REDUNDANT FEATURES
IN A CONTRAST-BASED APPROACH TO PHONOLOGY

Daniel Currie Hall
Saint Mary's University & University of Toronto

1. Introduction: Two questions about contrast

There is in phonological theory a widely held belief that contrast matters—that is, that the contrastive or redundant status of a given feature (on a given segment, in a given language) has some relevance to how that feature behaves phonologically (on that segment, in that language). Although this basic idea has both a long history and considerable currency (see Dresher 2009 and Hall 2011 for discussion of some of its incarnations), there is comparatively little agreement on the crucial details of its implementation. In particular, there are two essential questions that must be answered in order to give the theory empirically testable substance:

(1) a. How can the contrastive or redundant status of a feature be identified?
b. Exactly how does a feature's contrastive or redundant status constrain its phonological patterning?

1.1 The first question

The best answer to question (1a), as argued by Dresher, Piggott, and Rice (1994), Dresher (2009: ch. 2), and Hall (2007: §1.2.7), is that contrastive features in a system are identified by successively dividing the inventory until all phonemes have been featurally distinguished. A formal statement of this approach, the Successive Division Algorithm (SDA), is given in (2):

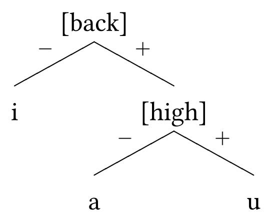
(2) The Successive Division Algorithm (Dresher 2009: 17)
a. In the initial state, all tokens in inventory I are assumed to be variants of a single member. Set I = S, the set of all members.
b. i. If S is found to have more than one member, proceed to (c).
ii. Otherwise, stop. If a member, M, has not been designated contrastive with respect to a feature, G, then G is *redundant* for M.
c. Select a new *n*-ary feature, F, from the set of distinctive features. F splits members of the input set, S, into *n* sets, $F_1 - F_n$, depending on what value of F is true of each member of S.
d. i. If all but one of $F_1 - F_n$ are empty, then loop back to (c). (That is, if all members of S have the same value of F, then F is not contrastive in this set.)
ii. Otherwise, F is *contrastive* for all members of S.
e. For each set F_i, loop back to (b), replacing S by F_i.

Actes du congrès annuel de l'Association canadienne de linguistique 2012.
Proceedings of the 2012 annual conference of the Canadian Linguistic Association.

Under the SDA, a feature will be designated as contrastive only if it marks some phonemic distinction in the inventory at the point at which it is considered. The ordering of the features, which is not specified by the algorithm itself, often plays an important role in determining whether a given feature is contrastive. For example, consider the three-vowel inventory /i, a, u/ and the binary features [back] and [high]. The two possible orderings of the features result in different specifications:

(3) a. [±back] ≫ [±high]

i. Divisions:

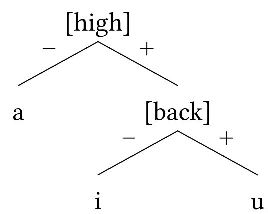


ii. Contrastive specifications:

/i/	[−back]
/a/	[+back, −high]
/u/	[+back, +high]

b. [±high] ≫ [±back]

i. Divisions:



ii. Contrastive specifications:

/i/	[+high, −back]
/a/	[−high]
/u/	[+high, +back]

Under either of these orderings, both [+back] and [+high] are contrastive on /u/, [−back] on /i/, and [−high] on /a/. If [back] takes wider scope, as in (3a), then [+back] will also be contrastive on /a/, because it serves to distinguish /a/ from /i/; if [high] takes wider scope, then [+high] will be contrastive on /i/, because it distinguishes /i/ from /a/. Contrastive hierarchies like those in (3) are characteristic of the SDA, but they have also appeared in work that predates this particular algorithm, such as Cherry, Halle, and Jakobson (1953), Halle (1959), and Postal (1968).

