Contrast and Phonological Activity in the Nez Perce Vowel System*

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0. Introduction

Features which pattern as inert with respect to phonological processes are often unnecessary in distinguishing segments in an inventory. The relationship between phonological activity and contrastiveness has been modeled in theories of underspecification (e.g. Archangeli 1984, Steriade 1987). However, there is no consensus on how to determine which features are contrastive.

The theory of the contrastive hierarchy (Jakobson and Halle 1956, Dresher 1998a,b) provides a method for determining contrasts in an inventory by ranking features so that some features take scope over others. This theory relies upon analyses of language-particular inventories. In OT, however, inventories arise from constraint ranking and language-specific inputs are rejected. The role of the inventory in determining phonological behaviour is therefore more limited in OT.

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

An alternative analysis of Nez Perce vowel harmony within the framework of OT is found in Bakovic (2000). As in our OT analysis, he uses featural faithfulness constraints and markedness constraints. His account differs from ours in its lack of reference to contrast. Appealing to the theory of the contrastive hierarchy we demonstrate that many of Bakovic's rankings are unmotivated and that making explicit reference to contrast can determine the crucial constraint rankings.

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

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

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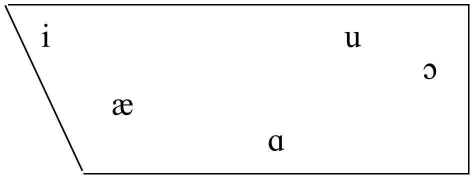
(N$1) Nez Perce surface vowels



Nez Perce has dominant-recessive ATR harmony in which [-ATR] functions as the dominant value. 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).

(N$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/	mæqæ	‘uncle VOC’
d)	/tɔt-æʔ/	tɔ:tɑʔ	‘father VOC’
e)	/cæqæt/	cæ:qæt	’raspberry’
f)	/cæqæt-ɑyn/	cɑqɑ:tɑyn	’for a raspberry’

(N$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)	/tuʔuynṳ ʔɑyn/	tɔʔɔynɔ ʔɑyn	‘for the tail, crupper’

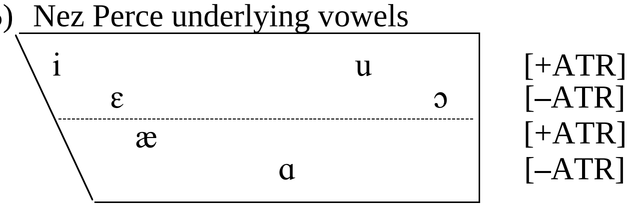
As illustrated in ($4), the vowel /i/ sometimes patterns with [-ATR] vowels ($4a,b), and other times with [+ATR] vowels ($4c,d), though it is phonetically [+ATR].

(N$4) Dual patterning of /i/

	Underlying	Surface	Gloss
a)	/næʔ̤ci: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/.

(N$5) Nez Perce underlying vowels



Thus, every vowel has a counterpart that contrasts with it in the feature [ATR]. By any definition, [ATR] is a *contrastive* feature in the underlying vowel system.

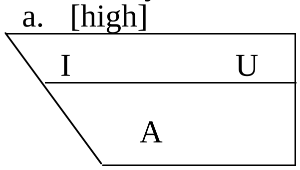
What are the other contrastive features? Abstracting away from [ATR], we have a classic three-vowel system, which we can designate /I A U/. Even in such a simple system, it is not obvious what the relevant contrasts are. We need a way to determine contrasts in an inventory.

2. Contrastive specification by a hierarchy of features

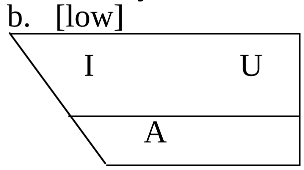
The approach we will take is that of Jakobson and Halle 1956. To determine contrastiveness of features, it is necessary to determine their relative *scope*, or *ordering*. In a simple three-vowel system, for example, exactly two features will be contrastive, though what these are can potentially vary.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

(N$6) Potentially contrastive features in three-vowel system

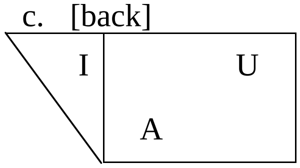
a. [high]



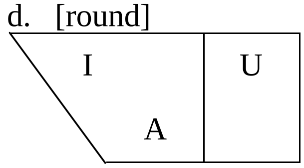
b. [low]



c. [back]



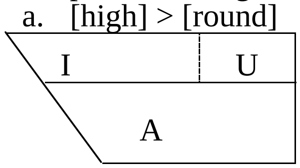
d. [round]



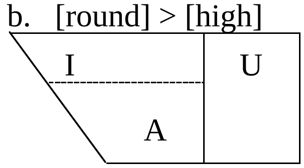
Ordering is required to select contrastive features. It also determines the relative scopes of the contrastive features that are selected. Suppose, for example, we choose the features [high] and [round]. We can first divide the vowels on the basis of [high] ($7a). Now [round] is relevant only as a contrast 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].

