Introduction

• It is well-known that the phonological ‘segment’ (consonant, vowel) is internally dynamic
  – Autosegmental phonology captured this with feature sequences (ordered in time) (e.g., Goldsmith 1976)
  – Articulatory phonology captures it with gesture sequences (overlapping but aligned to temporal landmarks) (e.g., Browman & Goldstein 1992)
Introduction

• Segments can be dynamic in a contrastive way (e.g. affricate vs. plain stop, prenasalized vs. oral stop, contour vs. level tone, etc.)
• Segments can be dynamic in a noncontrastive way (due to coarticulation)
• Phonological patterns can be sensitive to these internal states
• They need to be represented
• Contemporary research in Optimality Theory and Harmonic Grammar is highly segment-oriented
  – Agreement by Correspondence (ABC; Hansson 2001, Rose & Walker 2004, Bennett 2013, inter alia) and other surface correspondence theories of harmony and disharmony are theories of segmental correspondence
This talk: Q Theory

- Q Theory explodes the segment ‘Q’ (consonant, vowel) into a series of up to three temporally ordered subsegments ‘q’
  \[ Q(q^1 q^2 q^3) \]

  - Corresponds to recent findings that representing phones as three ordered subphones improves performance in automatic speech recognition (Sung & Jurafsky 2009)
  - Accounts for phonological behavior of contour segments
Q theory

• Owes debts to
  – Aperture Theory
  – Autosegmental Phonology
  – Articulatory Phonology

• Based on work with Stephanie Shih
Roadmap

Subsegmental contrasts
Subsegments in action: $Q$ vs. $q$ correspondence
The internal makeup of $Q$
Segments as emergent?
Subsegmental contrasts
Contour segments

Contour segments: segments with distinct phases sequenced in time*

a. pre- and post-nasalized segments (e.g., $n\text{d}$, $d^n$)
b. affricates (e.g., $[^f]$)
c. pre- or post-laryngealized segments (e.g., $k^h$, $^hk$)
d. contour tones (e.g., $\ddot{a}$, $\dot{a}$, $\dddot{a}$)
e. diphthongs (e.g., $ai$)
f. on- and off-glides (e.g., $ju$, $kw$)

*Sagey 1986; on (a)-(c), see Steriade 1993; 1994; on (b), see Lombardi 1990, Kehrein & Golston 2004
Q theory*

• Each vowel and consonant is subdivided into three quantized ‘q’ subsegments

\[ Q(q^1 \ q^2 \ q^3) \]

• Q varies over V, C

• each ‘q’ is a uniform feature bundle


3-part contours

C(n₁ t² ⌫³)  $^{n}{dz}$  (prenasalized affricate)
C(t₁ ⌫² h³)  $tf^h$  (aspirated affricate)
V(ɛ₁ a² i³)  ɛai  (triphthong)
V(à¹ à² à³)  ã  (rising-falling tone)

Up to three featurally distinct, phonologically relevant phases predicted possible in a single vowel or consonant
Aperture Theory: 2 subsegments for released consonants, just 1 for continuants.

“released plosives – in contrast to all other sound classes – have two positions that can anchor distinctive features” (Steriade 1994:210)

(Steriade 1994:210)
cf. aperture theory

• No representational options within the segment for diphthongs, triphthongs, tone contours

\[ [\dot{a}] \]

\[ \text{Amax} \]
\[ \backslash \]
\[ \text{HL} \]
\[ ? \]

Q theory: (á á à)
• even prenasalized affricates are challenging

Q theory: $C(n \text{ d z})$
cf. Autosegmental Theory

- 2- and 3-tone contours have been observed on single vowels, but
- contrastive 4-tone contours (e.g., LHLH or HLHL) are vanishingly rare
  (Hu 2011 describes 4232 and 2142 for Qiyang, but perceptual experiments suggest that only 2 of the internal F0 inflection points are perceptually relevant).
- This asymmetry is unexplained in autosegmental representations:
Summary

