Acoustic cues to the [j]-[i] distinction in American English

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Study Aims

1) To test whether American English has a glide-vowel distinction ([i] vs. [j]) occurring in uniform C_V environments.

2) To identify what acoustic aspects most consistently convey any such distinction, for the purposes of
   a) acoustic phonetic documentation,
   b) comparing phonological representations.
Background

glide-vowel distinctions

Existence

• fully phonologically predictable (Steriade 1984)
  – [j] and [i] are surface allophones of the same phoneme

• a distinction available to the grammar (Levi 2004, 2008)
  – not fully predictable
Background

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Phonological representation

• constriction/height: /j/ = [–vocalic] (Padgett 2008)

• place/articulator: /j/ = Coronal; /i/ = Dorsal (Levi 2008)

• syllabic pre-linking (Levi 2008, Levin 1985)
Methods

• 9 native speakers of American English

• Sentence reading task
  – real words + nonce names (separate blocks, 4 reps each)
  – self-paced slide presentation
  – ½ target stimuli, ½ filler stimuli
  – semi-randomized
    • attention paid to spacing respective glide/vowel-expectant pairs

• Setting
  – sound-attenuated booth, NYU campus
  – Shure SM35-XLR head-mounted microphone
  – Marantz PMD 660 audio recorder
Stimuli
real word pairs

By expected pronunciation:

[iV]: Estonia, hernia, millennia, Armenia
[jV]: pneumonia, California, Kenya, gardenia

Example sentences:

The citizens of Estonia protested the decision.

Her pneumonia pushed her into a heavy fever.
### Stimuli

**nonce names**

<table>
<thead>
<tr>
<th>C_</th>
<th>initial</th>
<th>non-initial</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&lt;i&gt;</td>
<td>&lt;y&gt;</td>
</tr>
<tr>
<td>/p_/</td>
<td>Piácho</td>
<td>Pyásha</td>
</tr>
<tr>
<td>/b_/</td>
<td>Biási</td>
<td>Byásu</td>
</tr>
<tr>
<td>/f_/</td>
<td>Fiáki</td>
<td>Fyága</td>
</tr>
<tr>
<td>/m_/</td>
<td>Miáshu</td>
<td>Myáchi</td>
</tr>
<tr>
<td>/t_/</td>
<td>Tiágu</td>
<td>Tyáko</td>
</tr>
<tr>
<td>/d_/</td>
<td>Diáfa</td>
<td>Dyápu</td>
</tr>
<tr>
<td>/s_/</td>
<td>Siáko</td>
<td>Syági</td>
</tr>
<tr>
<td>/n_/</td>
<td>Niáfa</td>
<td>Nyápa</td>
</tr>
<tr>
<td>/k_/</td>
<td>Kiása</td>
<td>Kyáso</td>
</tr>
<tr>
<td>/g_/</td>
<td>Giáfu</td>
<td>Gyápi</td>
</tr>
</tbody>
</table>

Last names assigned random honorifics:
- Coach, Dr., Governor, Miss, Mr., Mrs., Officer, Reverend, Sister
Stimuli

nonce names

• Training
  – Directions (spoken, face-to-face)
    • Will say sentences with unfamiliar last names.
    • All use the vowels [ɑ], [i], [u], [o].
    • Be consistent: e.g., <g> is always [g].
    • The stressed vowel is marked with an accent.
  – Practice
    • Listen and repeat (honorific + nonce name).
    • Say + any feedback (honorific + nonce name).
    • Use in full sentence, making sure not to pause.

• Example Sentences
  Miss Vónia paused the movie.
  Judge Búnya paints beautifully.
Example Utterances and initial observations

Estonia (speaker CH43, utterance 4)

Pneumonia (speaker CH43, utterance 3)

\[jV\]: overall shorter duration
less of an apparent targeted climb of F2
earlier fall of F2 transitioning to following vowel
greater intensity range (yellow line)
Measurements and Predictions
re: vocalic material from C_ to _C

Place/Articulator (Levi 2008, Halle et al. 2000)

• F2max: [j] > [i] ([j] more front)

Constriction/Height (Padgett 2008)

• F1min: [i] > [j] ([j] higher)

Intensity range: [jV] > [iV] ([j] more constricted)

Earliness/Speed (pre-linking account: Levi 2008, Levin 1985)

