Representing the role of minimal contrast in phonology
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Abstract
This study proposes a new system to encode minimal contrast in the phonology based on evidence from two harmony patterns. Minimally contrastive segments are pairs of segments that differ in just one property, e.g. height. Evidence for the active role of minimal contrast in phonology comes from vowel height harmony in Asturian varieties, where only vowels that are minimally contrastive for height can trigger the process. The relevance of minimal contrast is further supported by retroflex harmony in Gaagudju, which targets only segments that are not minimally contrastive for retroflexion. These facts show that minimal contrast can play a significant role in phonological processes. Therefore, I argue that the phonological representation must include information about minimal contrast, which can be active in the phonology. I formalize minimal contrast with a contrast-coindexing function, which applies to minimally contrastive segments that are able to distinguish pairs of words, within an Optimality Theory framework. This follows a systemic approach to contrast. The analysis of Gaagudju harmony illustrates this proposal. Finally, I argue that contrast-coindexing overcomes problems faced by underspecification, and it also presents a fruitful alternative to accounting for patterns before attributed to underspecification.
1. Introduction

The significance of contrast in phonology has been a recurrent focus of attention in the phonological literature (e.g. Archangeli, 1988; Steriade, 1987; Dresher et al., 1994; Flemming, 1995; Padgett, 2003; Ní Chiosáin & Padgett, 2001; Lubowicz, 2003). The present study contributes to this line of research by concentrating on the role of *minimal contrast*. Minimally contrastive segments are pairs of segments that differ in one property or dimension of contrast (Jakobson, Fant & Halle, 1952). For example, /i/ and /e/ are minimally contrastive for height because they only differ in terms of this property. This study argues that minimal contrast can have an active role in phonology and consequently, it should be part of the phonological representation. I based this conclusion on evidence from two harmony patterns from Asturian and Gaagudju, which show that minimally contrastive elements may have a special status. For example, they might be more resilient to change – as in Gaagudju – or they might be more easily promoted or enhanced – as in Asturian (cf. Kaun, 1995).

Vowel height harmony in Asturian, a Romance language spoken in northwestern Spain, offers an instance of a phonological process sensitive to minimal contrast. In Asturian, a stressed vowel assimilates in height to a following inflectional high vowel (Hualde, 1989). Interestingly, in some of these Asturian dialects, more precisely in Lena and Aller, the triggers of harmony must not only be high but also minimally contrastive for height. In these systems, high vowels show an asymmetrical behavior for harmony: vowels minimally contrastive for height can trigger the harmony but those that are not minimally contrastive for this dimension cannot. Additional evidence for the role of minimal contrast in phonology comes from retroflex harmony in the Australian language, Gaagudju. In this language, only those consonants that are not minimally contrastive for retroflexion are targeted by the harmony. Consonants that have a minimal contrast for this dimension are not affected by retroflex harmony, lending support to the proposal that minimal contrast can be active and determine the outcome of phonological phenomena.

Based on the facts from Asturian and Gaagudju, this study formalizes the phonological representation of minimal contrast as a *contrast-coindexing function*, which applies to minimally contrastive segments capable of distinguishing pairs of words. Minimal contrast is overtly represented in those segments that differ in just one property and are part of a minimal pair of words. Minimal contrast is assessed at the word level, adopting a systemic approach to contrast (cf. Flemming, 1995). Contrast-coindexing is here couched within Optimality Theory (Prince & Smolensky, 1993), but it should be noted that the need to represent minimal contrast needs to be addressed in any theoretical framework. Also, it is relevant to emphasize that I develop an analysis of the role of minimal contrast, which does not rely on underspecification. I argue that underspecification does not offer a satisfactory account of this kind of contrast.

