Articulating Finnish Vowels: Results from MRI and sound data

Pertti Palo, Daniel Aalto, Olli Aaltonen, Risto-Pekka Happonen, Jarmo Malinen, Jani Saunavaara and Martti Vainio*

*With affiliations too numerous to list here.

18.2.2012
Introduction

- We are building a mathematical and numerical model of vowel production.
- For this we need geometrical (i.e. anatomical) data on vowel production.
- We also need simultaneously recorded audio data for validation of the model.
- We are currently assessing the reliability of the pilot data set.
- At the same time we are developing a systematic assessment kit for new data sets.
Data acquisition: The setup
Data acquisition: The protocol

Cue (3 s); 110 Hz sine

Dynamic MRI sequence (7.8 s)

Sustained [æ] (10 s)
The data consists of the 8 Finnish vowels.
For each we have a clean sample from the beginning and end of the production.
From a purely F1-F2 point of view, the most reliable samples are /e/, /y/ and /ø/.
The acoustic analysis presents challenges.
Perceptual analysis of audio data: Setting

- 200 ms samples were listened by three students of phonetics.
- They categorised the samples as vowels in a forced choice setting.
- They also rated the samples in prototypicality (epätyypillinen vs. tyypillinen) and nasality (epänasaalinen vs. nasaalinen).
- Prototypicality and nasality were rated on a visual analog scale.
Perceptual analysis of audio data: Preliminary results

- /a/, /e/, /y/ and /ø/ were correctly categorised in all cases.
- The rest had one error each either in beginning or end.
- /e/ got the highest prototypicality score for both begin and end samples.
- The current /e/ sample seems to be the most reliable of this set.
- For the others the results are nonconclusive.
MRI data

MRI is a tomographic technique: The data is acquired in slices (on the right) rather than as a projectional average (on the left).
Asymmetry is evident in most samples. For example, in the tongue position of the /y/ sample.
## MRI data analysis: Measurements

<table>
<thead>
<tr>
<th>Phoneme</th>
<th>/a/</th>
<th>/e/</th>
<th>/i/</th>
<th>/o/</th>
<th>/u/</th>
<th>/y/</th>
<th>/æ/</th>
<th>/φ/</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jaw opening (cm)</td>
<td>7.4</td>
<td>7.3</td>
<td>6.8</td>
<td>8.2</td>
<td>8.2</td>
<td>7.0</td>
<td>8.6</td>
<td>8.2</td>
</tr>
<tr>
<td>Smallest area (cm²)</td>
<td>1.3</td>
<td>1.6</td>
<td>0.3</td>
<td>0.5</td>
<td>0.9</td>
<td>0.3</td>
<td>2.5</td>
<td>3.9</td>
</tr>
</tbody>
</table>
MRI data: Three dimensions

Play videos.
Conclusions

- It is difficult to produce representative vowels in these conditions.
- The tongue is grooved regardless of the vowel.
- There is contact between the sides of the tongue and either the palate or the pharyngeal wall regardless of the vowel.
- There is asymmetry in the articulations.