DETERMINING CONTRASTIVENESS: A MISSING CHAPTER IN THE HISTORY OF PHONOLOGY*

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0. Introduction

Since Saussure's (1916) famous statement that "dans la langue il n'y a que des différences," the notion of contrast has been at the heart of linguistic theory. But from Saussure's time until the present there has been remarkably little discussion of how contrast is to be determined. While it is relatively uncomplicated to determine whether or not two sounds are contrastive in a given language, it is another matter to decide whether a given feature is contrastive in any particular situation.

It is not that there have been no ideas as to how to determine contrast: rather, these ideas have rarely been made explicit. Further, these ideas have no history, in two senses: (1) nobody has written a history of them; and (2) more than that, they have no history in the sense of some more or less orderly entrances and exits. Ideas about contrast seem to come and go, adopted without argument, abandoned without explanation, and with no reference to other instances of the same events.

Recovering this missing chapter of phonological theory can shed new light on a number of old and new controversies over contrast in phonology. In particular, I will show that phonologists have vacillated between two different and incompatible approaches to determining contrastiveness:

1. Extraction of contrastive features from full specifications via minimal pairs.
2. Contrastive specification first by ordering features into a hierarchy.

I will argue that approach (1) is inadequate. This leaves approach (2) as the only viable theory of contrast.

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1. Extraction via Minimal Pairs

One approach to determining contrast is based on a comparison of fully specified minimal pairs. For example, given segments /p b m/ as in (1a) and the binary features [voiced] and [nasal], /p/ and /b/ contrast with respect to [voiced], and /b/ and /m/ contrast with respect to [nasal]. If only these specifications are taken to be contrastive, we would specify them as in (1b). These are the specifications proposed by Martinet (1964:64) for Standard French. Redundancy rules (1c) fill in unspecified features at some point before or during phonetic implementation.

(1) French /p b m/ (Martinet 1964:64)

a. Full specification

	p	b	m
voiced	–	+	+
nasal	–	–	+

b. Features distinguishing minimal pairs

	p	b	m
voiced	–	+	
nasal		–	+

c. Redundancy rules for (b)

[0 voiced] → [+ voiced]   [0 nasal] → [–nasal]

Extraction of contrastive features from full specifications via minimal pairs can be implemented by a formal algorithm. Such an algorithm was proposed by Archangeli (1988). I will call this the Pairwise Algorithm, given in (2):

(2) Pairwise Algorithm (Archangeli 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.

An illustration of how this algorithm is supposed to work is given in (3), which shows a typical five-vowel system characterized by the features [high], [low], and [back]. Features that do not distinguish minimal pairs are shaded.

(3) Five-vowel system, features [high], [low], [back]

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

Extraction from fully specified minimal pairs was evidently used by Trubetzkoy (1969). For example, he writes (68-9) that *d* and *n* "are the only voiced dental occlusives" in Standard French. He observes further that "neither voicing nor occlusion is distinctive for *n*, as neither voiceless nor spirantal *n* occur as independent phonemes." That is, Trubetzkoy understands a feature to be distinctive in a phoneme if there is a phoneme that is identical except for that feature. This notion of contrastiveness is consistent with the minimal pairs approach. Since there is no voiceless *n* and no fricative *n*, voicing and occlusion cannot be distinctive in /n/, as shown in (4a), where specifications that are contrastive in this sense are unshaded.

These specifications, however, pose a problem for Trubetzkoy's notion of a bilateral opposition, which is an opposition whose members share a unique set of contrastive features. Trubetzkoy asserts (without evidence) that both /t/ ~ /d/ and /d/ ~ /n/ form a bilateral opposition in French. Thus, he concedes that sometimes noncontrastive features must be considered in assessing if an opposition is bilateral, as shown in (4b), where redundant but necessary features are underlined.

(4) Some French consonants, bilateral oppositions (Trubetzkoy 1969:68-9)

a. Specifications: Noncontrastive features (by minimal pairs) shaded

	t	d	n	p	b	m	s	z	k	g
voiced	–	+	+	–	+	+	–	+	–	+
continuant	–	–	–	–	–	–	+	+	–	–
place	dnt	dnt	dnt	bil	bil	bil	alv	alv	dor	dor
nasal	–	–	+	–	–	+	–	–	–	–

b. Bilateral oppositions, with contrastive and <u>noncontrastive</u> features

Pair	In common	Pair	In common
t ~ d	[dnt, <u>–nasal</u>]	d ~ n	[dnt, <u>+voiced, –cont</u>]

It can be shown (Dresher 2002) that Jakobson (1949) took a similar approach to specification of the features of Serbo-Croatian.

