An Electropalatographic Study of Korean coronal obstruents

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Introduction

• Place of articulation of Korean affricates:
  – Phonological interaction with high front vocoids
  – Post-alveolar, palatal, alveolo-palatal, etc.
  – [-anterior], [+high, -back] or V-pl [Coronal]

• Previous articulatory studies:
  – Closure: denti-alveolar

• Current EPG study:
  – Linguopalatal contact pattern during closure and frication portion of affricates compared with coronal stops and fricatives
## Korean coronal obstruents

<table>
<thead>
<tr>
<th></th>
<th>Lenis</th>
<th>Fortis</th>
<th>Aspirated</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Stops</strong></td>
<td>t</td>
<td>t'</td>
<td>tʰ</td>
</tr>
<tr>
<td><strong>Affricates</strong></td>
<td>c</td>
<td>c'</td>
<td>cʰ</td>
</tr>
<tr>
<td><strong>Fricatives</strong></td>
<td>s</td>
<td>s'</td>
<td></td>
</tr>
</tbody>
</table>
Phonological patterning of Korean affricates (i)

• Affrication (a.k.a. “Palatalization”)
  – Coronal stops become affricates before a high front vowel or glide.
  – Applies across morpheme boundaries only.

  /mat-i/ [maci] ‘the eldest’
  /katʰ-i/ [kacʰi] ‘together’

cf. /titi-ta/ [titita](< tɨjtɨjta) *[cicita] ‘to tread’
Phonological patterning of Korean affricates (ii)

• Yod-dropping
  – Within a morpheme: *Coronal obstruent + j
  – Derived sequences of coronal obstruent + j
    • Stops and fricatives: contrast Cj vs. C
      /pʌtʰi-ʌ/ \(\rightarrow [pʌtʰj\Lambda]\) ‘to withstand’
      /maʃi-ʌ/ \(\rightarrow [maʃj\Lambda]) \rightarrow [maʃ\Lambda] ‘to drink’
    • Affricates
      /kaci-ʌ/ \(\rightarrow [kačj\Lambda]) \rightarrow [kač\Lambda] ‘to have’
      /tacʰi-ʌ/ \(\rightarrow [tacʰj\Lambda]) \rightarrow [tacʰ\Lambda] ‘to get hurt’
Phonological patterning of Korean affricates (iii)

- **Umlaut**
  
  \[
  \begin{align*}
  &[\text{api}] \sim [\text{æpi}] \quad \text{‘father’} \\
  &[\text{aki}] \sim [\text{æki}] \quad \text{‘baby’}
  \end{align*}
  \]

- **Intervening coronals, palatals (i.e., affricates and derived palatals) in particular, tend to block Umlaut.**
  
  \[
  \begin{align*}
  &[\text{tacita}] \sim *[\text{tæcita}] \quad \text{‘to mince’} \\
  &[\text{kac}^{\text{hi}}] \sim *[\text{kæc}^{\text{hi}}] \quad \text{‘value’}
  \end{align*}
  \]
Feature specification

• Primary constriction:
  [-anterior]

• Secondary articulation:
  [-back, +high] or V-pl [Coronal]
(Hume 1990, Kiparsky 1993, etc.)
Previous articulatory studies

• X-ray (Skaličková 1960, cited in H. Kim 2001)
• Static palatography (H. Kim 2001, Anderson et al. 2003)
• Electropalatography (Shin 1996, Baik 2003)
• MRI (H. Kim 2004)
Previous studies:
Primary constriction

- Denti-alveolar

- Laminal or apico-laminal

(Anderson et al. 2003)
Previous studies: Secondary articulation

- Affricates have a relatively higher tongue body position than stops, although not as extreme as contrastively palatalized consonants such as Russian /tʃi/ (H. Kim 2005).
Remaining question: primary constriction

• Previous studies on Korean affricates mostly focused on the closure portion.

• *Does the release portion of affricates have “posterior” constriction?*

Cf. Recasens and Espinosa (2007):

– EPG study

– alveolar /ʦ dʃ/ vs. alveolopalatal /ʧ ʤ/ in two dialects of Catalan

– The anteriority contrast was more substantial during frication than during closure.
Remaining question: secondary articulation

• *Do affricates have more palatalized tongue body position than alveolar stops or fricatives?*

Cf. H. Kim (2004, 2005)’s MRI study is limited to stops vs. affricates in /a_a/ context only.
Design

• Participants
  – 1 male (M1) and 2 female (F1, F2) Seoul Korean speakers.

• Stimuli
  – C: t t’ tʰ c c’ cʰ s s’ (p k h n l j)
  – V: a i u (ɨ θ jʌ)
  – “maCV”: mostly nonsense words; but some are real words.
  – Carrier Sentence:
    *ice maCV-rako malhæjo* ‘Say maCV now.’

