Acoustic comparison of /t/ glottalization and phrasal creak

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Introduction

- In American English, creaky voice has several linguistic origins, such as:
  - /t/ glottalization – about [əbər]/
  - Phrasal creak – creaky voice that is prosodically conditioned, e.g. phrase-final creak.
- Different sources of creaky voice can co-occur on a single word (Fig. 1).

Fig 1: ‘about’ with glottalization/ creak

• Listeners can distinguish minimal pairs like glottalized ‘motley’ [məˈlɪ] and creaky ‘Molly’ [mɔlɪ] (Garellek 2015).
  - This suggests different articulatory mechanisms and acoustic realizations.

Research questions:

- Do different linguistic sources of creaky voice have distinct articulations and acoustic attributes?
- Part of a broader effort towards taxonomy of types of creaky voice based on their acoustic characteristics and uses in language (e.g. Keating et al. 2015).

Corpus and measures

- 40 Ohioan speakers from Buckeye Corpus (Pitt et al. 2007), gender-balanced.
- Words with coda /t/ in simple codas, realized as [t] or [ʈ] (annotations from corpus, hand-checked).
- Phrasal creak was identified based on corpus log files, hand-checked.
- Vowel before /t/ was analyzed

<table>
<thead>
<tr>
<th>Measure</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>H1*-H2*</td>
<td>Difference in amplitude between H1 &amp; H2</td>
</tr>
<tr>
<td>H2*-H4*</td>
<td>Difference in amplitude between H2 &amp; H4</td>
</tr>
<tr>
<td>H1*-A1*</td>
<td>Difference in amplitude between H1 &amp; harmonic nearest F1</td>
</tr>
<tr>
<td>H1*-A2*</td>
<td>Difference in amplitude between H1 &amp; harmonic nearest F2</td>
</tr>
<tr>
<td>H1*-A3*</td>
<td>Difference in amplitude between H1 &amp; harmonic nearest F3</td>
</tr>
<tr>
<td>H4*-2K*</td>
<td>Difference in amplitude between H4 &amp; harmonic nearest (-2K)</td>
</tr>
<tr>
<td>2K*-5K*</td>
<td>Difference in amplitude between Harmonic &amp; nearest (-2K) harmonic nearest 5000 Hz</td>
</tr>
<tr>
<td>FO</td>
<td>Fundamental frequency</td>
</tr>
<tr>
<td>CPP</td>
<td>Centripetal peak prominence</td>
</tr>
<tr>
<td>HNR05</td>
<td>Harmonics-to-noise ratio &lt;500 Hz</td>
</tr>
<tr>
<td>SHR</td>
<td>Subharmonics-to-harmonics ratio</td>
</tr>
</tbody>
</table>

- Measures correlated with common properties of creaky voice, relative to modal voice:
  - Lower spectral tilt (H1*-H2* through \(-2K\)–5K*]
  - Lower f0
  - Lower periodicity (CPP, HNR05)
  - Stronger subharmonics (SHR)

- Each measure was standardized within speaker, outliers removed (~20% of total data).
- In total, 8751 vowels were analyzed:
  - Non-creaky = 7665; Creaky = 1086
  - [t] = 3253; [ʈ] = 5498

- For each measure, we included average value and change in measure from first to final third of vowel.

Analysis

- Linear discriminant analysis (LDA): contribution of the acoustic measures to the identification of glottal stops and phrasal creak.

Confusion matrix from LDA:

<table>
<thead>
<tr>
<th>Actual</th>
<th>Non-creaky</th>
<th>Creaky</th>
<th>Non-creaky</th>
<th>Creaky</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-creaky</td>
<td>1803</td>
<td>144</td>
<td>631</td>
<td>89</td>
</tr>
<tr>
<td>Creaky</td>
<td>10</td>
<td>2</td>
<td>10</td>
<td>3</td>
</tr>
<tr>
<td>Non-creaky</td>
<td>1057</td>
<td>214</td>
<td>4098</td>
<td>573</td>
</tr>
<tr>
<td>Creaky</td>
<td>7</td>
<td>16</td>
<td>49</td>
<td>45</td>
</tr>
</tbody>
</table>

Discussion

- Glottalization shows large drop in periodicity over course of vowel.
- As expected, phrasal creak is characterized by lower f0.

Fig 4: Changes in CPP over vowel

- Given that listeners are sensitive to pitch and noise measures (Garellek et al. 2016), listeners likely use these characteristics to differentiate different types of creaky voice.

- Spectral tilt measures less effective predictors of creak/glottalization, perhaps due to variability in realization of creak:
  - Some speakers show increase in spectral tilt measures, consistent with vocal fold spreading (cf. Slifka 2006).

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References