Deriving contrastive features by extraction from full specifications via minimal pairs is unworkable for several reasons. First, it fails to adequately contrast segments that are not minimal pairs. Consider again French /p b m/ in (1). The contrastive specification in (1b) distinguishes /b/ from /p/ on one side and from /m/

on the other; but what about the contrast between /p/ and /m/? /p/ is [–voice] and /m/ is [+nasal]; since these are not privative features but truly binary, we cannot conclude that the absence of a specification is necessarily distinct from a specification. Without running through the redundancy rules, we cannot decide if /p/ is distinct from /m/ or not. But then we have failed to arrive at a proper contrastive specification. Thus, the Pairwise Algorithm fails the Distinctness Condition proposed by Halle (1959), which states that 0 is not distinct from a plus or minus value in a binary feature system that is not privative.

One can argue about whether contrastive specifications ought to meet the Distinctness Condition (I think they do, but Stanley 1967 is one of a number who disagree). However, the minimal pairs method faces much more severe problems of adequacy, in that there are two types of common situations in which it fails by any measure to distinguish the members of an inventory.

First, the Pairwise Algorithm fails when there are too many features relative to the number of phoneme. We have seen that the algorithm succeeds in the three-dimensional feature space in (3). But recall that the algorithm starts from *fully specified* specifications; the limitation of the feature space to three features is arbitrary and unjustified. Full phonetic specification implies that the vowels be specified for *all* vowel features. Even adding just one more feature, say [round], causes the Pairwise Algorithm to fail. The results are shown in (5), where specifications that are noncontrastive according to the Pairwise Algorithm are shaded.

(5) Five-vowel system, features [high], [low], [back], [round]

	i	e	a	o	u	<u>Contrasts</u>
high	+	–	–	–	+	{i, e}; {o, u}
low	–	–	+	–	–	
back	–	–	+	+	+	
round	–	–	–	+	+	

The only minimal pairs are {i, e} and {o, u}; the addition of the fourth feature turns what used to be minimal pairs into pairs that are distinguished by more than one feature. The features [back] and [round] are each redundant given the other, but one of them has to be retained: the Pairwise Algorithm cannot decide which. It is not clear, then, that the minimal pairs approach can handle even the simplest sound systems, once all features are taken into account.

There is another type of case in which the Pairwise Algorithm fails, and this does not involve extra features, but rather the way in which the members of an inventory are dispersed over the space defined by the feature set. That the Pairwise Algorithm gives a contrastive specification at all, whether correct or not, is due to the connectedness of the paths through the space defined by the set of features.

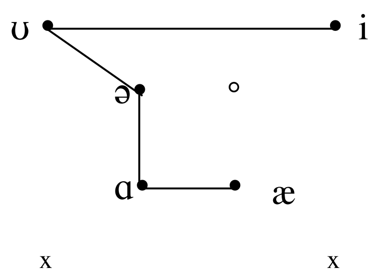
Archangeli (1988) points out that not every five-vowel system can be assigned a contrastive set of specifications by the Pairwise Algorithm. An example of such an inventory is the vowel system of Maranungku (Tryon 1970). This vowel system is given in (6); again, specifications not designated contrastive are shaded.

(6) Maranungku, features [high], [low], [back]

	i	æ	ɑ	ə	ʊ	Contrasts
high	+	–	–	–	+	{ə, ʊ}
low	–	+	+	–	–	{ɑ, ə}
back	–	–	+	+	+	{i, ʊ}; {æ, ɑ}

We can model the space corresponding to the inventory in (6) and the minimal pair paths through it with a diagram as in (7). In this case, /i/ and /æ/ have the same contrastive specification because they occupy parallel positions in a contrast, as shown graphically in (7), but have no other neighbours that could further differentiate them in terms of this algorithm. An empty circle represents an unoccupied node, and x represents an impossible combination of [+high, +low].

(7) Maranungku, features [high], [low], [back]



Whether or not an inventory has paths that make its members distinguishable by the Pairwise Algorithm is an accidental property, and should not be the basis of a theory of contrastiveness.

2. Specification of contrasts by a hierarchy of features

Another approach to contrastiveness also has roots in the earliest work on contrast in phonology. In his discussion of the Polabian vowel system, Trubetzkoy (1969: 102-3) observes that a “certain hierarchy existed” whereby the back ~ front contrast is higher than the rounded ~ unrounded one, the latter being a subclassification of the front vowels. Trubetzkoy’s rationale for this analysis is that palatalization in consonants is neutralized before all front vowels (and before “the maximally open vowel a which stood outside the classes of timbre.”). Also, the oppositions between back and front vowels are constant, but those between rounded and unrounded vowels of the same height are neutralizable (after *v* and *j* to *i* and *ê*). The vowel system, according to Trubetzkoy’s contrastive distinctions, is given in (8). The diagram suggests that the feature [back] has wider scope than [rounded].