• 3 repetitions * 2 rounds = 6 tokens per stimuli
Electropalatography

- Instrumentation:
  - A WinEPG system (Wrench et al. 2002) with EPG data sampled at 100 Hz, acoustics at 22,050 Hz.
  - Custom-made artificial palates with 62 electrodes constructed for each participant.
Measurements

• Closure:
  – the frame of maximum EPG contact during the closure

• Frication:
  – the midpoint of frication. The onset and offset of frication was determined based on the spectrogram.

M1 /mac’a/
(Fontdevila, et al. 1994)
Primary constriction: maximum closure

<table>
<thead>
<tr>
<th></th>
<th>Maximum (closure)</th>
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<th></th>
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<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>[mat' u]</td>
<td>[mac' u]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M1</td>
<td><img src="#" alt="M1 Alveolar" /></td>
<td><img src="#" alt="M1 Postalveolar" /></td>
<td><img src="#" alt="M1 Alveolar" /></td>
<td><img src="#" alt="M1 Postalveolar" /></td>
<td><img src="#" alt="M1 Alveolar" /></td>
<td><img src="#" alt="M1 Postalveolar" /></td>
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<td><img src="#" alt="M1 Alveolar" /></td>
<td><img src="#" alt="M1 Postalveolar" /></td>
</tr>
<tr>
<td>F1</td>
<td><img src="#" alt="F1 Alveolar" /></td>
<td><img src="#" alt="F1 Postalveolar" /></td>
<td><img src="#" alt="F1 Alveolar" /></td>
<td><img src="#" alt="F1 Postalveolar" /></td>
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<td><img src="#" alt="F1 Postalveolar" /></td>
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<td><img src="#" alt="F1 Alveolar" /></td>
<td><img src="#" alt="F1 Postalveolar" /></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Stops</th>
<th>Affricates</th>
</tr>
</thead>
<tbody>
<tr>
<td>M1</td>
<td>alveolar</td>
<td>alveolar ~ (postalveolar)</td>
</tr>
<tr>
<td>F1,2</td>
<td>alveolar ~ (postalveolar)</td>
<td>alveolar ~ (postalveolar)</td>
</tr>
</tbody>
</table>
Mean contact ratio per row at maximum closure (R1-R5)
Mean contact ratio at maximum closure (R1-R5)

Affricates are overall very consistent in contact pattern compared to stops.
Mean contact ratio per row at maximum closure: alveolar (R1-R2) and postalveolar(∼prepalatal) (R3-R5) zones

F1,2:
- affricates and stops have almost identical contact pattern.
Mean contact ratio per row at maximum closure: alveolar (R1-R2) and postalveolar(~prepalatal) (R3-R5) zones

F1,2:
- affricates and stops have almost identical contact pattern.
- slightly less posterior contact for stops than for affricates
Mean contact ratio per row at maximum closure: anterior (R1-R2) and postalveolar(~prepalatal) (R3-R5) zones

M1: - stops are mainly denti-alveolar - far less alveolar and posterior contact for stops than for affricates
Primary constriction: frication midpoint

<table>
<thead>
<tr>
<th></th>
<th>midpoint (frication/release)</th>
<th>Fricatives</th>
<th>Affricates</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>[masu]</td>
<td>[macu]</td>
<td></td>
</tr>
<tr>
<td>M1</td>
<td></td>
<td></td>
<td>alveolar</td>
</tr>
<tr>
<td></td>
<td>[a u]</td>
<td></td>
<td>alveolar ~</td>
</tr>
<tr>
<td></td>
<td>(postalveolar)</td>
<td></td>
<td>(postalveolar)</td>
</tr>
<tr>
<td>M1</td>
<td>[masi]</td>
<td></td>
<td>postalveolar</td>
</tr>
<tr>
<td></td>
<td>[maci]</td>
<td></td>
<td>alveolar ~</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(postalveolar)</td>
</tr>
<tr>
<td></td>
<td>[i]</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The table above shows the distribution of fricatives and affricates across different positions and segments. The fricatives are identified by their position in the M1 segment, while the affricates are indicated by their proximity to the midpoints of the frications.

Diagram:

The diagram visualizes the sound distribution across segments and positions, with distinct symbols representing different fricative and affricate sounds. The symbols are color-coded to highlight the transitions and affricates, providing a clear visual representation of the sound structures.
Mean contact ratio per row at **frication** midpoint (R1-R5)
Mean contact ratio per row at fricative midpoint: alveolar (R1-R2) and postalveolar (~prepalatal) (R3-R5).

