Contrast in Phonology: Overview

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1. Two Poles: Contrast (Negative) vs. Substance (Positive)

The notion of contrast is central to linguistic theory. In this brief overview, we will survey some of the ways that contrast has been expressed in phonological theory, and outline some of the contemporary issues which we hope this conference will address.

Throughout the history of phonological theory, there has been a recurring tension in how phonological units are defined, either negatively or positively, i.e. as expressing contrasts, or encoding substantive properties. One pole of this duality would define phonemes purely contrastively. It is not clear that anyone has ever held this position in its pure form, but we can find formulations that approach it. One well-known one is by Saussure. According to an often- quoted passage (Saussure 1916), "dans la langue il n'y a que des differences ... sans termes positifs." Saussure's position has often been interpreted as positing that phonological units are defined only in terms of contrast. Tending toward this view also are the positions of Twaddell, among American structuralists, and Firth. Twaddell (1935), in "On Defining the Phoneme," proposed to define phonemes in terms of minimal contrasts, limited to particular positions. The first step is to isolate units which participate in minimal contrasts and characterize them in terms of their articulatory differences (la), such as the series in (lb):

(1)   Defining phonemes in terms of minimal contrasts (Twaddell 1935)

      a.   Articulatory components (partial list)

      1. bilabial   2. aspirated   3. voiceless   4. exploded stop   5. alveolar
      6 palato-velar   7. voiced   8. unaspirated   9. unexploded stop

      b.   Minimal contrasts

Class I		Class II		Class III	
pill	1 - 2 - 3 -4	nap	1 - 8 - 3 - 9	spill	1 - 8 -4
till	5 - 2 - 3 - 4	gnat	5 - 8 - 3 - 9	still	5 - 8 - 4
kill	6 - 2 - 3 -4	knack	6 - 8 - 3 - 9	skis	6 - 8 - 4
bill	1 - 8 - 7 - 4	nab	1 - 8 - 7 - 9	(*sbill)	

Within each class, articulatory differences must be distinguished from the similarities (c):

      c.   Differences (micro-phonemes) and similarities

Class I		Class II		Class III	
pill	(1-2-3) - (4)	nap	(1-3) - (8-9)	spill	(1) - (8-4)
till	(5-2-3) - (4)	gnat	(5-3) - (8-9)	still	(5) - (8-4)
kill	(6-2-3) - (4)	knack	(6-3) - (8-9)	skis	(6) - (8-4)
bill	(1-8-7) - (4)	nab	(1-7) - (8-9)		

Each series defines a set of micro-phonemes. Twaddell observes that the micro-phonemes of Class I and Class II, characterized by the differences among terms in each series, are similarly ordered. Factoring out the difference in aspiration of initial voiced and voiceless stops as being predictable, we can line up the micro-phonemes in Classes I and II as in (d):

      d.   Macro-phonemes (partial)

Class I		Class II		Class III	
pill	(1-3) - (2)	nap	(1-3)	spill	(1)
till	(5-3) - (2)	gnat	(5-3)	still	(5)
kill	(6-3) - (2)	knack	(6-3)	skill	(6)
bill	(1-7) - (8)	nab	(1-7)		

"The sum of all similarly ordered terms (micro-phonemes) of similar minimum phonological differences among forms is called a macro-phoneme" (Twaddell 1935, 73 in Joos 1957). The common terms of Class I and II show that initial and final stops can be combined into macrophoneme, so that initial [ph] is part of the same macro-phoneme as final [p-]. However, the same does not hold for stops following Is/: since a contrast between voiceless and voiced stops is lacking in this position, the three-member list of differences in Class III cannot be aligned with the four-member lists of Classes I and II: "The stops of "spill, spare", etc. are significantly bilabial and stop, but not sign)ficantly voiceless; the stops of "pill, nap, tapper", are significantly bilabial, stop, and voiceless." (p. 74 in Joos). For similar reasons it follows from this procedure that nasals in initial position are different phonemes from those in final position, because the former participate in a two-way contrast, whereas the latter form a three-way contrast:

  e. Nasals: Initial: {m,n) map - nap b. Final: {m,n,˜} sum - sun - sung

In this theory, there is no such thing as a phoneme /n/ in English: there is an initial (including medial) /n/ and a final /n/. These may be phonetically very similar, but phonemically they are different. Jumping ahead now: if phonological representations are governed by considerations of contrast, it could follow that initial /n/ and final /n/ will have different representations; similarly for stops after Is/ and stops in other positions. *A fortiori*, /n/ in English could have a very different set of representations from /n/ in Sanskrit.

  Twaddell's algorithm is presented only with partial examples. Thus the series of initial stops is not limited to {p-t-k-b}, but also includes (d, g}. But why limit it to stops? Why not include all initial consonants? The procedure is also very sensitive to accidental gaps: e.g. it follows that [ph] in pig {pig - *tig -*kig - big} is not part of the same macrophoneme as [ph] in pill, a result which appears to be undesirable. More needs to be said about this algorithm; we will not pursue this topic here, but it should be noted that many of these problems also arise in other contrast-driven systems of representation.

