# 5aSC1. A biomechanical model for infant speech and aerodigestive movements


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## Background and objective

**How do infants learn speech movements *rapidly* and with *limited input?***

**Hypothesis**: Core speech movements may build on preexisting aerodigestive movements [1, 2].

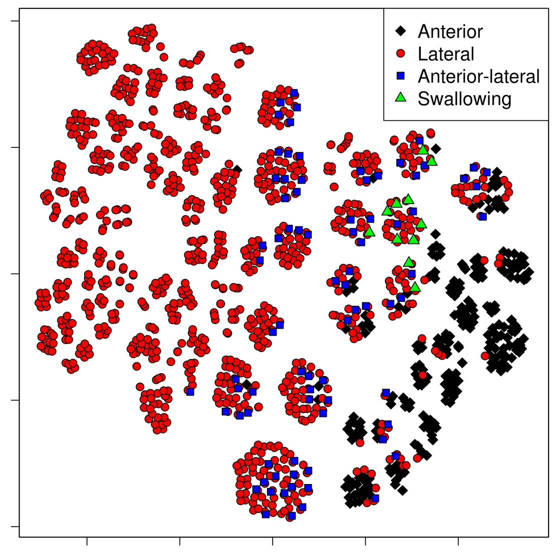
- e.g. swallowing, suckling, etc.
- There is neurological, clinical, and kinematic evidence relating speech and aerodigestion.
- Existing structure makes learning problem tractable.

**Problem:** Difficult to test from the perspective of motor control.

**Solution:** *Biomechanical modeling* provides a way to test some of the predictions of this hypothesis.

Biomechanical models of the adult vocal tract have been used to test hypotheses about infants [3].

- But adults and infants have different vocal tracts!

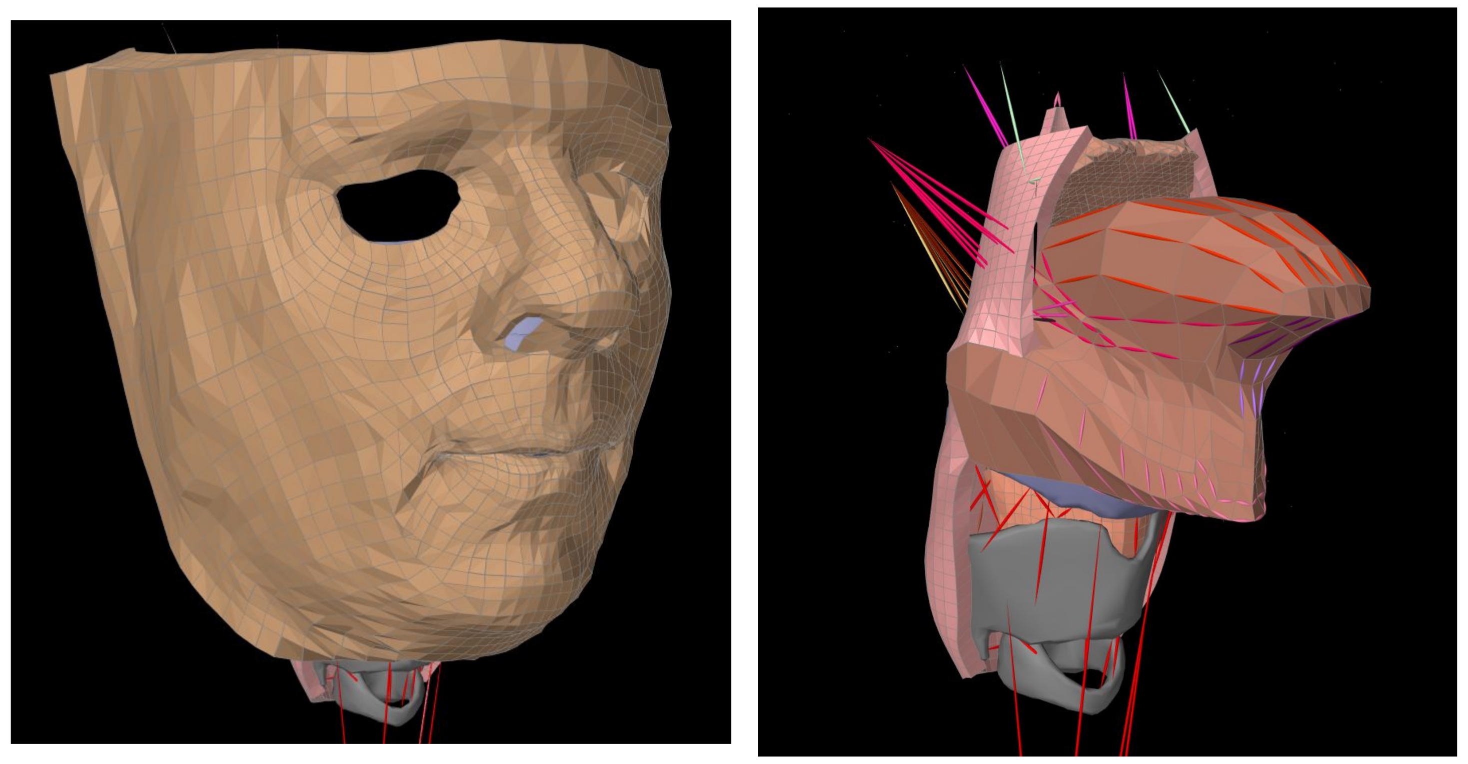



A t-SNE visualization of the muscle activation space for various speech and aerodigestive movements [3].