An obvious alternative to the SDA, and one that would initially appear to do away with the need for feature ordering, would be to start with full specifications for all phonemes, identify pairs of segments that differ by only a single feature specification, and mark those crucial features as the contrastive ones. For example, if the full specifications of the three vowels /i, u, a/ are as in (4a), then the minimal pairs of segments are /i, u/ (differing only in [back]) and /u, a/ (differing only in [high]), and the contrastive specifications are as in (4b):

(4) a.

	i	u	a
[back]	−	+	+
[high]	+	+	−

b.

	i	u	a
[back]	−	+	
[high]		+	−

This is a narrower definition of contrast than the one provided by the SDA, and in (4) it seems to produce a reasonable result: given that /i/ is [−back], it is predictable that it is also [+high], and given that /a/ is [−high], it is predictably also [+back]. This result is illusory, though, because [back] and [high] are not the only features. If we start with a fuller set of specifications, as in (5), then there will be no minimal pairs of segments, and so no features will be designated as contrastive at all.

(5)

	i	u	a
[back]	−	+	+
[high]	+	+	−
[low]	−	−	+
[round]	−	+	−

In (5), every feature value is predictable given the others, but if all feature values are eliminated as redundant, then there remain no specifications from which to predict the omitted values. The only way to resolve this problem is by giving some features scope over others. For example, if [high] takes scope over [low], then we can say that the values of [low] are predictable from the values of [high] without also having to say that [high] is redundant because it can be predicted from the values of [low]. But this idea of scope—i.e., of arranging features into a contrastive hierarchy—is the essence of the Successive Division Algorithm. There is thus no reason to appeal to the minimal pairs test: the minimal pairs test cannot produce adequate specifications without recourse to hierarchical scope relations, but scope relations can produce adequate contrastive specifications without recourse to the minimal pairs test. Because it considers each feature only in the context of features above it in the hierarchy, rather than in the context of *all* other features, the SDA will designate as contrastive some features that the minimal pairs test would consider redundant. Cases such as the inventory in (5), however, show that specifications which the minimal pairs test designates as contrastive do not always suffice to identify all the contrasts in an inventory.[1]

1.2 The second question

The second question, (1b), can be seen as a question about how much information the phonological computation has access to. The most restrictive answer, which Hall (2007) and Dresher (2009) call the Contrastivist Hypothesis, is that only contrastive features are phonologically visible; redundant properties of segments are filled in at phonetic implementation, but are not accessible to phonological rules or constraints.

Other theories of contrastive specification have been more permissive. For example, Archangeli's (1988) Radical Underspecification holds that redundant features are absent from underlying representations, but are filled in as the derivation progresses. Rather than saying that only contrastive features are visible, this approach holds that only redundant features can be invisible. Nevins

[1]See also Archangeli (1988) and Dresher (2009: §2.5) for more detailed discussion of the inadequacy of the minimal pairs approach.

(2005) goes further, positing Parametric Visibility: any phonological rule may refer to all features, or only to contrastive feature values, or only to marked contrastive feature values. In this approach, contrast enriches rather than restricts the amount of information available to the phonological computation: contrastiveness functions as a metafeature that some rules refer to and others do not. Parametric Visibility thus gives phonology even more information to work with than theories that simply posit full specification, with no distinction between contrastive and redundant features at all (a position argued for by Stanley (1967), and assumed by various others).

Of the possible answers to question (1b), the Contrastivist Hypothesis, because it is the one that most narrowly circumscribes the information available to the phonological computation, is the one most susceptible to falsification, and this suggests that it should be the first to be investigated in greater depth. To make such an investigation possible, the CH must be stated clearly enough that its predictions are evident. Hall (2007: 20) formulates it as in (6):

(6) The Contrastivist Hypothesis (Hall 2007: 20)
The phonological component of a language *L* operates only on those features which are necessary to distinguish the phonemes of *L* from one another.

This is insufficiently precise: what, exactly, does "operate on" mean? If it means only that the input to the phonology does not contain redundant features, then the CH is indistinguishable from the position of Archangeli (1988), because redundant features, by definition, are ones that can be filled in by rules. If the amount of information available to the phonological computation is to be restricted any further than this, then the computation itself must somehow be prevented from enriching the material available to it.