In section 2, I introduce the facts about Asturian vowel harmony. Section 3 presents the relevant data from Gaagudju retroflex harmony. In section 4, I develop the *contrast-coindexing function* to represent minimal contrast, and in section 5, this proposal is illustrated through the analysis of Gaagudju harmony. Section 6 discusses the main conclusions and directions for future research.
Several Asturian varieties show a vowel harmony pattern so that a post-tonic inflectional high vowel triggers assimilation in a preceding stressed vowel, usually raising. For example, compare the Lena Asturian forms [tʃuɓu] ‘wolf.masc.sg.’ and [tʃoɓa] ‘wolf.fem.sg.’. These examples show alternation between stressed [u-o] depending on the height of the inflectional vowel. Interestingly, in Lena only the high vowel [u] can trigger raising. Inflectional [i] fails to cause harmony as can be seen in [máɗri] ‘mother.sg.’ (cf. [máɗres] ‘mother.pl.’). I argue that this is due to the fact that inflectional [i] is not minimally contrastive for height since inflectional [e] is not part of the Lena system. On the other hand, in Aller Asturian both inflectional [u] and [i] can initiate the harmony process, as illustrated by [eɓri] ‘open.imper.’ vs. [ábre] ‘open.pres.’, where the imperative form displays raising of the stressed vowel. The difference between Lena and Aller is that the latter has a contrast between inflectional [i] and [e] in its verbal paradigm that the former lacks. This means that Aller inflectional [i] is minimally contrastive for height and, thus, able to trigger harmony. The following sections explain the facts from Asturian in more detail.

2.1 Lena Asturian harmony

Lena is a central dialect of Asturian. As mentioned earlier, Lena has a vowel height harmony process by which a post-tonic, unstressed high vowel triggers raising of a non-high stressed vowel (Hualde, 1989; Dyck, 1995; Walker, 2005). Some examples of Lena harmony are presented in (1).

\[
\begin{array}{llll}
masc. sg. & fem. sg. & masc. pl. & gloss \\
\text{tũntu} & \text{tontə} & \text{tontos} & \text{‘dumb’} \\
\text{fũ} & \text{féa} & \text{fėos} & \text{‘ugly’} \\
\text{sěntu} & \text{sánta} & \text{sántos} & \text{‘holy’} \\
\end{array}
\]

The examples in (1) show three morphologically related forms, i.e., masculine singular, feminine singular, and masculine plural, for each gloss. The masculine singular examples show the vowel harmony pattern. A word final /u/ causes raising of the preceding stressed vowel. On the other hand, the forms for the feminine singular and masculine plural do not undergo metaphony given that those forms do not contain a post-tonic high vowel. Stressed high vowels (/i, u/) do not change in the harmonizing environment, as can be seen in (2).

\[
\begin{array}{llll}
masc. sg. & fem. sg. & masc. pl. & gloss \\
\text{frũ} & \text{fría} & \text{fríos} & \text{‘cold’} \\
\text{mũntʃu} & \text{mũntʃa} & \text{mũntʃos} & \text{‘much/many’} \\
\end{array}
\]

The claim about the relationship between minimal contrast and harmony in Asturian builds on Dyck’s (1995). However, the current study presents additional data about the realization of the inflectional high front vowel in Lena and harmony patterns in Aller.
A relevant fact about Lena metaphony is that the trigger of the harmony is always a word-final inflectional suffix (Hualde, 1992; Dyck, 1995; Walker, 2005). The forms in (3) show that a post-tonic high vowel in the stem does not trigger the harmony. In this example, the feminine and plural forms have a post-tonic /i/ (in italics), which is part of the stem. However, the stressed vowel does not raise to /i/, indicating that only inflectional suffixes may cause the stressed vowel to raise.

(3) masc. sg. fem. sg. masc. pl. gloss
silikūku silikōtika silikōtikos ‘suffering from silicosis’

These facts suggest that the inflectional vowel inventory is the relevant set that has the potential to trigger metaphony. For this reason, I focus on the inflectional inventory in Lena and show how the contrast relationships that are established among the different vowels are responsible for selecting the trigger of metaphony. Table 2 shows the Lena phonemic inflectional vowel inventory (left) and its realization (right).

Table 2. Lena inflectional vowel inventory (left) and its realization (right)

<table>
<thead>
<tr>
<th>Front</th>
<th>Central</th>
<th>Back</th>
<th>Front</th>
<th>Central</th>
<th>Back</th>
</tr>
</thead>
<tbody>
<tr>
<td>/e/</td>
<td>/u/</td>
<td>High</td>
<td>/i/e</td>
<td>[u]</td>
<td>High</td>
</tr>
<tr>
<td></td>
<td>/o/</td>
<td>Mid</td>
<td></td>
<td>[o]</td>
<td>Mid</td>
</tr>
<tr>
<td>/a/</td>
<td></td>
<td>Low</td>
<td></td>
<td>[a]</td>
<td>Low</td>
</tr>
</tbody>
</table>

The Lena inflectional system is asymmetrical. The back vowels /u, o/ differ in terms of their height, indicating that they are minimally contrastive for this property. On the other hand, production of the front vowel ranges from [i] to [e], but crucially, it lacks a height contrast (Granda, 1960). This means that only back vowels are minimally contrastive for height.

