Marginal CONTRASTs and the Contrastivist Hypothesis[1]

Daniel Currie Hall (Saint Mary's University) & Kathleen Currie Hall (University of British Columbia)
daniel.hall@utoronto.ca kathleen.hall@ubc.ca

Linguistics Association of Great Britain ∾ SOAS, University of London ∾ 29 August 2013

1. Introduction

1.1. The Contrastivist Hypothesis

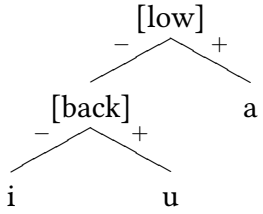
(1) The Contrastivist Hypothesis (Dresher 2009; D. C. Hall 2007):
   a. The only features that can be phonologically active in any language are those that serve to distinguish the phonemes of that language from one another.
   b. Contrastive features are identified by the Successive Division Algorithm:

(2) The Successive Division Algorithm (Dresher 2009: 16)
   1. Begin with *no* feature specifications; assume all sounds are allophones of a single undifferentiated phoneme.
   2. If the set is found to consist of more than one contrasting member, select a feature and divide the set into as many subsets as the feature allows for.
   3. Repeat step 2 in each subset; keep dividing up the inventory into sets, applying successive features in turn, until every set has only one member.

(3) The order in which features make divisions can vary from one language to another. The order of divisions determines the relative scope of features in a **contrastive hierarchy**.

(4) Dividing the inventory /i, a, u/ with the features [±low] and [±back]:

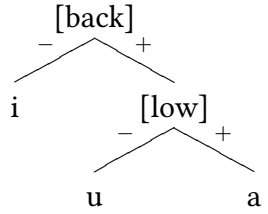
a. Divisions:



Feature specifications:

	i	a	u
[low]	−	+	−
[back]	−		+

b. Divisions:



Feature specifications:

	i	a	u
[back]	−	+	+
[low]		+	−

(5) This presupposes that we can tell what's a (separate) phoneme and what isn't.

1. Thanks to John T. Hall and Doug Pulleyblank for help in marshalling and digitizing resources on Pulaar, and to Yuni Kim and Pavel Iosad for proposing a themed session at the intersection of our core research interests and thereby prompting us to finally give a joint talk.

1.2. Marginal contrasts

(6) A number of researchers have pointed out the existence of phones in a language that are not easily categorized as either phonemic or allophonic (e.g., Gleason 1961; Crothers 1978; Goldsmith 1995; Hill 1998; Hualde 2005; Ladd 2008; Scobbie & Stuart-Smith 2008; Kager 2008; K. C. Hall 2009, 2012; Bye 2009; Dresher 2011; Ferragne et al. 2011; Boulenger et al. 2011).

(7) K. C. Hall (2013) provides a comprehensive overview of such intermediate relationships, and in particular provides a typology illustrating the many different ways in which contrasts can be 'marginal.'

(8) See K. C. Hall (2009) for discussion of one type of intermediate relation: phones that are intermediate on the basis of the criterion of predictability of distribution. K. C. Hall (2009) proposes that there is a continuum of possible relations that can hold between two phones, from completely predictable allophony to total contrastiveness in all environments.

(9) Contrastiveness can be quantified as entropy (uncertainty, or unpredictability; Shannon & Weaver 1949):

a. 1 = totally unpredictable (perfect contrast)

b. 0 = totally predictable (perfect allophony)

(10) Two 'contrasting' sounds may have an entropy of less than 1 if (e.g.):

a. they contrast in some environments but not in others

b. one sound is significantly less frequent than the other

(11) Other reasons that phones might be intermediate between being fully contrastive and being fully allophonic include:

a. They are predictably distributed, but only when reference is made to non-phonological information (such as morpheme boundaries);

b. They are foreign or specialized, or otherwise belong to some distinct stratum of the language;

c. They are variable in their realization.

(12) A question and an answer:

Ⓠ Does the existence of such intermediate degrees of contrastiveness make the Contrastivist Hypothesis untenable, or even meaningless?

Ⓐ No. Furthermore, marginal contrasts may offer insights into how contrastive hierarchies change diachronically, and what it takes for learners to acquire them.

