Towards an Articulatory Understanding of Historical Phonology

Z.L. Zhou
zzhou1@swarthmore.edu

Hunter Undergraduate Linguistics and Language Studies Conference 6

May 6, 2016

What I want to convince you of

- It is important to be able to explain sound change
- This is best and most easily done with theories that make explicit reference to the mouth, such as Articulatory Phonology (AP)
- AP and OT combined are a powerful tool for describing and explaining sound change

Roadmap

1 Introduction

2 Icelandic

3 Articulatory Phonology

4 AP/OT

5 Conclusion

Historical phonology

What is historical phonology?

- Study of sound change over time
- Reconstruction of historical forms from current languages
- Not very concerned with the "how"s of sound change

Icelandic

- West Scandanavian language, North Germanic branch, Indo-European family
- Spoken by about 310,000 people, mostly in Iceland
- Little dialectal variation. We're going to talk about Northern Icelandic — less allophony
- Very popular in syntax: true quirky subjects
    - Less popular in phonology
    - Mostly, people care about preaspiration

Preaspiration

"Preaspiration" is a misnomer. Phonetic studies show existence of real [h], longer than [ʰ].

   (1)   *hvít-ur* [kʰvitʰʏr] 'white-ᴍᴀsc.sɪɴɢ.ɴᴏᴍ'

   (2)   *hvít-t* [kʰviht] 'white-ɴᴇᴜᴛ.sɪɴɢ.ɴᴏᴍ'

Synchronically, /pʰpʰ/, /tʰtʰ/, /kʰkʰ/ > [hp], [ht], [hk]
How do you get a pattern like that? Where did it come from?

Historical records

- The cultural literature of Icelandic is huge, we have over 1000 years worth of sagas, essays, and poems
- Changes in spelling provide clues to changes in pronunciation from Old Norse (ON)
- Other resource: the *First Grammatical Treatise* (FGT)
  - Written some time between 1125 and 1175 by unknown author
  - Recommendation on how to standardize Icelandic orthography
  - Methodology strikingly similar to that of modern linguistics
  - Describes pronunciation explicitly

Sound changes

Because of the FGT, we know where we started from. We can collect data on where we are now. We know of two major chain shifts in the oral stops:

- Voiced geminates devoiced (*gg > kk)
- Voiceless geminates preaspirated (*kk > hk)
- Voiced singletons devoiced (*g > k)
- Voiceless singletons aspirated (*k > kʰ)

So preaspiration is historically motivated, but how did this change happen?

Articulatory Phonology

Articulatory Phonology (AP; Browman and Goldstein 1986, 1990, 1992) is a formal theory of representational phonology wherein *gestures*, movements of the articulators of the mouth, and their relative positions in time, are construed as the most basic units of phonological analysis. These gestures are depicted on diagrams known as *gestural scores.*
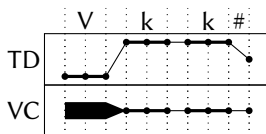
Example score: variables

(3)
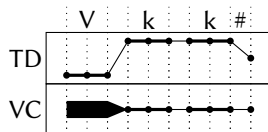
- X-axis represents time
- Boxes for *vocal tract variables*
 - *Variables* come in two flavors: *locations* and *degrees*

Example score: t-units

(3)

- Vertical dotted lines mark *t-units* — each t-unit is an important unit of time as considered by current analysis
    - Length of time each t-unit represents is left purposefully vague
    - Some may be shorter than others, approach having no length
    - The extension of dotted line into transcription row indicates which t-units are part of a segment
    - In (3), the [V] is two t-units long. Following the [V] is a single transition t-unit to a [k]; the [k] is also two t-units long.