Evidence for the contrast between /u/ and /o/ in Lena comes from the distinction between masculine singular count forms, which take the suffix /-u/, and mass forms, which are formed with the suffix /-o/ (Penny, 1970). See (4).

(4) masc. sg. mass gloss
fríu frío frí ‘cold’
múntʃu múntʃo múntʃ ‘much/many’

On the other hand, the Latin distinction between inflectional /i/ and /e/ was lost in Lena (Granda, 1960). However, the precise realization of the front vowel is not totally undetermined – there is not free variation between [e] and [i] like it is found in other Asturian varieties (Granda 1960), where the inflectional front vowel seems to be unspecified for height and its realization is variable. In Lena, some forms always show an inflectional /-e/, for example those in (5).

<table>
<thead>
<tr>
<th>(5)</th>
<th>masc. sg.</th>
<th>mass</th>
<th>gloss</th>
</tr>
</thead>
<tbody>
<tr>
<td>fríu</td>
<td>frío</td>
<td>múntʃu</td>
<td>múntʃo</td>
</tr>
</tbody>
</table>

\(^2\) All Asturian varieties have a five vowel stem inventory /i, e, a, o, u/.
(5) [póte] ‘pot.masc.sg.’ (cf. [pot-a] ‘wide pot.fem.sg.’)
   [fére] ‘type of hawk.masc.sg.’ (cf. [feres] ‘type of hawk.masc.pl.’)

On the other hand, some conditions tend to favor the production of a final front
inflectional vowel as [i] (Granda, 1960). First, when there is a preceding (pre-)palatal sound, the word-final front vowel tends to be realized as [i] (see (6a)).
Second, there is also a tendency to pronounce the vowel as [i] when there is a
preceding stressed [i] in the stem (see (6b)). Finally, [i] production may result
from analogy to forms within the same semantic field that have a word-final [i]
due to one of the preceding factors.

(6) (a) [jet[i]] ‘milk.fem.sg.’ (cf. [jet[es] ‘milk.pl.’ glasses of milk)
   (b) [imbíti] ‘push.masc.sg.’ (cf. [imbites] ‘push.pl.’, Spanish [embite])

The conclusion from this discussion about the factors conditioning the
realization of the inflectional front vowel is that a word-final [i] has a fixed target
for height, rather than being unspecified\(^3\) for this property. First, there is evidence
to support that the realization of this vowel has a phonetic target for height
suggesting that this property is not underspecified in the output form: This vowel
surfaces as either [e] or [i] but not as something inbetween as an output
underspecification approach would predict. Furthermore, this front vowel seems to
get a [+high] feature due to assimilation to other elements within the same word
(see (6)). Finally, [i] may occur as the result of analogy to words from the same
semantic field that have an inflectional [i] as a result of the assimilation processes
explained above. Phonological analogy involves the copy of a phonological
feature from one form into another (Bybee 1985). In Lena, analogy results in the
transfer of the vowel height features from a semantically-related word to another.
This means that the high vowel has a specified representation for its height
features, lending further support to the claim that inflectional [i] is specified as
[+high].

Summarizing, the crucial observation is that Lena inflectional back vowels are
minimally contrastive for height, whereas inflectional front vowels lack this
minimal contrast. Relevant here is that an inflectional front vowel realized as [i]
ever triggers harmony. In principle, this vowel should be able to initiate the
process, given that it is a suffixal high vowel, specified [+high], the relevant
feature triggering the metaphony. However, the examples in (7) show that forms
with inflectional [i] fail to undergo raising of their stressed vowel (cf. Dyck,
1995).

(7) [bénti] ‘twenty’ (cf. [bentidós] ‘twenty-two’)
    [pádrí] ‘father’
    [mádrí] ‘mother’
    [matéstis] ‘you pl. killed’ (cf. [matémos] ‘we kill’)

\(^3\) Underspecification is further discussed in section 6.
The data from Lena indicate that only inflectional /u/ can trigger the vowel harmony. Therefore, Lena illustrates a case of an asymmetrical system in so far as only a high vowel that is minimally contrastive for height can trigger the harmony. In section 2.2, Lena harmony is placed within the vowel harmony typology derived from other Asturian varieties. I present data from these dialects, and show that the notion of minimal contrast is crucial in explaining the observed typological pattern.