  Phonology has never adopted pure contrast as the sole criterion for defining phonological units. Positive, substantive properties have always played a role also. At the opposite pole from a purely contrastive definition is a purely substantive one. The theory of *SPE* (Chomsky & Halle 1968) comes close to this pole. In *SPE,* segments at all levels are defined in terms of a universal fully-specified set of distinctive features. Thus, an underlying /t/, to the extent it is a /t/ and not something else, will have a certain set of feature specifications, regardless of what it is in contrast with. In other words, a /t/ is a [t].

  An interesting example of this view is Kiparsky's 1965 discussion of Armenian dialects. Kiparsky noted that, in a classical structuralist theory where phonemes are defined in terms of contrast, problems arise in the description of dialects. Strictly speaking, the phonemic systems of closely related dialects become incommensurable if they differ in the number of phonemes they have. This is because a /t/ which contrasts with two other coronal stops (say, /d/ and /th/ cannot be compared with a /t/ which contrasts with only one other coronal stop, say /d/. Against this view, Kiparsky asserted that a /t/ is a [t]. His argument draws on developments in the various dialects descending from Proto-Armenian:

(2) Armenian dialects (Kiparsky 1965)

Old Armenian	th	t	d	Contrasts			Rules
East Central	th	t	dh	2			Aspiration
West Central	th	d	dh	2	Voicing		Aspiration
Northern	th	t	d	2			
Eastern	th	t	t	1		Devoicing	
Western	th	d	d	1	Voicing		
Northwestern	th	d	th	1	Voicing		Aspiration
Southern	th	d	t	2	Voicing	Devoicing	

He proposed that the current situation can most plausibly be attributed to three rules which spread through different geographic regions. Kiparsky points out that these rules spread from one dialect to another, regardless of how many contrasts they contained. If we were to classify the dialects in terms of the oppositions they displayed, we would arrive at groupings which are meaningless as

far as explaining any synchronic or diachronic facts. He writes (p. 17): "An incidental feature of the present example is that it highlights the pointlessness of a structural dialectology that ... distinguishes dialects according to points of structural difference rather than according to the innovations through which they diverged ... If in the present example we were to divide the dialects into those with two stop series and those with three, we would be linking together dialects that have nothing to do with each other and separating dialects that are closely related."

Most theories of phonology fall somewhere in between the two poles. The Prague School is a good example. Jakobson (1941/68) emphasized the oppositional nature of phonemes; but these oppositions are made in terms of distinctive features which have substantive content. For example, in his theory of how the system of distinctive features develops in the course of acquisition, Jakobson proposes that learners begin with an undifferentiated representation which first splits into a C and a V. This formal opposition has phonetic content: V represents a sound of greater sonority, and C one of lesser sonority. The first split among the vowels is then likewise one between a vowel of greater sonority and one of lesser sonority. (The theory of van der Hulst 1993 is similar in spirit.) When these oppositions are maximized, the optimal syllable turns out to be /pa/, and the first vocalic split is between /a/ and /I/.

Similarly, Trubetzkoy (1939) constantly appeals to both contrast and substantive properties in characterizing segmental systems. An example is his discussion of the phoneme /r/ in a variety of languages. German has two liquids, /r/ and /l/, which form an isolated bilateral opposition; that is, they are set apart from all other consonants by being liquids, and the distinction between them is unique to this pair. Trubetzkoy observes (p. 73) that the "phonemic content" of German /r/ is "very poor, actually purely negative: it is not a vowel, not a specific obstruent, not a nasal, nor an 1. Consequently, it also varies greatly with respect to its realization." He notes that some speakers pronounce tr/ as a dental vibrant, some as a uvular vibrant, some as a noiseless guttural spirant, and it varies a great deal in different contexts as well. By contrast, "Czech /r/ has a much richer phonemic content, as it stands in a relation not only to *l* but also to a special Czech phoneme *r*‡ *r* and *l* are the only liquids, *r* and *r* are the only two vibrants of Czech. r is distinguished from r in that it is not an obstruent but a liquid; from *l* in that it is a vibrant. For this reason, Czech *r* is always, and in all positions, pronounced as a clear and energetically trilled sonorant." In Gilyak /r/ is opposed to a voiceless spirant, and the two fall into place as the dental members of a series of oppositions between voiced and voiceless spirants, from which it follows that Gilyak /r/ is always dental:

(3)   /r/ in different languages (Trubetzkoy 1939)

a. German	b. Czech	c. Gilyak				
r-l	r‡	v	r	z	©	©‡
	|	|	|	|	|	|
	r - l	f	rä	s	x	**x‡**

Trubetzkoy concludes that "the phonetic realization of *r*, the number of its variants, etc., can be deduced from its phonemic content."

Notice that the contrastive aspect is joined to a substantive one which is provided by a universal feature theory, which allows the participants in a contrast to have asymmetrical status. Thus, one member might have a property the other lacks (a privative opposition); or one can identify a marked and unmarked member of a contrast. In the above example, though *r* contrasts with l in German, the *r* is characterized negatively compared to *l*, which has the "positive" content.