Example score: degrees

(3)
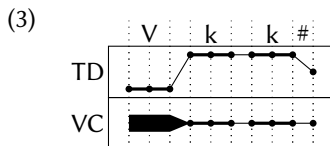
- Articulators that create constrictions: y-axis location of articulator relative to top of mouth
    - Gesture line is dark when part of segment, light during transition t-units. Dots are placed at beginnings and endings of gestures, as well as midway between those points.
- Articulators with states: shown in visually appropriate manner
    - Voicing is depicted as thick section and lack of voicing as regular gesture line. Transition shown as a triangle

Mapping from feature bundles

- Constriction gestures in AP are said to have five constrastive degrees: [closed], [critical], [mid], [narrow], and [wide].
- In actual production, there are theoretically infinite realizable degrees, although the idea is that there would be just five *contrastive* degrees.

Mapping from feature bundles

- Constriction gestures in AP are said to have five constrastive degrees: [closed], [critical], [mid], [narrow], and [wide].
- In actual production, there are theoretically infinite realizable degrees, although the idea is that there would be just five *contrastive* degrees.
- These distinctions correspond to the general categories of sounds: [closed] refers to stops, [critical] to fricatives, and [mid], [narrow], and [wide] to approximants and vowels, with all approximants being [mid] and vowels being any of the three, depending on vowel height.

Why t-units?

(4)
       (a)(b)(c)(d)(e)
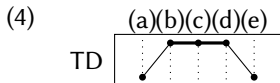
- Gestures have five *gestural landmarks*, shown in (4) (Gafos 2002)
- In the middle of the gesture is the *perceptual plateau*, what listeners identify as a particular sound
  - The plateau includes three landmarks, the target (b), the center (c), and the release (d).
- On both sides of the plateau are transitions
  - (a) is the onset, from no specified gesture to target
  - (e) is the offset, from release to either unspecified or to following target.
- t-units formalize parts of gesture into countable objects ($\rightarrow$ OT)

The data

We know explicitly from the FGT which how sounds were pronounced in the past, so we know:
(*gg,*kk,*g,*k) > (kk,hk,k,kʰ)
Out of consideration for time, I will only go over the analysis for the velar geminates here — the same analysis holds for the other oral geminates, but with just slightly different constraints.

Motivations I

To explain the lack of merger, I use *Merge:

(5) *Merge
     No word of the output has multiple correspondents in the input.
     Mark one violation for instance where two inputs map onto the
     same output. (Padgett, 2003)

$$\begin{bmatrix} g_1 & gg_2 \\ k_3 & kk_4 \end{bmatrix} > \begin{bmatrix} g_1 & \\ k_3 & kk_{2,4} \end{bmatrix}$$

g_1 gg_2 k_3 kk_4	*Merge
a. ☞ g_1 gg_2 k_3 kk_4	
b. g_1 k_3 $kk_{2,4}$	*!

Motivations II

To explain the direction of the chain shift, I use *VVO:

(6)   *VoicedVelarObstruent (*VVO)
      There is no voiced constriction at the velum of any degree [critical]
      or higher. Mark one violation for each t-unit that contains any
      amount of voicing as well as a tongue dorsum gesture with a
      constriction degree of [critical] or [closed].

Motivated by tendency for velar obstruents to devoice and the double
tendency for geminate velar obstruents to devoice. (Ohala, 1983; Westbury
and Keating, 1986; Napoli et al., 2014)

Motivations II

Note that geminates do not change length in any way. This is a
consequence of *Merge interacting with Max.
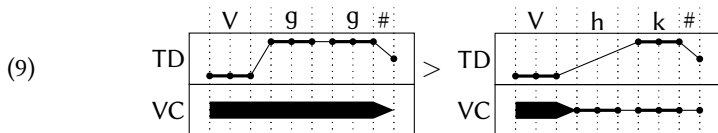
(7) Max
     Do not delete any segments. Mark one violation for each segment
     present in an input not present in an output. (based on Prince and
     Smolensky, 1993/2004)

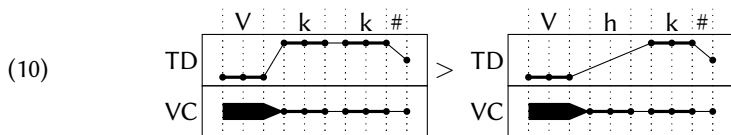Essentially, keeps timing units consistent.

