A Data Driven Phoneme-Specific Analysis of Articulatory Importance

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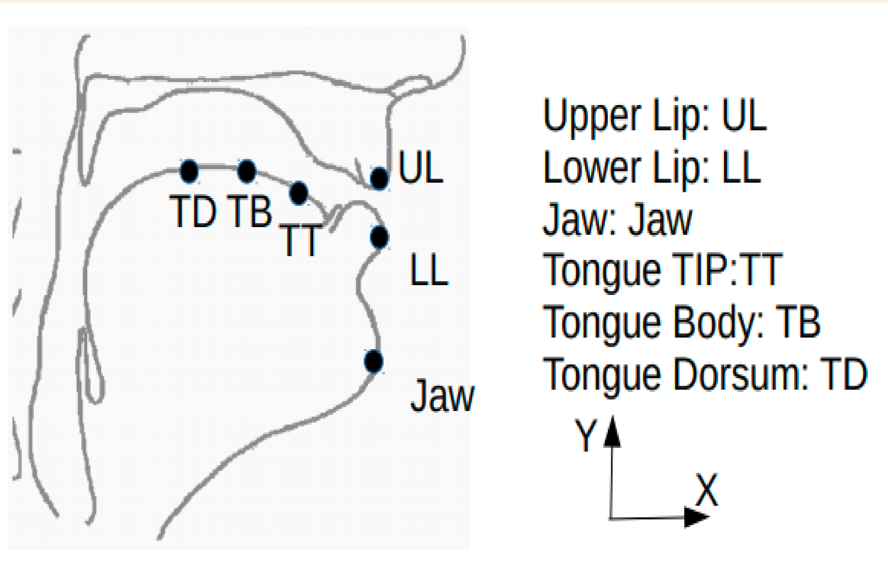
Introduction

- **Motivation**:The main motivation behind this paper is to find the degree of importance of each articulator in speech production.
- **Proposed approach**:
  - In articulatory space, critical articulators of specific sound exhibit minimal variance at target position based on which articulators can be critical or non-critical. [1]
  - In this work, instead of assigning a binary decision on articulators being critical or not, we attempt to assign an articulatory importance value between 0 to 1 in data driven manner.
- **Key findings**:
  - The Critical Articulators comparatively have high importance values and are consistent across subjects.

Data Collection

- Articulatory movement data recorder: → **EMA AG501**. [2]
- **Speech Stimuli**: 460 phonetically balanced English sentences from the MOCHA-TIMIT corpus are chosen as the stimuli for data collection.
- **Six** sensors are connected: UL-Upper Lip, LL-Lower Lip, Jaw-Jaw, TT-Tongue Tip, TB-Tongue Body, TD-Tongue Dorsum.



- From the **six** sensors, we obtain **12**-dimensional articulatory features (AFs) namely, $UL_x, UL_y, LL_x, LL_y, Jaw_x, Jaw_y, TT_x, TT_y, TB_x, TB_y, TD_x, TD_y$.
- We collect data from 38 speakers comprising 24 males and 14 females in an age group of 21-28 years.

Articulatory Importance Function

- Importance of an articulator is calculated using negative logarithm of the ratio of phoneme specific variance to the global variance as given by

$$i^{a_k} = -\log \frac{\sigma_p^{a_k}}{\sigma_g^{a_k}} \quad (1)$$

- $\sigma_p^{a_k}$ and $\sigma_g^{a_k}$ and the phoneme specific and global variance calculated from the collection of samples from the mid point of a/all phoneme segment(s).

