The obstruent sonority paradox as a markedness interaction effect

Jennifer L. Smith
University of North Carolina, Chapel Hill • *jlsmith@email.unc.edu*

Overview

§I Subdivisions in obstruent sonority vary by language
→ This has generally been treated as a language-particular 'parameter'

§II Proposal: Sonority is an **interaction between two markedness scales** with the same ***prominence polarity***

§III Typological predictions: Non-modal-voiced sonorants

§IV Theoretical implications

I. Subdivisions in obstruent sonority

(1) Sonority scale = continuum from... (see Parker 2002 for a thorough review)
low ('C-like'/prototypical onset) → *high* ('V-like'/prototypical nucleus)

(2) Core sonority scale: obstruents < nasals < liquids < vocoids (Clements 1990)

(3) Evidence for a finer-grained sonority division is observed in many languages
- (a) *vocoids:* high < mid < low, etc. (Dell & Elmedlaoui 1985, 1988; Kenstowicz 1996)
- (b) *liquids:* laterals < rhotics (Einarsson 1949; Zec 1995)

(4) Evidence also supports a finer-grained division of the class of *obstruents*
- (a) voiceless obstruents < voiced obstruents
- (b) stops < fricatives
- (c) But: obstruent divisions are **not cross-linguistically consistent**
  - It seems to be a language-particular choice which is the **primary** distinction

(5) Specifically, there are two possibilities:
- (a) Subdivide by *voicing* first, then by *continuancy* within voicing category
  ([t] > **[s]**) > (**[d]** > [z])
  - Example: Pirahã (Everett & Everett 1984)
  - Heavy syllables are preferred over light syllables for stress (within last three syllables)
  - Then, voiceless onsets are preferred over voiced (∴ lower sonority)

káa.gai	'word'	**bii̲.sái**	'red'
pa.**hái.bii̲**	(proper name)	ʔi.**bao̲.sái̲**	'her cloth'

- acute accent = stress
- underline = high tone
- bold = σ to compare

(b) Subdivide by *continuancy* first, then by *voicing* within continuancy category
([t] > **[d]**) > (**[s]** > [z])

- Example: Imdlawn Tashlhiyt Berber (Dell and Elmedlaoui 1985: 113, 1988)
  - Any segment can be a nucleus (shown CAPITALIZED), but higher-sonority nuclei preferred
  - Voiceless fricatives are preferred over voiced stops

/t–bxl = akk^w/	**tbX**.lakk^w ,	* **tBx**.lakk^w	'she even behaved as a miser'
cf. /ma = ra–t–g–t/	ma.ra.**tGt**		'what will happen of you?'

(6) Thus, when there are finer-grained distinctions among the obstruents:

(a) voiceless stops are always lowest in sonority

(b) voiced fricatives are always highest in sonority

(c) **relative position of voiced stops and voiceless fricatives** varies by language

(7) Unlike the subdivisions in the liquids and vocoids, these obstruent subdivisions appear to require a language-particular 'parameter' in the sonority scale (e.g., two distinct 'subscales' for obstruent sonority in de Lacy 2002)

- Abandons the idea of a single cross-linguistically consistent scale
- What is the motivation for these language-particular parameters or subscales?

II. Proposal: Two-dimensional sonority

(8) Insight: The 'sonority scale' is composed of **two separate, interacting scales**

> "Some sounds are...more sonorous than others. **Voiced** sounds are more audible than unvoiced, for the obvious reason that to the oral noise they add the tone produced in the larynx. It is equally obvious that the more **open** a sound, the greater its volume."
>
> Bloomfield (1914: 42); emphasis added

> "Perhaps the best way to look at lenition/fortition overall is in terms of two strength scales, one of **openness** and one of **sonority**: movement down the first involves **decreased resistance to airflow**, movement down the second an increase in the output of **periodic acoustic energy**."
>
> Lass (1984: 178); emphasis added

- Proposal here is to **implement this insight in constraint-based phonology**

(9) Two scales available to the phonological grammar

(a) *Aperture*—openness of vocal tract (oral+nasal) (term inspired by Saussure 1916)

