles

Background

This study:

Determine *muscular* dominance in lateral tongue bracing

Q: In other "-ednesses," muscles activate on the *same side* as movements – Same for tongue?

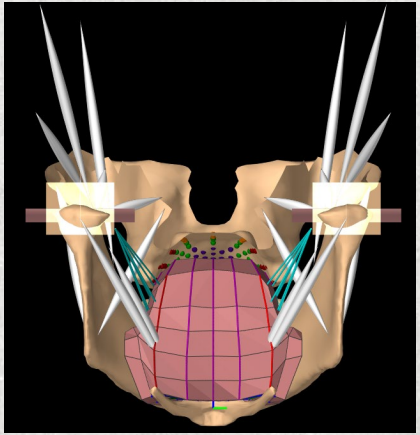
- Biomechanical simulations of tongue muscle activation
- Effect of *hydrostatic** properties of the tongue on lateral bracing

*(like a water balloon)

Methods

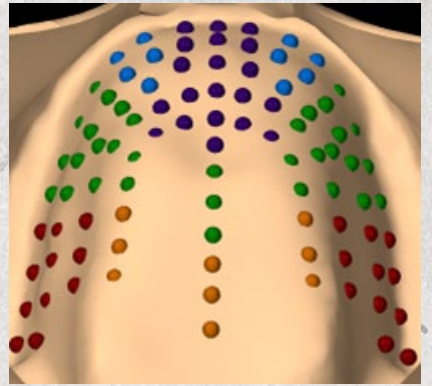
ArtiSynth biomechanical modeling platform (artisynth.org)

- Tongue, jaw, palate and hyoid complex



96 virtual contact sensors detect tongue-palate contact

- Varied activation of left-side muscles



Methods

Agonists

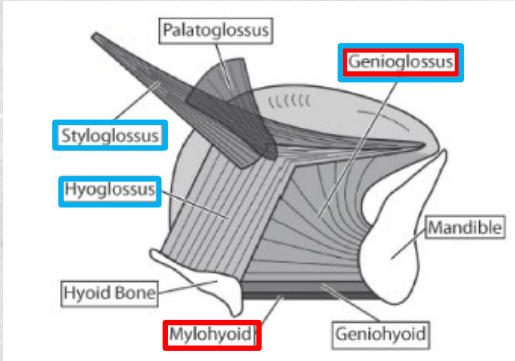
Muscles that *increase* bracing

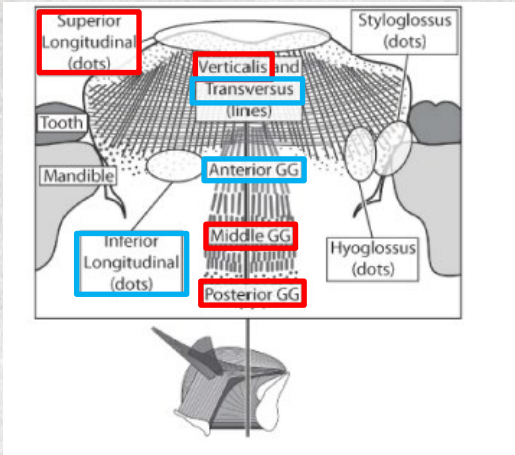
- Raise/widen tongue
- *Posterior Genioglossus, Middle Genioglossus, Mylohyoid, Verticalis, Superior Longitudinal*

Antagonists

Muscles that *decrease* bracing

- Lower/narrow tongue
- *Anterior Genioglossus, Styloglossus, Hyoglossus, Transverse, Inferior Longitudinal*

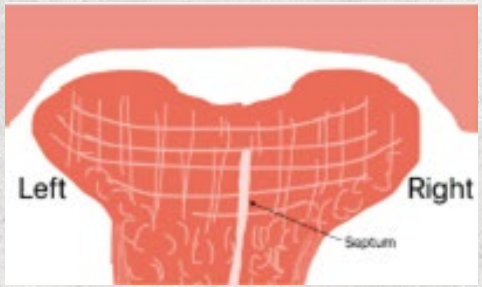




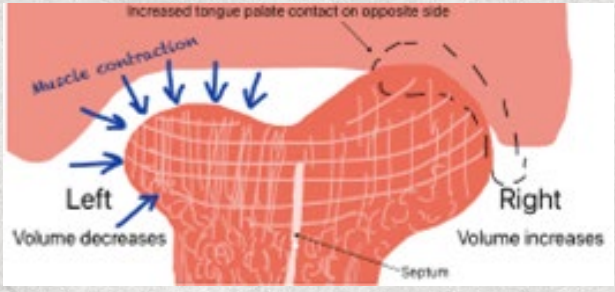
Results

- Preview of results:

  Tongue muscle activations cause greater movements on the *opposite* side!