• Q theory: maximum of 3 $q$ subsegments per segment $Q$
  – Autosegmental theory: no upper bound on possible contours
  – Aperture theory: upper bound of 2, and only for plosives
Subphones in automatic speech recognition

“the spectral and energy characteristics of a phone vary dramatically as it is uttered. Following conventional HMM systems, we capture this non-homogeneity by modeling each phone as a sequence of 3 sub-phones (states). Thus our model can use different parameters to describe the characteristics of the beginning, middle, and end of each phone” (Sung & Jurafsky 2009)
2-part contours

• What about segments with only 2 clearly distinct internal phases? Why would we want 3 $q$’s for these?
• Maybe we don’t, always (see next section).
• But allowing up to 3 $q$’s allows us to capture some intriguing alignment contrasts
Remijsen (2013): Dinka contrasts a late-aligned HL contour with an early-aligned HL contour.

\[ \text{--- (H}^1\text{H}^2\text{L}^3\text{)(late-aligned)} \]

\[ \text{— (H}^1\text{L}^2\text{L}^3\text{)(early-aligned)} \]

*The vowel illustrated here, from Bor South Dinka, is long (Dinka has short, long, and overlong vowels), but Rejmisen cites reports of the same alignment contrast on short vowels in Agar and Luanyjang Dinka.

Two distinct alignments predicted possible for internal transition in 2-tone vowel
Consonant-internal contour alignment

Pycha 2010:146: Hungarian postalveolar affricates have a longer closure (relative to total duration) than alveolar affricates do. This holds true under gemination as well.

\[
\begin{array}{ll}
/\text{ts}/ & /\text{tf}/ \\
\text{Pycha:} & [t_x s_x] & [t_{xx} s_x] \\
\text{Q-theory:} & \text{C}(t^1 s^2 s^3) & \text{C}(t^1 t^2 s^3)
\end{array}
\]

Two distinct alignments predicted possible for internal transition in affricate
Subsegmental contrast, summarized

- Q theory offers more fine-grained representation of contour than Aperture Theory (more positions) and Autosegmental Theory (internal timing differences)
- Q theory constrains segment-internal contours to a higher degree than Autosegmental Theory does (upper bound on contours)
- Q theory replaces these representations

\[ Q(q^1 q^2 q^3) \]
Subsegmental contrast, summarized

• Q Theory shares with Articulatory Phonology the insight that segment-
  internal relative timing matters, but is focused more on speech chunks
  than on gestures. The two types of representation co-exist and are
  related.

• Subsegments, being discrete, are a more natural plug-in to familiar
  phonological rules and constraint formalisms of the kind we will talk
  about next.

\[ Q(q^1 q^2 q^3) \]
Subsegments in action

• Phonology can reference q subsegments.
• Focus of examples in this section: assimilation
• Modeled using ABC+Q theory = ABC+Q
Agreement by Correspondence (ABC)

• Under conditions of (natural class) similarity and proximity, local pairs of segments are compelled (via CORR) to correspond
• Corresponding segments are compelled (via IDENT) to be identical in some respect
  – consonant harmony (Walker 2000; Hansson 2001; Rose and Walker 2004; a.o.)
  – vowel harmony (Sasa 2009; Walker 2009; Rhodes 2010/2012; a.o.)
  – dissimilation (Bennett 2013)
  – tone and consonant tone interactions (Shih 2013, Shih & Inkelas 2014)
ABC+Q