**Objective:** Create a biomechanical model of an infant tongue and palate using Artisynth [4, 5].

## The Frank vocal tract model

The biomechanical modeling platform *Artisynth* contains a model of the adult vocal tract, called *Frank*.

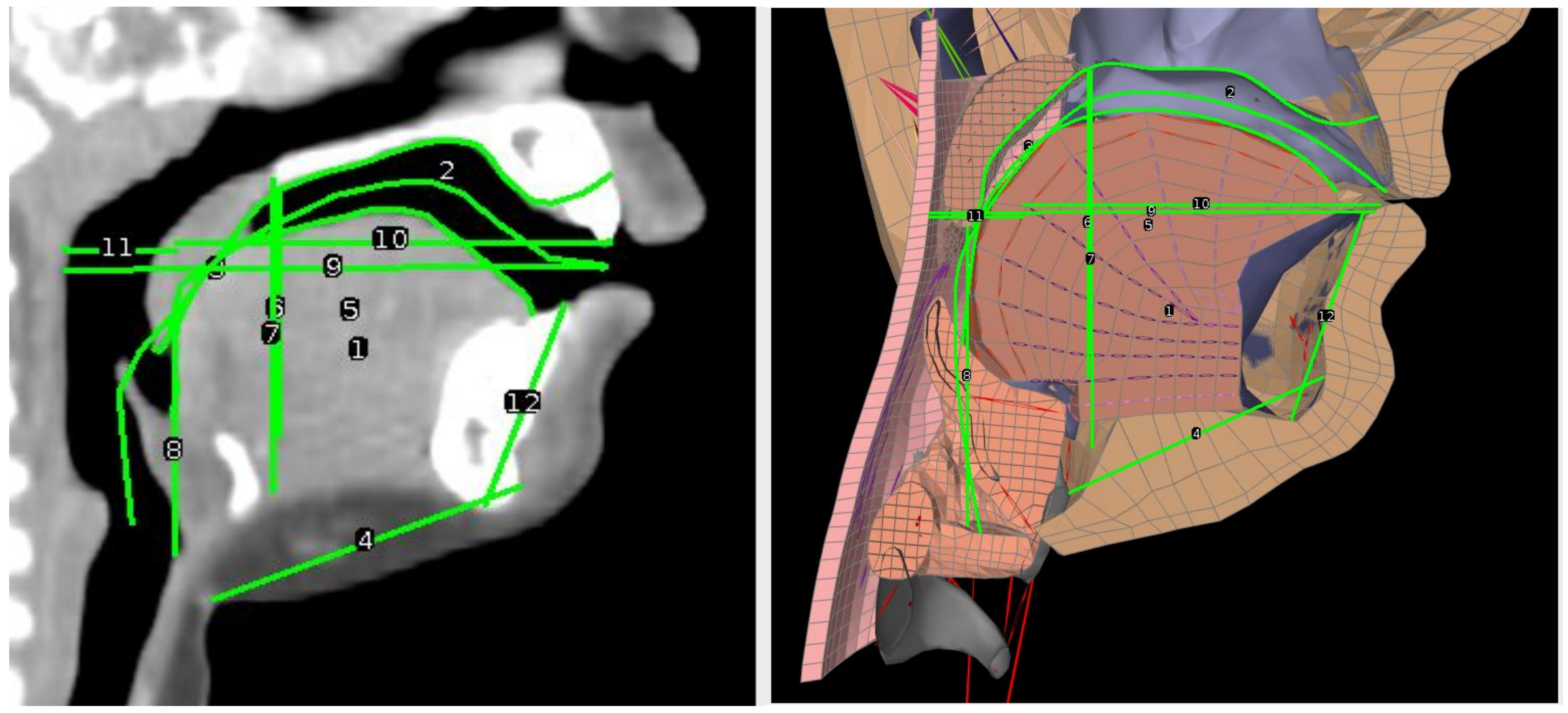


## Comparing the infant and Frank vocal tracts

We compared a midsagittal CT image of an 11-month male infant vocal tract with a midsagittal image of the Frank model.

Quantitative comparison was done using biometric measurements adapted from previous developmental studies of the vocal tract [6, 7].

1. **Vocal tract length**
2. **Hard palate length**
3. **Soft palate length**
4. **Mandibular length**
5. **Tongue length**
6. **Hyoid height**
7. **Larynx height**
8. **Oropharynx length**
9. **Vocal tract horizontal length**
10. **Anterior cavity length**
11. **Oropharynx width**
12. **Mandible height**



Each measurement is normalized based on the **mandible height** from the same image.