2. What counts as contrastive, and where

2.1. Dividing the continuum

(13) In general, the existence of a continuum in no way precludes the possibility of categorical distinctions.

(14) In the specific case of entropy defining a continuum of contrastiveness, there is an obvious line to be drawn between pairs of phones with zero entropy and pairs with non-zero entropy: if two phones are unpredictable in at least some contexts (i.e., entropy > 0), then the system of phonological representations must have some means of distinguishing them.

(15) The SDA assumes a binary split: if a phone is *at least* marginally contrastive—that is, if there are at least *some* contexts in which it cannot be predictably derived from other information independently known to be present in the representation—then it must be treated as a phoneme for the purposes of the SDA.

(16) (Caveat: A pair of phones with non-zero entropy at the surface may nonetheless be predictable on the basis of more abstract properties of their contexts.)

(17) An extreme example: if a single foreign word enters a language and would introduce a new contrastive phoneme, then the new phoneme must be treated either as an 'exception' (and therefore not integrated into the regular phonological system), or as indeed contrastive and subject to the SDA.

2.2. Contrastive specification ≠ a complete absence of redundancy

(18) Note that in the SDA, features are assigned only when they serve a contrastive function, but there is no guarantee that features will be assigned in the most efficient way.

(19) Indeed, given standard binary or privative features, contrastive specifications *cannot* be maximally efficient unless the number of phonemes happens to be a power of two (Mackie & Mielke 2011).

(20) Similarly, even if the entropy of a pair of phonemes is less than one, a discrete phonological computation cannot use less than one feature to distinguish them.

2.3. The SDA cares about underlying contrast, not surface contrast

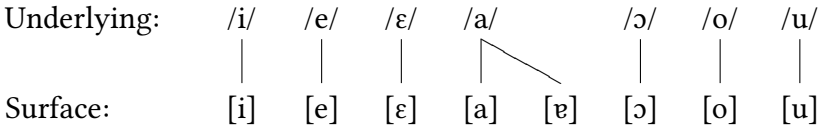
(21) Measuring the entropy of phones at the surface level gives an index of their *functional* contrastiveness in an information-theoretic sense.

(22) The SDA, however, only needs to assign enough features to distinguish phonemes that contrast *formally* at the underlying level of representation.

(23) Marginal surface contrasts can arise from differences in underlying structure other than differences between phonemes.

(24) Consider the vowel system of European Portuguese (Spahr 2012):

(25) European Portuguese vowels (in stressed syllables)

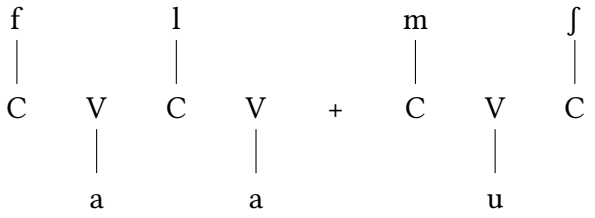


(26) A surface minimal pair

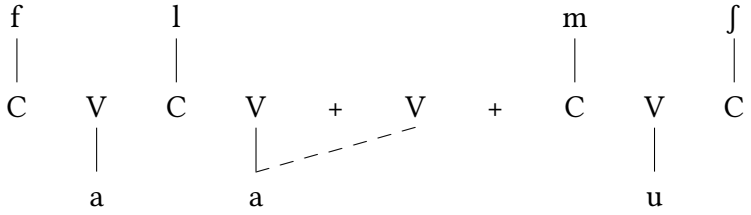
a. *falamos* [fɐˈlɐmuʃ] 'we speak'
b. *falámos* [fɐˈlamuʃ] 'we spoke'

(27) As analyzed by Spahr (2012), the contrast in (26) arises not from an underlying phonemic contrast in quality between a and ɐ, but from a morphological contrast in the presence or absence of a V slot:

(28) a. [fɐˈlɐmuʃ] = 'speak' + 1PL.



b. [fɐˈlamuʃ] = 'speak' + PERFECT + 1PL.