**CORR-QQ**  Similar segments (segments with similar q sequences, and/or in similar structural positions) correspond

**IDENT-QQ**  Corresponding segments are identical (overall all the q’s they contain), in some respect

*Some assumptions:*

- **CORR** and **IDENT** constraints are linked (see e.g. Hansson 2014, Walker 2015)
- **CORR** constraints can be proximity-restricted (e.g. Hansson 2001, Rose & Walker 2004)
- Correspondence is local and pairwise (not global) (e.g. Hansson 2001, Rhodes 2012); thus **CORR** applies only to consecutive segments meeting the structural description of the **CORR** constraint
<table>
<thead>
<tr>
<th><strong>CORR-QQ</strong></th>
<th>Similar segments (segments with similar q sequences, and/or in similar structural positions) correspond</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>IDENT-QQ</strong></td>
<td>Corresponding segments are identical (overall all the q’s they contain), in some respect</td>
</tr>
<tr>
<td><strong>CORR-qq</strong></td>
<td>Similar subsegments (segments in a natural class, and/or in similar structural positions) correspond</td>
</tr>
<tr>
<td><strong>IDENT-qq</strong></td>
<td>Corresponding subsegments are identical, in some respect</td>
</tr>
</tbody>
</table>
Subsegments in action

ABC+Q predicts two kinds of assimilation:

– Q to Q: total assimilation. Can copy simple segments and contour segments (diphthongs, affricates, contour tones)

– q to q: partial assimilation. Can copy subsegments, thus creating or smoothing out contour segments and contour tones.
q to q harmony: prenasalization

Prenasalization as partial assimilation in Mbya: suffix-initial plosive becomes prenasalized following nasal vowel (Thomas 2014)

a. ava-′k^w_\text{e} e
   kũnã-′ŋ^w_\text{e}
   ‘men’
   ‘women’

b. o-etʃa-′pa
   ō-mañõ-′mba
   ‘she saw them all’
   ‘they all died’
q to q harmony: prenasalization

**Corr-q+q**  
q subsegments correspond across a suffix boundary

**Ident-qq(nas)**  
corresponding q subsegments agree in nasality

**Ident-IO-c(nas)**  
input-output c identity in plosive nasality

<table>
<thead>
<tr>
<th></th>
<th>V(ã ā ā)+C(k k k)</th>
<th>Corr-q+q</th>
<th>Ident-qq</th>
<th>Ident-IO-nas</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td>V(ã ā ā)+C(k k k)</td>
<td>-1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b.</td>
<td>V(ã ā ạ̄i)+C(ḳi k k)</td>
<td></td>
<td>-1</td>
<td></td>
</tr>
<tr>
<td>c.</td>
<td>V(ã ā ạ̄i)+C(ŋ̣i ɡ ɡ)</td>
<td></td>
<td></td>
<td>-1</td>
</tr>
<tr>
<td>d.</td>
<td>V(ã ā ạ̄i)+C(ŋ̣i ŋ ŋ)</td>
<td></td>
<td></td>
<td>-3</td>
</tr>
</tbody>
</table>
q to q harmony: tone ‘spreading’

Tonal contours can arise from partial assimilation across a syllable boundary of one tone to another, e.g. Yoruba (a) and Haya (b)

a. /rárâ/ $\rightarrow$ [rárâ] (H.L $\rightarrow$ H.HL)
   ‘elegy’

b. /mu-kônò/ $\rightarrow$ [mù-kônò] (H.L $\rightarrow$ HL.L)
   ‘arm’

Akinlabi & Liberman 2001

Hyman 2007:20
q to q harmony: tone ‘spreading’

**CORR-v**: $v$ subsegments correspond across a syllable boundary ($\$\$)

**IDENT-vv(T)**
Corresponding $v$ subsegments are tonally identical

**IDENT-IO-v(T)**
$v$ subsegments are tonally identical in input, output

<table>
<thead>
<tr>
<th></th>
<th>V(á á á)CV(à à à)</th>
<th>CORR-v:$v$</th>
<th>Ident-vv</th>
<th>Ident-IO</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td>V(á á á)CV(à à à)</td>
<td>-1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b.</td>
<td>V(á á á$\acute{i}$)CV(à $\acute{i}$ à à)</td>
<td></td>
<td>-1</td>
<td></td>
</tr>
<tr>
<td>c.</td>
<td>V(á á á$\acute{i}$)CV(á$\grave{i}$ à à)</td>
<td></td>
<td></td>
<td>-1</td>
</tr>
<tr>
<td>d.</td>
<td>V(á á á$\acute{i}$)CV(á$\grave{i}$ á á)</td>
<td></td>
<td></td>
<td>-3</td>
</tr>
</tbody>
</table>
Vowel breaking (diphthongization, vowel contour formation) in San Francisco del Mar Huave (Kim 2008): occurs when vowel and coda consonant disagree in palatality