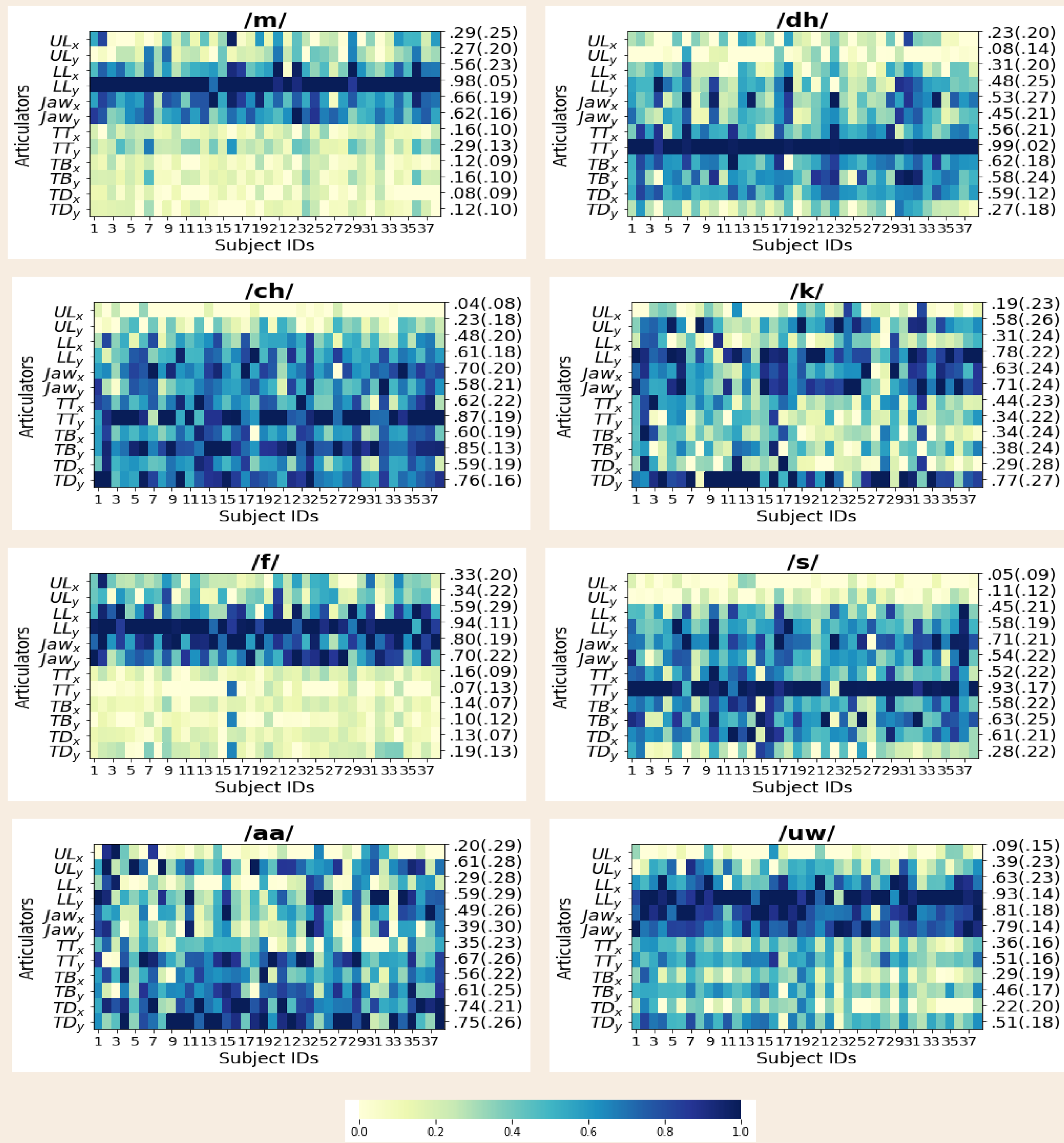
Normalized Articulatory Importance Function

- i^{a_k} is the importance function of an articulator which takes values greater than zero for $\sigma_p^{a_k} < \sigma_g^{a_k}$.
- The lesser the $\sigma_p^{a_k}$ than the $\sigma_g^{a_k}$, more is the importance of the corresponding articulator. To bound the range of values between 0 to 1, we further normalize i^{a_k} to I^{a_k} using the equation below.

$$I^{a_k} = \frac{i^{a_k} - min_k(\{i^{a_k}\})}{max_k(\{i^{a_k}\}) - min_k(\{i^{a_k}\})} \quad (2)$$

Results and Discussion

Normalized articulatory importance function values (color-coded from 0-1) for different consonants and vowels for each of 38 subjects (x-axis shows subject index, y-axis indicates different articulators)



- These average AIF values across all the subjects are observed to be consistent with the critical articulators reported in [3]
- The critical articulators comparatively have high importance values and is consistent across subjects.
- The spread of importance function across subjects for critical articulators is minimum.

Conclusion

- This work gives a better understanding about the importance of various articulators in phoneme production.
- This analysis could benefit to the understanding of inter speaker variability in speech production mechanisms and provide articulatory feedback in language learning tasks.

References

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