No activations

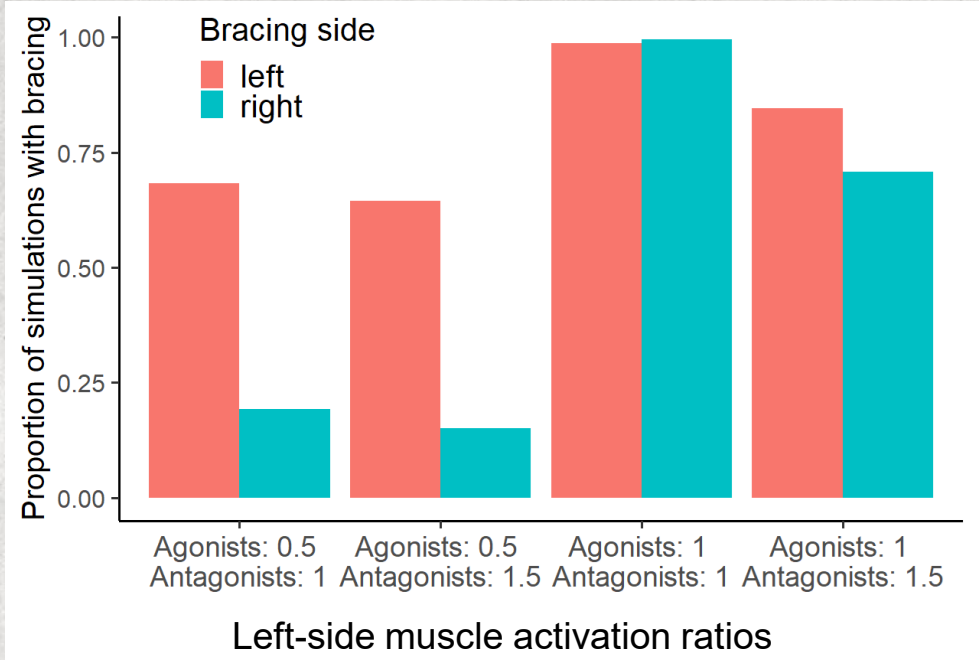


Muscles activated on the left

...because the tongue is a muscular hydrostat

Results

- 2083 / 2528 successful simulations
- ↑ L agonist activation = ↑ L & R bracing



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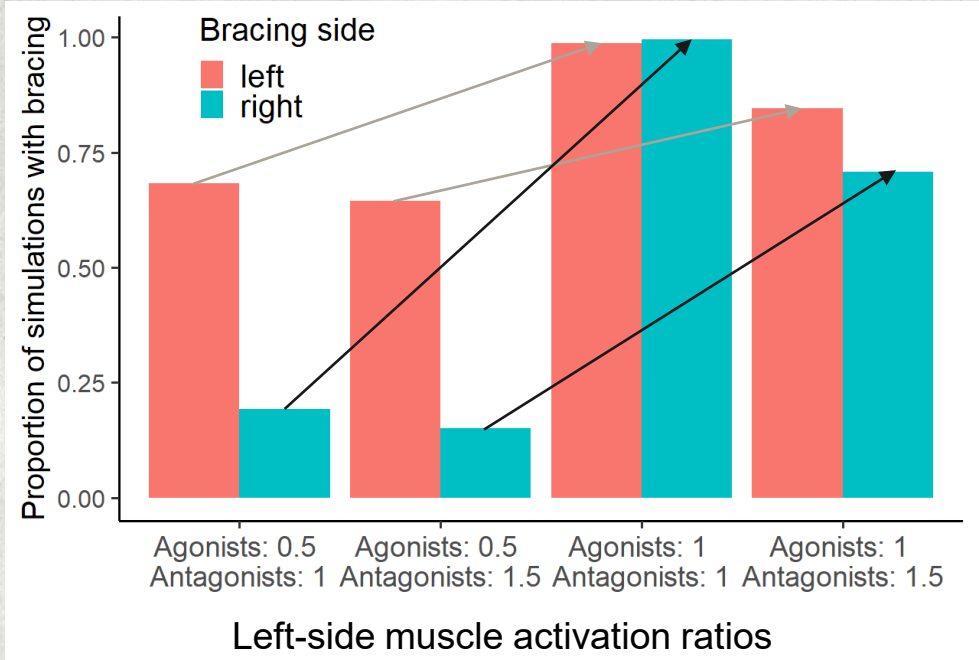