<table>
<thead>
<tr>
<th></th>
<th>Non-palatal C</th>
<th>Palatal C</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Back V</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>u, o, a</td>
<td>sap</td>
<td>sap&lt;sub&gt;pal&lt;/sub&gt; → saip</td>
</tr>
<tr>
<td></td>
<td>puk</td>
<td>puk&lt;sub&gt;pal&lt;/sub&gt; → puik</td>
</tr>
<tr>
<td><strong>Front V</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>i, e</td>
<td>mik → miok</td>
<td>贝壳&lt;sub&gt;pal&lt;/sub&gt;</td>
</tr>
<tr>
<td></td>
<td>chip → chiop</td>
<td>贝壳&lt;sub&gt;pal&lt;/sub&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>贝壳&lt;sub&gt;pal&lt;/sub&gt;</td>
</tr>
</tbody>
</table>
### q to q harmony: diphthongization

**CORR-q:$$:q**

Adjacent subsegments correspond across a segment boundary (in syllable rime)

**IDENT-qq(pal)**

Corresponding subsegments agree in palatality

**IDENT-IO-q(pal)**

Subsegments are input-faithful in palatality

<table>
<thead>
<tr>
<th></th>
<th>V(a a a)C(p\text{pal} \ p\text{pal} \ p\text{pal})</th>
<th>CORR-v::c</th>
<th>Ident-qq</th>
<th>Ident-IO</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td>V(a a a)C(p\text{pal} \ p\text{pal} \ p\text{pal})</td>
<td>-1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b.</td>
<td>V(a a a_i)C(p\text{pal}_i \ p\text{pal} \ p\text{pal})</td>
<td>-1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c.</td>
<td>V(a a i_i)C(p\text{bal}_i \ p\text{bal} \ p\text{bal})</td>
<td>-1</td>
<td></td>
<td>-1</td>
</tr>
<tr>
<td>d.</td>
<td>V(i i i_i)C(p\text{bal}_i \ p\text{bal} \ p\text{bal})</td>
<td></td>
<td></td>
<td>-3</td>
</tr>
</tbody>
</table>
Without q’s?

How would Yoruba tone assimilation be modeled in standard, segment-based ABC?

**CORR-VV**  
Consecutive vowels correspond

**IDENT-VV(T)**  
Corresponding vowels are tonally identical

**IDENT-IO-V(T)**  
Vowels are tonally identical in input, output

<table>
<thead>
<tr>
<th>/áCà/</th>
<th>(H.L)</th>
<th>CORR-VV</th>
<th>Ident-VV</th>
<th>Ident-IO</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. áCà</td>
<td>(H.L)</td>
<td>-1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. á_iCà_i</td>
<td>(H.L)</td>
<td></td>
<td>-1</td>
<td></td>
</tr>
<tr>
<td>(☞) c. á_iCâ_i</td>
<td>(H.HL)</td>
<td></td>
<td>-1</td>
<td>-1</td>
</tr>
<tr>
<td>♦ d. á_iCá_i</td>
<td>(H.H)</td>
<td></td>
<td></td>
<td>-1</td>
</tr>
</tbody>
</table>
Without q’s?

How would Huave vowel diphthongization be modeled in standard, segment-based ABC?

