# Vowel Acoustics and Tongue Postures across Different Head Angles

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## Background

- Different postural changes may induce different degrees of changes on acoustic speech signals (Flory, 2015; Vorperian et al., 2015).
- While the preservation of formant profiles across different postures is suitably accounted for by the **two-tube model** (Stevens, 1998; Fant, 2006) and **perturbation theory** (Chiba & Kajiyama, 1941), it remains unclear whether the preservation of formants is resulted from the accommodation of tongue postures.
- The angle between the front and back tubes does not impact on the vowel acoustics, including pitch and formants. ⇒ ***Not empirically tested.***
- Can the tongue accommodate the changes in head angles while maintaining target acoustics? ⇒ ***Not empirically tested.***

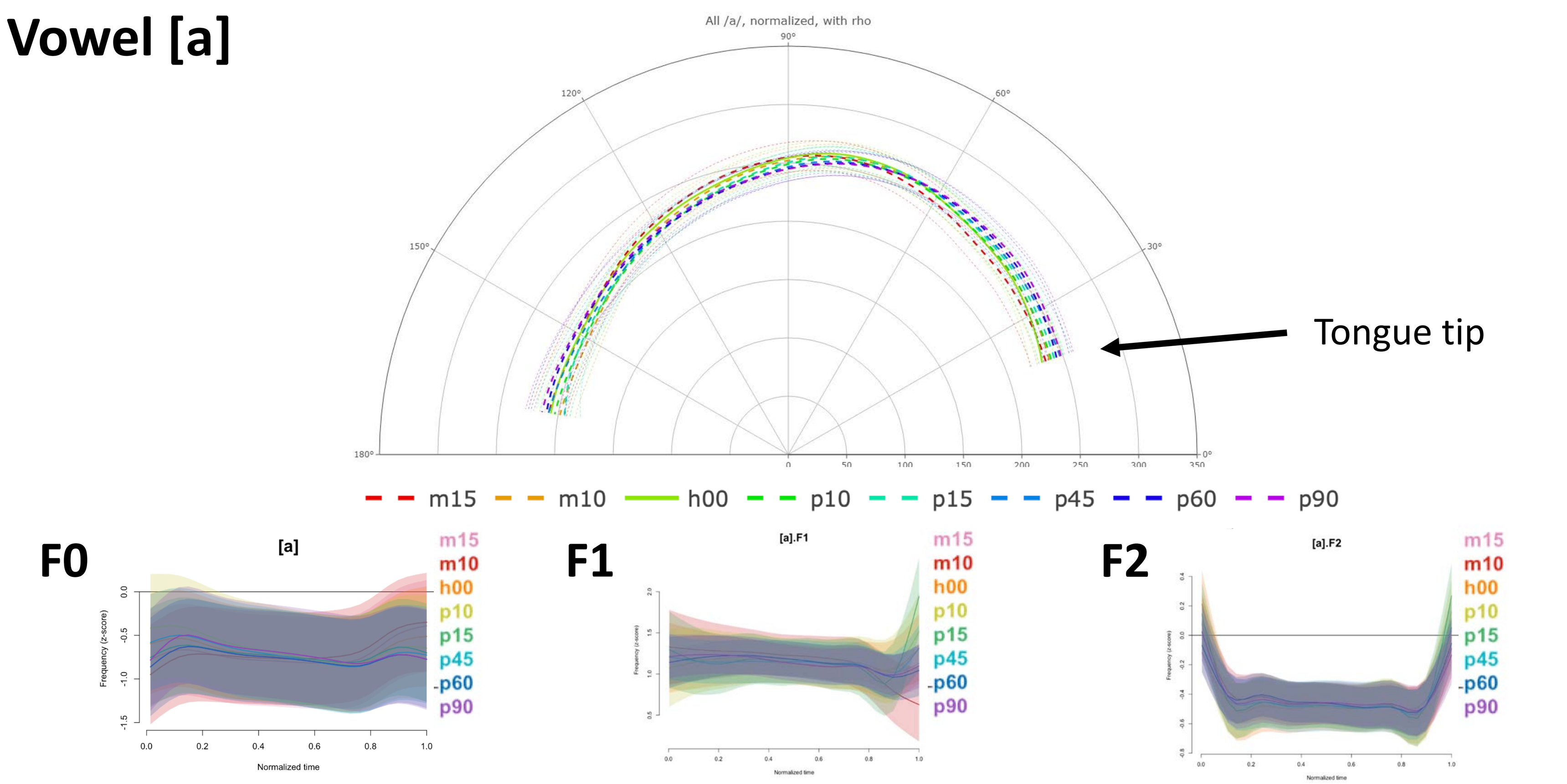
## Research Question

Is the preservation of formants across different head angles resulted from the accommodation of tongue postures?