(N$7) Scope or ordering of features

a. [high] > [round]



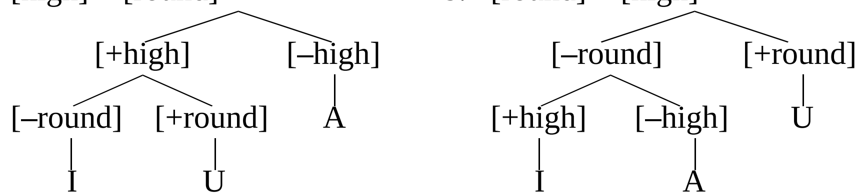
b. [round] > [high]



These two orderings correspond to two different contrastive hierarchies ($8).

(N$8) Scope or ordering of features

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

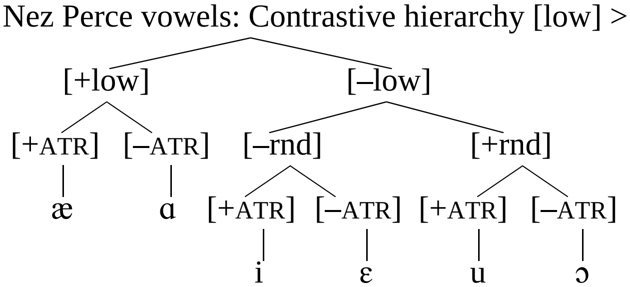


Given a contrast based on [high], a further contrast based on [round] is required only for members that are specified as [+high]. Given a contrast based on [round], a further contrast based on [high] is required only for members that are specified as [–round]. We might expect that the two vowel systems will pattern differently. For example, system (a) might show alternations or neutralization between /i/ and /u/; in system (b) /i/ might be more closely related to /a/.

We suppose that the hierarchy can vary within limits. Determining what it is for any particular language will require language-particular evidence as to what the active features are in addition to principles of UG.

In the case of Nez Perce, we choose [low] rather than [high] because the surface nonlow [ATR] pair is not strictly [+high], whereas the low pair are both [+low]. Following Jakobson and Halle (1956), we assume that a contrast between high and low sonority is, preferably, ordered before one based on place. 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.

(N$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, based on Jakobson and Halle 1956). An informal version is given in ($10).

(N$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, the contrastive hierarchy does not necessarily presuppose underspecification. At its most basic, the Successive Division Algorithm 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 Successive Division Algorithm 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.

Thus, 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 [+sonorant] is predictable given [+nasal] (where there are no nasal obstruents); but this specification is rarely omitted. 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 to contrast: an ordering of features is required to determine which feature values are contrastive.

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. Totally irrelevant features are rarely specified. The result is 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, Rice 2002); the theory of representational economy of Clements (2001); and Hyman's system-driven specifications (Hyman 2002a, 2002b).

4. The Contrastive Hierarchy in Optimality Theory (OT)

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; and (b) there are no limitations on underlying inventories. 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 modelled 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 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 modelling contrast.

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

Constraints: We will employ two basic constraint types:

(N$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.

The first feature in the Nez Perce 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], hence *[+low, round]. This constraint is 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 features are redundant and are excluded. We can obtain this result by adding the constraint *[F], which filters out all but contrastive specifications. The resulting constraint hierarchy is summarized in ($12).

(N$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 given in ($13).

(N$13) Converting a contrastive hierarchy into a constraint hierarchy

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

b. In the next stratum of constraints, 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 can be converted into a 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 and a number of nonexistent vowels that need to be excluded:

(N$14) Features of existing and absent vowels (Bakovic 2000)

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

To ensure faithful mapping of the actual vowels, Bakovic employs feature-specific IO-IDENT constraints. To penalize absent vowels, he uses markedness constraints that militate against antagonistic tongue gestures, such as *[–high, +ATR]. 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 [u].

(N$15)

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

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).

(N$16)

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

Similarly, Bakovic (2000) 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]:

(N$17)

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	*!			*	*	

Again, there are many other ways of excluding this vowel.

(N$18)

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

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

(N$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]

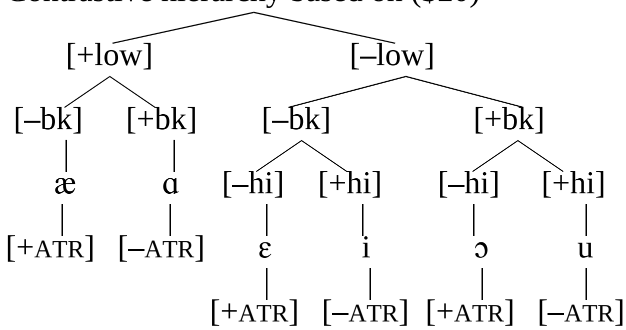
He proposes that these faithfulness constraints and cooccurrence restrictions exclude nonexistent vowels and ensure that vowels present in the inventory will surface faithfully.

Looking only at the faithfulness constraints, we find the following hierarchy:

(N$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:

(N$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 restricts the set of possible grammars.

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