<table>
<thead>
<tr>
<th>/ap\textsuperscript{pal}/</th>
<th>CORR-VC</th>
<th>Ident-VC</th>
<th>Ident-IO</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. ap\textsuperscript{pal}</td>
<td>*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. a\textsubscript{i}p\textsuperscript{pal}\textsubscript{i}</td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>(媒介) c. a\textsubscript{i}p\textsuperscript{pal}\textsubscript{i}</td>
<td></td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>d. i\textsubscript{i}p\textsuperscript{pal}\textsubscript{i}</td>
<td></td>
<td></td>
<td>**</td>
</tr>
</tbody>
</table>
Interim summary

- Segment-based approaches to assimilation, like ABC, need some way of referring to the individual, sequenced portions of contour segments
- Subsegments provide this
- ABC+Q predicts that subsegmental assimilation will show the same similarity basis and proximity generalizations as segmental assimilation
Q segments in action

• In Q Theory, the traditional segment still has representational status
  – Q is a string of q (though strings can be related via correspondence without having to be constituents; see e.g. Zuraw 2002, etc.)
  – Phonological patterns and constraints can be stated in terms of Q as well as q
  – Useful for garden-variety segmental processes
  – Solves problems in case of contour segments that act as units
Q to Q harmony

Changzhi: tone contours copy as unit

a. /kuə\textsuperscript{213} -tə\textsuperscript{535}/ → [kuə\textsuperscript{213} -tə\textsuperscript{213}] ‘pan-DIM’
b. /sən\textsuperscript{24} -tə\textsuperscript{535}/ → [sən\textsuperscript{24} -tə\textsuperscript{24}] ‘rope-DIM’
c. /ti\textsuperscript{535} -tə\textsuperscript{535}/ → [ti\textsuperscript{535} -tə\textsuperscript{535}] ‘bottom-DIM’
d. /kʰu\textsuperscript{44} -tə\textsuperscript{535}/ → [kʰu\textsuperscript{44} -tə\textsuperscript{44}] ‘pants-DIM’
e. /təu\textsuperscript{53} -tə\textsuperscript{535}/ → [təu\textsuperscript{53} -tə\textsuperscript{53}] ‘bean-DIM’

(see Yip 1989; Bao 1990; data cited from Duanmu 1994)
Q to Q harmony

Changzhi: tone contours copy as unit

**CORR-VV** *Entire vowels correspond*

**IDENT-VV(T)** *Corresponding vowels are tonally identical*

**IDENT-IO-(T)** *Vowels are tonally identical in input, output*

<table>
<thead>
<tr>
<th>/kuə_213 -tə̂_535/</th>
<th>CORR-VV</th>
<th>IDENT-VV</th>
<th>IDENT-IO</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. ku(ə_2 ə_1 ə_3)-t(ə_5 ə_3 ə_5)_i</td>
<td>WI</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. ku(ə_2 ə_1 ə_3)_i-t(ə_5 ə_3 ə_5)_i</td>
<td></td>
<td>WI</td>
<td></td>
</tr>
<tr>
<td>c. ku(ə_2 ə_1 ə_3)_i-t(ə_2 ə_1 ə_3)_i</td>
<td></td>
<td></td>
<td>LI</td>
</tr>
</tbody>
</table>

→ consecutive vowels have to agree tonally (the second assimilates to the first)
Q to Q harmony

Kiyaka: only internally level Q’s correspond in nasal harmony

a. kéb-ele ‘faire attention’
   sód-ele ‘déboiser’

b. kém-ene ‘gémir’
   són-ene ‘colorer’

c. finúk-ini ‘bouder’
   míituk-ini ‘bouder’

Plosives are transparent to nasal harmony

*Hyman 1995*
Q to Q harmony

Kiyaka: only internally level Q’s correspond in nasal harmony

a. kéb-ele  ‘faire attention’
   sód-ele  ‘déboiser’
b. kém-ene  ‘gémir’
   són-ene  ‘colorer’
c. finúk-ini  ‘bouder’
   míituk-ini  ‘bouder’

Prenasalized C’s are also transparent to nasal harmony

d. bééⁿg-ele  ‘mûrir’
   kóóᵐb-ele  ‘balayer’
e. méeⁿg-ene  ‘haïr’
   nááⁿg-ini  ‘durer’

*Hyman 1995*
Q to Q harmony

Kiyaka: only internally level Q’s correspond

\[ \text{CORR-CC}(N N N)C(D D D) \]
\[ \text{IDENT-CC}(\text{nas}) \]
\[ \text{IDENT-IO-}(\text{nas}) \]