2.2 Vowel harmony in other Asturian varieties

Aller is a central dialect of Asturian, spoken in the region geographically adjacent to the Lena area. Aller and Lena are very closely related and show comparable phonological patterns (Rodriguez, 1952; Neira, 1963, 1982). However, there is a relevant difference between these two varieties. Aller presents a harmony pattern similar to that of Lena: an inflectional high vowel causes raising of a preceding stressed vowel. Example (8) illustrates this phenomenon in Aller.

(8) masc.sg. plural gloss
kaldíru kaldéros ‘pot’
fiťú fétjos ‘fact’

Aller inflectional vowel inventory also displays a difference between the mass and count grammatical categories, which is realized as a contrast between inflectional /u/ and /o/. Similarly to Lena, Aller nouns lack an inflectional distinction between /i/ and /e/, and forms that end in inflectional [i] do not undergo metaphony. However, unlike Lena, Aller shows a limited inflectional contrast between /i/ and /e/ for the verbal paradigm. This contrast comes from the phonological difference between the second person singular imperative suffix /-i/ and the third person singular present suffix /-e/. The verbal forms in (9) exemplify this contrast.

(9) imperative present gloss
bíbi bibe ‘to live’
kúbrí kúbre ‘to cover’

Interestingly, Aller imperative forms undergo vowel harmony triggered by inflectional /i/ when the stressed vowel is non-high, following the same pattern as the nominal forms in (10). Verbal harmony is illustrated in (10).

(10) imperative present gloss
ébri ábre ‘to open’
kúri kóre ‘to run’

The data from Aller offer further evidence about the role of minimal height contrast in harmony. In this variety, only inflectional vowels that have a minimal contrast for height can trigger the harmony. These vowels are /u/ in the nominal and adjectival forms and /i/ in the verbal paradigm.

The Western Asturian inflectional system is more simplified than that of Lena
and Aller. It includes /e, a, o/ (Rodriguez-Castellano, 1954). Western Asturian does not have a contrast between the suffixes /u/ and /o/. Also, the /i/ vs. /e/ opposition is absent from the system. Relevant for the harmony typology, Western Asturian does not display vowel harmony at all. Even those forms that are realized with a final high vowel do not show harmony. The examples in (11) compare the same words in Western Asturian and in Lena in order to highlight the lack of harmony in the Western dialects.

(11) Western Asturian Lena gloss
tʃóbu tʃʊbu ‘wolf’
pέ̃tu pέ̃tu ‘breast’

Table 4 shows the vowel harmony typology derived from the inflectional vowel systems and harmony patterns from the Asturian varieties presented in the above. Shaded cells indicate unattested patterns.

<table>
<thead>
<tr>
<th>Harmony by /u/ &amp; /i/</th>
<th>Harmony by /u/ only</th>
<th>No harmony</th>
</tr>
</thead>
<tbody>
<tr>
<td>/u-o/, /i-e/ contrast</td>
<td>Aller</td>
<td></td>
</tr>
<tr>
<td>/u-o/ but not /i-e/ contrast</td>
<td>Lena</td>
<td></td>
</tr>
<tr>
<td>No /u-o/, /i-e/ contrast</td>
<td>Western Asturian</td>
<td></td>
</tr>
</tbody>
</table>

The typology strongly suggests that the presence of minimal height contrast can play a determining role in whether harmony takes place in the system or not. In Lena, only back vowels are minimally contrastive for this property and only /u/ can trigger the raising. On the other hand, Aller has a minimal height contrast for both its front and back inflectional vowels. Correspondingly, this variety shows harmony triggered both by /u/ and /i/. Finally, Western Asturian lack a minimal contrast for their inflectional vowel altogether and vowel harmony does not take place.

3. Minimal contrast and retroflex harmony in Gaagudju

In this section, I present further arguments for the importance of minimal contrast from the Australian language Gaagudju, which has a pattern of retroflex harmony where the target is a consonant that is not minimally contrastive for retroflexion. Coronal consonants in Australian languages are usually divided into two categories: apical, where the active articulator is the tongue tip, and laminal, articulated with the tongue blade. Within each of these two categories, further subdivisions are made on the basis of the place of articulation. The laminal sounds can be dental or alveopalatal, while the apical sounds can be alveolar or retroflex. Gaagudju belongs to a group of languages that show a three-way contrast among its coronal consonants: apico-alveolar, apico-retroflex and
lamino-alveopalatal. The Gaagudju consonant inventory is given in Table 5. The contrast between alveolars and retroflexes is illustrated by the (near) minimal pairs in (12) (Hamilton, 1996; Harvey 2002).