*gg > kk, hk

(8) MAX-GESTURE (MAX-G)
Do not delete any gestures from segments. Mark one violation for
each gesture present in an input not present in an output segment.

(9)

Vgg		MAX-G
a.	Vgg	
b.	Vkk	∗ ∗
c.	Vhk	∗ ∗ ∗

*kk > hk

(10)

Vkk		Max-G
a.	Vkk	
b.	Vhk	∗

Huh. We have a problem.

Paradox

(11)

(gg, kk)		*MERGE	MAX-G
a. ☞ (kk, hk)			∗ ∗ ∗
b. ☞ (hk, kk)			∗ ∗ ∗

- /gg/ > [kk] incurs two violations for the deletion of the voicing gestures
- /gg/ > [hk] incurs three violations for the deletion of the voicing gestures + dorsal gesture
- /gg/ > [kk] forces /kk/ > [hk], incurs one violation for the deletion of the dorsal gestures

Both outcomes are equally bad, and have three total violations.

A solution

Max-G is not important as a constraint by itself; we need to self-conjoin: Max^2-G.

(12) Max^2-Gesture (Max^2-G)
Do not delete two or more gestures. Mark one violation for each gesture present in an input not present in an output, as long as two or more gestures are not present.

Constraint conjunction

Can we make constraints like Max^2-G?

- Conjunction is a way of being more selective about violations
  - Local multiple constraint violations are categorically worse than the same violations in a nonlocal context (Prince and Smolensky, 1993/2004)
- Self-conjunction is a special type of conjunction where violations are only counted if the same constraint is locally violated multiple times (Alderete, 1997)
- Conjoined constraints prevent outputs from changing too radically from their inputs in a specific feature while still allowing change
- Obviously relevant in chain shifts: inputs must be prevented from skipping the line

Max²-G

(13)
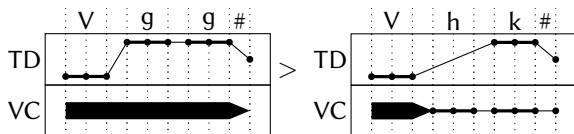
Vgg	Max²-G	Max-G
a.　　　Vgg		
b.　☞　Vhk	*!*	* * *

Crucially, /gg/ > [hk] violates Max²-G, and we know Max²-G outranks Max-G!

The geminates, solved I

(14)

	(gg, kk)	*MERGE	MAX^2-G	MAX-G
a. ☞ (kk, hk)			$*$	$* * *$
b. (hk, kk)			$* *!$	$* * *$

MAX^2-G is crucial to describing ON $>$ Icelandic. Actually, MAX^2-G outranking MAX-G is unimportant; it's enough for MAX^2-G to be ranked under *MERGE to get Icelandic from ON.

The geminates, solved II

Even limiting $\textsc{Max}^2$-G's scope to a segment instead of a number of segments works:

(15)

	(gg, kk)	*$\textsc{Merge}$	$\textsc{Max}^2$-G	$\textsc{Max}$-G
a. ☞	(kk, hk)			$***$
b.	(hk, kk)		$*!$	$***$

The exact formulation is unimportant; the concept suffices.

Summary

- The use of AP makes clear the necessity of particular constraints
- By using gestures and t-units, it is extremely apparent what constraints might be violated, allowing us to immediately see which violations are permissible, and thus ranked lowly, and which violations are not, and thus ranked highly
- This sort of comparison is best done when both inputs and outputs are known, such as in historical phonology

Acknowledgements

This research couldn't have been accomplished without the advising of Prof Nathan Sanders, who also helped me turn my thesis into this presentation.

Thanks also goes to my second reader, Prof Emily Gasser, and my peer reader, Rachel Vogel.

References I

Alderete, John. 1997. Dissimilation as local conjunction. In Kiyomi Kusumoto, ed. *Proceedings of the North East Linguistics Society* 27. Amherst, MA: GLSA, University of Massachusetts. 17–31.