The **<u>aperture scale</u>**	stops < fricatives < nasals < liquids < vocoids

(b) *Resonance*—periodic energy

The **<u>resonance scale</u>**	voiceless < voiced

→ The **scales are universal**, but their **interaction is language-particular**

(10) 'Sonority' constraint families are generated from a combination of these scales

(a) High-'sonority'-preferring positions prefer ***high aperture*** and ***high resonance***

(b) Low-'sonority'-preferring positions prefer ***low aperture*** and ***low resonance***

(c) Why would aperture and resonance pattern together? See §IV

A. Formal implementation in strict-dominance OT: Constraint lattice

(11) Constraints formed from a combination of these two scales make up a **constraint lattice** (Baertsch 1998, 2002; compare Gouskova 2004)

(a) Constraints on aperture levels: universally ordered by the aperture scale

(b) Constraints on resonance levels: universally ordered by the resonance scale

(c) But, the lattice also contains constraints that are **not universally ordered** (those that **differ in both resonance and aperture**)

(12) Example: onset as a context preferring ***low aperture*** and ***low resonance***

- Lattice—when a line connects two constraints, the *upper* one is universally ranked *higher*

```
                 *Ons/voc&vcd                              high sonority ( * )
                  /    \                                          ↑
       *Ons/voc&vcls    *Ons/liq&vcd                              |
                  \    /    \                                     |
          *Ons/liq&vcls    *Ons/nas&vcd                           |
                      \    /    \                                 |
             *Ons/nas&vcls    *Ons/fric&vcd                       |
                          \    /    \                             |
                *Ons/fric&vcls    *Ons/stop&vcd                   |
                              \    /                              ↓
                   *Ons/stop&vcls                          low sonority (☺)
```

(13) This lattice makes the correct prediction for obstruent sonority levels:

(a) Stops < fricatives | Stops are better onsets

(b) *Voiceless obstruents* < **voiced obstruents** | Voiceless obstruents are better onsets

(c) But—no universal ordering between **voiced stops** and *voiceless fricatives*

- Result: The constraints on these two categories can be freely ranked

(14) Example: peak as a context preferring ***high aperture*** and ***high resonance***

- Since both scales interact with sonority-preferring positions in the same way, if we consider a high-sonority-preferring context, the entire lattice inverts

```
                 *Peak/stop&vcls                           low sonority ( * )
                  /    \                                          ↑
       *Peak/stop&vcd  *Peak/fric&vcls                            |
                  \    /    \                                     |
          *Peak/fric&vcd  *Peak/nas&vcls                          |
                      \    /    \                                 |
             *Peak/nas&vcd    *Peak/liq&vcls                      |
                          \    /    \                             |
                *Peak/liq&vcd    *Peak/voc&vcls                   |
                              \    /                              ↓
                   *Peak/voc&vcd                           high sonority (☺)
```

(15) Again, this lattice makes the correct prediction for obstruent sonority levels:

(a) Stops < fricatives | Fricatives are better peaks

(b) *Voiceless obstruents* < **voiced obstruents** | Voiced obstruents are better peaks

(c) But—no universal ordering between **voiced stops** and *voiceless fricatives*

B. Harmonic Grammar implementation

(16) In Harmonic Grammar (HG; Smolensky & Legendre 2006), constraints are ***weighted*** rather than ranked, and the weights of all assigned violations are cumulative

- This allows ***gang effects***, where multiple constraints act together

(17) In HG, *Onset/*aperture* and *Onset/*resonance* can be formalized as simple **constraint families** (no need for a lattice)

(a) The *Onset/*Aperture* family:
*Ons/vocoid >> *Ons/liquid >> *Ons/nasal >> *Ons/fric >> *Ons/stop

(b) The *Onset/*Resonance* family: *Ons/voiced >> *Ons/voiceless

- Gang effects can be used to model the interaction between these families

(18) Example: <u>onset</u> as a context preferring ***low aperture*** and ***low resonance***

- Each constraint's *weight* is shown below the constraint name
- Constraint *violations* are notated '–1' for each instance, rather than ' * '
- Each candidate's *harmony score* = sum of (violation score)*(weight) for each constraint