Moving now a bit closer to the present, we observed that generative phonology around the time of *SPE* swung quite close to the substantive side of the polarity. Gradually, however, contrast began to leak back into generative phonology, though in unsystematic and sometimes ad hoc ways. An example is supplied by Kiparsky again, this time Kiparsky (1985), in his discussion of structure preservation. He observes that in English voicing is distinctive for obstruents but not sonorants. He proposed that this fact implies that no value of the feature [voice] may be assigned to sonorants, either underlyingly, or throughout the lexical phonology:

(4)   Underspecification and Structure Preservation (Kiparsky 1985)
        a.   *[voiced, +sonorant]
        b.   Lexical voicing assimilation is triggered by and applies to obstruents, not sono-
                rants.

A similar example concerns the operation of the strict cycle in stress rules. As was much dis-
cussed, English stress rules apply to underived words, which receive main stress by the same
principles as derived words do. However, in languages with lexical accent, such as Russian or
Vedic, stress rules may not apply to underived words:

(5)   Contrast in stress and the Strict Cycle
        a.   English (Kiparsky 1982): no systematic lexical stress; stress may apply to
                underived words
        b.   Vedic (Kiparsky & Halle 1977): lexical accent; stress may not apply to
                underived words
        c.   Moses-Columbia Salish (Czaykowska-Higgins 1993): lexical accent on affixes;
                stress may apply to underived words

The distinction has been formulated in terms of a difference between structure-building and struc-
ture-changing rules. As Halle and Vergnaud put it (1987, p. 68), 'The stress rules are struc-
ture-changing in Vedic but not in English because stress … must systematically be indicated in the
lexical representations of Vedic but not in those of English. It is this need for systematic recording
of stress in the lexical representation of morphemes that makes stress rules structure- changing
(that is, distinctive) in Vedic.'
        Czaykowska-Higgins (1993, p. 260) adds a further variant on this theme in her analysis of
Salish: Salish has an underlying contrast of accented and unaccented morphemes, but stress
applies to nonderived stems. According to Czaykowska-Higgins, underlying stress contrasts exist
only in affixes. Stress can apply to underived stems because stress in stems is predictable, i.e.
noncontrastive.

2. Contrast and underspecification

In recent years, analyses which make crucial use of contrast have proliferated, and there are many
different ideas about what role it plays in phonology, and how it should be reflected in phonologi-
cal theory. One way of incorporating contrast is in terms of underspecification of representations.
It is not logically necessary to construe the effects of contrast in this way - in fact, Anderson
(1985) argues that Saussure and Twaddell's notion of opposition is more accurately worked out in
terms of rules applying to fully specified representations. Nevertheless, the theories we will look at
here all assume, in different ways, that contrast influences representations. We will look at three
recent theories: Radical Underspecification as developed in various works by Archangeli,
Pulleyblank, and others (e.g. Abaglo & Archangeli 1989, Archangeli 1988, Archangeli &
Pulleyblank 1986, 1989); Contrastive Specification as developed by Steriade (1987), Clements
(1988), and others; and finally, Modified Contrastive Specification, as developed in work at the
University of Toronto and McGill (e.g. Avery & Rice 1991, Dyck 1992, Rice 1993, Rice & Avery
1991, 1993, Rose 1993, Walker 1993, Wu 1994). We will focus on how these theories go about
capturing contrasts.
        As a preliminary observation, we note that all these theories agree that each language chooses
from a universal set those features that are distinctive in the particular language. This choice of
features is not in itself trivial as implicational universals have been identified; for instance, the
presence of a labial generally implies the presence of a coronal; the presence of a voiceless sono-
rant implies the presence of a voiced sonorant, and so on (see, for example, Maddieson 1984,
Greenberg 1963 for discussion). As discussed by Maddieson (1984) and others, small inventories
tend to be similar across languages, with inventories differing as they get larger. We will not be
particularly concerned with this type of contrast here.
        A second notion of contrast can be defined based on the specific sounds of a language and the
inventories these sounds occur in. Within a particular set of distinctive features, the question of
contrast has come to be interpreted as whether the representation of a particular sound must always
be the same, both within and between languages, or whether it can differ (depending on position

within a language; depending on inventory cross-linguistically; or in the course of a derivation). In examining the various theories and how they deal with contrast, we will look at how each deals with several questions:

(i) Features
How are the features relevant to the inventory chosen?
Are the features binary-valued or privative?
What feature values can function actively as part of underlying representation?
(ii) Determining contrasts
What principles drive how contrasts are determined?
How is the domain of contrast delimited?
(iii) Determining phonetic representations
What is the relation between contrast and phonetic representations?

2.1. Radical Underspecification

In Radical Underspecification (RU), the set of features is chosen so as to minimize the number of features and the number of feature markings while at the same time capturing the facts of the language. RU allows for two types of rules. First, default rules capture universal restrictions on feature co-occurrence, and are context dependent. We continue with an example that we used earlier, voicing on sonorants. Because voicing on sonorants is completely predictable, the feature [voice] need not be included in the underlying representation of sonorants, but is instead predictable by a context-dependent rule known as a default rule of the form in (6):

(6)   Default rule for sonorants in (4a): [+sonorant] --> [+voice]

The second rule type proposed in RU, complement rules, are context free rules that introduce the opposite feature value on a language specific basis if a default rule is not available to supply the feature value. Suppose, for instance, that there are two series of stops in a language, voiced stops and voiceless stops. Voicing is clearly distinctive in this language. In RU, it is proposed that only a single value of a distinctive feature need be marked. Two possible markings are possible for any single feature, as in (7).