(8) Polabian (Trubetzkoy 1969: 102-3): [back] > [rounded]

front		back
(unrounded)	rounded	
i	ü	u
ê	ö	o
e		ɑ
a		

In another example Trubetzkoy observes that Greek has a bilabial stop /p/ and labiodental fricatives /f v/, and a postdental stop /t/ and interdental fricatives /θ ð/. Is the primary contrast one of stop vs. fricative or of place? Trubetzkoy appeals to “parallel” relations between stops and fricatives at different places. In the sibilant and dorsal series (/ts s z/ and /k x ɣ/, respectively), the contrast is unambiguously one of stop vs. fricative, since stops and fricatives occur at exactly the same place of articulation. By parallelism, Trubetzkoy proposes that the same contrast should apply to the ambiguous cases, which leads to the conclusion that the minor place splits are phonologically irrelevant. The picture that emerges is given in (9).

(9) Greek: major place, voicing, occlusion > minor place

	Labial		Apical			Dorsal
	bilabial	labiodental	interdental	postdental	sibilant	dorsal
voiceless stops	p			t	ts	k
voiceless fricatives		f	θ		s	x
voiced fricatives		v	ð		z	ɣ

In French, however, Trubetzkoy (1969: 126) argues for a split labial series. “For in the entire French consonant system there is not a single phoneme pair in which the relation spirant : occlusive would occur in its pure form.” Indeed, he follows this analysis to its logical conclusion and disputes that there is an opposition between occlusives and spirants in French, because degree of occlusion cannot be regarded independently of position of articulation. Thus, Greek and French require a different ordering of the continuant feature relative to minor place features.

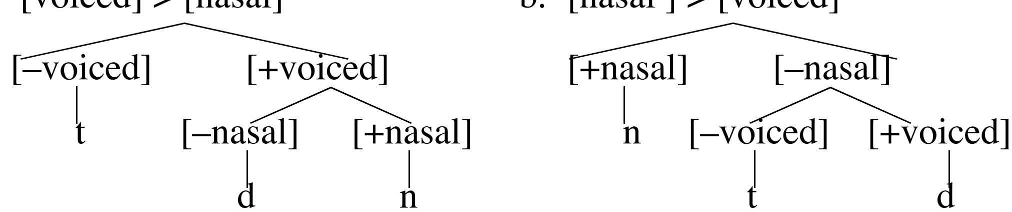
(10) French obstruents (based on Martinet 1964:65)[1]

	bilabial	labiodental	apical	alveolar	pre-palatal	dorso-velar
voiceless	p	f	t	s	š	k
voiced	b	v	d	z	ž	g

This analysis is inconsistent with Trubetzkoy's earlier discussion of bilateral oppositions in French. Whereas earlier he assumed that /t/ and /d/ were contrastively occlusive, now we see that [continuant] plays no role at all in the French consonant system. Moreover, in a hierarchical approach to contrastive specification, voicing is not always redundant for /n/. For example, if [voiced] is ordered above [nasal], then the voicing contrast includes in its purview the nasal consonants as well, as shown in (11a). In this ordering, /d/ ~ /n/ participate in a bilateral opposition, but /t/ ~ /d/ do not. If the features are ordered as in (11b), then nasals are not specified for voicing, /d/ ~ /n/ do not form a bilateral opposition, but /t/ ~ /d/ do. The tree diagrams in (11) show one characteristic of specification by a top-down hierarchy: feature values that are logically redundant, such as [+voiced] for /n/, or [–nasal] for /t/, may still be designated as contrastive.

(11) French dental obstruents and nasals:

a. [voiced] > [nasal] b. [nasal] > [voiced]



As far as I know, the first person to explicitly argue for the contrastive hierarchy was Roman Jakobson. Even he employed it inconsistently. The hierarchy was given a prominent place by Jakobson and Halle (1956). They refer to it as the "dichotomous scale," and adduce "several weighty arguments" in support of this

[1] As Trubetzkoy does not give a chart, I adapt this one from Martinet (1964), whose analysis is clearly influenced by Trubetzkoy.

hierarchical approach to feature specification. One argument involves language acquisition. They suggest that distinctive features are necessarily binary because of the way they are acquired, through a series of "binary fissions." They propose (1956:41) that the order of these contrastive splits is partially fixed, thereby allowing for certain developmental sequences and ruling out others. The notion of a developmental sequence of phoneme acquisition did take hold in the field of child language, but had a rockier fate in phonological theory itself.