However, phonological rules must be capable of introducing at least some non-contrastive information. For example, Canadian Raising, which gives rise to the allophonic distinctions between [aj] and [ʌj] and between [aw] and [ʌw], is demonstrably a phonological process rather than a phonetic one: it crucially applies before flapping, and it is not affected by speech rate (Chambers 1973; Bermúdez-Otero 2004). Allophonic processes like Canadian Raising are not quite the same thing as redundancy rules: they fill in information that is syntagmatically predictable from the context in which a segment appears, rather than information that is paradigmatically predictable from the contrastive features of the segment itself. However, it is not obvious how this distinction could be formally stated so as to allow one type of redundancy and not the other; any paradigmatic redundancy rule can always be made to look like a syntagmatic allophonic rule by the addition of a vacuous context.

The purpose of this paper is to set out the possibility of embracing the paradox: phonological rules can introduce redundant information, but cannot refer to it. In other words, non-contrastive features introduced by the phonology are visible only to phonetic interpretation, and not to the phonology itself. This could be implemented as a variant of van Oostendorp's (2007) theory of Coloured

Containment. In Coloured Containment, all underlying structure has an indelible 'colour' identifying its morphological affiliation; non-underlying structure is colourless. In this adaptation, colourless features can be introduced, but not subsequently referred to, by phonological rules. (Other non-underlying structure, such as new association lines between existing features and segments, would still be visible to the phonological computation.)

This approach would solve another problem for the Contrastivist Hypothesis discussed by Hall (2007). Hall (2007: ch. 2–3) identifies some cases in which non-contrastive features must be present in the representation before (some) phonological processes apply, because they would be unrecoverable afterwards. The phonology itself does not need to see these features, but they must be present. For Hall (2007), these 'prophylactic' features are an odd partial exception to the general absence of redundant features. Under the new view, they are a natural consequence of how the Contrastivist Hypothesis is implemented.

2. A case study: Yowlumne Yokuts

Vowel features in Yowlumne Yokuts present one case in which Hall (2004), Hall (2007) argued for the necessity of prophylactic features. This section shows how the same facts would be treated under the present proposal. All data in this section are ultimately from Newman (1944).

2.1 The facts

Yowlumne has four contrasting underlying vowel qualities, shown in (7).

(7)			
	i		u
		a	o

Yowlumne is famous in the phonological literature for the opaque ordering of several of its phonological rules (Kuroda 1967; Kisseberth 1969; Kenstowicz and Kisseberth 1977, 1979; Archangeli and Suzuki 1997). The crucial processes here are height-dependent rounding harmony and long vowel lowering, both of which can be seen in the derivation of /c'uum+hn/ [c'omhun] 'destroy+aorist':

(8)	UR	/c'uum+hn/	
	Epenthesis	c'uumhin	Epenthetic i breaks up unsyllabifiable consonant clusters.
	Harmony	c'uumhun	Rounding spreads rightward between Vs of same height.
	Lowering	c'oomhun	Long vowels are lowered.
	Shortening	c'omhun	Long vowels are shortened in closed syllables.
	SF	[c'omhun]	

Harmony causes a vowel to become round (and back) when it is preceded by a round vowel of the same height. /u/ triggers harmony on /i/ but not on /a/, as shown in (9b); /o/ triggers harmony on /a/ but not /i/, as in (9d).

(9) Alternations showing harmony (Kenstowicz and Kisseberth 1977: 35)

	Root		Aorist /-hn/	Dubitative /-al/
a.	/xil/	'tangle'	[xil-hin]	[xil-al]
	/giy'/	'touch'	[giy'-hin]	[giy'-al]
b.	/dub/	'lead by hand'	[dub-hun]	[dub-al]
	/hud/	'recognize'	[hud-hun]	[hud-al]
c.	/xat/	'eat'	[xat-hin]	[xat-al]
	/max/	'procure'	[max-hin]	[max-al]
d.	/bok'/	'find'	[bok'-hin]	[bok'-ol]
	/k'oʔ/	'throw'	[k'oʔ-hin]	[k'oʔ-ol]

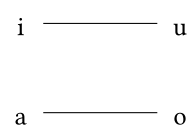
Lowering affects long high vowels. Long /uu/ lowers to [oo]; long /ii/ lowers to [ee] (a quality not present underlyingly).