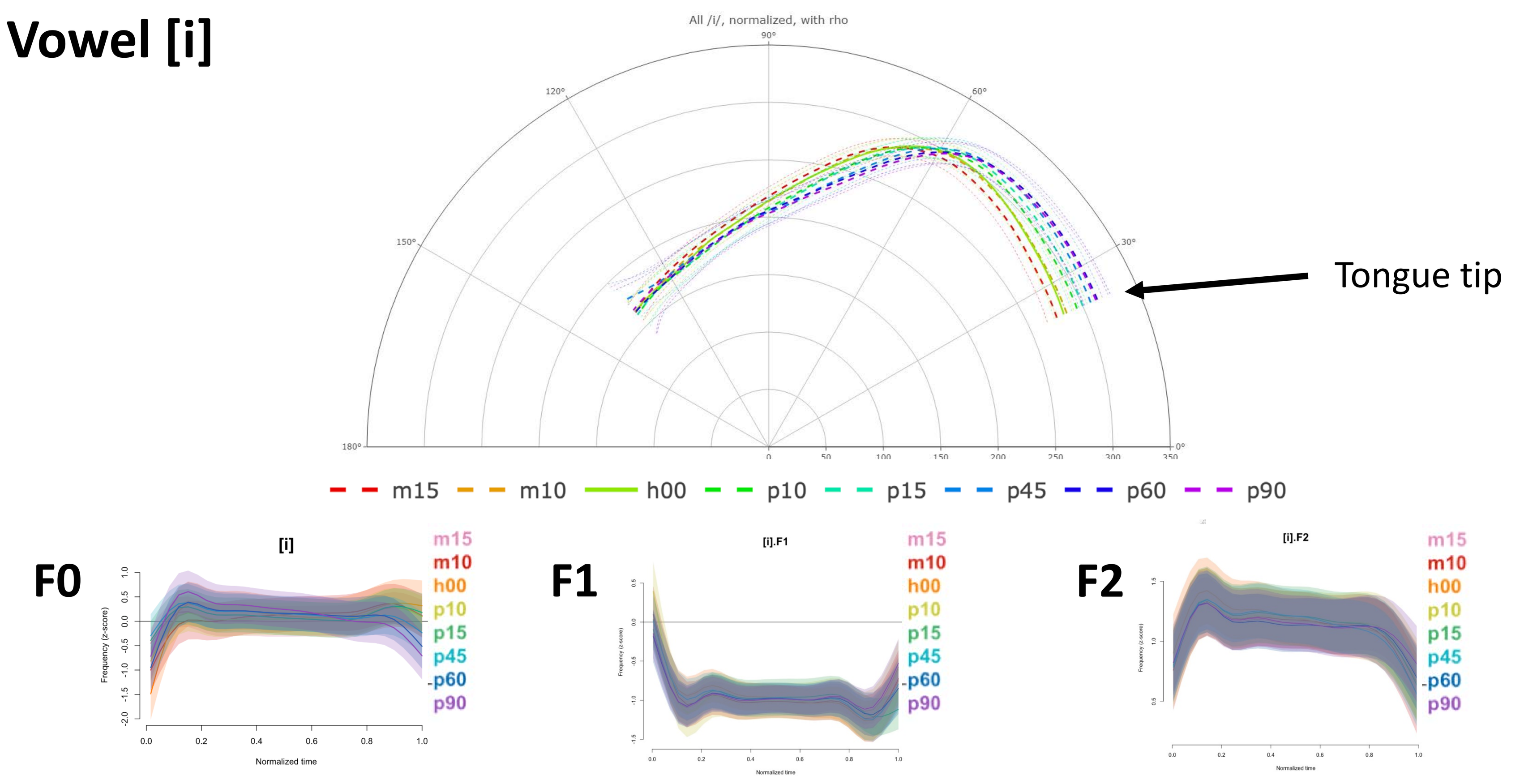
- Preserved acoustics
- Preserved tongue postures