(7)   Possible specifications for [voice] in Radical Underspecification (RU)

	a. p	t	k	b	d	g	b. p	t	k	b	d	g
voice	+	+	+				-	-	-			

Either the plus value of the feature is marked, as in (a), or the minus value of the feature is marked, as in (b), but not both. It is suggested that one of the markings (in this case (a)) will be preferred by universal grammar but that language-particular considerations can override this, yielding (b) as a second possibility.
Let's now look at a more interesting case. Consider, for instance, the Nyangumata three vowel inventory. Archangeli & Pulleyblank (1986) propose the representations in (8a) for this inventory:

(8)   Nyangumata

	a. RU (Archangeli & Pulleyblank)			b. Nonminimal specification		
	a	i	u	a	i	u
high		+			+	+
round			+			+

In this case, only two features are required to distinguish the three sounds. An alternative set of markings (8b) is available using the same two features. In order to choose between these two possibilities, RU utilitizes an evaluation metric that selects the simpler set of combinations: since /u/ can be identified either by two marked features or by a single marked feature, the inventory in (a) is preferred over that in (b). All other things being equal, minimality becomes the deciding factor in choosing which possible inventory is chosen.
Note that the examples in (8) illustrate only two of the possibilities for specification of the three vowel inventory /i a u/, one in which positive values of the features [high] and [round] are chosen.

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It would be possible to choose other features (e.g. [low] and [back]) and other feature markings (marked negative values). We will return to RU later, but let us turn now to Contrastive Specification.

2.2. Contrastive Specification

Contrastive Specification (CS) shares some properties with RU but differs in a crucial way, namely in how, given a choice of possible underlying representations, a particular one is chosen.

Steriade (1987) proposes to distinguish between two rule types. First, there are redundancy, or it-rules. These are similar to the default rules of RU, introducing a redundant value within a class for which that value is fully predictable. The familiar voicing on sonorants provides a prototypical example of an R-value introduced by an it- rule: the feature [voice] is introduced on sonorants by the redundancy rule, as in (6). Sonorants are thus underlyingly unmarked for voicing.

The second class of rules, D-rules, introduce D-values, i.e. feature values which distinguish between segments. The feature [voice] is distinctive in the obstruent inventory in (7), and so is a D-value for the obstruents. Steriade argues that though R- values are absent underlyingly, both values of distinctive features must be present underlyingly.
Thus, in a language with both voiced and voiceless stops, the voiced stops are specified as [+voice] and the voiceless stops as [-voice].

In her analysis of Pasiego, a language with a five-vowel system, Steriade argues that la/ has no marking for the feature [high]. This is because "the impossibility of simultaneous [+high, +low] specifications establishes that the height of low vowels is a Rvalue" (342). Again, this analysis appears to be unproblematic, especially when the vowel system is diagrammed as in (9), where la/ is the obvious odd man out with respect to the feature [high]:

(9)   Pasiego (Steriade 1987)

i	u	+high	D-class
e	o	-high	of [high]
a		-high	it-class

It is our view, however, that these cases are deceptively simple-looking, and that the basis according to which D-values are determined is not self-evident. Steriade (1987) does not specify an explicit formal mechanism for determining contrasts, but rather provides evidence for particular analyses which can be viewed as consistent with an asymmetry between the patterning of redundant and contrastive features. Archangeli (1988), in an overview of RU and CS, proposes an algorithm for determining contrasting classes in the theory of CS. Her algorithm is based on pairwise comparisons of segments in an inventory, so we will call the Pairwise Algorithm for CS, given in (10):

(10) Pairwise Algorithm for CS (Archangel) 1988)
   a. Fully specify all segments.
   b. Isolate all pairs of segments.
   c. Determine which segment pairs differ by a single feature specification.
   d. Designate such feature specifications as 'contrastive' on the members of that pair.
   e. Once all pairs have been examined and appropriate feature specifications have been marked 'contrastive', delete all unmarked feature specifications on each segment.

Following this algorithm, Archangeli proposes that a five-vowel system, fully specified as in (11a), would be underspecified as in (11b):

(11)   Five-vowel system

a. Full specifications

	i	e	a	o	u
high	+	-	-	-	+
low	-	-	+	-	-
back	-	-	+	+	+

b. CS according to the Pairwise Algorithm

	i	e	a	o	u	Contrasts
high	+	-		-	+	{i,e}; {o,u}
low			+	-		{a,o}
back	-			+	+	{i,u}; {e,o}

This pairwise algorithm creates, amongst other classes, a class of la/ and /o/, a set of sounds that does not necessarily define a class in a typical five-vowel system. Archangeli (1988) argues a the-

ory of CS which relies on the Pairwise Algorithm is inadequate for reasons of learnability and descriptive adequacy, and concludes that RU is the preferred theory.

