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Contrast and Phonological Activity in the Nez Perce Vowel System*

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0. Introduction

Features that pattern as inert with respect to phonological processes are often unnecessary in distinguishing segments in an inventory. A natural way of accounting for the phonological inertness of noncontrastive features is via underspecification. If noncontrastive features are absent from underlying representations and barred from the phonology, it follows that they will not be visible to phonological processes. However, there has been no consensus on how to determine which features are contrastive in any given case. This and other objections have detracted from the appeal of theories of underspecification.

In Optimality Theory (OT, Prince and Smolensky 1993), moreover, representational devices such as underspecification and constraints on underlying forms have been generally rejected in favour of constraints on output forms. Inventories arise from constraint ranking, and the role of the inventory in determining phonological behaviour is therefore quite limited. However, the question of how to account for the relationship between contrast and phonological activity within OT remains open.

The theory of the contrastive hierarchy (Jakobson and Halle 1956, Dresher 1998b, 2003) provides a method for determining contrasts in an inventory by ordering features so that some features take scope over others. This theory overcomes the major objections to underspecification theory, and connects contrast to phonological activity, because the size and shape of an inventory will affect the number of features needed in order for each segment to be contrastively specified.

This paper provides an analysis of the Nez Perce vowel system within the framework of the contrastive hierarchy. Our analysis follows Jacobsen (1968), Rigsby and Silverstein (1969), Zwicky (1971), and Hall and Hall (1980) in assuming an abstract front vowel that participates in ATR harmony. In addition, we demonstrate that contrastive specifications are compatible with OT and can be achieved using mechanisms which are central to that theory, such as IDENT constraints and contextual markedness constraints.

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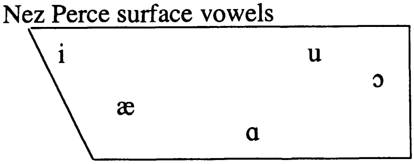
An alternative analysis of Nez Perce vowel harmony within the framework of OT is proposed by Bakovic (2000). He uses featural faithfulness constraints and markedness constraints. His account differs from ours in its lack of reference to contrast. The case is of some interest, because in the analysis of Bakovic (2000) the feature [ATR], which is phonologically active in the vowel system of Nez Perce, appears to be noncontrastive, contrary to the observation we made at the outset that noncontrastive features tend to be phonologically inert.

Appealing to the theory of the contrastive hierarchy, we will demonstrate that the crucial constraint rankings in Bakovic 2000 are unmotivated, and that [ATR] is a contrastive feature in the Nez Perce vowel system. Whereas every contrastive hierarchy can be expressed as a set of ranked OT constraints, not every OT constraint hierarchy can be converted to a contrastive hierarchy. Requiring grammars to adhere to the contrastive hierarchy can help to determine the crucial constraint rankings and constrain the set of possible grammars.

1. The Nez Perce Vowel System (Aoki 1966, 1970, Hall and Hall 1980)

The surface vowels of Nez Perce are shown in (1) (Aoki 1966, 1970):

(1) Nez Perce surface vowels



Nez Perce has dominant-recessive ATR harmony. All vowels in a word apart from /i/ must agree with respect to [ATR], and the value [–ATR] is dominant. /æ/ alternates with /ɑ/ (2) and /u/ alternates with /ɔ/ (3).

(2) ATR harmony: /æ/ alternates with /ɑ/

	Underlying	*Surface*	*Gloss*
a)	/næʔ-mæq/	næʔmæχ	'my paternal uncle'
b)	/næʔ-tɔt/	nɑʔtɔt	'my father'
c)	/mæq-æʔ/	mæqæʔ	'uncle VOC'
d)	/tɔt-æʔ/	tɔ:tɑʔ	'father VOC'
e)	/cæqæt/	cæ:qæt	'raspberry'
f)	/cæqæt-ɑyn/	cɑqɑ:tɑyn	'for a raspberry'