Level consonants (which could differ from one another in nasality) correspond

Corresponding consonants are identical for [nasal]

Input-output identity required for [nasal]

<table>
<thead>
<tr>
<th>/náa\textsuperscript{ŋ}g-ili/</th>
<th>Corr-CC</th>
<th>Ident-CC</th>
<th>Ident-IO</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. (n n n)\textsuperscript{áa(ŋ g g)i(1 1 1)i}</td>
<td>WI</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. (n n n)\textsuperscript{áa(ŋ g g)i(1 1 1)i}</td>
<td></td>
<td>WI</td>
<td></td>
</tr>
<tr>
<td>c. (n n n)\textsuperscript{áa(ŋ g g)i(n n n)i}</td>
<td></td>
<td></td>
<td>LI</td>
</tr>
</tbody>
</table>
Q-internal diversity

• What’s the range of possible subsegments \((q^1, q^2, q^3)\) that can be in a given segment \(Q\)?
• Does \(Q\) theory overgenerate possible assimilation patterns?
• Do \(q\)’s all have to all be specified underlyingly?
• Does every \(Q\) have to have 3 \(q\)’s?
Constraining q diversity

• What’s the **lower bound** of diversity among different subsegments \((q^1, q^2, q^3)\) in a given segment \(Q\)?
• What’s the **upper bound** of diversity among different subsegments \((q^1, q^2, q^3)\) in a given segment \(Q\)?
Lower bound of diversity

• Does Q theory overpredict possible segment contrasts?
  – $C(s \cup s)$ vs. $C(s \cap s)$ vs. $C(s \cap s)$, etc.
  – $V(i \cup i)$ vs. $V(i \cap i)$ vs. $V(i \cap i)$, etc.

• The problem in contrasts that can technically be represented phonologically but are not utilized for perceptual reasons is well-known and has solutions, e.g. Steriade’s (2001) P-Map, Dispersion Theory, etc.

• Certainly Q theory would draw support from such approaches in motivating the Q-internal q correspondence constraints that could limit Q-internal diversity
Lower bound of diversity

• Sequences of too-similar segments are repaired in ABC by assimilation or dissimilation (e.g. sibilant harmony, vowel harmony, cluster assimilation).

• Similar repairs are enforceable at the q level

\[
\text{CORR-} q_{\text{sib}}::q_{\text{sib}} \quad \text{An adjacent pair of sibilant q’s must correspond}
\]

\[
\text{Ident-qq-[ant]} \quad \text{Corresponding sibilant q’s must agree in anteriority}
\]

\[
\therefore s, \int \text{can’t co-occur in same segment}
\]
Upper bound of diversity

What’s the upper bound of diversity among the possible subsegments \( (q^1, q^2, q^3) \) in a given segment \( Q \)?

- Steriade (2014), speculating on how to exclude \( (r \circ p) \) from being a \( Q \) in \( Q \) theory:
  
  “a mutual compatibility condition on the set of features belonging to one segment: they must correspond to a set of potentially simultaneous articulatory gestures. This allows \( nts(h), (?)nts, \) but not \( rop, kis, iuai \)”
Upper bound of diversity

– But: excludes sequenced incompatible features, like tone contours on short vowels, or nasal and oral sequences
– A string of q’s that is internally more similar, in terms of sonority or constriction, than any other 3-q string that any of those q’s might be parsed into?
– If Q are q strings, the definition of ‘segment’ becomes emergent, fungible, an insight that Articulatory Phonology has been pushing for decades
Q-internal diversity

• What’s the range of possible subsegments \((q^1, q^2, q^3)\) that can be in a given segment \(Q\)?

• Does \(Q\) theory overgenerate possible assimilation patterns?

• Do q’s all have to all be specified underlyingly?

• Does every \(Q\) have to have 3 q’s?
Does Q theory overpredict assimilation patterns?