- Allows comparison between images with different scales

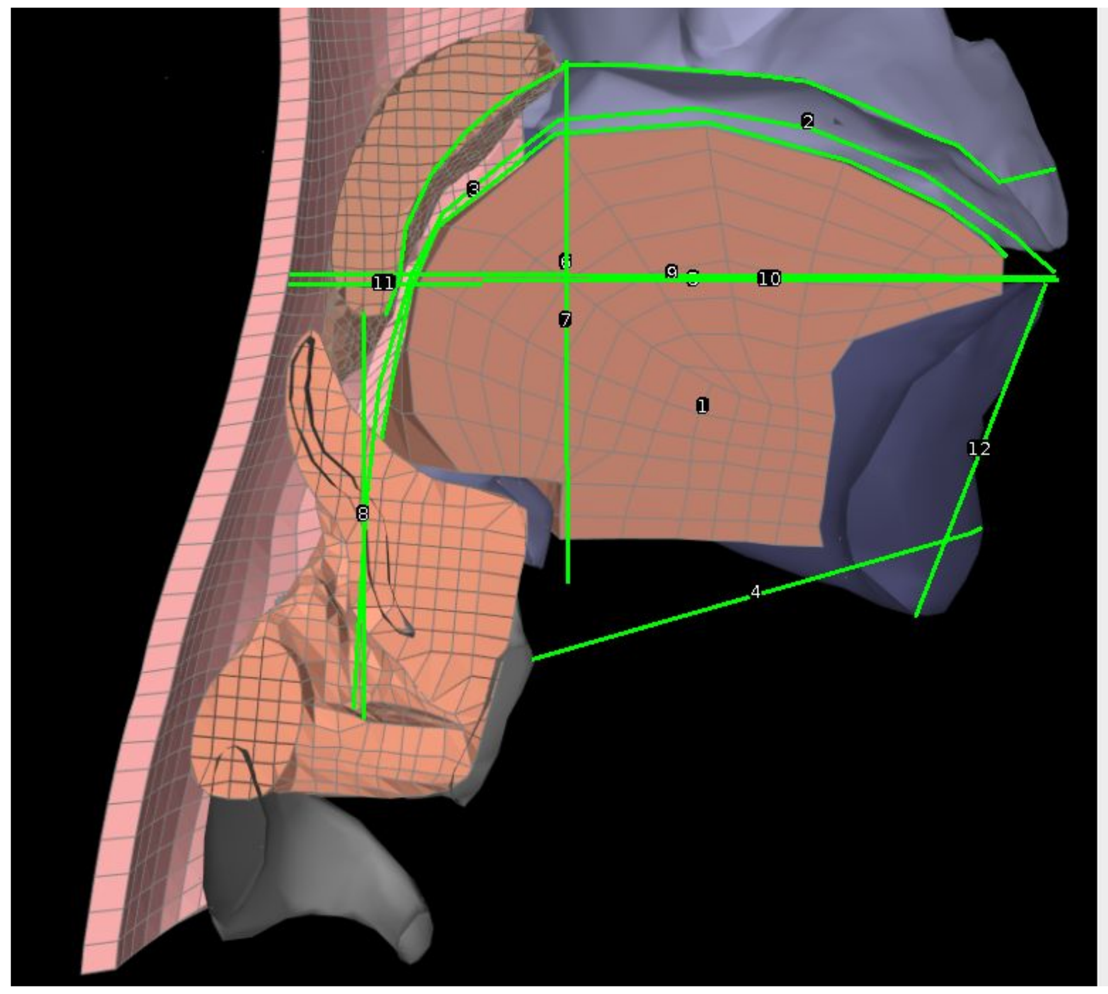
## Modifying the Frank vocal tract

Compared to Frank the infant has proportionally a:

- **Higher larynx**
- **Higher hyoid**
- **Longer anterior cavity**

We modified the structures in the Frank vocal tract with:

- Rigid body translations
- Affine transformations
- Removal of excess tissue including face



## Quantifying comparisons

We use the following measure to quantify the difference between the infant and Artisynth vocal tracts:

$$\theta = \sum_{i=1}^{m} I_i (M_i - I_i)^2$$

Where

- *i:* indexes over the set of measurements
- $M_i$: normalized measurement from model
- $I_i$: normalized measurement from infant

This measurement:

- Penalizes differences in grosser measurements
- Indicates a better fit with lower values (0 = perfect)

## Results

Original Frank model: **θ = 1.438**

Infant Frank model: **θ = 0.373**

The infant Frank model corresponds more closely to the proportions of the infant vocal tract

## Discussion and future work

This model will allow researchers to:

- Simulate aerodigestive and speech movements.
- Supplement evidence from other domains bearing on connection between speech and aerodigestion.

Generally useful for research on the infant vocal tract.

**Future directions:**

- Ensure muscle insertions are accurate.
- Replace skull with models generated from infant data.
- Simulate swallowing and speech sounds.

## References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