• F2max time: [i] > [j] ([j] less targeted) (Chitoran 2002)

• F2 slope: [j] > [i] ([j] faster) (Liberman et al. 1956, Gay 1968)

• Duration: [iV] > [jV] ([jV] only 1syll)
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- Intensity range: \([jV] > [iV]\) ([j] more constricted)

Earliness/Speed (pre-linking account: Levi 2008, Levin 1985)

- Duration: \([iV] > [jV]\) ([jV] only 1syll)
- F2max time: \([i] > [j]\) ([j] = earlier transition) (Chitoran 2002)
- F2 slope: \([j] > [i]\) ([j] faster) (Liberman et al. 1956, Gay 1968)

(While the other accounts should also predict temporal differences, the pre-linking account should, if anything, predict more centralization of formants for [j].)
Acoustic Cue Analysis

Generalized linear mixed-effects (Glmer) analysis predicting expected outcome

• acoustic measurements scaled and tested against each other as predictors*

• random slopes per speaker (individual differences):
  e.g., speech rate → duration

• terms of interaction with stimulus aspects:
  e.g., syllable count × duration
  C_ place × F2max time

* See Li et al. (2009) for a similar model reversing dependent and independent variables.
Acoustic Cue Results

real word stimuli (predicting expected pronunciation)

<table>
<thead>
<tr>
<th>Fixed Effect</th>
<th>Estimate</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>[j] &gt; [i] Int. range</td>
<td>1.2456</td>
<td>1.82e-6 ***</td>
</tr>
<tr>
<td>[i] &gt; [j] F1min</td>
<td>-.5559</td>
<td>.0106 *</td>
</tr>
<tr>
<td>[i] &gt; [j] F2max time</td>
<td>-.6047</td>
<td>.0203 *</td>
</tr>
<tr>
<td></td>
<td>duration</td>
<td>-.9936</td>
</tr>
<tr>
<td></td>
<td>F2slope</td>
<td>-.3641</td>
</tr>
<tr>
<td></td>
<td>F2max</td>
<td>.1089</td>
</tr>
<tr>
<td>LogLik</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-130.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td># of obs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>274</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(+ estimate: higher value more likely to come from [j]-expectant stimulus)

[j]: lower intensity (relative to following vowel)
higher articulation
earlier transition to following vowel
not significantly more frontward
Acoustic Cue Results
nonce name stimuli (predicting orthography)

<table>
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<tr>
<th>Fixed Effect</th>
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<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>[i] &gt; [j] F2max time</td>
<td>-0.3564</td>
<td>0.00058 ***</td>
</tr>
<tr>
<td>[i] &gt; [j] Int. range</td>
<td>-0.1985</td>
<td>0.00336 **</td>
</tr>
<tr>
<td>[j] &gt; [i] F2slope</td>
<td>0.1651</td>
<td>0.08524 •</td>
</tr>
<tr>
<td>[i] &gt; [j] F1min</td>
<td>-0.0988</td>
<td>0.09558 •</td>
</tr>
<tr>
<td></td>
<td>0.1597</td>
<td>0.15614</td>
</tr>
<tr>
<td></td>
<td>0.1062</td>
<td>0.37071</td>
</tr>
</tbody>
</table>

(+ estimate: higher value more likely to come from <y> stimulus)

[j]:
- earlier transition to following vowel
- faster transition
- higher articulation

(intensity reversal suspected task effect: att’n to stress placement)
Conclusions

• Distinction? Seems to be one.

• Acoustic cues:
  – F2max earliness most consistent cue: [j] earlier transition than [i]
  – Both real word (sig.) and nonce name (trend) stimuli suggest that [j] also has higher articulation (F1min).

• Phonological interpretation:
  – Results support Padgett’s (2008) constriction/height-based characterization for this distinction.
  – Results suggest that [j] and [i] do not differ in articulator/frontness.
  – F2max earliness cue dependence could explain apparent constraint against dorsal Cj sequences. (Ohala 1978)

    e.g., adaptation of Tokyo [toː.kioː] → [tou.ki.ou] (cf. [tou.kjou])
Further Directions

• Perception
  – Do listeners perceive this distinction?
  – Do the cue weightings line up with those observed here?

• Extension
  – Languages previously reported on to support competing representations
  – Use of this kind of cue modeling in the acoustic classification of other distinctions
References


Thank [j]ou!

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