(29) Singly linked /a/ raises to [ɐ] in unstressed syllables and before nasals; doubly linked /a/ is realized as [a].

(30) The SDA doesn't need to differentiate ɐ from a (though we might ask whether an empty V slot is a 'phoneme' in any relevant sense).

(31) As mentioned in (11a), there are many other cases of marginal surface contrasts that are entirely predictable from underlying morphophonological information. (See, e.g., Harris 1994; Carr 2008; Bye 2009; K. C. Hall 2013.)

2.4. Another question and answer

(32) ◎ Does the existence of a categorical distinction between zero and non-zero entropy make the study and quantification of marginal contrasts untenable, or even meaningless?

Ⓐ No.

(33) a. Understanding and quantifying marginal contrasts in the ways described above can be useful for modelling aspects of phonology such as diachronic change and psycholinguistic processing.

b. Furthermore, the existence of a categorical split into 'phonologically active' (and hence assigned by the SDA) vs. 'inactive' doesn't preclude further study into the *extent* to which features are active.

i. In the context of the SDA, a contrast could be considered marginal if it is relatively low in the contrastive hierarchy, particularly if it appears on only a small number of branches.

ii. Contrasts with low scope might be expected to be diachronically unstable—either emerging or disappearing (Oxford 2012; Dresher, Harvey & Oxford 2013)—and synchronically more susceptible to neutralization (Spahr 2013).

(34) Thus, the study of marginal contrasts and the study of the Contrastivist Hypothesis and the SDA can be entirely symbiotic.

3. The case of Pulaar

(35) Pulaar ATR harmony provides an example of the importance of marginal contrasts for the Contrastivist Hypothesis (D. C. Hall 2000, 2007).

(36) The vowel inventory:

a. Underlying (*selon* Paradis 1986, 1992):

i	u
ɛ	ɔ
a	

b. Surface:

i	u
e	o
ɛ	ɔ
a	

3.1. The pattern

(37) ATR harmony as described by Archangeli & Pulleyblank (1994):

a. High vowels are [+ATR].
b. /a/ is [−ATR].
c. Mid vowels are [+ATR] when the next vowel to the right is [+ATR], and [−ATR] otherwise.

(38) So [+ATR] mid vowels occur in all positions to the left of any high vowel as long as no /a/ intervenes.

(39) High vowel in singular suffix triggers [+ATR] mid vowel in stem; mid vowel in diminutive plural suffix yields [−ATR] mid vowel in stem.

	SINGULAR	DIM. PL.	
a.	[sof-ru]	[cɔf-ɔn]	‘chick’
b.	[ser-du]	[sɛr-kɔn]	‘butt of a rifle’
c.	[ᵐbeːl-u]	[ᵐbɛːl-ɔn]	‘shadow’
d.	[dog-oː-ru]	[dɔg-ɔ-w-ɔn]	‘runner’

(40) Instrumental applicative suffix triggers [+ATR] harmony:

	INFINITIVE		INSTRUMENTAL INFINITIVE	
a.	[ɓɛt-dɛ]	‘to weigh’	[ɓet-ir-dɛ]	‘to weigh with’
b.	[hɛl-dɛ]	‘to break’	[hel-ir-dɛ]	‘to break with’

(41) /a/ blocks [+ATR] harmony:

a. [bɔːt-aː-ri] ‘lunch’
b. [pɔːf-aː-li] ‘breaths’
c. [nɔdd-aː-li] ‘call’
d. [ᵑgɔr-aː-gu] ‘courage’

(42) This looks like a problem for the Contrastivist Hypothesis.

a. If [±ATR] is the feature that distinguishes /i u/ from /ɛ ɔ/, then we would expect harmony to turn /ɛ ɔ/ into [i u], not [e o].[2]

b. If [±ATR] is not the feature that distinguishes /i u/ from /ɛ ɔ/, then a non-contrastive feature is phonologically active.

i. Archangeli & Pulleyblank (1994: 134): "[A]lthough completely predictable, [ATR] values play an active role in the phonology of Pulaar."

ii. Campos Astorkiza (2007: 194): "According to underspecification theories, the [ATR] value for high and low vowels should not play an active role in the phonology of the language."