Table 5. Gaagudju consonant inventory

<table>
<thead>
<tr>
<th></th>
<th>Labial</th>
<th>Alveolar</th>
<th>Retroflex</th>
<th>Alveopalatal</th>
<th>Velar</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stop</td>
<td>p</td>
<td>t</td>
<td>t</td>
<td>c</td>
<td>k</td>
</tr>
<tr>
<td>Nasal</td>
<td>m</td>
<td>n</td>
<td>ɳ</td>
<td>ɲh</td>
<td>ŋh</td>
</tr>
<tr>
<td>Lateral</td>
<td>l</td>
<td>l</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trill</td>
<td></td>
<td>r</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Approximant</td>
<td>w</td>
<td>ɭ</td>
<td>j</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(12) pata ‘leg’ pata ‘beeswax’
wannniri ‘grey hair’ wannmalaj ‘mud’
palapumu ‘to talk’ palapumu ‘to sing’
cara ‘he went down’ caqa ‘beard’

Like in other Australian languages, the alveolar vs. retroflex contrast is maintained only post-vocally. This contrast is neutralized in word-initial positions. In Gaagudju, word-initial apicals are consistently realized as alveolar (Hamilton, 1996). Butcher (1995) notes that word-initial apicals seem to represent an original single phoneme which has failed to ‘split’, as opposed to postvocalic positions, rather than, a merge of two originally contrasting sounds. Interestingly, these word-initial apicals undergo retroflex assimilation when followed by a retroflex consonant within the same word (Hamilton, 1996; Steriade, 1995; Harvey, 2002). Assimilation does not target apicals in any other position. Also, non-apicals are reported not to undergo assimilation. In (13)a), the word-initial apical agrees in retroflexion with the following consonant. In (13)b), the initial apical does not assimilate to the place of a following non-retroflex consonant, indicating that only retroflex elements can trigger the process. (13)c) shows that a non-apical initial consonant fails to undergo the assimilation. Finally, the alveolar apical in (13)d) fails to assimilate to the preceding retroflex, indicating that assimilation only targets word-initial elements.

(13) (a) təɛnmi ‘again’
    ṇɛtɛŋmar ‘water snake’
(b) nəawu ‘pronoun.3rd sg. masc.’
    nɪnja ‘just’
(c) kəŋnu ‘morning’
(d) montanbu ‘they finish’

The main generalization from Gaagudju is that apical consonants are targeted by retroflex harmony only when they are not minimally contrastive for
retroflexion, namely word-initially. Minimally contrastive apicals fail to undergo the harmony. This is an instance where minimally contrastive segments are resistant to change. In the following section, I develop a formal system to overtly include minimal contrast in the phonological representation and in section 5, I provide an analysis of Gaagudju harmony.

4. Representation of minimal contrast: contrast-coindexing function

Based on the evidence from Asturian and Gaagudju, I argue that the phonological representation needs to explicitly include information about minimal contrast, which phonological phenomena can access. I propose to formalize the representation of minimal contrast as a contrast-coindexing function of minimally contrastive segments. This function assigns a contrast-coindex to all segments that are minimally contrastive for some property in a given sound system. Recall that minimally contrastive segments are pairs of segments that differ just along one dimension of contrast. The definition of contrast-coindexing is given in (14)4:

(14) Contrast-Coindexing function:
For two words, \(w_1\) and \(w_2\), that form a minimal pair, i.e., two words with the same set of segments that are distinct in just one of these segments and where those distinct segments occur in the same position in the canonical order of segments:
Let \(\alpha\) and \(\beta\) be two segments so that \(\alpha \in w_1\) and \(\beta \in w_2\),
let \(D_i\) be a given dimension of contrast,
if \(\alpha\) and \(\beta\) have a \(\text{SPACE}<1\) for \(D_i\), and there is no other dimension \(D_j\) for which \(\alpha\) and \(\beta\) have a \(\text{SPACE}<1\),
then \(\alpha_{D_i}\) and \(\beta_{D_i}\), i.e., \(\alpha\) and \(\beta\) are contrast-coindexed for \(D_i\).