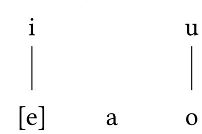
(10) Alternations showing lowering (Archangeli 1984; D'Arcy 2003)

	Root		Aorist /-hn/	Dubitative /-al/
a.	/hiwiit/	'walk'	[hiwet-hin]	[hiweet-al]
b.	/c'uum/	'destroy'	[c'om-hun]	[c'oom-al]
c.	/ʔopoot/	'get up'	[ʔopot-hin]	[ʔopoot-ol]
d.	/p'axaat'/	'mourn'	[p'axat'-hin]	[p'axaat'-al]

From the perspective of harmony, the underlying inventory looks phonologically symmetrical: one pair of high vowels and one pair of non-high vowels, each pair consisting of one rounded vowel and one unrounded one. Lowering, however, makes the underlying inventory seem asymmetrical: /o/ is the non-high counterpart to /u/, but /i/ and /a/ are not counterparts.

(11) a. Harmony: Symmetrical b. Lowering: Asymmetrical





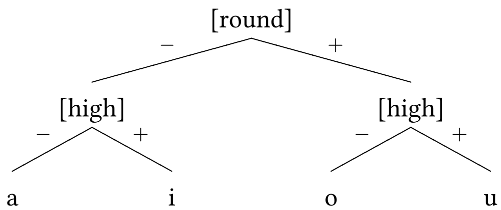
2.2 The problem

Both height and rounding are clearly phonologically active: Round vowels trigger harmony; harmony is height-depended; lowering affects height.

Once we assign the features [round] and [high], we have fully distinguished all four vowel qualities, as shown in (12).[2] Here, the ordering of divisions is not crucial, because the two features fully cross-classify.

[2]Binary features are used here for simplicity; a privative analysis is also possible, but somewhat more complicated.

(12)



No additional features can be contrastive here. The problem, though, is that these specifications incorrectly imply that when lowering applies to /i/, making it [−high], the result will be featurally identical to /a/.

2.3 Where redundant features come in

Hall (2004), Hall (2007) argues that there must be some redundant feature that will enable us to distinguish /a/ and lowered /i/ in phonetic implementation, but this feature does not actually need to be phonologically visible.

The additional feature cannot be [−back] (or [Coronal]) on /i/, because that would incorrectly predict that rounding harmony would turn /i/ into *[y]. However, we could specify a feature on /a/—either [+low] or [+back]. Hall (2004) uses [Low], which makes the prediction that harmony will turn /a/ into something more like [ɔ] than [o]. Interestingly, this prediction turns out to be correct; although most authors transcribe the vowel in question as [o], Newman (1944: 19) transcribes it as [ɔ] and writes that it is "always open, as in German *voll* and English *law*." However, both underlying /o/ and lowered /u/ also surface phonetically as [ɔ], which would seem to be a coincidence in Hall's (2004) analysis. Accordingly, let us suppose that the crucial feature is [+back].

Under the new implementation of the Contrastivist Hypothesis, [+back] is not present on /a/ in the underlying representation, as [Low] is in Hall's (2004) prophylactic-feature analysis. Rather, it is inserted by a redundancy rule at some point in the derivation, but it is not visible to subsequent phonological rules (only to phonetic interpretation). The redundant feature must be present before lowering applies, because it would not be possible to recover it after this point.

Is there any principled way of deciding at what point in the derivation [+back] comes in? Possibly.

Part of the original motivation for looking at Yowlumne from the point of view of underspecification (Archangeli 1984) is that when /i/ becomes rounded by harmony, it automatically is also realized as back. Backness is predictable from rounding both in the underlying inventory and in the output of harmony.

After harmony has applied, but not before, the surface backness of all vowels can be determined; no subsequent rules affect this feature. Suppose that, for a given feature [F] that is redundant on at least some segments:

- All redundancy rules filling in values of [F] apply at the same point.
- Once [F] has been redundantly specified, its values cannot be altered (because it is not phonologically visible).