(19) Scenario (I): Voiceless fricatives < voiced stops

	*Ons/*voc* *6*	*Ons/*liq* *5*	*Ons/*nas* *4*	*Ons/*fric* *3*	*Ons/*stop* *2*	*Ons/*vcd* *3*	*Ons/*vcls* *1*	*harmony score*
za				–1		–1		6
<u>da</u>					–1	–1		**<u>5</u>**
<u>sa</u>				–1			–1	**<u>4</u>**
ta					–1		–1	3

- Voiceless fricatives are preferred over voiced stops as onsets

(20) Scenario (II): Voiced stops < voiceless fricatives

	*Ons/*voc* *6*	*Ons/*liq* *5*	*Ons/*nas* *4*	*Ons/*fric* *3*	*Ons/*stop* *1*	*Ons/*vcd* *2*	*Ons/*vcls* *1*	*harmony score*
za				–1		–1		5
<u>sa</u>				–1			–1	**<u>4</u>**
<u>da</u>					–1	–1		**<u>3</u>**
ta					–1		–1	2

- Voiced stops are preferred over voiceless fricatives as onsets

(21) Generalization: Consider two constraint families A–B and X–Y, each with a fixed weight ordering such that $w_a > w_b$ and $w_x > w_y$

(a) Necessarily, $w_a + w_x > w_b + w_x$ and $w_a + w_y > w_b + w_y$

(b) Necessarily, $w_a + w_x > w_a + w_y$ and $w_b + w_x > w_b + w_y$

(c) Necessarily, $w_a + w_x > w_b + w_y$

(c) But, no necessary ordering between $w_a + w_y$ and $w_b + w_x$

C. Summary: Formalizing two-dimensional sonority

(22) Sonority as an interaction between an aperture scale and a resonance scale can be formalized in a constraint-based framework:

- (a) in strict-dominance OT, by means of a constraint lattice
- (b) in HG, by means of simple constraint families

III. Typological predictions

(23) The voiced/voiceless distinction should **interact with other levels** in the sonority scale just as it does with obstruents

- (a) **Voiceless sonorants** should behave as though they were lower in sonority than their voiced counterparts: **R̥ < R**
- (b) Extension—If "resonance" is about having periodic acoustic energy (Lass 1984), then **glottalized sonorants** should also behave as though they were lower in sonority than their (modal-)voiced counterparts: **R' < R**
- (c) The language-specific **sonority ordering** we see between voiced stops and voiceless fricatives should occur with other adjacent pairs of aperture levels

A. Voiceless sonorants

(24) Kokota (Palmer 1999ab): R̥ < R

(a) Voiced and voiceless sonorants: nasals, laterals, rhotics (Palmer 1999b: 78)

no**m**i	'our (exc)'	no**m̥**i	'hear (tr)'
niɣo	'2SG undergoer'	**n̥**iɣo	'finish'
nono**l**o	'be straight'	no**l̥**o	'bird sp.'
ɾuta	'swamp taro'	**ɾ̥**uta	'untangle'

(b) Onset clusters are allowed (Palmer 1999a: 35, 323-326)

pɾosa	'slap self w. flipper (of turtles)'	**pl**eku	'be bent'
fɾo	'squeeze'	**fl**alo	'fly'
vɾaha	'*vitex cofassus*'	**kl**ahe	'be bald'
kɾaŋo	'be dry'	**gl**aba	'moon'
gɾuɣu	'night'		
		bnakua	'be slow'
		knaso	'be empty'

(c) However, onset clusters must be obstruent + *voiced* coronal sonorant

→ *Compatible with claim* that **voiceless sonorants < voiced sonorants**

- Onset clusters tend to prefer dispersed, rising sonority (Clements 1990)

(25) Norwegian (Rice 2003): R̥ < R

(a) Imperative of verb = bare stem (data shows *infinitive – imperative*)