Árnason, Kristján. 1978. Palatalization in Modern Icelandic: A case for historicism in synchronic linguistics. *Lingua* 46:185–203.

Árnason, Kristján. 1980. *Quantity in historical phonology: Icelandic and related cases.* Cambridge: Cambridge University Press.

Árnason, Kristján. 2011. *The phonology of Icelandic and Faroese.* New York: Oxford University Press.

Bandle, Oscar, Kurt Braunmüller, and E. H. Jahr, eds. 2002. *Nordic languages: An international handbook of the history of the North Germanic languages.* Berlin: De Gruyter Mouton.

Benediktsson, Hreinn. 1959. The vowel system of Icelandic: A survey of its history. *The Word-Journal of the International Linguistic Association* 15:282–312.

Benediktsson, Hreinn. 1972. *The first grammatical treatise: Introduction, text, notes, translation, vocabulary, facsimiles.* Reykjavík: Institute of Nordic Linguistics.

Bradley, Travis G. 2002. Gestural timing and derived environment effects in Norwegian clusters. In Line Mikkelsen and Christopher Potts, eds. *WCCFL 21 Proceedings.* WCCFL. Cascadilla Press. 43–56.

Bradley, Travis G. 2007. Morphological derived-environment effects in gestural coordination: A case study of Norwegian clusters. *Lingua* 117:960–985.

Bradley, Travis G. 2014. Optimality Theory and Spanish phonology. *Language and Linguistics Compass* 8:65–88.

Browman, Catherine P. and Louis M. Goldstein. 1986. Towards an articulatory phonology. *Phonology* 3:219–252.

Browman, Catherine P. and Louis M. Goldstein. 1988. Some notes on syllable structure in Articulatory Phonology. *Phonetica* 45:140–155.

Browman, Catherine P. and Louis M. Goldstein. 1990. Tiers in Articulatory Phonology, with some implications for casual speech. In John Kingston and Mary E. Beckman, eds. *Papers in laboratory phonology I: Between the grammar and physics of speech.* Cambridge: Cambridge University Press. 341–376.

Browman, Catherine P. and Louis M. Goldstein. 1992. Articulatory Phonology: An overview. *Phonetica* 49:155–180.

Bybee, Joan. 2001. *Phonology and language use.* No. 94 in Cambridge Studies in Linguistics. New York: Cambridge University Press.

Campbell, Lyle. 2013. *Historical linguistics.* Cambridge, MA: The MIT Press. 3rd ed.

Chapman, Kenneth G. 1962. *Icelandic-Norwegian linguistic relationships.* Boston, MA: Scandanavian University Books.

References II

Cho, Taehong. 1998. Intergestural overlap and timing in Korean palatalization: An Optimality Theoretic approach. *Japanese/Korean Linguistics* 8:261–276.

Cho, Young-mee Yu. 1995. Language change as a reranking of constraints. In Richard M. Hogg and Linda van Bergen, eds. *Historical linguistics: Germanic linguistics. Selected papers* 2. Amsterdam: John Benjamins Publishing Company. 45–62.

Chomsky, Noam. 1995. *The minimalist program*. Cambridge: Cambridge University Press.

Clements, George N. 1976/1980. *Vowel harmony in nonlinear generative phonology*. Bloomington, IN: Bloomington Indiana University Linguistics Club.

Davidson, Lisa. 2003. *The atoms of phonological representation: Gestures, coordination and perceptual features in consonant cluster phonotactics*. Doctoral dissertation. Johns Hopkins.

de Saussure, Ferdinand. 1912/1959. *Course in general linguistics*. Columbia University Press. Translated by Wade Baskin.

Einarsson, Stefán. 1945. *Icelandic: Grammar, texts, glossary*. Baltimore, MD: Johns Hopkins Press.

Eriksen, Anne and Jón Viðar Sigurðsson. 2015. *Negotiating pasts in the Nordic countries: Interdisciplinary studies in history and memory*. Lund: Nordic Academic Press.