In a sense, this creates a picture of the phonology–phonetics interface that is similar to the Multiple Spell-Out view of the syntax–phonology interface (Uriagereka 1999; Chomsky 2001): at certain stages in the derivation, certain pieces of structure are 'shipped off' for phonetic interpretation, and material that has already been interpreted cannot subsequently be altered. The difference here is that the material that is interpreted, and thereby frozen, is not a temporally contiguous substructure of the string to be pronounced, but rather a particular feature of each vowel in the phonological representation.

The schematic derivation in (13) shows the representations of the relevant vowels at different steps in the phonological computation:

(13) Schematic derivation

	/a/	/o/	/i/	/u/	/ii/	/uu/
UR:	μ [−rd, −hi]	μ [+rd, −hi]	μ [−rd, +hi]	μ [+rd, +hi]	μ μ [−rd, +hi]	μ μ [+rd, +hi]
Harmony:	↓ ↘	↓	↓ ↘	↓	↓ ↘	↓
	μ [−rd, −hi]	μ [+rd, −hi]	μ [−rd, +hi]	μ [+rd, +hi]	μ μ [−rd, +hi]	μ μ [+rd, +hi]
Fill in [±*bk*]:	↓	↓	↓	↓	↓	↓
	μ [−rd, −hi, +*bk*]	μ [+rd, −hi, +*bk*]	μ [−rd, +hi, −*bk*]	μ [+rd, +hi, +*bk*]	μ μ [−rd, +hi, −*bk*]	μ μ [+rd, +hi, +*bk*]
Lowering:	↓	↓	↓	↓	↓	↓
	μ [−rd, −hi, +*bk*]	μ [+rd, −hi, +*bk*]	μ [−rd, +hi, −*bk*]	μ [+rd, +hi, +*bk*]	μ μ [−rd, **−hi**, −*bk*]	μ μ [+rd, **−hi**, +*bk*]
SF:	[a]	[o]	[i]	[u]	[ee]	[oo]

In the underlying representations, only [±round] and [±high] are specified. Harmony changes some instances of /a, i, ii/ to /o, u, uu/ (respectively), leaving others as they are. After harmony has applied, the redundant values of [±back] are filled in; their invisibility to subsequent phonological rules is indicated by italic type. After the values of [±back] have been added, lowering applies to the long vowels. In the case of /ii/, this produces a vowel that is identical to /aa/ as far as the phonology itself can see, but which has a phonetically interpretable feature [−back] that will cause it to be realized as [ee].

3. Conclusions

Archangeli (1984) offers the following condition on the ordering of redundancy rules:

(14) **Redundancy-Rule Ordering Constraint**
A redundancy rule assigning "a" to F, where "a" is "+" or "−", is automatically ordered prior to the first rule referring to [a F] in structural description (Archangeli 1984: 85).

The essence of the Contrastivist Hypothesis—however it is ultimately to be formulated—is that this is exactly the wrong view of the role of redundant features. According to the Contrastivist Hypothesis, redundant features can never affect whether a form satisfies the structural description of a rule. Cases such as Yowlumne, however, tell us that redundancy rules cannot simply be postponed until after all other phonological processes have applied.

Under the proposed implementation, redundant features are introduced as the phonology finishes having its say about particular aspects of the form (in this example, backness) and hands them off to phonetics. If this is on the right track, then the phonological invisibility of redundant features is a bit like phase impenetrability. It also eliminates the need to stipulate that some redundant features, but not others, are prophylactically present in underlying representations; the difference between 'prophylactic' redundant features and other redundant features reduces to the familiar phenomenon of rule ordering.

This approach raises some difficult questions for future research. First, is there any independent principle that determines when a given redundant feature is introduced? In the case of Yowlumne, we can determine empirically that [±back] must be filled in after harmony and before lowering, but is there some general principle from which this ordering can be made to follow?