## Results

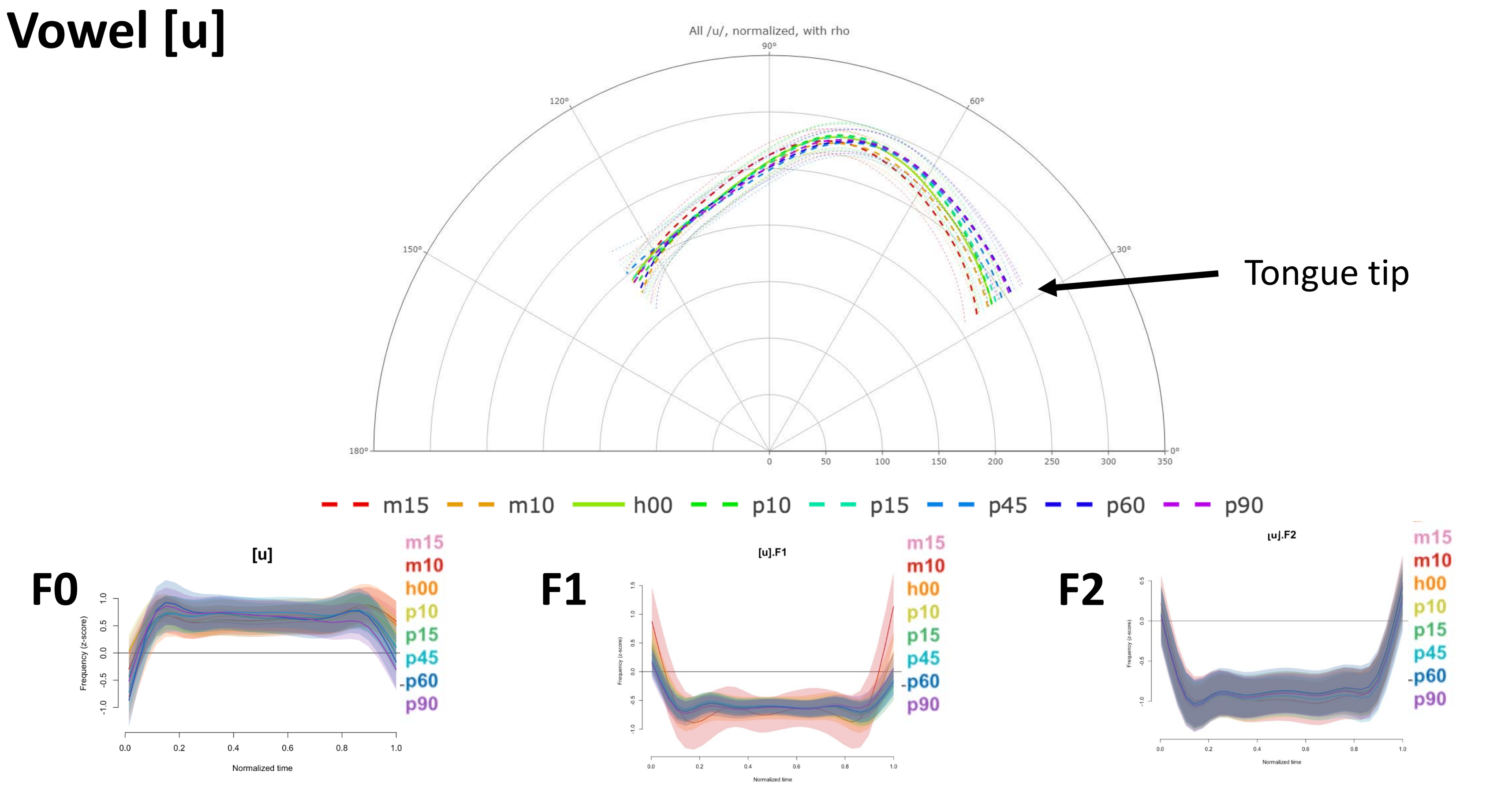
### Vowel [a]




### Vowel [i]




### Vowel [u]




## Discussion

### Acoustics

- Preserved acoustics across all head angles (true for all vowels).

### Tongue postures

- Vowel-dependent tongue movements were observed.

*Vowel [a]*

- As the head angle increases, the tongue root is pulled toward the pharyngeal wall.
- Less force was required to achieve the intended tongue root position.

*Vowel [i]*

- Pivotal rotation pattern.
- As head angles go up, much more force is given for the tongue root to fight against the gravity.
- As the head goes down, the tongue tip is squeezed to a larger degree to fight over the gravitational pull.

*Vowel [u]*

- When the head angle continues to rise, the effect of gravity helps to reduce the need of muscle contraction.
- When the head angle lowers, the tongue tip is pulled down by gravity. More force was implemented to achieve the intended target.