Archangeli's argument against the Pairwise Algorithm does not show that the theory of CS is incorrect, however, since the Pairwise Algorithm is only one possible mechanism for deriving representations consistent with the intuitions that lie behind a CS theory. In fact, Steriade hints at a different conception in her paper. She suggests that stricture is examined prior to place of articulation, with place contrasts defined within stricture contrasts but not vice versa. In vowel systems, Steriade considers height to be a type of stricture feature. Consider, for example, the case of Nyangumata given above. Steriade argues that the feature specifications in (8a) achieved on the basis of minimality are incorrect, because /i/ and /u/ both function as high vowels throughout the phonology of Nyangumata, suggesting that the nonminimal specifications in (8b) are to be preferred. In some way, then, the feature [high] takes precedence over the feature [round]. But we need an algorithm that will give us this result.

We recall an insight of Jakobson and Halle (1956): in their view, distinctive features are necessarily binary because of the way they are acquired, through a series of "binary fissions". An algorithm corresponding to this idea, which we call the Continuous Dichotomy Hypothesis, is given in (12):

(12) Continuous Dichotomy Hypothesis
    a. In the initial state, all sounds are assumed to be variants of a single phoneme.
    b. An initial binary distinction (dichotomy) is made on the basis of one of the universal set of distinctive features.
    c. Keep applying the dichotomy to each remaining set until all distinctive sounds have been differentiated.

On this hypothesis, the ordering or ranking of the various features is crucial; indeed, it is this ranking which determines what the relevant contrasts in the system are. As an example, consider again the five-vowel inventory in (11). Suppose that the feature [low] is dominant, i.e. marked first, and the feature [high] is ranked second, as in (13a). The first dichotomy, based on [low], produces a split between /a/ on the one hand, and all the other vowels on the other. In a CS theory, this means we have to mark /a/ as [+low], and every other vowel as [-low]. The low vowel is now differentiated from the others, and need not receive any other marks. In the nonlow set, the next split is in terms of the feature [high], creating a [+high] set and a [-high] set. Finally, each of these sets is split by the feature [back]:

(13) Five-vowel system: Continuous Dichotomy

a. [low] > [high] > [back]

	i	e	a	o	u	Contrasts
low	-		+			{a}/{i,e,o,u}
high	+	-		-	+	{i,u}/{e,o)
back	-	-		+	+	{i}/{u};{e}/{o}

b. [high] > [back] > [low]

	i	e	a	o	u	Contrasts
high	+	-			+	{i,u}/{e,a,o}
back	-	-	+	+	+	{i}/{u};{e}/{a,o}
low			+			{a}/{o}

A different feature hierarchy yields a different set of markings, as shown in (13b). (13a) and (13b) make different claims about what the relevant contrasts are; we can speak here of the scope of each feature. In (13a), all vowels are in the scope of the feature [low], because it is at the top of the hierarchy; in (13b), [low] is at the bottom, and its scope is limited to just the vowels /a/ and /o/. Following this type of procedure, it becomes an empirical question just what the feature hierarchy is, or whether there is a universal feature hierarchy.

The Continuous Dichotomy is a procedure for determining the scope of a contrast, given a ranking of features. It is orthogonal to theories of specification. Thus, consider step (b) of the algorithm in (12). In keeping with the spirit of CS, we have been marking both values of a feature on all segments within its scope. We can apply the same algorithm in conjunction with a RU the-

ory of specification by only marking one value at each dichotomy. So consider again the difference in the specifications in (8a) and (8b) in terms of feature ranking and the contrasts captured. The system in (8a), argued for by Archangeli & Pulleyblank, can be derived by the Continuous Dichotomy by ranking the feature [round] over [high], as in (14a):

(14)   Nyangumata in terms of Continuous Dichotomy

a. Minimality: [round] > [high]

	a	i	u	Contrasts
round	(-)	(-)	+	{u}/{a,i}
high	(-)	+		{i}/{a}

b. Stricture > Place: [high] > [round]

	a	i	u	Contrasts
high	(-)	+	+	{i,u}/{a}
round		(-)	+	{u}/{i}

Values in parentheses are those which would be required by CS; let us assume for the moment that they are not filled in. The system in (8b) can be derived by ranking [high] over [round].

