A Contrastive Approach to Similarity: Evidence from Yucatec

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1 Introduction

Under Gallagher and Coon (2009)'s modified view of long distance consonant harmony, total identity is a special assimilation process that is unique from partial identity. They reduce partial identity to function by spreading (Gafos, 1999) and maintain that only total identity is a true long distance effect, like correspondence (Hansson, 2010; Rose and Walker, 2004). They depart from the standard approach to correspondence approaches to harmony exactly by claiming that partial identity constraints do not cumulatively result in total identity. They refer to the mechanism which enforces total identity as linking.

Like correspondence, linking is subject to similarity. Gallagher and Coon compute similarity using a modified form of Frisch et al. (2004)'s shared feature algorithm which weights some features. The choice of weighings is motivated by the observation that some features seem to matter more for similarity than others.

I propose that similarity is not calculated over fully specified segments but rather arises from strict reference to contrastive features Dresher (2009); Mackenzie (2009). I adopt the theory of the contrastivist hierarchy to demonstrate that similarity does not need to be formally defined,
but rather that it is a surface phenomenon that rides on contrastive representations. I will argue that neither constraints which necessitate linking nor those which necessitate correspondence are needed to account for harmony. Finally, I show that in Yucatec identity is not a unique restriction, but rather arises from constraints banning the co-occurrence of different feature values within a root.

I will use data from Yucatec in order to show that adopting a strict feature specifications can capture complex interactions between multiple harmony processes. Yucatec, like Chol and other Mayan languages, restricts the co-occurrence of consonants that differ in only in ejectivity, as shown in (1), coronal consonants that differ only in anteriority, as shown in (2) and restricts non-affricate coronal consonants from appearing after affricates, as shown in (3).

(1) Ejectives must be homorganic
   a. páap ‘spicy’ *p’...t’/etc.
   b. t’oot’ ‘a type of frog’ *t’...p’/etc.
   c. ts’àats’ ‘marsh’ *k’...t’/etc.

(2) Stridents must agree in minor place
   a. sasaʔ ‘cough’ *s...ʃ/ʃ
   b. fáaf ‘side [of a hammock]’ *f...s/ts
   c. fətʃ ‘separate’ *f...s/ts

(3) Coronals following a affricate must agree in stricture
   a. tfátʃ ‘lacy’ *tf...tʃ
   b. tsuts ‘close’ *ts...tʃ

While Gallagher and Coon (2009) argue that only anterior harmony applies to all segments which contrast for anteriority, I take the much stronger stance that all harmony processes are essentially restricted to segments which bear the relevant features. This analysis is far more powerful if features are determined using a contrastive hierarchy and assuming that only those features thusly specified are available to the phonology.
This paper is organized as follows. In section 2 I introduce the Yucatec data and demonstrates the harmonies discussed briefly above. In section 3 I provide an Optimality Style analysis of Yucatec (Prince and Smolensky, 2004). In section 4 I compare my approach with a correspondence based approach (Rose and Walker, 2004) and with a linking based approach (Gallagher and Coon, 2009). Finally, section 5 provides closing remarks and additional work that needs to be done.

2 Data

Yucatec is a Mayan language spoken in a geographically large swath of Mexico and parts of Belize by about 750,000 people. The present data is drawn from Bricker et al. (1998), a dictionary based on a dialect of Yucatec spoken in Hocabá by about 5,000 people.

Yucatec has twenty consonants and five vowels. The consonant inventory is given (4) below. I have omitted consonants found only in Spanish loan words.

(4) Yucatec consonants (Bricker et al., 1998)

<table>
<thead>
<tr>
<th></th>
<th>Bilabial</th>
<th>Alveolar</th>
<th>Coronal</th>
<th>Postalveolar</th>
<th>Velar</th>
<th>Glottal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stop</td>
<td>p</td>
<td>t</td>
<td>k</td>
<td></td>
<td></td>
<td>?</td>
</tr>
<tr>
<td></td>
<td>p’</td>
<td>t’</td>
<td>k’</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Affricate</td>
<td>ts</td>
<td>tf’</td>
<td>ts’</td>
<td>tf’</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fricative</td>
<td>s</td>
<td>f</td>
<td></td>
<td>h</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nasal</td>
<td>m</td>
<td>n</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Approximant</td>
<td>w</td>
<td>l</td>
<td>j</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

For now I will assume feature specifications for expository purposes. In section 4 I describe which features are contrastively defined for which features. Keep in mind that only contrastive features are proposed to be active in the phonology. A brief note should be made that the implosive voiced bilabial stop does not participate in the laryngeal co-occurrence restriction. It will become clear why it does not participate after we examine how contrastive specifications are obtained and how restrictions are formulated.