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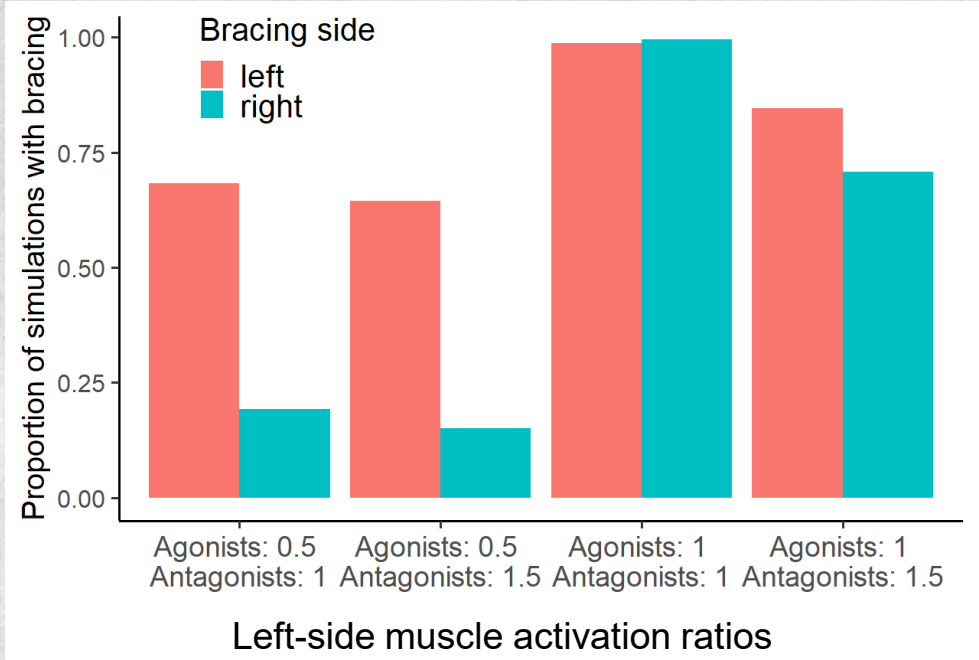

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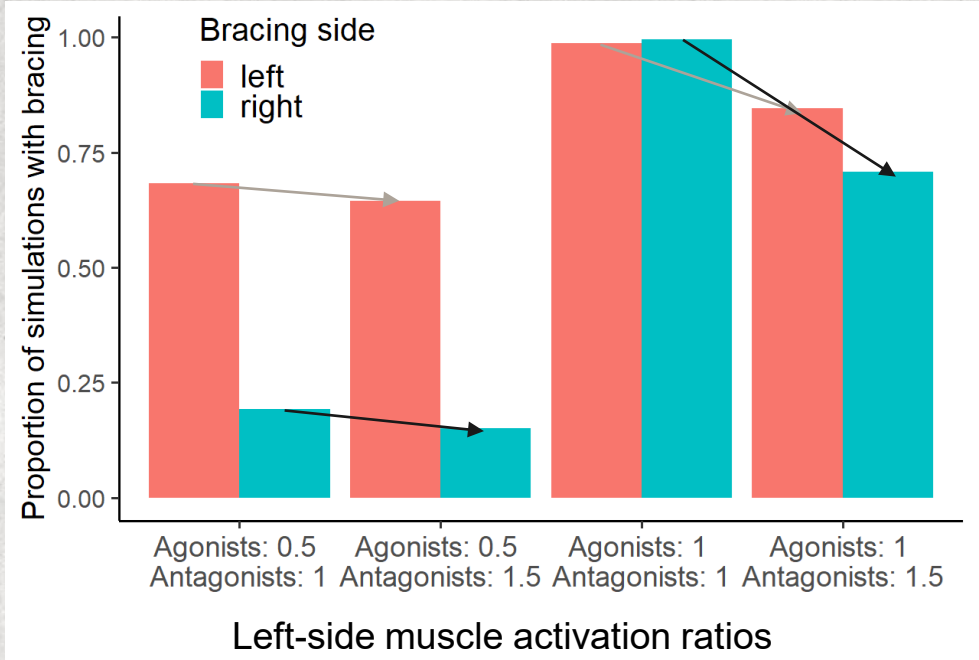
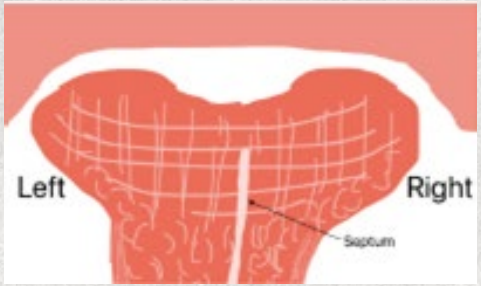


Discussion

Bracing is enacted primarily by *contralateral* muscle activation
> because of the muscular-hydrostatic properties of the tongue

The dominant side in tonguedness may be the *opposite* of other "-ednesses"
> at least insofar as muscle activation matters



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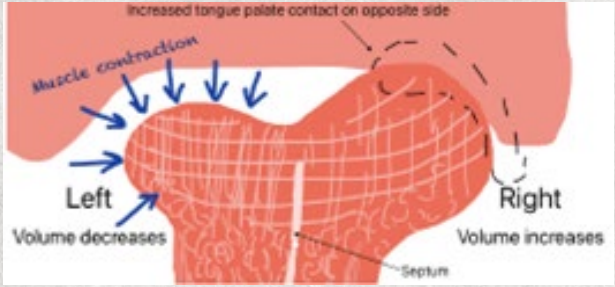

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Thanks!

Do you have any questions?