3.2. The marginal contrast

(43) But /e o/ may be marginally contrastive. According to Paradis (1992: 90), there are three morphemes that counterexemplify the generalization that [+ATR] mid vowels occur only to the left of high vowels:

(44) a. [fof] 'all'
b. [-(g)el] diminutive singular
c. [-(g)ol] noun class marker

(45) Furthermore, two of these are suffixes: *-(g)ol* and *-(g)el* appear in a variety of other forms, and they trigger harmony in the stems that precede them:

(46)

	SINGULAR	DIM. SG.	DIM. PL.	
Suffix:	-(g)ol	-(g)el	-ɔn	
a.	[lef-ol]	[lef-el]	[lɛf-ɔn]	'ribbon'
b.	[keːr-ol]	[keːr-el]	[kɛːr-ɔn]	'boundary'
c.	[ceːlt-ol]	[ceːlt-el]	[cɛːlt-ɔn]	'cut'
d.	[cef-ol]	[cef-el]	[cɛf-ɔn]	'incantation'

(47)

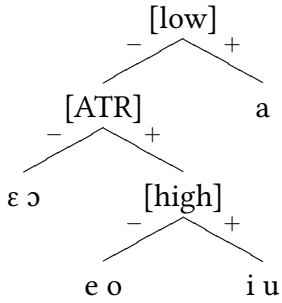
	SINGULAR	DIM. SG.	
Suffix:	various	-(g)el	
a.	[ᵐbaroː-di]	[baro-gel]	'lion'
b.	[pɛmᵐbɔːw-ɔ]	[pemᵐbow-el]	'hairdresser'
c.	[hɔr-dɛ]	[kor-el]	'calabash'

(48) Paradis (1992) avoids positing underlying /e o/ by analyzing these morphemes as /fɔuf/, /-(g)ɛil/, and /-(g)ɔul/, with the [+ATR] mid vowels arising either through coalescence or through harmony followed by deletion of the high vowels.

(49) However, if the marginal surface contrast is analyzed as a categorical underlying contrast, with /e o/ included in the phonemic inventory despite their apparently low type frequency, then [ATR] can be characterized as contrastive in the Pulaar system.

2. This is a slight oversimplification. If the inventory is first divided by [±ATR], and then the [−ATR] vowels are divided by [±low], then [e o] generated by harmony might be formally distinguishable from [i u] by the fact that the former are specified as [−low] and the latter are not. But this potential distinction would not meet Halle's (1959) Distinctness Condition, and [i u] are of course phonetically [−low].

(50) A partial contrastive hierarchy with phonemic /e o/:[3]



(51) Given the representations in (50), harmony can be unproblematically represented as the leftward spreading of [+ATR] from one non-low vowel to the next.

(52) If /e o/ are indeed phonemic, we might expect them to appear in more than three morphemes. In fact, there's some evidence that they do (see below).

(53) As other related languages have a more robust ATR contrast (Casali 2003), Pulaar as described by Paradis may represent a diachronic change from an earlier stage in which [+ATR] mid vowels were more prevalent.

3.3. How marginal is it?

(54) The entropy of a pair of sounds in a single environment is calculated as in the formula in (55) (see K. C. Hall 2009). The probability of each sound's occurring in that environment (p_i) is multiplied by the log of that probability (i.e., the information content), and these products are summed for the two sounds. Recall that entropy ranges from 0 (no uncertainty, perfect allophony) to 1 (complete uncertainty, perfect contrast).

(55) $H(e) = -\sum p_i \log_2 p_i$

(56) To calculate the entropy of a pair of sounds across multiple environments, the formula in (57) is used. The entropy for each environment $H(e)$ is calculated separately, as in (55), and then each entropy is weighted by the overall frequency of that environment $p(e)$. The weighted entropy values are summed. The values for this systemic entropy calculation again range from 0 to 1.

(57) $H = \sum (H(e) \times p(e))$

(58) Data come from Niang (1997), a Pulaar–English / English–Pulaar dictionary based on "the Pulaar dialect spoken essentially in Mauritania, Senegal, and The Gambia" (Niang 1997: x).