(3) ATR harmony: /u/ alternates with /ɔ/

	Underlying	*Surface*	*Gloss*
a)	/tæwæ:-pu:/	tæwæ:pu:	'the people of Orofino, Idaho'
b)	/sɔ:yɑ:-pu:/	sɔ:yɑ:pɔ:	'the white people'
c)	/tuʔuynu/	tuʔuynu	'tail'
d)	/tuʔuynu-ʔɑyn/	tɔʔɔynɔʔɑyn	'for the tail, crupper'

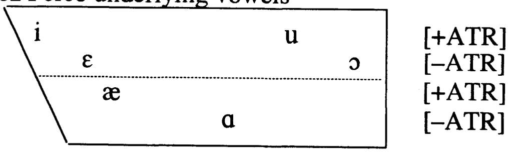
As illustrated in (4), the vowel /i/ sometimes patterns with [–ATR] vowels (4a,b), and other times with [+ATR] vowels (4c,d), though it is phonetically [+ATR].

(4) Dual patterning of /i/

	Underlying	*Surface*	*Gloss*
a)	/næʔ̣ci:c/	nɑʔci:c	'my paternal aunt'
b)	/ ci:c-æʔ/	ci:cɑʔ	'paternal aunt VOC'
c)	/næʔ-i:c/	næʔi:c	'my mother'
d)	/ʔi:c-æʔ/	ʔi:cæʔ	'mother VOC'

Following Hall and Hall (1980) we assume that surface [i] represents a merger of /i/ and a [–ATR] vowel we will represent as /ɛ/. In (4a, b) the underlying vowel is /ɛ/ and in (4c, d) the vowel is [+ATR] /i/.

(5) Nez Perce underlying vowels



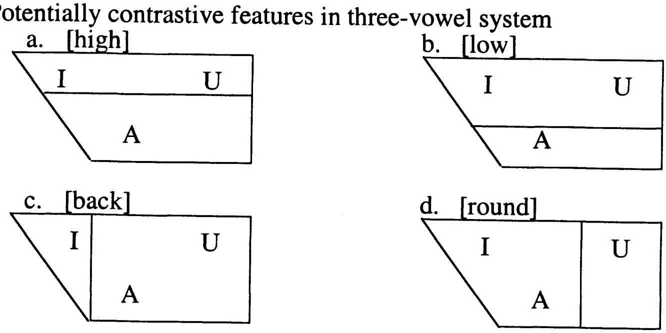
Thus, every vowel has a counterpart that contrasts with it in the feature [ATR].

2. Contrastive specification by a hierarchy of features

By any definition, [ATR] is a *contrastive* feature in the underlying vowel system of Nez Perce. What are the other contrastive features? Abstracting away from [ATR], we have a classic three-vowel system, which we can designate /I A U/. Even in such a simple system, it is not obvious what the relevant contrasts are. We need a way to determine contrasts in an inventory.

The approach we will take is that of Jakobson and Halle (1956). To determine contrastiveness of features, it is necessary to determine their relative *scope*, or *ordering*. In a simple three-vowel system, for example, exactly two features are needed for each segment to be contrastively specified, though what these are can potentially vary. Some candidates are shown below:

(6) Potentially contrastive features in three-vowel system



Ordering is required to select contrastive features. It also determines the relative scopes of the contrastive features that are selected. Suppose, for example, we choose the features [high] and [round]. We can first divide the vowels on the basis of [high] (7a). Now [round] is relevant only as a contrast among the [+high] vowels: /i/ and /u/ are 'partners', /a/ is neutral. In this ordering, [high] > [round], all vowels are contrastive for [high], but only /i/ and /u/ are contrastive for [round]. Alternatively, we can first divide the vowels on the basis of [round] (7b). Now [high] is relevant only among the [–round] vowels: /i/ and /a/ are 'partners', /u/ is neutral. In this ordering, [round] > [high], all vowels are contrastive for [round], but only /i/ and /a/ are contrastive for [high].