In a nutshell, contrast-coindexing applies to minimally contrastive segments that are able to distinguish minimal pairs of words. Let us explain this definition in more detail. Following Padgett (1997), dimensions of contrast are conceptualized as spaces along which contrasts may be established. Thus, there is a space for each possible contrastive property, e.g., height, backness, retroflexion and so on. If a segment has a \(\text{SPACE}=1\), i.e., the entire space, for some dimension, it means that it does not have a minimally contrastive element for that property. However, if a segment has \(\text{SPACE}<1\) for any given dimension, this implies that it is sharing the whole space with some other element, i.e., there is a contrast along that dimension. Thus, two segments that have a common \(\text{SPACE}<1\) for one and only one dimension are minimally contrastive and get a contrast-coindex for the relevant property. On the other hand, two segments that have a \(\text{SPACE}<1\) for two or more common dimensions do not get a contrast-

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4 Couched within Optimality Theory, the contrast-coindexing function is argued to take place after GEN generates all the candidates and before EVAL operates over them. For more details see Campos-Astorkiza (2007).
coindex by virtue of those distinctions (although those segments might be minimally contrastive with others and therefore be assigned a contrast-coindex).

For example, Lena inflectional /o/ and /u/ have both a SPACE<1 for height. They do not have any other common SPACE<1, since they only differ in height. Thus, they are contrast-coindexed for this property. However, there is no segment that has in common with the inflectional front vowel /e/ only a SPACE<1 for height. /e/ and /a/ have a SPACE<1 for height but also for backness, given that they differ in these two properties. Therefore, they cannot get contrast-coindexed for height or backness. Note that /el is contrast-coindexed for backness due to its relation with back /ol/.

Coming back to the definition of contrast-coindexing in (14), the first clause makes reference to the fact that minimal pairs of words are necessary in order to assess whether two segments minimally contrast or not. By looking at the word level during contrast evaluation, we capture the insight that a segment is phonemic if there is a minimal pair that differs in this element. It also ties to the notion that phonology evaluates whole systems of contrast (Flemming, 1995), rather than individual segments. Work on contrast shows the relevance of a systemic view. According to this systemic approach to contrast, the well-formedness of a form must be evaluated with respect to other forms with which it contrasts and not just independently (e.g. Flemming, 1995; Ní Chiosáin & Padgett, 2001; Lubowicz, 2003; Padgett, 2003). Under this view, the whole language needs to be assessed as a system where the behavior of one form could affect the output of another. This line of research capitalizes on the importance of referring to the entire system of contrasts when evaluating the optimal output for a given grammar. The contrast-coindexing function follows this systemic approach.

Furthermore, the consequences of contrast assessment at the word level seem to be in accordance with the result of neutralization, i.e., loss of contrast in a given environment. When a contrast is neutralized, there are no minimal pairs that contain that contrast in the neutralizing context. Then, according to our word level requirement, no contrast relation is established in that environment, even if in other contexts the contrast does exist, and contrast-coindexing does not apply.

At this point it is useful to consider the relationship between phonological processes and contrast-coindexing. Given the proposed function, we expect contrast-coindices to be active in the grammar. Phonology has access to these coindices and can be sensitive to them, so phonological processes might single out segments with certain contrast-coindices, as opposed to other segments lacking them. This idea is captured through the proposal that constraints driving phonological processes can make reference to contrast-coindices. ⁵ To illustrate the proposal that constraints might make reference to contrast-coindices, I develop an analysis of Gaagudju retroflex harmony.

5. Analysis of Gaagudju retroflex harmony

⁵ Note that constraints cannot make reference to the lack of coindices. This stems from the idea that phonological rules do not refer explicitly to zero.
Recall from section 3, that retroflex harmony in Gaagudju targets only coronal consonants that are not minimally contrastive for retroflexion. Notice that this corresponds to instances where a contrast-coindexed element is not targeted. These cases, where the only target of a process is a non-contrast-coindexed element, can be analyzed as the result of constraint interaction. The relevant conflict would be between a constraint initiating the harmony process and a faithfulness constraint protecting contrast-coindexed elements. Let us develop this analysis step by step.

According to the contrast-coindexing proposal, in Gaagudju those segments that are minimally contrastive for retroflexion are coindexed for this property. This means that apicals in word-initial position – where there is no contrast for retroflexion – are not contrast-coindexed for this dimension, whereas apicals in other positions bear such a coindex. Here, the focus is on the target of harmony rather than on the trigger. Following Ní Chiosáin & Padgett (1997), I analyze the harmony process as being triggered by a $S$-PREAD constraint (see (15)) requiring that the retroflex feature of an apical consonant is associated with a preceding apical consonant.footnote{footnote{6}}

(15) $S$-PREAD-[retroflex]

A [+retroflex] feature associated with an apical segment $S_\alpha$ is also associated to any apical segment $S_\beta$ that precedes $S_\alpha$.