Now it should be clear that arguments between CS and RU do not involve the relevance of contrast in determining feature specifications. RU, like CS, uses contrast crucially: each possible split in the inventory establishes a particular set of contrasts, e.g. round vs. nonround, high vs. nonhigh, and so on. The difference between these theories turns on two other issues. The first has to do with how one selects the appropriate set of contrasts. RU proposes an evaluation metric which chooses the minimal representation. It follows from the minimality principle that the ranking of features may vary considerably from language to language, depending on the particular facts of the language. CS makes appeal to the substantive nature of the features involved: for example, if height classes dominate place classes, then (14b) is required. (14a) would be ruled out because it contrasts place of articulation prior to distinguishing height classes. In terms of Steriade (1987), this issue has to do with how one establishes what the D-features are and what the it-features are. In (14a), [high] is distinctive only within the class of nonround vowels, and is redundant in the class of round vowels. In (14b), [high] is distinctive for the whole class of vowels.
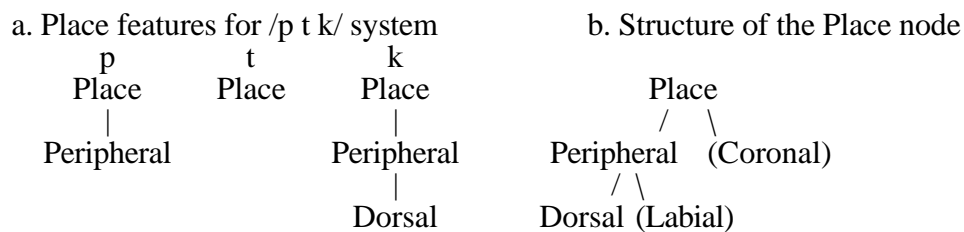
The second issue that distinguishes RU and CS is of course whether or not both values of a distinctive feature are specified: RU says no, CS says yes. This question does not bear on the notion of contrast, but has to do with whether there is evidence for the 'other' value being active in the phonology. In our view, this issue is not nearly as central as the first one. For what if features are not binary? What if the feature [round] is privative, as has been variously argued, which is to say that we do not distinguish between [+round] and [-round], but between [round] and its absence? What if all features are like this? Then the second issue disappears, but the first is left untouched. This brings us to our third theory of specification.

2.3. Modified Contrastive Specification

In various papers by phonologists at the University of Toronto and McGill (e.g. Avery & Rice 1989, Dyck 1992, Rice 1993, Rice & Avery 1991, 1993, Rose 1993, Walker 1993, Wu 1994), a model of contrastive specification has been developed that attempts to address some of the problems in other models, a theory that Paradis & Prunet (1991) have called Modified Contrastive Specification (MCS). Basically, MCS utilizes a hierarchical feature structure with contrasts being inherent in the way in which the structure is built up. Here we will discuss some properties of the model of Avery and Rice.

First, Avery & Rice (1989) assume that features are organized hierarchically. Not only are features organized into constituents (following Clements 1985, Sagey 1986, McCarthy 1988, etc.), but within a constituent the features are also organized into a hierarchical rather than flat structure. This structure is illustrated for place of articulation in
(15a), assuming a language with a /ptk/ system. Non-place features are ignored; the Place node is argued to have the structure in (15b):

(15)   Modified Contrastive Specification (Avery & Rice 1989)

a. Place features for /p t k/ system   b. Structure of the Place node

```
         p          t          k
      Place      Place      Place                    Place
        |                     |                      /   \
    Peripheral           Peripheral          Peripheral  (Coronal)
                             |                    / \
                          Dorsal          Dorsal (Labial)
```

The features on the right are unmarked, and are, except in cases of contrast, absent underlyingly; these features play no role in the phonology and are usually filled in by phonetic enhancement rules.

The structure proposed in MCS also provides a hierarchy for determining the ranking of higher-level constituents. Rice & Avery (1991) argue that place features are dependents of manner features, assigning overall structure as in (16):
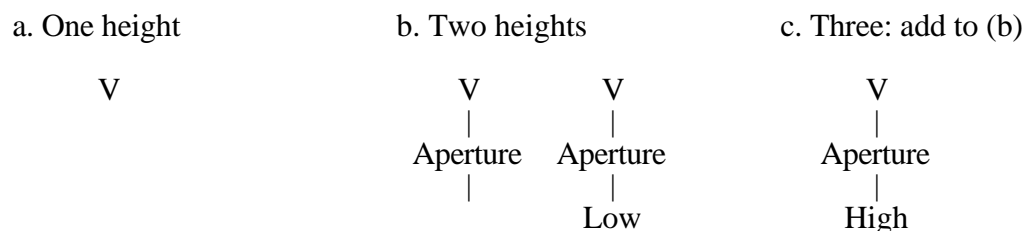
(16)   Hierarchy

```
            Root
             |
          Air Flow
             |
          Sonority
             |
           Place
```
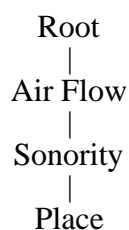
Given dependency relations, it is inherent in this structure that place contrasts are made within manner classes and not vice versa. Thus, the ranking required by the Continuous Dichotomy is in large measure derived from these representations.

Avery & Rice (1989) argue that contrast drives the amount of structure that is present in a representation. In the absence of contrast in, say, a vowel height system, a vowel will have a minimal representation (17a). Once a contrast in height is introduced, the structures in (b) are created. The addition of a third height contrast adds the representation in (c) to those in (b); see Dyck (1992) for development:

(17)   MCS: Representation of vowel height

a. One height   b. Two heights   c. Three: add to (b)

```
        V                    V         V                      V
                             |         |                      |
                         Aperture   Aperture              Aperture
                             |                                |
                            Low                              High
```

While these representations appear to be underspecified, the actual phonetic interpretation is driven by the contrasts in the inventory. Within a single height system (17a), the vowel can be realized as any height, with contextual and language particular factors determining the height; within a two-height system (b), one vowel is interpreted as low and the other as non- low, but potentially variable within the non-low range; within a three-height system (b,c), one vowel is low, one is high, and the third is non-overlapping with those two, and thus mid. Place of articulation is viewed in a similar way. In the absence of place contrasts, a vowel is unmarked for place, having the representation in (a) above. The addition of a place contrast creates the representations in (18):

(18) Vowel Place: one contrast

a.　　　　　　V　　　　　　　　b.　　　　　　V
　　　　　　　|　　　　　　　　　　　　　　　|
　　　　　　Place　　　　　　　　　　　　Place
　　　　　　　　　　　　　　　　　　　　　　|
　　　　　　　　　　　　　　　　　　　　Peripheral

The first representation is interpreted as non-back and the second as back. The addition of another non-back vowel forces the addition of the feature Coronal, with the vowel marked Coronal interpreted as front, the vowel unmarked for coronality interpreted as central, and the vowel marked as Peripheral being back.