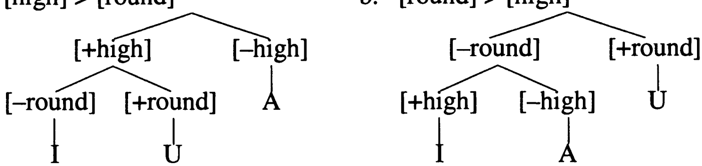
(7) Scope or ordering of features

a. [high] > [round] b. [round] > [high]

These two orderings correspond to two different contrastive hierarchies, as shown in (8). Given a contrast based on [high], a further contrast based on [round] is required only for members that are specified as [+high] (8a). Given a contrast based on [round], a further contrast based on [high] is required only for members that are specified as [–round] (8b).

(8) Scope or ordering of features

a. [high] > [round] b. [round] > [high]

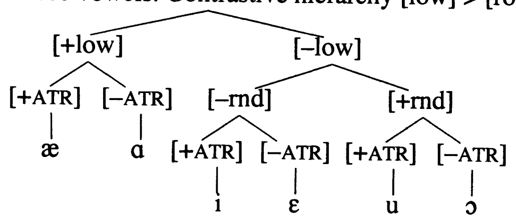


We might expect that the two vowel systems will pattern differently. For example, system (8a) might show alternations or neutralization between /i/ and /u/; in system (8b) /i/ might be more closely related to /a/.

We assume that the contrastive hierarchy can vary within limits determined by Universal Grammar (UG). In determining what the hierarchy is for any particular language it is necessary to examine phonological processes for evidence as to what the active features are.

In the case of Nez Perce, we choose [low] as the first feature in the hierarchy. We choose [low] rather than [high] because the surface nonlow [ATR] pair is not strictly [+high], whereas the low pair are both [+low]. The choice of [low] as the initial feature is also consistent with Jakobson and Halle's (1956) assumption that a contrast between high and low sonority is, preferably, ordered before one based on place (but see Ghini 2001 for a different view). We choose [round] as the second feature. This contrast is relevant only among the nonlow vowels. Because of the symmetry of the system, it does not matter very much where [ATR] is ordered. For concreteness, we will assume it is ordered third. We thus arrive at the contrastive hierarchy illustrated in (9).

(9) Nez Perce vowels: Contrastive hierarchy [low] > [round] > [ATR]



The above approach to contrastive specification by a hierarchy of features can be implemented by an algorithm called the Successive Division Algorithm (SDA) (Dresher 1998a, 1998b, 2002, 2003, Dresher and Zhang this volume). An informal version is given in (10).

(10) Successive Division Algorithm (SDA)

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.
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.

3. The Contrastive Hierarchy and Specification

The contrastive hierarchy is not contingent on a particular theory of phonological operations or representations. In particular, it does not necessarily presuppose underspecification. At its most basic, the SDA assigns contrastive features. What about redundant features?

One possibility is that all features are specified, and the algorithm designates some as contrastive. Certain phonological processes can then be designated as targeting only contrastive features (Calabrese 1995). A stronger theory would be one that makes redundant features unavailable to the (lexical) phonology except under special conditions. Such a restriction is captured in a natural way by supposing that only features assigned by the SDA are specified.

In recent years a number of arguments have been raised against underspecification that have appeared to undermine such an approach. However, the contrastive hierarchy puts these issues in a new light.

First, it has been argued (Steriade 1995, Kirchner 1997) that there is no consistent way to decide which specifications to omit. For example, in most languages there are no nasal obstruents, so [+sonorant] is predictable given [+nasal]; nevertheless, this specification is rarely omitted. The conclusion is that underspecification is applied inconsistently. The answer to this objection is that the contrastive hierarchy decides which features are omitted. In particular, phonological redundancy is not the same as logical redundancy. Many features that are logically redundant are designated as contrastive by the SDA. Indeed, the arbitrariness argument applies not only to underspecification, but also to contrast. It is necessary to have a principled method for determining which features are contrastive as well as which features may be unspecified. The contrastive hierarchy and the SDA provide such a method.