For this analysis co-occurrence restrictions in Yucatec will be considered categorical (Hansson,
2010). For a comprehensive analysis of Modern and Classical Yucatec see Noguchi (2007), also based on the Bricker et al. (1998) dictionary. The analysis does not hinge on restrictions being categorical.

### 2.1 Laryngeal restrictions

Yucatec restricts homorganic pulmonic and glottalic plosives from occurring root internally; additionally, if two segments differ only in their glottal specification, they cannot co-occur. This restriction applies to the largest subset of phonemes in Yucatec, the five obstruents /p, t, k, ts, tʃ/ and their rejective counterparts /p’, t’, k’, ts’, tʃ’/. Descriptively, ejectives in a root must be identical and segments that contrast for only ejectivity cannot co-occur.

The examples in (5a) show that consonants with differing place of articulation or manner do not need to agree for glottalization. The examples in (5b) show that consonants that agree in place and manner must also agree in glottalization. The schema in (6) summarize unattested and attested consonant combinations where T and K represent pulmonic consonants with differing place (or manner) and T’ and K’ are their ejective counterparts.

(5) Laryngeal restrictions in Yucatec (Bricker et al., 1998)

<table>
<thead>
<tr>
<th>a.</th>
<th>b.</th>
</tr>
</thead>
<tbody>
<tr>
<td>pak’ ‘to plant’</td>
<td>páap ’spicy’</td>
</tr>
<tr>
<td>papatʃ’ ‘weak’</td>
<td>p’éep’ ‘to rob’</td>
</tr>
<tr>
<td>p’ak ‘tomato herb’</td>
<td>t’oot’ ‘a type of frog’</td>
</tr>
<tr>
<td>p’at ‘to leave’</td>
<td>ts’àats’ ‘marsh’</td>
</tr>
</tbody>
</table>

(6) Unattested and attested root schema

<table>
<thead>
<tr>
<th>a.</th>
<th>b.</th>
</tr>
</thead>
<tbody>
<tr>
<td>*T … T’</td>
<td>T’…K</td>
</tr>
<tr>
<td>*T’…T</td>
<td>T…K’</td>
</tr>
<tr>
<td>*T’…K’</td>
<td>T…K</td>
</tr>
</tbody>
</table>
The only roots which seemingly contradict this generalization are those with voiced implosives bilabial stops. As previously mentioned this segment does not participate in the laryngeal harmony. It can occur with any other ejective segment though does not appear with any other bilabial segment.

### 2.2 Strident restrictions

Yucatec restricts coronal stridents from differing in minor place. This restriction applies to four segments, /ts, tʃ, s, ʃ/ and the ejective counterparts of the affricates. Within a root, all stridents must but either alveolar or postalveolar.

The examples in (7a) illustrate that fricatives must agree in minor place within a root. The examples in (7b) illustrate that affricates also agree, both with other affricates and with fricatives. The schema in (8) show unattested patterns in Yucatec.

\[(7)\] Strident restrictions in Yucatec

\[
\begin{align*}
a. & \text{ sasa? ‘cough’} & */s\ldotsʃ/
\text{ʃáaf ‘side [of a hammock]’} & */ʃ\ldotss/
b. & \text{ tsuts ‘to close’} & */ts’\ldotstf/ 
\text{ʃatʃ ‘separate’}
\end{align*}
\]

Note that for affricates the laryngeal restriction also holds. Forms like /ts’...ts/ are unattested even though they do not violate the restriction on minor place agreement in stridents.