Faarlund, Jan Terje. 2001. The notion of oblique subject and its status in the history of Icelandic. In Jan Terje Faarlund, ed. *Grammatical relations in change*. Amsterdam: John Benjamins Publishing Company. 99–135.

Faarlund, Jan Terje. 2002. *Old and Middle Scandinavian*. In König and van der Auwera (2002). 38–71.

Flemming, Edward S. 1995. *Auditory representations in phonology*. Doctoral dissertation. University of California Los Angeles.

Flemming, Edward S. 2004. Contrast and perceptual distinctiveness. In Bruce Hayes, Robert Kirchner, and Donca Steriade, eds. *Phonetically-based phonology*. New York: Cambridge University Press. 232–276.

Gafos, Adamantios I. 1999. *The articulatory basis of locality in phonology*. Outstanding dissertations in linguistics. New York: Garland Publishing Inc.

Gafos, Adamantios I. 2002. A grammar of gestural coordination. *Natural Language & Linguistic Theory* 20:269–337.

Goldsmith, John. 1976. *Autosegmental phonology*. Doctoral dissertation. MIT.

Gordon, Eric Valentine. 1927. *An introduction to Old Norse*. New York: Oxford University Press.

Hall, Nancy. 2003. *Gestures and segments: Vowel intrusion as overlap*. Doctoral dissertation. University of Massachusetts, Amherst.

Harbert, Wayne. 2007. *The Germanic languages*. Cambridge Language Surveys. New York: Cambridge University Press.

References III

Haugen, Einar. 1950. First grammatical treatise. The earliest Germanic phonology. *Language* 26:4–64.

Haugen, Einar. 1958. The phonemics of modern Icelandic. *Language* 34:55–88.

Haugen, Einar. 1976. *The Scandanavian languages: An introduction to their history.* Cambridge, Massachusetts. Harvard University Press.

Haugen, Einar. 1982. *Scandanavian language structures: A comparative historical survey.* Tübingen, Germany: M. Niemeyer.

Helgason, Pétur. 2002. *Preaspiration in the Nordic languages: Synchronic and diachronic aspects.* Doctoral dissertation. Stockholm University.

Huffman, Franklin E. 1976. *The register problem in fifteen Mon-Khmer languages.* No. 1 in Oceanic Linguistics Special Publications. Honolulu, Hawai'i: University of Hawai'i Press.

Jespersen, Otto. 1949. *A Modern English grammar on historical principles. part I: Sounds and spellings.* Crows Nest, ID: George Allen & Unwin.

Karvonen, Daniel and Adam Sherman. 1997. Sympathy, opacity, and u-umlaut in Icelandic. In Motoko Katayama, Daniel Karvonen, and Rachel Walker, eds. *Phonology at Santa Cruz* 5. Santa Cruz, CA: University of Santa Cruz Press. 37–48.

Kawahara, Shigeto. 2006. A faithfulness ranking projected from a perceptibility scale: The case of [+voice] in Japanese. *Language* 82:536–574.

König, Ekkehard and Johan van der Auwera, eds. 2002. *The Germanic languages.* Routledge Language Family Descriptions. New York: Routledge.

Labrune, Laurence. 2012. *The phonology of Japanese.* Oxford: Oxford University Press.

Lass, Roger. 1994. *Old English: A historical linguistic companion.* Cambridge: Cambridge University Press.

Lewis, M. Paul, Gary F. Simons, and Charles D. Fennig, eds. 2015. *Ethnologue: Languages of the world.* Dallas, TX: SIL International. 18th ed. Online version: http://www.ethnologue.com.

Łubowicz, Anna. 2003. *Contrast preservation in phonological mappings.* Doctoral dissertation. University of Massachusetts, Amherst.

Malone, Kemp. 1923. *The phonology of Modern Icelandic.* No. 15 in Ottendorfer Memorial Series of Germanic Monographs. Lawrence, KS: The Collegiate Press.