(59) 6332 words, representing all distinct forms appearing as headwords in the Pulaar–English section, were taken as input. In Niang's orthography, [+ATR] mid vowels are represented as ⟨é, ó⟩ and [−ATR] ones as ⟨e, o⟩.[4]

(60) The entropy between [+ATR] mid vowels on the one hand and [−ATR] vowels on the other was calculated. Three mutually exclusive and comprehensive environments were chosen:

3. Some feature such as [round] or [back] must also be present, to distinguish /u/ from /i/, /o/ from /e/, and /ɔ/ from /ɛ/; we omit it from the hierarchy in (50) because its scope relative to the other features cannot be determined on the basis of the data considered here.

4. The fact that Niang represents the [ATR] distinction at all is itself suggestive.

cases where [±ATR] vowels occur before [+ATR] vowels, cases where they occur before [−ATR] vowels, and cases where they are the final vowel in a word.

(61) If there were no contrast between [±ATR] mid vowels, we would expect 0 entropy in all three environments, with [+ATR] mid vowels occurring in the first one, and [−ATR] mid vowels occurring only in the second and third ones. A non-zero entropy in any of these environments indicates at least a partial surface contrast in that environment.

(62)

Environment e	$H(e)$	$p(e)$
Before [+ATR]	0.37	0.15
Before [−ATR]	0.08	0.33
Before #	0.38	0.52
Systemic	0.28	—

(63) As can be seen in (62), the entropy is non-zero in all three environments, and the overall weighted average entropy is 0.28. This is clearly in the realm of being contrastive, but is also clearly a 'marginal' contrast, with a relatively low entropy value.

(64) As a comparison, consider the contrast between [±back] mid vowels, in analogous conditioning environments of before [+back] vowels, before [−back] vowels, and word-finally. There has never been, as far as we know, any suggestion of vowel harmony or allophony in this domain.

(65)

Environment e	$H(e)$	$p(e)$
Before [+back]	0.93	0.22
Before [−back]	0.83	0.26
Before #	0.81	0.52
Systemic	0.84	—

(66) As can be seen in (65), the [±back] mid vowels are much more clearly contrastive across all three environments, and the average weighted entropy is 0.84.

(67) Thus, there is clearly a difference between the *degree* of contrastiveness for [±ATR] mid vowels on the one hand and [±back] mid vowels on the other. At the same time, both are indeed squarely in the 'contrastive' range of the continuum.

(68) In terms of raw counts, there are 401 words in our 6332-word lexicon that contain [+ATR] mid vowels that are not immediately followed by another [+ATR] vowel and are thus 'contrastively' (unpredictably) [+ATR]. While many of these involve the suffixes in (44), they also include borrowings (largely from French) and a number of other apparently native words that are transcribed with [+ATR] mid vowels, lending credence to the hypothesis that such vowels are in fact underlyingly contrastive.

(69)

	SPELLING	INFERRED IPA	GLOSS	PAGE IN NIANG
a.	*biró*	/biro/	'office' (< French *bureau*)	9
b.	*gééc*	/geːʧ/	'ocean; sea' (< Wolof *geej*)	36
c.	*góó*	/goː/	'one'	xii, 37
d.	*jóy*	/ʤoj/	'five'	xii, 51
e.	*ñóndo*	/ɲo^{n}dɔ/	'person whose speech is affected by nasalization'	78
f.	*pulóók*	/puloːk/	'cassava; yam'	83
g.	*taartóyaade*	/taːrtojaːdɛ/	'take a scenic route'	95
h.	*taggéé*	/taggeː/	'death message broadcast on radio'	95
i.	*tééw*	/teːw/	'meat; flesh'	97

(70) There are also 101 words that contain [−ATR] mid vowels immediately followed by a [+ATR] vowel, and which thus contribute to the overall degree of contrastiveness of [±ATR] mid vowels in environment 1 (before [+ATR] vowels). Given the orthographic conventions in the dictionary, in which [+ATR] mid vowels are marked with an acute accent, it is possible that these are simply typos. If we assume that this is the case and that entropy should in fact be 0 in this environment, the overall weighted average entropy for [±ATR] mid vowels decreases to 0.22, but is still clearly non-zero.