• *singleton*	å spise – spi<u>s</u>!	'eat'	• *falling sonority*	å tenke – te<u>nk</u>!	'think'
	å gjøre – gjø<u>r</u>!	'do'		å fjerne – fje<u>rn</u>!	'remove'
• *geminate*	å legge – le<u>gg</u>!	'lay'	• *two obstruents*	å vokse – vo<u>ks</u>!	'grow'
	å finne – fi<u>nn</u>!	'find'		å fiske – fi<u>sk</u>!	'fish'

(b) Exception: Stems ending in an obstruent+sonorant cluster

*.åpn. 'open' *.sykl. 'bike' *.klatr. 'climb'

- One strategy used (if obstruent=voiceless): devoice the sonorant (Rice 2003: 35)

→ *Compatible with claim* that **voiceless sonorants < voiced sonorants**

- If the correct generalization is that coda clusters must not rise in sonority, this pattern suggests that obstruents and voiceless sonorants are patterning as one sonority level; this can be modeled as *conflation* (de Lacy 2002) of the T(,S,D,Z)+R̥ categories

---

B. Glottalized sonorants

(26) Kwakwala (Boas 1947; Zec 1988; Gordon 2000): R' < R

(a) Stress is weight-sensitive (data from Boas 1947; transcriptions after Zec 1988: 44-47)

• *Initial* CV *does not attract stress (indicated* á*)*		• *Initial* CVː *attracts stress*	
nə.pá	'to throw a round thing'	qáː.sa	'to walk'
w'ə.dá	'it is cold'	c'éː.kʷa	'bird'
c'ə.xə.lá	'to be sick'	xʷáː.kʷ'ə.na	'canoe'

(b) Coda sonority affects syllable weight

• *Initial* CVO *does not attract stress*		• *Initial* CVR *attracts stress*	
maxʷ.c'á	'to be ashamed'	m'ə́n.sa	'to measure'
c'ət.xá	'to squirt'	də́l.xa	'damp'
gas.xá	'to carry on fingers'	tə́l.qʷa	'soft'

(c) Glottalized sonorant codas do not make a syllable heavy

• *Initial* CVR' *does not attract stress*

ɢəm'.χá	'to use the left hand'
kʷən'.χá	'clams are spoiled'
məl'.qá	'to repair canoe'

→ *Evidence for claim* that **glottalized sonorants < voiced sonorants**

- The obstruent pattern is a point in favor of seeing this as sonority-related

(27) Kashaya (Buckley 1994: §2.3.3): D < N’

(a) Voiced stops, glottalized nasals in complementary distribution

- [b, d] in onset; [m’, n’] in coda

ca.**d**ú	‘look’	cá**n’**.pʰi	‘if he sees’
duh.lu.**d**í˙.biʔ	‘start to pick off’	duh.lú**n’**.ba	‘having picked it off’
mah.sa.**d**ún	‘while taking it away’	mah.sá**n’**qʰ	‘must have taken it away’

(b) This pattern *has a sonority-relevant interpretation:* onsets prefer lower sonority; codas prefer higher sonority (Clements 1990)

- Buckley (1995) specifically proposes that [d] < [n’] < [n] in his discussion of this alternation; he notes that the putative change /n’/ → *[n] would require fewer feature changes, so why [d], if not to reduce sonority?
- Problem: There is an independent prohibition on glottalized sonorants in onset position, unrelated to sonority; other languages *do* have /n’/ → [n] in (non-postvocalic) onsets (Howe & Pulleyblank 2001)
- So what Kashaya most directly supports is [d] < [n] (…which we knew...)

→ *Compatible with claim* that **voiced obstruents < glottalized sonorants**

(28) Coda consonants in Hakha Lai (Hyman & VanBik 2002): R ≠ { R’, T }

(a)	Allow tonal contrast on syllable:	Sonorants	/m n ŋ l r j w/
(b)	No tonal contrast on syllable:	Glottalized sonorants	/m’ n’ ŋ’ l’ r’ j’ w’/
		Obstruents	/p t k/

- Glottalized sonorant codas also show special behavior in that the nucleus can only be a short vowel; sonorant, obstruent codas allow a vowel length contrast
- Is this example truly a sonority-based grouping of R’ with T?