The constraint in (15) conflicts with the faithfulness constraint that preserves the retroflex specification of consonants, $I$DENT-IO[retroflex]. If $S$-PREAD dominates $I$DENT, then all apicals would assimilate to a following retroflex consonant. On the other hand, if $I$DENT is ranked above $S$-PREAD, then assimilation is blocked. The facts from Gaagudju do not accommodate to either of these two situations, since assimilation is limited to apicals that are not minimally contrastive for retroflex, i.e., apicals in word-initial position. The contrast-coindexing proposal allows us to account for this: consonants with a contrast-coindex for retroflex are not affected by the harmony. This can be captured by introducing a faithfulness constraint that makes reference to contrast-coindexed elements, given in (16).

(16) $I$DENT-IO[retroflex]$_R$

Do not change the retroflex specification of a segment that is contrast-coindexed for retroflexion.footnote{footnote{7}}

$I$DENT-IO[retroflex]$_R$ preserves the retroflex value of elements that are contrast-coindexed for retroflexion. Word-initial apicals in Gaagudju are not contrast-coindexed for this property. Therefore, the constraint in (16) is silent about any changes that these apicals may undergo. However, the general $I$DENT-IO[retroflex] constraint bans modification of any apical. The ranking between the

footnote{6} I adopt Ní Chiosáin & Padgett’s (1997) spreading constraint but do not argue for or against it. What constraint drives the harmony is not crucial for the current analysis.

footnote{7} Retroflex is assumed to be binary.
three relevant constraints is shown in (17).

\[(17) \quad \text{IDENT}[\text{retroflex}]_R \gg \text{SPREAD-LEFT-[retroflex]} \gg \text{IDENT}[\text{retroflex}]\]

The tableaux in Table 6 illustrate how this ranking works for a word that undergoes retroflex harmony (a), and for a form that does not undergo the assimilation (b).

### Table 6. Tableaux illustrating the analysis for Gaagudju retroflex harmony

(a) ɗeŋmi ‘again’ → retroflex harmony

<table>
<thead>
<tr>
<th></th>
<th>/ɗeŋmi/</th>
<th>IDENT[retroflex]$_R$</th>
<th>SPREAD-L-[retroflex]</th>
<th>IDENT[retroflex]</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td>ɗeŋmi</td>
<td>!</td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>b.</td>
<td>ɗeŋmi</td>
<td></td>
<td></td>
<td>!</td>
</tr>
</tbody>
</table>

(b) montanbu ‘they finish’ → no retroflex harmony

<table>
<thead>
<tr>
<th></th>
<th>/montanbu/</th>
<th>IDENT[retroflex]$_R$</th>
<th>SPREAD-L-[retroflex]</th>
<th>IDENT[retroflex]</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td>montanbu</td>
<td>!</td>
<td></td>
<td>!</td>
</tr>
<tr>
<td>b.</td>
<td>montanbu</td>
<td>!</td>
<td></td>
<td>!</td>
</tr>
</tbody>
</table>

In tableau (a), the potential target of the SPREAD constraint is a word-initial apical. This consonant lacks a contrast-coindex for retroflex because apicals in this position do not contrast for retroflexion. For this reason, IDENT[retroflex]$_R$ is not violated by either candidate. Thus, SPREAD-L-[retroflex] is crucial in selecting the optimal candidate. Candidate (b), which fails to undergo harmony, fatally violates the SPREAD constraint and it is ruled out. Candidate (b), the actual winner, incurs a violation of the low ranked faithfulness constraint but it satisfies the higher-ranked constraint driving the harmony. In tableau (b), the potential target of harmony is a word-medial apical consonant, an element that bears a contrast-coindex for retroflex given that it minimally contrasts for this property in this position. Consequently, the top-ranked constraint IDENT[retroflex]$_R$ rules out any candidate that modifies the retroflex specification of this medial apical. Candidate (a) is ruled out due to its violation of this constraint. On the other hand, candidate (b) satisfies the highly ranked faithfulness constraint at the expense of violating the SPREAD constraint. This candidate is selected as the optimal form.

The analysis of Gaagudju illustrates an instance where a phonological process targets only elements that are not contrast-coindexed for some property. As described above, this is the result of the interaction between some markedness constraint initiating the process and a faithfulness constraint that makes reference to contrast-coindexed elements.