(71) At the same time, the functional load of the [±ATR] contrast is almost null; there is at most one minimal pair that hinges on this contrast in the dictionary, (72), but this is a possible instance of an incorrectly transcribed [−ATR] vowel occurring before a [+ATR] vowel. By comparison, there are 55 minimal pairs that hinge on [±back] contrasts in mid vowels.

(72)

	SPELLING	INFERRED IPA	GLOSS	PAGE IN NIANG
a.	*doppude*	/dɔppudɛ/	'put out a fire'	23
b.	*dóppude*	/doppudɛ/	'repel'	23

(73) Even with a larger number of apparently unpredictable surface [+ATR] mid vowels, Paradis's hiatus-resolution analysis in (48) might still be tenable. But it's worth noting the variety of different surface forms in (69): some have long vowels, others short; some have a following glide /j/ or /w/, others don't. If this is hiatus resolution, does it have a consistent outcome?

4. Conclusions

(74) There is no incompatibility between the Contrastivist Hypothesis and recognizing the existence of a continuum between pure contrast and pure allophony.

(75) To some extent, these two approaches to phonological contrast are orthogonal:

a. The Contrastivist Hypothesis is about the information that may/must be present in underlying representations.

b. K. C. Hall's entropy measure quantifies contrastiveness in terms of unpredictability of distribution at the surface level.

(76) However, they can also work synergistically.

(77) In the case of Pulaar, the Contrastivist Hypothesis leads us to expect a phonemic distinction between /e o/ and /ɛ ɔ/.

(78) Entropy gives us a way of exploring how robust the predicted contrast is at the surface level.

(79) This could have implications for acquisition—surface entropy may be one of the factors that determine when learners posit separate underlying phonemes.

(80) Conversely, if contrastiveness is indeed a prerequisite for phonological activity, then the fact that [ATR] is phonologically active may serve as a cue to learners that it is contrastive, thereby sustaining the contrast diachronically despite its marginal status. The diachronic progress of marginal contrasts is thus a prime testing ground for the Contrastivist Hypothesis.

References

Archangeli, Diana & Douglas Pulleyblank. 1994. *Grounded Phonology*. Cambridge, MA: MIT Press.

Boulenger, Véronique, Emmanuel Ferragne, Nathalie Bedoin & François Pellegrino. 2011. Derived contrasts in Scottish English: An EEG study. In: *Proceedings of the 17th International Congress of Phonetic Sciences (ICPhS XVII)*, 352–355.

Bye, Patrik. 2009. Three types of marginal contrast. Presented at the Toronto–Tromsø Phonology Workshop, University of Toronto, October 2009.

Campos Astorkiza, Judit Rebeka. 2007. *Minimal Contrast and the Phonology–Phonetics Interaction*. PhD thesis. University of Southern California.

Carr, Philip. 2008. *A Glossary of Phonology*. Edinburgh: Edinburgh University Press.

Casali, Roderic F. 2003. [ATR] value asymmetries and underlying vowel inventory structure in Niger-Congo and Nilo-Saharan. *Linguistic Typology* 7.3: 307–382.

Crothers, John. 1978. Typology and universals of vowel systems. In: *Universals of Human Language, Volume 2: Phonology*. Ed. by Joseph H. Greenberg, Charles A. Ferguson & Edith A. Moravcsik. Stanford, CA: Stanford University Press, 93–152.

Dresher, B. Elan. 2009. *The Contrastive Hierarchy in Phonology*. Cambridge: Cambridge University Press.

———. 2011. The phoneme. In: *The Blackwell Companion to Phonology*. Ed. by Marc van Oostendorp, Colin J. Ewen, Elizabeth Hume & Keren Rice. Vol. 1. Oxford: Wiley-Blackwell, 241–266.

Dresher, B. Elan, Christopher Harvey & Will Oxford. 2013. Synchronic systems in diachronic change: The role of contrast. Presented at GLOW 36, Lund University, April 2013.