Steriade 2014: $q^2$ correspondence and agreement predicts the massive creation of contours via $q^2$ correspondence

e.g., in Fake Turkish, for an input *sareli*,

$$s(a \ a^2 \ a)r(e \ e^2 \ e)l(i \ i^2 \ i) \rightarrow \ s(a \ a^2 \ a)r(e \ a^2 \ e)l(i \ u^2 \ i)$$

This is predicted iff Fake Turkish has triphthongs *and* allows them to be derived (vs. preserved from UR), but not otherwise (i.e. not if the language prohibits triphthongs)
Does Q theory overpredict assimilation patterns?

• Syllable-internal correspondence & identity could rule out triphthongs in a language that lacks them

• Could reduce to the failure of (e a e), (e e e), (a e a) to contrast in a given language, due to insufficient perceptual distinctiveness
Q-internal diversity

• What’s the range of possible subsegments \((q^1, q^2, q^3)\) that can be in a given segment \(Q\)?
• Does \(Q\) theory overgenerate possible assimilation patterns?
• Do \(q\)’s all have to all be specified underlyingly?
• Does every \(Q\) have to have 3 \(q\)’s?
Must every q be featurally specified?

Underspecification of edge (marginal) q’s could be suitable for interpolated transitions

\[ V(L \ L \ \emptyset) V(\emptyset \ H \ H) \]
= tonal interpolation between targets

\[ V(i \ i \ I) CV(u \ u \ u) \]
= anticipatory V to V coarticulation

("I" = unspecified for [rd])
Must every q be featurally specified?

Another alternative for representing coarticulation would be the use of subfeatures, as proposed by Lionnet (2015, forthcoming):

\[ V(i\ i\ i')CV(u\ u\ u) = \text{anticipatory V to V rounding (\& backing) coarticulation} \]

\[ C(b\ b\ b)V(\partial\ \partial\ \partial) = \text{carryover C to V rounding coarticulation} \]
Comparison with Articulatory Phonology

- AP: each gesture is timed independently
- \([p^h\ae d]\), from Browman & Goldstein 1992:158):
Example: consonant prevocalization

Consonant prevocalization (e.g., Operstein 2010), often a historical precursor of diphthongization: closure of (often, coda) consonant vocalizes, preserving certain features of the consonant:

**Djabugay:**
- dunyu [duɲu] ‘husband’
- burrany [burrɐɲ] ‘fly.PAST’

**Br. Portuguese:**
- arroz [a'xoʒ] ‘rice’
- cf. arrozal [axo'zaw] ‘rice paddy’

**Maxakalí:**
- /nɯʔcip/ [muʔʃiɤp] ‘full of’
- /tapet/ [tapeŋ] ‘paper’
Example: consonant prevocalization

[ɬ] prevocalization, from Operstein 2010 (pp. 53,66)

Q theory

\[ C(\breve{c} \breve{c} \breve{c}) \]

\[ C(\breve{\eta} \breve{\eta} \breve{\eta}) \]
Q-internal diversity

- What’s the range of possible subsegments \((q^1, q^2, q^3)\) that can be in a given segment \(Q\)?
- Does \(Q\) theory overgenerate possible assimilation patterns?
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- Does every \(Q\) have to have 3 \(q\)’s?
Does every Q have to have 3 q’s?

• No
• Inherent q-count differences
  – flaps
  – excrecent vowels, intrusive consonants
  – schwa
• Contextual q deletion
  – loss of transitional subsegments in coda or in consonant clusters
Does every Q have 3 q’s?

Excrescent vowels: a single subsegment?

e.g. Moroccan Colloquial Arabic: \(tb\) cluster produced as \([t^\varepsilon b]\), as in \(katb\) \([kat^\varepsilon b]\) ‘to write’ (Gafos 2002:278)

\[C(t \ t \ t)C(b \ b \ b) \rightarrow C(t \ t \ t)V(\varepsilon)C(b \ b \ b)\]
Does every Q have 3 q’s?