In the above example, it is more common for [sonorant] to take scope over [nasal] than it is for [nasal] to take scope over [sonorant]. Therefore, [+sonorant] must be specified even where it is made logically redundant by [+nasal]. The hierarchy [nasal] > [sonorant] is less likely and leads to an unusual set of contrasts in an inventory.

Second, it has been argued that there is relatively little evidence for underspecification. This argument assumes that full specification is the null hypothesis, unless positive evidence is found to the contrary. Thus, the burden of proof has been placed on underspecification. But it is not clear that the burden of proof *should* be on underspecification. There is in fact no positive evidence for full specification. In practice, most analyses that reject underspecification do not adopt full specification: features totally irrelevant to an analysis are rarely specified. The result is not full specification but arbitrary specification.

Some recent approaches start from the premise that features are specified only if there is positive evidence to do so. Examples are Modified Contrastive Specification as developed in Toronto (Avery and Rice 1989, Avery 1996, Ghini 2001, Rice 2002, Hall 2003); the theory of representational economy of Clements (2001); and the system-driven specification of Hyman 2002a, 2002b.

4. The Contrastive Hierarchy in Optimality Theory

Some ways of implementing the contrastive hierarchy are inconsistent with assumptions commonly made in OT to the effect that (a) there is no necessary underspecification (Itô, Mester and Padgett 1995), and (b) there are no limitations on underlying inventories (Prince and Smolensky 1993). These issues concern implementation of the contrastive hierarchy, and are orthogonal to the notion of the contrastive hierarchy of features itself. We will show that the contrastive hierarchy can be modeled in OT.

It has been claimed (Kirchner 1997) that contrasts emerge from constraint rankings, so one might think that there is no need to say anything more about contrast. But an arbitrary constraint ranking will not express a connection between contrast and phonological activity. If there is such a connection, it should be captured in any phonological theory. OT analyses that are consistent with a contrastive hierarchy can express this connection.

In converting the contrastive hierarchy into an OT constraint set, we must make some assumptions about the output and the input.

Output: We will assume that the output of an OT version of the SDA is the same as the output of the algorithm itself: a set of contrastive specifications from which redundant feature specifications are excluded. In the case of Nez Perce, we will also assume that the output of this evaluation contains the [–ATR] counterpart of /i/. We will not attempt to model [ATR] harmony in this algorithm. How the processes of neutralization and [ATR] harmony) are to be incorporated is not crucial to our proposal for modeling contrast.

Input: We will assume for now that the input consists of fully-specified representations. The analysis can be extended to include underspecified inputs, but we shall not do so here.

Constraints: We will employ two basic constraint types, feature-specific IDENT constraints and contextual markedness constraints of the form *[αF, Φ].

(11) Constraints regulating contrast

a. IO-IDENT F: 'Correspondent segments must have the same value of the feature F (either + or –)'.

b. *[αF, Φ]: 'Exclude αF in the context Φ', where α ranges over + and –, and Φ is the set of features (with wider scope than F) forming the context of F.

To convert a contrastive hierarchy into a constraint ranking, faithfulness constraints referring to contrastive features will be ranked in the same order as the features in the contrastive hierarchy. At each point when a segment is uniquely specified a contextual markedness constraint will be introduced, preventing further specification.

In the case of Nez Perce the first feature in the hierarchy is [low]. It has no exclusions. Therefore, we place the constraint IO-IDENT [low] in the highest constraint stratum, ensuring that the underlying value of this feature is maintained.

The second feature is [round]. It is excluded with [+low], because the feature [round] does not serve to further distinguish segments in the [+low] set. Hence the constraint *[+low, round] must be ranked ahead of IO-IDENT [round]. Thus, no segment with underlying value [+low] will be able to surface with a value for [round]; [–low] segments must keep their underlying value of [round].