→ *Compatible with claim* that **glottalized sonorants < voiced sonorants**, *if* this is a sonority-based pattern

---

C. Summary: Non-nodal-voiced sonorants and the sonority scale

(29) Large-scale **predictions** of the two-dimensional sonority approach for voiceless (a) and glottalized (b) sonorants (R=sonorants; Z/S=fricatives; D/T=obstruents)

```
(a)   … R              (b)   … R          (lattices here represent abstract
       / \                    / \            sonority levels, not constraints)
      R̥   Z                  R’   Z
       \ / \                  \ / \
        S   D                  S   D
         \ /                    \ /
          T                      T
```

(30) The typological patterns reviewed above are consistent with:

(a) R̥ < R | Kokota, Norwegian

(b) R’ < R | Kwak’wala, *??*Hakha-Lai

(c) D < R’ | Kashaya

D. Prediction: 'Aperture-level swaps'

(31) Analogous to the ordering options we see between voiced stops and voiceless fricatives, the two-dimensional sonority model developed here predicts that there should be ordering options between any categories represented by constraints that differ in resonance and have aperture levels that are adjacent on the scale

(a) voiced liquids and voiceless/glottalized glides
(b) voiced nasals and voiceless/glottalized liquids
(c) voiced fricatives and voiceless/glottalized nasals
(d) ...etc. → No examples found yet

IV. Theoretical implications

(32) Are there positions that prefer high aperture but low resonance, or vice versa?

- Perhaps not, given the principle of *prominence alignment* (Prince & Smolensky 1993): High aperture and high resonance are functionally related, so will be attracted to or repelled from the same sets of positions—they have the same ***prominence polarity***

(33) Do we ever see aperture or resonance constraint families acting individually?

- This might be difficult to distinguish empirically from traditional 'sonority' or [±voice]-related patterns

(34) What formalism is most appealing for implementing two-dimensional sonority?

(a) HG allows simple constraint families, rather than a lattice or other formal conjunction operation (see Pater, to appear, for related discussion)
(b) In strict-domination OT, an alternative approach for modeling sonority effects is **stringency** (Prince 1997; de Lacy 2002, 2004)
  - Each constraint in the family bans a successively larger subset of the scale *ONS/*vocoid*, *ONS/*voc+liquid*, *ONS/*voc+liq+nasal*, ...
  - What predictions would this make under two-dimensional sonority?

(35) Implications for multiple sonority-sensitive processes in the same language

(a) If each constraint family or lattice operates independently, we predict the possibility of different sonority thresholds or subgroupings for different phenomena in the same language
(b) But this is a general prediction of approaches that use constraint families projected from the sonority scale (see Parker 2011 for related discussion)

(c) Alternative: Each language sets the relationships among scale levels
  - Rankings between categories that are not universally ranked
  - Conflation of levels into more general categories

  Constraints are then projected from this adjusted scale

V. Summary and conclusions

(36) Two-dimensional sonority:

(a) Makes explicit use of the insight that sonority has two distinct components, **aperture** and **resonance**

(b) Can be **implemented** in OT or HG

(c) Correctly captures cross-linguistic differences in **obstruent sonority** behavior

(d) Makes predictions about non-modal-voiced **sonorants** that are, so far, not seen to be contradicted

Acknowledgements

Many thanks to Mary Kohn, Elliott Moreton, and the members of the Phonology/Phonetics Research Group at UNC-CH for comments and discussion.

References

Baertsch, Karen. 1998. Onset sonority distance constraints through local conjunction. *CLS* 34(2): 1-15.

Baertsch, Karen. 2002. *An Optimality Theoretic Approach to Syllable Structure: The Split Margin Hierarchy.* Doctoral dissertation, Indiana University Bloomington.

Bloomfield, Leonard. 1914. *An introduction to the study of language*. New York: Henry Holt.

Boas, Franz. 1947. Grammar of Kwakiutl (with a glossary of the suffixes). *Transactions of the American Philosophical Society* 37: 201-377.

Buckley, Eugene. 1994. *Theoretical aspects of Kashaya phonology and morphology.* Stanford: CSLI.

Buckley, Eugene. 1995. Constraint domains in Kashaya. *WCCFL 14.* Stanford: CSLI.