Malone, Kemp. 1952. The phonemes of Modern Icelandic. In L. R. Lind, ed. *Studies in Honor of Albert Morey Sturtevant.* No. 29 in Humanistic Studies. Lawrence, KS: University of Kansas Press. 5–21.

McCarthy, John. 1981. A prosodic theory of nonconcatenative morphology. *Linguistic Inquiry* 3:373–418.

McCarthy, John and Alan Prince. 1995. Faithfulness and reduplicative identity. In Jill Beckman, Laura Walsh Dickey, and Suzanne Urbanczyk, eds. *Papers in Optimality Theory.* Amherst, MA: Graduate Linguistic Student Association.

References IV

Montreuil, Jean-Pierre. 2006. Contrast preservation theory and historical change. In Randall Gess and Deborah Arteaga, eds. *Historical Romance linguistics: Retrospective and perspectives*. Amsterdam: John Benjamins Publishing Company. 111–129.

Napoli, Donna Jo, Nathan Sanders, and Rebecca Wright. 2014. On the linguistic effects of articulatory ease, with a focus on sign languages. *Language* 90:424–456.

Nielsen, Hans Frede. 1989. *The Germanic languages: Origins and early dialectal interrelations*. Tuscaloosa, AL: University of Alabama Press.

Noske, Roland. 2012. The Grimm-Verner push chain and contrast preservation theory. In Bert Botma and Roland Noske, eds. *Phonological explorations. Empirical, theoretical and diachronic issues*. Berlin: De Gruyter. 63–86.

Ohala, John J. 1983. The origin of sound patterns in vocal tract constraints. In Peter F. MacNeilage, ed. *The production of speech*. New York: Springer. 189–216.

Padgett, Jaye. 2003. Contrast and post-velar fronting in Russian. *Natural Language & Linguistic Theory* 21:39–87.

Pater, Joe. 1999. Austronesian nasal substitution and other NC effects. In René Kager, Harry van der Hulst, and Wim Zonneveld. eds. *The prosody-morphology interface*. Cambridge: Cambridge University Press. 310–343.

Pater, Joe. 2001. Austronesian nasal substitution revisited. In Linda Lombardi, ed. *Segmental phonology in Optimality Theory: Constraints and representations*. Cambridge: Cambridge University Press. 159–182.

Prince, Alan and Paul Smolensky. 1993/2004. *Optimality Theory: Constraint interaction in generative grammar*. Hoboken, NJ: Wiley-Blackwell.

Proctor, Michael Ian. 2009. *Gestural characterization of a phonological class: The liquids*. Doctoral dissertation. Yale.

Þráisson, Höskuldur. 1978. On the phonology of Icelandic prespiration. *Nordic Journal of Linguistics* 1:3–54.

Þráisson, Höskuldur. 2002. *Icelandic*. In König and van der Auwera (2002). 142–189.

Reiss, Charles. 2003. Language change without constraint reranking. In D. Eric Holt, ed. *Optimality Theory and language change*. Berlin: Kluwer Academic Publishers. 143–168.

Sanders, Nathan. 2003. *Opacity and sound change in the Polish lexicon*. Doctoral dissertation. University of California, Santa Cruz.

Sandøy, Helge. 2002. *The typological development of the Nordic languages I: Phonology*. In volume 2 of Bandle et al. (2002). 1852–1886.

Schulte, Michael. 2002. *Phonological developments from Old Norse to Early Modern Nordic I: West Scandanavian*. In volume 2 of Bandle et al. (2002). 1081–1097.

Sigmundsson, Svavar. 2002. *Trends in the linguistic development since 1945: Icelandic*. In volume 2 of Bandle et al. (2002). 1832–1839.

Sigurðsson, Jón Viðar. 1995. The Icelandic aristocracy after the fall of the free state. *Scandinavian Journal of History* 20:153–166.

Sweet, Henry. 1895. *An Icelandic primer with grammar, notes, and glossary*. Oxford: Clarendon Press.

Trubetzkoy, Nikolai. 1876/1969. *Principles of phonology*. Los Angeles: University of California Press. Translated by Christiane A. M. Baltaxe.