### 6. Conclusion and issues for further research

The main conclusion of this study is that minimal contrast can play an active role
in phonology, based on evidence from harmony patterns in Asturian and Gaagudju. Thus, I have argued that minimal contrast has to be explicitly included in the phonological representation. The proposed contrast-coindexing function allows us to encode minimal contrast in the representational structure. Furthermore, constraints driving phonological processes can make reference to contrast-coindices in order to signal out minimally contrastive segments. The analysis of Gaagudju retroflex harmony illustrates how a contrast-coindexed faithfulness constraint can restrict the targets of harmony to segments that are not minimally contrastive for some property, in this case retroflexion. This captures the insight that minimally contrastive elements might be more resistant to change.

Here, it is worth considering underspecification, a device that has been previously used to explain the special behavior of contrastive elements. Underspecification faces theoretical and empirical issues that have been discussed elsewhere in the literature (e.g., Mohanan, 1991; McCarthy & Taub, 1992; Steriade, 1995; Baković, 2000). Furthermore, underspecification seems incompatible with the output orientation of OT. In OT, the grammar does not contain a separate system governing inputs which could enforce a particular degree of (under)specification. The constraint ranking should be able to select the correct output form irrespective of the degree of input (under)specification. In OT, the input could potentially be underspecified but the surface form is crucial for assessing the different phonological phenomena in a given language. This means that the process has to be surface-true, regardless of the input. Thus, any possible explanatory power of underspecification with respect to the role of minimal contrast in certain processes is blurred since it mixes two things. On the one hand, phonological processes might change surface contrasts and make features specified or unspecified. On the other hand, contrastivity would rely on the presence or absence of features in the input. However, this is not a reliable indicator of contrast. Something might have been underspecified but then underwent assimilation or some other process so that it became specified. Such an approach blurs results since it equates being specified with being contrastive. Note that contrast-coindexing does not run into this problem since it separates contrastivity from the result of phonological processes and evaluates the contrastive status of the different elements in a language based on the output representation.

A further difference between underspecification and contrast-coindexing is that a non-contrast-coindexed element can be both a trigger and a target, whereas an underspecified element cannot function as a trigger. Only specified elements may be triggers. This means that underspecified elements cannot be active in a process that calls for that feature. On the other hand, non-contrast-coindexed elements can display a dual behavior: they may be relevant or active for some process but inactive for some other. The reason for this behavior is that the property that is not minimally contrastive is present in the representation and thus, a potential trigger, although it lacks a contrast-coindex. Consequently, a phonological process might make reference to all elements with that feature or property

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8 Inkelas (1994) that input underspecification might be the result of Lexicon Optimization under certain conditions.
regardless of their contrast-coindexing status, or only to those with a contrast-
coindex. Thus, according to the contrast-coindexing proposal, we expect to find
cases where a feature that does not participate in a certain process is active for
some other pattern. Lena exemplifies a case where a non-minimally contrastive
element, the high front vowel [i], is both active and non-active in the phonology.
It is inactive in vowel harmony, since it cannot trigger the process. However, it is
active in cases of analogy, a phenomenon that applies at the phonological level
(Bybee, 1985; Burzio, 2000), resulting in the transfer of the vowel height features
from a semantically-related word to another (see section 3). Lena’s facts are
incompatible with an underspecification account.

To conclude, an interesting question for future research concerns the relation
between contrast-coindexing and constraints. First, it is relevant to consider what
constraints, whether markedness or faithfulness, can make reference to contrast-
coindices. In Gaagudju, a contrast-coindexed faithfulness constraint is
responsible for the observed pattern. As for markedness constraints, Campos-
Astorkiza (2007) argues that they can also be contrast-coindexed. This would be
the case in Asturian harmony. Second, it would also be worth considering
whether all types of markedness and faithfulness constraints may single out
contrast-coindexed elements, for instance constraints that apply to elements
bigger than the segment (e.g. the syllable).

References
207.
Rutgers University.
London: Routledge.
form. Amsterdam: John Benjamins.
Dresher, B. E., G. L. Piggott, & K. D. Rice. (1994). ‘Contrast in Phonology:
Exemplification from Spanish and Italian Dialects., Ph.D. dissertation,
University of Toronto.
UCLA.
Galmés de Fuentes (ed.), Trabajos sobre el dominio románico leonés.
of Australian Aboriginal Languages. Ph.D. dissertation, University of
Toronto.