A natural way of determining contrast, then, is by splitting the inventory by means of successive divisions, governed by an ordering of features. An algorithm corresponding to this idea is given in (12).

(12) Successive Division Algorithm (SDA) (informal version)
   a. Begin with no feature specifications: assume all sounds are allophones of a single undifferentiated phoneme.
   b. If the primordial allophonic soup 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. (With binary features, it becomes the Successive Binary Algorithm.)
   c. Repeat step (b) in each subset: keep dividing up the inventory into sets, applying successive features in turn, until every set has only one member.

This algorithm solves the problems encountered by the Pairwise Algorithm: (a) it adequately contrasts all members of an inventory; (b) it is guaranteed to work in all inventories; (c) it does not have to adopt auxiliary mechanisms for multiple logical redundancies; and (d) it does not assume prior full specification – a child's detailed *phonetic* perception is not equivalent to a *phonological* representation.

Despite their arguments for it, the contrastive hierarchy was employed inconsistently by Jakobson and Halle in the late 1950s. While they gave conceptual and acquisition arguments for it, they did not present empirical arguments that would connect it to accounts of phonological activity. Perhaps the inconsistency is due to their failure to arrive at a single universal hierarchy that could apply to all the languages they studied. It appeared in the "branching diagrams" of Halle's (1959) *Sound Pattern of Russian*. The use of "branching diagrams" was challenged on various grounds by Stanley (1967). Though the contrastive hierarchy disappeared from generative phonology, the intuition that "there is obviously some kind of hierarchical relationship among the features which must somehow be captured in the theory" (Stanley 1967) continued to haunt generative phonological theory, and has reappeared in various guises in markedness theory, feature geometry, and theories of underspecification.

3. Implicit hierarchies in phonological descriptions

With a few notable exceptions mentioned above, there is almost nothing in the phonological literature on the contrastive hierarchy. Nevertheless, hierarchies are implicit in the practice of phonologists. Consider the arrangement of tables of segmental inventories in descriptive grammars; compare, for example, the tables of Siglitun (13) and Kolokuma Ịjọ (14). I present them as they are given in the sources (with some changes to the phonetic symbols but not to the arrangement).

(13) Siglitun consonants (Dorais 1990:70)[2]

	bilabial	apical	velar	uvular
stops	p	t	k	q
voiced fricatives	v	l j	ɣ	ʀ
voiceless fricatives		ɬ s		
nasals	m	n	ŋ	

(14) Consonant phonemes of Kolokuma Ịjọ (Williamson 1965)[3]

	plosive		continuant				
			fricative		sonorant		
					non-lateral		lateral
	vl.	vd.	vl.	vd.	oral	nasal	
labial	p	b	f	v	w	m	
alveolar	t	d	s	z	r	n	l
back	k	g	(h)	(ɣ)	j	ŋ	
labiovelar	k͡p	g͡b					

Note in particular the different placements of /l/ and /j/. The chart of Ịjọ expresses a hierarchy in which [continuant] has wider scope than [sonorant] and [voiced], and [lateral] has wider scope than [nasal]. The Siglitun chart is not as overtly hierarchical, but [lateral] has very narrow scope, whereas [nasal] is higher in the hierarchy. Apart from the nasals, the other sonorants are not set apart in Siglitun, suggesting that the feature [sonorant] is lower in the hierarchy than in Ịjọ.

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[2] I have simplified Dorais's *j/dj* and *s/ch* to *j* and *s*, respectively; as he makes clear, these are variants of single phonemes.

[3] I substitute *j* for Williamson's *y*. Williamson notes that Back = palatal, velar or glottal, Vl. = voiceless, and Vd. = voiced. She omits from her table a marginal phoneme /ɣ/. I have added it because it appears to be no less marginal than /h/, which is included.

4. Conclusion

I have argued that one common approach to determining contrastive feature specifications is wrong, and that an approach based on ordering of features with respect to their contrast scope is correct. If this approach is correct, it raises anew a number of issues that are quite central to phonological theory. This topic is the subject of ongoing work in the project on Contrast and Complexity in Phonology at the University of Toronto (http://www.chass.utoronto.ca/~contrast/). Some relevant references are: Avery (1996), Avery and Rice (1989), Balcaen (1998), Barrie (2002), Causley (1999), Dresher (1998a,b, 2002, 2003), Dresher and Zhang (2000), Dresher, Piggott, and Rice (1994), Dyck (1995), Frigeni (2002), Ghini (2001), Hall (1998, 2002), Hirayama (2002), Mackenzie (2002), Mercado (2002), Moulton (2002) Rice (1993, 1995, 1997), Rice and Avery (1995), Vilks (2002), Walker (1993), Wu (1994), Zhang (1996), and Zhou (1999).

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