We will now turn to some further issues involving contrast.
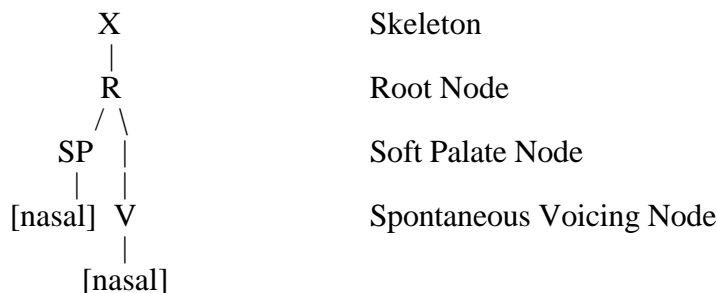
3. Ternarity

We have seen that RU is opposed to CS and MCS with regard to the criterion for determining relevant contrasts: minimality in RU versus a ranking of features. This ranking is built into the hierarchy of MCS, though there is room for variability where no fixed hierarchical order obtains. MCS is opposed to both RU and CS in its adoption of privative features throughout. We observe that a specification theory with binary features which allows underspecification has the potential to make three-way contrasts, between plus, minus, and zero. Ternarity was deemed undesirable in linear generative phonology for various reasons, but subsequent research has revealed cases where it appears to be empirically supported. One example is typical autosegmental spreading, where a segment associated with, let us say [+F], spreads this feature to segments unspecified for F; this spreading is blocked by opaque elements, specified for [-F]. In representations where all features are privative, we give up the ability to distinguish between [-F] and [0F]: both are represented by the absence of F. Here then is another important issue dealing with contrast: does phonology ever use a three-way contrast in a single feature?

We observe that privative feature systems have an ability to represent a range of cases which look like they involve three values through other means. For example, it appears that some features come in opposing pairs, e.g. ATR and RTR, or maybe BACK and FRONT.So what appears to be a distinction between [+ATR], [-ATR], and no ATR, or [0ATR] might be instead [ATR], [RTR], and nothing:

(19) Ternary values [+ATR], [-ATR], [0ATR] or opposite features [ATR],[RTR]?

Hierarchical privative feature models can also achieve the effect of temerity in another way which can be illustrated by Piggott's analysis of nasal harmony systems. In a series of papers, Piggott has argued that the feature [nasal] has two possible positions in segment structure, as shown in (20):

(20) Variable Dependency of the feature [nasal] (Piggott 1992)

```
        X               Skeleton
        |
        R               Root Node
       / \
    SP   |              Soft Palate Node
    |    |
 [nasal] V              Spontaneous Voicing Node
         |
       [nasal]
```

In some cases, nasal is a dependent of the Soft Palate (SP) node functioning as an active articulator, while in other cases nasality is an expression of sonority, and is a dependent of the Spontaneous Voicing (V) node. Piggott also proposes a typologyof systems of nasal harmony, whose properties follow in part from the variable dependence of the feature [nasal]. In many sys-

tems of nasal harmony, which Piggott calls Type A, nasality spreads to vowels and glides, but not to consonants, which are also opaque, and block further spread. In Type A harmony, [Nasal] is dependent on the SP node. This type of nasal harmony has traditionally been treated as the spread of the binary feature [+nasal] (henceforth [+N]), where nasal vowels and consonants are specified [+N]. The opacity of consonants would imply that they are specified [-N], whereas transparent segments have no specification, as in (21a). This kind of ternarity appears to be problematic if [N] is monovalent. It is not, though, because Piggott argues that it is SP, not the Nasal node, that spreads in nasal harmony. In general, vowels and glides have no SP node, whereas obstruents do. So the [+N] - [-N] - [ON] opposition becomes the one in (21b) ([R [SP N]] - [R [SP]] - [R])

(21)   Ternary Contrast in Type A
         a. with binary feature [N]   b. with SP-N
               n   t   a   n   t   a
             [+N]   [-N]   [0N]   R   R   R
                                                    | |
                                                    SP   SP
                                                    |
                                                    N

4. Predictability of Contrasts

Another issue which this example bears on is that of the predictability of contrasts. Recall that Trubetzkoy suggested that the properties of a segment can almost be deduced from its position in a system of contrasts. We observed that by ranking features in different orders in terms of the Continuous Dichotomy we can change the domains of relevant contrast. Where the order follows from Universal Grammar, this is not a problem. But when a theory allows for variability, we again have to decide what the ranking is. Can this ranking somehow be deduced from the segment inventory and knowing the relevant features in play?