Ferragne, Emmanuel, Nathalie Bedoin, Véronique Boulenger & François Pellegrino. 2011. The perception of a derived contrast in Scottish English. In: *Proceedings of the 17th International Congress of Phonetic Sciences (ICPhS XVII)*, 667–670.

Gleason, H. A. (Jr.) 1961. Review of *African language studies I* by Malcolm Guthrie; *The role of tone in the structure of Sụkụ́ma* by I. Richardson. *Language* 37.2: 294–308.

Goldsmith, John A. 1995. Phonological theory. In: *The Handbook of Phonological Theory*. Ed. by John A. Goldsmith. Cambridge, MA: Blackwell, 1–23.

Hall, Daniel Currie. 2000. Redundant features in Pulaar… and why they aren't. Presented at the Montréal–Ottawa–Toronto (MOT) Phonology Workshop, York University, Toronto, February 2000.

———. 2007. *The Role and Representation of Contrast in Phonological Theory*. PhD thesis. University of Toronto.

Hall, Kathleen Currie. 2009. *A Probabilistic Model of Phonological Relationships from Contrast to Allophony*. PhD thesis. The Ohio State University.

———. 2012. Phonological relationships: A probabilistic model. *McGill Working Papers in Linguistics* 22.1: 14 pp.

———. 2013. A typology of intermediate phonological relationships. *The Linguistic Review* 30.2: 215–275.

Halle, Morris. 1959. *The Sound Pattern of Russian: A Linguistic and Acoustical Investigation*. The Hague: Mouton.

Harris, John. 1994. *English Sound Structure*. Oxford: Blackwell.

Hill, Kenneth C. 1998. Review of *Registro de la veración fonológica en el náhuatl moderno: Un estudio de caso* by Cristina Monzón. *International Journal of American Linguistics* 64.1: 70–73.

Hualde, José Ignacio. 2005. Quasi-phonemic contrasts in Spanish. *WCCFL* 23: 374–398.

Kager, René. 2008. Lexical irregularity and the typology of contrast. In: *The Nature of the Word: Essays in Honor of Paul Kiparsky*. Ed. by Kristin Hanson & Sharon Inkelas. Cambridge, MA: MIT Press, 397–432.

Ladd, D. Robert. 2008. 'Distinctive phones' in surface representation. In: *Laboratory Phonology 8*. Ed. by Louis Goldstein, D. H. Whalen & Catherine T. Best. Berlin: Mouton de Gruyter, 3–26.

Mackie, Scott & Jeff Mielke. 2011. Feature economy in natural, random, and synthetic inventories. In: *Where Do Phonological Features Come From? Cognitive, Physical and Developmental Bases of Distinctive Speech Categories*. Ed. by G. Nick Clements & Rachid Ridouane. Amsterdam: John Benjamins, 43–64.

Niang, Mamadou Ousmane. 1997. *Pulaar–English English–Pulaar Standard Dictionary*. New York: Hippocrene.

Oxford, Will. 2012. Patterns of contrast in phonological change: evidence from Algonquian vowel systems. Ms., University of Toronto.

Paradis, Carole. 1986. *Phonologie et morphologie lexicales: Les classes nominales en pulaar (Fula)*. Doctoral dissertation. Université de Montréal.

———. 1992. *Lexical Phonology and Morphology: The Nominal Classes in Fula*. Translation (by the author) of Paradis 1986. New York: Garland.

Scobbie, James M. & Jane Stuart-Smith. 2008. Quasi-phonemic contrast and the indeterminacy of the segmental inventory: Examples from Scottish English. In: *Contrast in Phonology: Theory, Perception, Acquisition*. Ed. by J. Peter Avery, B. Elan Dresher & Keren D. Rice. Berlin: Mouton, 87–114.

Shannon, Claude E. & Warren Weaver. 1949. *The Mathematical Theory of Communication*. Urbana, IL: University of Illinois Press.

Spahr, Christopher. 2012. Positional neutralization in the Contrastive Hierarchy: The case of phonological vowel reduction. Ms., University of Toronto.

———. 2013. A contrastive hierarchical account of positional neutralization. Presented at GLOW 36, Lund University, April 2013.