2. Figure 1: (Red)
First five formants automatically extracted in Praat at the time of maximal constriction of each gesture in a pre-aperture task.

Aperture by Articulator and Task

Palatal aperture by position and task

Pharyngeal aperture by position and task

ARTICULATORY AND ACOUSTIC ANALYSIS

Articulatory Analysis
- Time of maximum constriction for each gesture found using a Region of Interest technique [4].
- Four pseudo-circular regions (radius of 3 pixels) manually defined along vocal tract midline (Figure 3).
- Regions used in analysis: Labial region, Anterior and Posterior Palatal regions, and Pharyngeal region.
- Average pixel intensity inside each region calculated for each frame (higher pixel intensity = more tissue within the region).
- Time of maximum constriction found using the find_max algorithm [5], and defined as the movement velocity minimum closest to a manually identified pixel intensity maximum.

Acoustic Analysis
- F1 and F2 formants automatically extracted in Praat at the time of maximal constriction of each constriction gesture.
- F3 selected for analysis due to the importance of low F3 as an acoustic feature of /ɹ/.

RESULTS: TASK EFFECTS ON ARTICULATION

- Linear Mixed Effects Models were fit to the data in R [7] to examine both task effects on articulation and articulatory-acoustic relations within the two tasks.
- Palatal aperture values significantly smaller than Pharyngeal aperture values overall (p < 0.0001).
- Significant main effect of Task (p < 0.0001) indicates that smaller average aperture values are observed in the Citation Condition than in the Connected Condition.
- Interaction between Articulator and Task not significant at the .05 level (p = 0.09).

RESEARCH QUESTIONS
1. What articulatory effect(s) of speech task are observed in the production of the palatal and pharyngeal constriction gestures for American English /ɹ/?
2. How do other factors that may affect gestural realization, such as a segment's position in the syllable, interact with the observed task effects?
3. How do task effects on articulation affect the acoustic outcome in /ɹ/ production, specifically its characteristic low F3 value?

PARTICIPANTS AND METHODS

- Articulatory data taken from real-time MRI recordings of three native speakers of American English (2 male, 1 female)
- Acoustic data from simultaneous audio recordings of each MRI session
- Participants recorded reading single words in isolation (Citation Condition) and sentences (Connected Condition)
- A total of 361 tokens of /ɹ/ analyzed (180 from Citation Condition, 321 from Connected Condition)
- Syllabic position and surrounding vowel context of the target consonant controlled for all words in the Citation Condition.

<table>
<thead>
<tr>
<th>Syllabic Positions</th>
<th>Simple Onset (BL)</th>
<th>Complex Onset (BBL)</th>
<th>Simple Coda (BLf)</th>
<th>Complex Coda (BBLf)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vowel Contexts</td>
<td>/ɪ/</td>
<td>/ɪ/</td>
<td>/ɪ/</td>
<td>/ɪ/</td>
</tr>
</tbody>
</table>

Table 1: Positions and Vowel Contexts from which tokens were taken in both the Citation and Connected Conditions

- Connected Condition tokens taken from words in the USC-TIMIT corpus [3] that contained /ɹ/ in the same contexts found in the Citation Condition.

SUMMARY AND IMPLICATIONS

- Effects of speech task observed for both Palatal and Pharyngeal aperture measurements, with a greater degree of constriction (smaller aperture values) observed in the Citation Condition for both constriction gestures.
- Nature of the interaction between position and task effects differs between the palatal and pharyngeal gestures, possibly reflecting differences between primary and secondary articulations.
- Palatal aperture demonstrates a greater effect of task in onset position, with the greatest effect observed for simple onsets.
- Lack of an interaction between Articulator and Task for pharyngeal aperture in coda positions.
- Difference in average F3 values across the two speech tasks reflects observed articulatory differences.
- Lower F3 values observed in Citation Condition, which follows from the greater degree of constriction observed for both constriction gestures in this condition.