The third feature is [ATR]. It also has no exclusions, so we place the constraint IO-IDENT [ATR] next in the constraint hierarchy.

All other vowel features are redundant and are excluded. We can obtain this result by adding the constraint *[F], which filters out all but contrastive specifications that have higher-ranking IO-IDENT constraints. The resulting constraint hierarchy is summarized in (12).

(12) Nez Perce constraint hierarchy regulating contrasts in the inventory
IO-IDENT [low] >> *[+low, round] >> IO-IDENT [round] >> IO-IDENT [ATR] >> *[F]

A general algorithm for converting a contrastive hierarchy to an OT constraint hierarchy, given an ordering of features, is shown in (13).

(13) Converting a contrastive hierarchy into a constraint hierarchy

a. Select the next contrastive feature in the list, F_i. If there are no more contrastive features, go to (e).

b. In the next stratum, place any co-occurrence constraints of the form *[αF_i, Φ], where Φ consists of features ordered higher than F_i.

c. In the next stratum, place the constraint IO-Ident [F_i].

d. Go to (a).

e. In the next constraint stratum, place the constraint *[F], and end.

Every contrastive hierarchy can be converted into a constraint hierarchy by the above procedure. But the converse does not hold: not every constraint hierarchy corresponds to a well-formed contrastive hierarchy.

5. The Analysis of Bakovic 2000

An OT analysis of the Nez Perce vowel system is given in Bakovic 2000. His analysis has some properties in common with ours. Like us, he needs a hierarchy of featural faithfulness constraints, and constraints to exclude certain combinations of features. However, he goes about defining the Nez Perce vowel inventory in quite a different fashion.

Bakovic begins with the following table showing the actual Nez Perce surface vowels (in bold) and a number of nonexistent vowels that need to be excluded:

(14) Features of existing and absent vowels (Bakovic 2000:243 (270))

	[+ATR]		[−ATR]	
[+high, −low]	i	u	ɪ	ʊ
[−high, −low]	e	o	ɛ	ɔ
[−high, +low]	æ		e	ɑ
	[−back]	[+back]	[−back]	[+back]

Starting from the assumption that inputs are not restricted to language-specific inventories, Bakovic introduces constraints to derive the surface inventory. To ensure faithful mapping of the actual vowels, he employs feature-specific IO-IDENT constraints. To penalize absent vowels, he uses markedness constraints that militate against antagonistic tongue gestures. For example, the constraint *[−high, +ATR] suggests there is an antagonism between a lowered tongue body and an advanced tongue root.

The IDENT constraints refer to the features shown in (14). But no arguments are given for why these features were selected and others omitted. This is neither full nor contrastive specification, but rather arbitrary specification. Viewed against our contrastive hierarchy for Nez Perce, the features [high] and [back] are redundant, and a contrastive feature, [round], is missing.

According to Bakovic, the motivation for a high ranking of faithfulness to [high] is to ensure that a hypothetical input /o/, a vowel which does not exist in Nez Perce, will surface as [ɔ] rather than as [u] (15). But no evidence is adduced that an input /o/ does in fact surface as [ɔ] and not, say, as [u]. Therefore, the relatively high ranking of this constraint has no real motivation, for we cannot exclude a constraint hierarchy such as in (16).

(15) Role of IO-IDENT[hi] (Bakovic 2000:245 (273))

Input /o/	*[−high, +ATR]	IO-IDENT [high]	IO-IDENT [ATR]
a. o	*!		
b. u		*!	
c. ☞ ɔ			*

(16) Evaluation of /o/ with low-ranking IO-IDENT[hi]

Input /o/	*[−high, +ATR]	IO-IDENT [ATR]	IO-IDENT [high]
a. o	*!		
b. ☞ u			*
c. ɔ		*!	

Similarly, Bakovic (2000:246) wishes to ensure that input /e/ surfaces as [i]. In his analysis, faithfulness to [back] plays a prominent role in preventing /e/ from surfacing as *[ɔ] (17). Again, there are many other ways of excluding this vowel; one is shown in (18).