Flaps: only transitional subsegments and not the target c^2?

\[ \text{betting} \quad [\text{ˈbeɾɪŋ}] \quad V(\varepsilon \varepsilon \varepsilon)C(ɾ \ ɾ)V(ɪ \ ɪ \ ɪ)C(ŋ \ ŋ \ ŋ) \]

cf. observations that flap seems ambisyllabic (Kahn 1976, Gussenhoven 1986), perhaps by virtue of lacking a target closure that belongs to one syllable vs. another
Does every Q have 3 q’s?

Loss of consonantal release = deletion of $c^3$

• $t', t^h \rightarrow t$ in Korean coda (e.g., Steriade 1993, 1994)

\[ C(t^1 t^2 h^3) \rightarrow C(t^1 t^2) \]

• English ‘robbed’ is [rəbd], not *[rəb̩d] (Gafos 2002; open transition between C’s is deleted)

\[ C(b^1 b^2 b^3)C(d^1 d^2 d^3) \rightarrow C(b^1 b^2)C(d^2 d^3) \]
Does every Q have 3 q’s?

Loss of trapped transition = deletion of $c^3$, possibly also following $c^1$

Polish geminate affricates: realized as doubly articulated or as singly articulated with longer closure (Thurgood 2001, Thurgood and Demenko 2003):

$$(t^1 t^2 c^3)(t^1 t^2 c^3) \rightarrow (t^1 t^2)(t^2 c^3)$$

e.g. leccie ‘fly’
Gestural overlap

• Gestural overlap (as discussed in the voluminous literature on Articulatory Phonology) is the cause of the loss of trapped transition

• Gestural overlap can also result in effects like intrusive stops, e.g. [t] in /ns/ clusters
Gestural overlap

- Gestural overlap can also result in effects like intrusive stops, e.g. [t] in /ns/ clusters

intrusive [t] in /ns/, from Browman & Goldstein 1992

(figure modified from Operstein 2010:45)
See also Gick 1999

(n n n)(s s s) → (n n t)(t s s) ?
Interim summary

- What q string can constitute a Q is language-specific
- The number of q’s in a Q is context-sensitive
- q’s can be added or subtracted by grammar
- q’s can be featurally fully specified or underspecified
Length
How is length represented in Q theory?

• What’s the representation of a long V, or a geminate C?

\[
\begin{align*}
V(a\ a\ a)_{\mu\mu} & \quad V(a\ a\ a)_{\mu}V(a\ a\ a)_{\mu} & \quad V(a\ a\ a\ a\ a\ a)^* \\
C(t\ t\ t)_{\mu} & \quad C(t\ t\ t)C(t\ t\ t) & \quad C(t\ t\ t\ t\ t)^*
\end{align*}
\]

*no because 3 is upper bound
How is length represented in Q theory?

• What’s the difference between these (Steriade 2014)?

\[
V(i \ a \ u) \quad V(i \ i \ i)V(a \ a \ a)V(u \ u \ u)?
\]

• What’s the representation of a geminate affricate? How can we account for the fact that gemination affects closure duration more than release duration? (Pycha 2010)

\[
C(t \ t \ f)_\mu \quad C(t \ t \ f)C(t \ t \ f)
\]
q is not a unit of duration

• q subsegments are not themselves units of duration. They represent (potentially) featurally different temporally ordered subphases of a segment (or simply ordered ‘vertical’ chunks of speech)

• Phonological representations of length, like the mora, can be associated with Q as before
q is not a unit of duration

• It is interesting to speculate on the assignment of grammatical duration (quantity) to q subsegments

• Katz 2012, on compression effects, calls for future research to develop “a theory with overt representation of auditory duration” to “determine directly which types of compression are accounted for by overlap and which by gestural shortening.”
Conclusions

• Subsegments act independently and need to be independently referenced by the phonological grammar
• Strictly segmental theories, from SPE to standard ABC, lack the ability to refer to subsegments.
• Q Theory brings the insights behind Autosegmental Phonology and Aperture Theory into a new subsegmental representation that is compatible with Agreement by Correspondence theory
• Q Theory offers the possibility of better integrating the fundamental insights of Articulatory Phonology into segment-oriented formalisms
Thank you

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