Second, could this version of the Contrastivist Hypothesis be implemented in Optimality Theory? Coloured Containment, one of the inspirations for the present proposal, is couched within OT. However, Coloured Containment does not attempt to impose any restriction on the phonological visibility of 'colourless' features. Such a restriction would be difficult to implement. The constraints that require the redundant features to be filled in must of course be able to see them, but other constraints should not. This means that we would need to distinguish somehow between 'redundancy constraints' and other kinds of constraints. However, in OT, the presence of any feature, redundant or otherwise, is never attributable to any single constraint, but rather to the interaction among various constraints. It therefore seems very difficult to translate the present proposal from derivational terms into Optimality-Theoretic ones.

References

Archangeli, Diana. 1984. Underspecification in Yawelmani phonology and morphology. Doctoral dissertation, Massachusetts Institute of Technology.

Archangeli, Diana. 1988. Underspecification in phonology. *Phonology* 5:183–207.

Archangeli, Diana, and Keiichiro Suzuki. 1997. The Yokuts challenge. In *Derivations and Constraints in Phonology*, ed. Iggy Roca, 197–226. Oxford: Clarendon.

Bermúdez-Otero, Ricardo. 2004. Raising and flapping in Canadian English: Grammar and acquisition. Presented at the CASTL Colloquium, University of Tromsø, November 2004.

Chambers, J. K. 1973. Canadian raising. *Canadian Journal of Linguistics / Revue canadienne de linguistique* 18:113–135.

Cherry, E. Colin, Morris Halle, and Roman Jakobson. 1953. Toward the logical description of languages in their phonemic aspect. *Language* 29:34–46.

Chomsky, Noam. 2001. Derivation by phase. In *Ken Hale: A Life in Language*, ed. Michael Kenstowicz, 1–52. Cambridge, MA: MIT Press.

D'Arcy, Alex. 2003. Yowlumne reexamined: A challenge for contrastive specification. *Toronto Working Papers in Linguistics* 20:21–46.

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

Dresher, B. Elan, Glyne L. Piggott, and Keren D. Rice. 1994. Contrast in phonology: Overview. *Toronto Working Papers in Linguistics* 13:iii–xvii.

Hall, Daniel Currie. 2004. Prophylaxis and asymmetry in Yokuts. In *Proceedings of the 2003 Annual Conference of the Canadian Linguistic Association*, eds. Sophie Burelle, and Stanca Somesfalean, 97–108. Montréal: Université du Québec à Montréal.

Hall, Daniel Currie. 2007. The role and representation of contrast in phonological theory. Doctoral dissertation, University of Toronto. Distributed by Toronto Working Papers in Linguistics.

Hall, Daniel Currie. 2011. Contrast. In *The Blackwell Companion to Phonology*, eds. Marc van Oostendorp, Colin Ewen, Elizabeth V. Hume, and Keren D. Rice, vol. 1, 27–53. Oxford: Blackwell.

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

Kenstowicz, Michael J., and Charles W. Kisseberth. 1977. *Topics in Phonological Theory*. New York: Academic Press.

Kenstowicz, Michael J., and Charles W. Kisseberth. 1979. *Generative Phonology: Description and Theory*. New York: Academic Press.

Kisseberth, Charles W. 1969. Theoretical implications of Yawelmani phonology. Doctoral dissertation, University of Illinois, Urbana.

Kuroda, Sige-Yuki. 1967. *Yawelmani Phonology*. Cambridge, Mass.: MIT Press.

Nevins, Andrew Ira. 2005. Conditions on (dis)harmony. Doctoral dissertation, Massachusetts Institute of Technology.

Newman, Stanley. 1944. *Yokuts Language of California*. New York: Viking Fund.

van Oostendorp, Marc. 2007. Derived environment effects and consistenct of exponence. In *Freedom of Analysis?*, eds. Sylvia Blaho, Patrik Bye, and Martin Krämer, 123–148. Berlin: Mouton de Gruyter.

Postal, Paul. 1968. *Aspects of Phonological Theory*. New York: Harper and Row.

Stanley, Richard. 1967. Redundancy rules in phonology. *Language* 43:393–436.

Uriagereka, Juan. 1999. Multiple spell-out. In *Working Minimalism*, eds. Samuel David Epstein, and Norbert Hornstein, chap. 10. Cambridge, Mass.: MIT Press.