(17) Role of IO-IDENT[bk] (adapted from Bakovic 2000:246 (279))

Input /e/	IO-ID [low]	*[–bk, –ATR]	IO-ID [back]	*[-hi, +ATR]	IO-ID [high]	IO-ID [ATR]
a. e				*!		
b. ☞ i					*	
c. ɛ		*!				*
d. ɔ			*!		*	*
e. æ	*!			*	*	

(18) Evaluation of /e/ without IO-IDENT[bk]

Input /e/	IO-ID [low]	*[+low, round]	IO-ID [round]	IO-ID [ATR]	*[F]
a. e					*! [hi]
b. ☞ i					
c. ɛ				*!	
d. ɔ			*!	*	
e. æ	*!				*

Proceeding in this way, Bakovic arrives at the ranking shown in (19).

(19) Constraint ranking for Nez Perce (Bakovic 2000)
*[+back, +ATR] & IO-ID [ATR], IO-ID [low], *[–back, –ATR] >> IO-ID [bk] >> *[–high, +ATR], *[+high, –ATR] >> IO-ID [high] >> *[+back, +ATR] >> *[-low, –ATR] >> IO-ID [ATR]

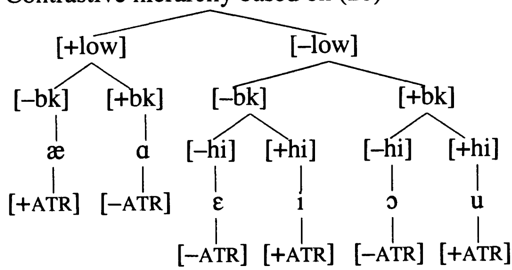
He proposes that these faithfulness constraints and cooccurrence restrictions are sufficient to exclude nonexistent vowels and to ensure that vowels present in the inventory will surface faithfully.

Looking only at the faithfulness constraints, we find the hierarchy in (20).

(20) Ranking of faithfulness constraints (Bakovic 2000)
IO-ID [low] >> IO-ID [back] >> IO-ID [high] >> IO-ID [ATR]

This constraint hierarchy translates into an ill-formed contrastive hierarchy:

(21) Contrastive hierarchy based on (20)



The feature [ATR] is redundant in this hierarchy, though it is the active feature in vowel harmony. It is redundant because of the presence of [high], which does not appear in our contrastive hierarchy. Recall that the motivation for a high ranking of faithfulness to [high] is to ensure that input /o/ will surface as [ɔ] rather than [u] (15). But an analysis that adheres to the contrastive hierarchy automatically prevents illicit vowels from surfacing. In this case, an /o/ has the same contrastive features as /u/; no other features may be specified (16).

The analysis in Bakovic 2000 thus appears to require a ranking of faithfulness constraints that is incompatible with any contrastive hierarchy for Nez Perce. Moreover, this analysis does not draw any connection between contrastiveness and phonological activity in Nez Perce. Given its low ranking, the feature [ATR] appears to be redundant, though it is the active feature in vowel harmony. However, this ranking is unmotivated by any empirical facts and relies primarily on unsupported assumptions about what nonexistent vowels should map to.

6. Conclusions

We have shown that the contrastive hierarchy can be implemented in OT using the same sort of constraints already in common use in the theory. We have also argued that the Nez Perce vowel system can be analyzed using only contrastive features. Although there are a number of possible contrastive hierarchies for Nez Perce, the analysis of Bakovic 2000 does not correspond to any of them. We conclude in particular that the feature [ATR] is contrastive in Nez Perce; thus, vowel harmony is implemented by a contrastive feature.

Finally, limiting OT constraint hierarchies to those that correspond to contrastive hierarchies provides a principled method for choosing between a number of possible constraint rankings. This limitation represents a significant restriction on the set of possible grammars.

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