Vaux, Bert and Bridget Samuels. 2005. Explaining vowel systems: Dispersion Theory vs natural selection. *The Linguistic Review* 32:573–599.

Westbury, John R. and Patricia A. Keating. 1986. On the naturalness of stop consonant voicing. *Journal of Linguistics* 22:145–166.

The singletons

(16) DEP-GESTURE (DEP-G)
Do not add any gestures. Mark one violation for each gesture
present in an input not present in an output.

(17)
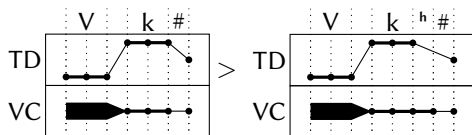
Vk		DEP-G
a.	Vkʰ	
b.	Vg	∗

Note that I assume a change in voicing is a deletion of a gesture followed
by reinsertion of another gesture. I have also analyzed it without this
assumption, and the principle still holds.

*g > k, kʰ

(18)

Vg			Dᴇᴘ-G
a.	☞	Vk	∗
b.	☞	Vkʰ	∗

Paradox, again

(19)

(g, k)	DEP-G
a. ☞ (k, kʰ)	∗
b. ☞ (kʰ, k)	∗

- /g/ > [k] incurs two violations for the deletion of the voicing gestures
- /g/ > [kʰ] incurs three violations for the deletion of the voicing gestures + dorsal gesture
- /k/ > [k] or [kʰ] do not have any violations

Both outcomes are equally bad, again!

A solution, again

Dep-G is not important as a constraint by itself; we need a modified
version: Max^2-LG.

(20) Dep-LongGesture (Dep-LG)
      Do not add any long gestures. Mark one violation for each gesture
   longer than a segment present in an input not present in an output.

Why Dep-LG?

The formulation of Dep-LG is slightly unclear because, the notion of a segment is slightly unclear. Here, I mean that adding gestures that are longer than the segments they "belong" to is a violation of Dep-LG: the extended voicelessness of [Vkʰ] counts as a long segment because it extends past the [k].

- I am assume that aspiration is not its own segment, as that would be an [h], but is also not a transition
- I am assume that changing the length of a pre-existing gesture does not require deletion and reinsertion

Dep-LG

(21)
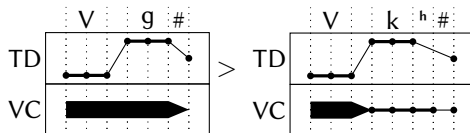
Vg		Dep-LG	Dep-G
a. ☞	Vk		∗
b.	Vkʰ	∗!	∗

Crucially, /g/ > [kʰ] violates Dep-LG.

The singletons, solved

(22)

	(g, k)	*Merge	Dep-LG	Dep-G
a. ☞	(k, kʰ)			*
b.	(kʰ, k)		*!	*

Dep-LG is crucial to describing ON > Icelandic. Dep-LG does not need to be ranked with respect to Dep-G; it's enough for Dep-LG to be ranked under *Merge to get Icelandic from ON.

The totality

(23)

(gg, g, kk, k)	*Merge	Max²-G	Dep-LG
a. ☞ (kk, k, hk, kʰ)		*	
b. (kk, kʰ, hk, k)		*	*!
c. (hk, k, kk, kʰ)		**!	
d. (hk, kʰ, kk, k)		**!	*!

With high-ranking *Merge, *VVO and Max, Max²-G/S and Dep-LG are sufficient to produce the attested Icelandic oral stop subsystem.
In fact, the winning, attested candidate harmonically bounds all of the other candidate outcomes!
Max²-L/G and Dep-LG are the only truly necessary constraints, and do not have to be ranked with respect to each other.

Further questions

- What does it mean to delete the constriction gesture of a segment but leave the voicing gesture? Are there intermediate steps that should be considered?
- What other types of seemingly weird phenomenon can AP/OT explain?
- How should aspiration be depicted in terms of gestures?