   Nasal harmony provides a relevant example, because the list of opaque segments can vary from language to language, as we can see from (22), where the targets of nasalization increase as we proceed down the list while the class of opaque segments becomes more narrowly characterized:

(22)   Variable Specification of SP in Type A

        a. Warao, Capanahua, Malay: Obstruents and liquids are opaque, but not vowels, semivowels, and laryngeal glides. Specify all consonantal segments for SP.
        b. Ijo, Itsekeri: Obstruents and /l/ are opaque, but not vowels, semivowels, or /r/. Semivowels and liquids are approximants. Only nonapproximants have SP (marked case).
        c. Applecross Gaelic: Oral stops, i.e. noncontinuant segments only, are opaque, but not vowels, semivowels, liquids, or fricatives. Only noncontinuant obstruents have SP (marked case).

This variation can be attributed to variable specification of SP. Can the specification of SP in each language be deduced from the system of contrasts? When we look at the inventories of the various languages, we observe a general increase of complexity in the consonantal inventory. Jila Ghomeshi (personal communication) has pointed out that, though there is no obvious criterion for measuring this complexity, it is at least plausible to try to derive the results from the Continuous Dichotomy. So in simple systems like Warao and Capanahua, with few consonant contrasts, there is one relevant class: consonantal, and SP is dominated only by that feature. As the system gains complexity, the line of consonants bifurcates, introducing approximant, and then continuant. SP is ranked lower than any of these stricture features, and so is specified on increasingly narrow classes. If this general approach is correct, we could correctly say that the details of nasal harmony rules derive from representations, and the representations derive from contrast together with a theory of segment structure.

   The matter, however, is not that straightforward. Consider, for example, the Kolokuma dialect of Ijo. The inventory displayed in (23) is taken from Williamson (1965):

(23)   Kolokuma dialect of Ijo (Williamson 1965)

	Plosive		Continuant				
			fricative		sonorant		
	vl.	vd.	vl.	vd.	non-lateral		lateral
					oral	nasal	
labial	P	b	f	v	w	m	
alveolar	t	d	s	z	r	n	l
back (P,V,G)	k	g	(h)		y	~	
labio-velar	kp	gb					

In Kolokuma, Nasalization spreads to the left to vowels as well as to /w/, /y/, and /r/. We can ask if the patterning of /r/, but not /l/, together with the semivowels in nasal harmony could have been predicted apart from the facts of nasal harmony. A first glance at the consonantal chart is encouraging, because /r/ appears to be part of the set of oral non-lateral sonorants, whereas /l/ is not part of this group. But why did Williamson choose to display the table this way? There are, after all, other possibilities. One would be to reverse the positions of /r/ and /l/, changing nonlateral to non-rhotic. Another symmetrical arrangement would be to put /r/ and /l/ together as liquids, and /w/ and /y/ as semivowels. Williamson writes (20), "w r y are treated as a set because they all become nasalized in the vicinity of a nasal."

    We can nevertheless investigate whether her arrangement could have been derived from other considerations. The crucial step is in allowing [Lateral] to dominate [Nasal], and to either subordinate [consonantal] or treat /r/ as a glide. Otherwise, we would derive a grouping where /r/ is opposed to /l/ as liquids, and the difference in SP would be elusive. We cannot pursue this example here, but further investigation of the phonology and phonetics of this kind of variation would be quite instructive with respect to issues involving contrast which we have been discussing here.

5. Conclusion

To conclude, we have touched on a number of issues relating to contrast in phonology. We will end by raising some additional questions concerning contrast.

    One question which arises from the preceding is: Can domains of contrast be predicted from the segment inventory? Another way of asking this question, assuming the Continuous Dichotomy: To what extent is the ranking of features predictable?

    Going beyond segmental features, we note that ranking can be used to describe other sorts of limitations on domain of contrast. For example, in the case of stress, we have seen that we can say that lexical accent is contrastive in a language, or we can delimit the domain further, to auffixes, for example, or to stems. In our terms, the first statement corresponds to a ranking of stress over morphology, and in the second statement, morphology dominates stress. Similarly with regard to features and prosodic positions: if position in a syllable dominates, for example, we would arrive at micro-phonemes in the sense of Twaddell, that is, segmental contrasts would be limited to particular prosodic positions. With a reverse ranking, segments would be in contrast regardless of prosodic position. As before, we would like to know what principles govern these rankings.

    Another issue concerns the relation of contrast to phonetics: given a ranking of features which determines contrast, can we then go on to deduce much of the phonetics and phonology? E.g. can we translate Trubetzkoy's idea of rich and poor phonemic content into degree of elaboration of a segment: so /r/ with poor content could be less specified than /r/ with rich content, and hence can be more variable in its phonetics. Or is it the other way around, with phonetic constraints limiting the range of contrasts which are possible in given positions?

    These are some of the interesting questions as we see them. The topic of contrast is obviously an important one, and a rich one. The papers in this volume all involve the notion of contrast in some critical way, and raise many issues, including those touched on in the present paper and many more.

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