Affricates are overall consistent in contact pattern compared to fricatives.
Mean contact ratio per row at frication midpoint:
- alveolar (R1-R2)
- postalveolar (~prepalatal) (R3-R5)

F1,2 [a u]:
- Affricates and fricatives have similar contact pattern.
- Affricates have slightly less alveolar contact and slightly more postalveolar contact.
Mean contact ratio per row at frication midpoint: alveolar (R1-R2) and postalveolar (~prepalatal) (R3-R5)

M1 [a u]: -Fricatives have (denti)-alveolar contact and very little postalveolar contact
Mean contact ratio per row at frication midpoint:
alveolar (R1-R2) and postalveolar(~prepalatal) (R3-R5)

- Affricates remain similar to [a u].
- For fricatives, the main contact shift to postalveolar before [i].
Interim summary: primary constriction

• **Q1: Does the release portion of affricates have “posterior” constriction?**
  
  – No.
  
  – The closure and the release portion of Korean affricates have similar constriction location.
  
  – The affricate release and the fricative have similar constriction location.

• The affricate constriction is sometimes but not always more posterior than that of corresponding stops and fricatives.
Interim summary: primary constriction

• But, affricates have more stable realization overall compared to stops and fricatives.
  – Affricates consistently show alveolar(~postalveolar) constriction:
    • across speakers
    • across vowel contexts and
    • both during the closure and the release
  – Stops and fricatives show more variation:
    • denti-alveolar
    • alveolar(~postalveolar)
    • postaveolar
Palatal contact (R6-R8) at maximum closure (M1, F1)

<table>
<thead>
<tr>
<th>M1, F1</th>
<th>Stops</th>
<th>Affricates</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>[a u]</td>
<td>minimal contact</td>
</tr>
<tr>
<td></td>
<td>[i]</td>
<td>more extensive contact</td>
</tr>
</tbody>
</table>

The tables and graphs illustrate the contact points for different sounds under maximum closure conditions.
Palatal contact (R6-R8) at maximum closure (F2)

<table>
<thead>
<tr>
<th></th>
<th>maximum (closure)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>[mat'u]</td>
<td>[mac'u]</td>
</tr>
<tr>
<td>F2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>[a u]</td>
<td>minimal contact</td>
<td></td>
</tr>
<tr>
<td>[i]</td>
<td>more extensive contact</td>
<td></td>
</tr>
</tbody>
</table>

### F2 Table

<table>
<thead>
<tr>
<th>F2</th>
<th>Stops</th>
<th>Affricates</th>
</tr>
</thead>
<tbody>
<tr>
<td>[a u]</td>
<td></td>
<td>minimal contact</td>
</tr>
<tr>
<td>[i]</td>
<td></td>
<td>more extensive contact</td>
</tr>
</tbody>
</table>
Palatal contact (R6-R8) at maximum closure

Quotient of palatal contact (Qp)
Qp= [(R6 + R7 + R8)/24]
Secondary articulation at maximum closure: palatal contact (R6-R8)

[a u]: no clear difference between affricates and stops
Secondary articulation at maximum closure: palatal contact (R6-R8)

[i]
F1, M1: increased palatal contact for stops but not for affricates
Secondary articulation at maximum closure: palatal contact (R6-R8)

[i]
F2: increased palatal contact for both stops and affricates
Secondary articulation at frication midpoint: palatal contact (R6-R8)
Interim summary: palatal contact

- **Q2: Do affricates have more palatalized tongue body position than alveolar stops or fricatives?**
  - No. Contrary to H. Kim (2005) we did not find evidence for higher/fronter tongue body position in affricates than in stops (or fricatives).
  - For two speakers (M1, F1), in [i] context, stops and fricatives had significantly *more* palatal contact than affricates.

- In general, the affricates have more *stable* palatal contact pattern than the stops or fricatives.
  - More resistant to coarticulatory influence of the following vowel.
Discussion

• The affricates are different from the corresponding stops and fricatives:
  – not so much in the primary constriction location or the degree of palatalization per se,
  – but in the stability of its articulatory realization.
    • The affricates are consistently alveolar-postalveolar while the stops and the fricatives are more variable.
    • The affricates have a more stable tongue body target while the palatalization in stops and fricatives are more contextually determined.
Lingual coarticulation

• Proportion of contexts where coarticulatory difference in palatal contact (Qp) is statistically significant (Scheffe, p<.05)

• Coarticulatory resistance
  – Affricates > Fricatives > Stops
  – factors affecting lingual coarticulation
    • coupling effects with primary articulator
    • aerodynamic requirement
Coarticulatory resistance and phonological activity

• Post-consonantal glides in Korean are phonetically realized as secondary articulation on the consonants.

• The difference in coarticulatory resistance is compatible with the asymmetrical patterning of affricates and non-affricates in yod-dropping.
  – *Affricate + j
  – Stop + j: ok
  – Fricative +j: ok
References


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More
Acknowledgements

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M1 mapi
M1 mapa