- **Tongue postures largely fight against gravity.**
- **Target-oriented strategy is employed.**

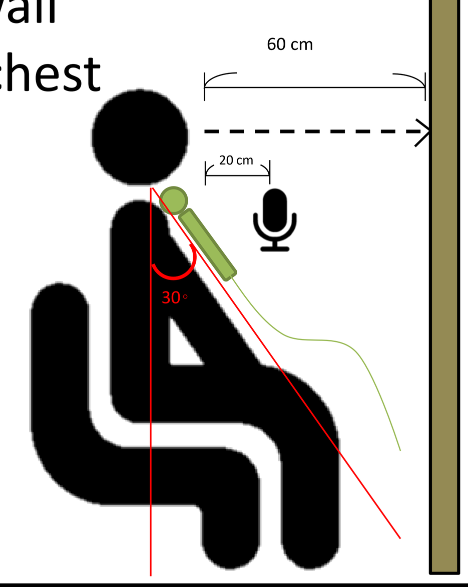
## Methods

### Apparatus

- Ultrasound: CGM OPUS 5100
- Transvaginal electronic curved array probe
- Ultrasound stabilization headset (Articulate Instruments metallic transducer stabilization system)

### Procedure

- Sit upright
- 60 cm to the wall
- 30 ◦ from the chest

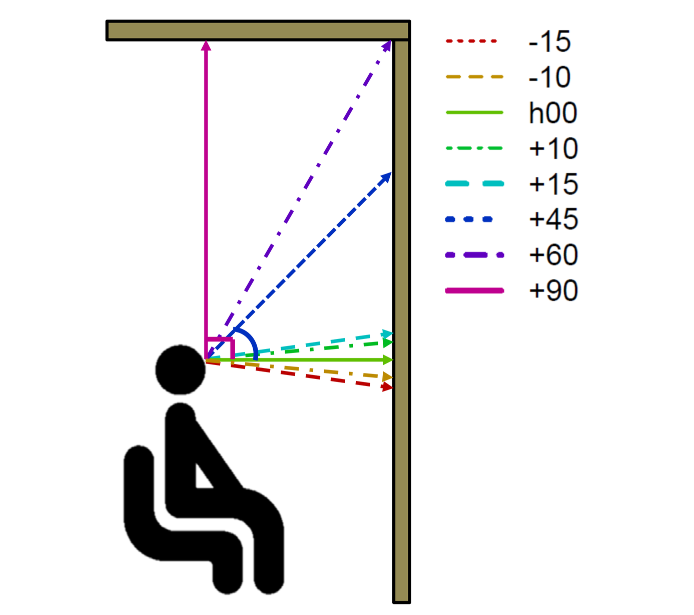


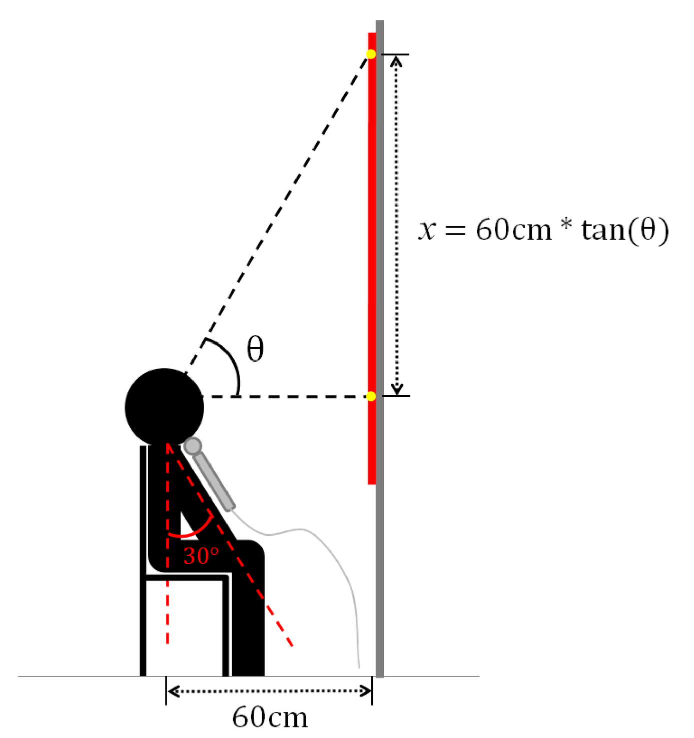

### Stimuli:

- 8 angles: -15°, -10°, 0°, 10°, 15°, 45°, 60°, 90°
- 3 vowels: [a], [i], [u]
- 10 tokens
- Rate: 1 word/sec
- 8 x 3 x 10 = 240 trials/person
- The point where the participants should focus on is computed through trigonometry.

### Data Analysis:

- Praat: F0, F1, F2 obtained (midpoint)
- MatLab: Images of tongue postures (midpoint)
- Livewire tracing: tongue postures traced (MatLab-based algorithm)
- R: polar coordinates (Henye, 2015) , Generalized Additive Mixed Models (GAMMs; Wieling, 2018).

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