Clements, George N. 1990. The role of the sonority cycle in core syllabification. In John C. Kingston and Mary E. Beckman (eds.), *Papers in Laboratory Phonology I: Between the Grammar and Physics of Speech,* 283-333. Cambridge: Cambridge University Press.

de Lacy, Paul. 2002. *The formal expression of markedness.* Doctoral dissertation, UMass Amherst.

de Lacy, Paul. 2004. Markedness conflation in Optimality Theory. *Phonology* 21: 145–199.

Dell, François, and Mohamed Elmedlaoui. 1985. Syllabic consonants and syllabification in Imdlawn Tashlhiyt Berber. *Journal of African Languages and Linguistics* 7:105-130.

Dell, François, and Mohamed Elmedlaoui. 1988. Syllabic consonants in Berber: Some new evidence. *Journal of African Languages and Linguistics* 10:1-17.

Einarsson, Stefan. 1949. *Icelandic: Grammar, Texts, Glossary.* Baltimore: The Johns Hopkins Press.

Everett, Daniel L., and Keren Everett. 1984. On the relevance of syllable onsets to stress placement. *Linguistic Inquiry* 15:705-711.

Gordon, Matthew. 2000. Re-examining default-to-opposite stress. *Berkeley Linguistics Society* 26: 101-112.

Gouskova, Maria. 2004. Relational hierarchies in OT: The case of syllable contact. *Phonology* 21: 201-250.

Greenberg, Joseph H. 1978. Some generalizations concerning initial and final consonant clusters. In Joseph H. Greenberg, Charles A. Ferguson, and Edith A. Moravcsik (eds.), *Universals of Human Language, vol. 2: Phonology,* 243-79. Stanford: Stanford University Press.

Howe, Darin, & Douglas Pulleyblank. 2001. Patterns and timing of glottalisation. *Phonology* 18: 45-80.

Hyman, Larry, & Kenneth VanBik. 2002. Tone and syllable structure in Hakha-Lai. *BLS* 28: 15-28.

Kenstowicz, Michael. 1996. Quality-sensitive stress. *Rivista di Linguistica* 9:157–187.

Lass, Roger. 1984. *Phonology: An introduction to basic concepts*. Cambridge: Cambridge University Press.

Palmer, Bill. 1999a. *A grammar of the Kokota language, Santa Isabel, Solomon Islands*. Doctoral dissertation, University of Sydney.

Palmer, Bill. 1999b. Voiceless sonorants—phonemes or underlying clusters? *Australian Journal of Linguistics* 19: 77-88.
Parker, Stephen G. 2002. Quantifying the sonority hierarchy. Doctoral dissertation, University of Massachusetts, Amherst.
Parker, Stephen G. 2011. Sonority. In Marc van Oostendorp et al. (eds.), *The Blackwell Companion to Phonology*, volume II, 1160-1184. Malden, MA: Wiley-Blackwell.
Pater, Joe. To appear. Universal Grammar with weighted constraints. In John McCarthy and Joe Pater, (eds.), *Harmonic Grammar and Harmonic Serialism*. London: Equinox.
Prince, Alan. 1997. Stringency and anti-Paninian hierarchies. Handout from LSA Institute, Cornell.
Prince, Alan S., and Paul Smolensky. 1993. *Optimality Theory: Constraint Interaction in Generative Grammar.* Ms., Rutgers University and University of Colorado, Boulder. [Published: Blackwell, 2004.]
Rice, Curt. 2003. Dialectal variation in Norwegian imperatives. *Nordlyd* 31:372-384.
Saussure, Ferdinand de. 1916 [1986]. *Course in general linguistics*. Roy Harris, trans. Peru, IL: Open Court Publishing.
Smolensky, Paul, and Géraldine Legendre. 2006. *The Harmonic Mind: From Neural Computation To Optimality-Theoretic Grammar.* Cambridge, MA: MIT Press.
Zec, Draga. 1988. *Sonority constraints on prosodic structure*. Doctoral dissertation, Stanford University.
Zec, Draga. 1995. Sonority constraints on syllable structure. *Phonology* 12:85-129.