### 2.3 Stricture restrictions

Yucatec has an ordering restriction on pulmonic affricates and other pulmonic coronals. Following an affricate, the only manner of coronal that may appear in a root is another affricate. Since this restriction is not an alternation that depends on morphology, the only evidence that it is directional comes from the types of roots found in Yucatec. While /TS...TS/ roots are common, /TS...S/ or /TS...T/ roots are unattested.
The examples in (9a) illustrate that when the first consonant of a root is an affricate, any coronal following it must also be an affricate. The examples in (9b) shows that this restriction does not force all coronals in a root to be affricates; coronals followed by an affricate may be stops or fricatives. The schema in (10) show unattested patterns in Yucatec.

(9) Stricture restrictions in Yucatec

a. tfátf ‘lacy’
stuts ‘close’

b. sasats’ ‘weak’
fatf ‘separate’

(10) Unattested stricture co-occurrence

*/ts…s/*
*/tʃ…ʃ/*
*/ts…t/*
*/tʃ…ʃ/*

The laryngeal restriction holds for stricture harmony as well; while /tʃ…ʃt/ is acceptable (because stricture harmony only applies to pulmonic consonants), /tʃ…ʃt/ is not, since the latter violates the laryngeal restrictions in Yucatec.

Noguchi (2007) notes a gap in the expected licit sequences. The otherwise unrestricted sequence /s…ts/ is not observed to occur and the sequence /t…ts/ only occurs in one root. These two glitches in the pattern may be accidental, but Noguchi (2007) also shows that /s…ts/ was absent in Classical Yucatec as well. In a more stringent analysis of Yucatec it might be prudent to account for this gap by positing that the strength of the restriction differs for alveolar and postalveolar coronals such that it is bidirectional for alveolars but only progressive for postalveolars; nevertheless, I will treat this gap to be accidental rather than systematic.

2.4 Interaction between restrictions

As we have seen the laryngeal restriction intersects with both the strident and stricture restriction while the strident restriction intersects with the stricture restriction. This series of overlapping interactions leads to total identity in several scenarios. When a root begins with a pulmonic affricate, any following coronal segments will necessarily agree in continuancy which will force even coronal stops, which are otherwise not contrastive for minor place, to agree in anteriority
with the initial affricate resulting in total identity. For a root with two fricatives, since they must agree in minor place, they will be identical. Finally, laryngeal harmony requires that homorganic segments agree for ejectivity, forcing identity.

To summarize the effects of co-occurrence restrictions, stridents in Yucatec roots must be identical in two cases, ejective segments must always be identical. Stridents will be identical when the first is a pulmonic affricate, or when both are fricatives. Identity in stridents is not enforced by a single restriction, but rather arises from two independent restrictions. Identity will be further analyzed in section 3; it will be claimed that it is not enforced by making all features between two segments agree in value, but rather by a restriction on where ejective segments can appear.

3 Analysis

In this section I will briefly show how contrastive features are calculated, then present and argue for contrastive feature specifications in Yucatec and using just those features explain co-occurrence restrictions in Yucatec in a Optimality Theory framework. My analysis shows that there is nothing particular to any process that enforces ‘total’ identity. All of the constraints I propose function over either natural classes (based on contrastive features) or segments which differ in value for only one feature. No additional mechanisms for obtaining a relationship between root consonants is necessary since similarity rides on contrastive specifications.

3.1 Contrastive hierarchy

According to the contrastivist hypothesis, only features which participate in phonological processes need to be specified and each segment in a languages inventory must be uniquely specified (Dresher, 2009). Furthermore, the higher a feature is ordered in the hierarchy the more segments in the inventory are contrastive for that feature. The choice of features is important. Take for instance a simple three vowel inventory, shown below in (11).
For the system above, only two features are needed to uniquely specify each segment in the inventory. This example highlights the importance of feature ordering. Two possible divisions and their hierarchical representations are given in (12) and (13) below.

The example in (12) illustrates an inventory in which front and back are contrastive for all three segments while height is only contrastive for front segments. The example in (13) illustrates an inventory in which height is contrastive for all three segments while only high segments are contrastive for front and back. Importantly, the inventories are identical; however, we could imagine that one hierarchy would be a better fit than the other once we leave a theoretical vacuum and examine real world inventories. Like order, the choice of feature makes a difference once we need to account for activity. For instance, consider the fact that in both options above, /i/ is tied for most marked segment. If we had chosen to use [±front] then we could imagine a system where /i/
is only marked as [+front]. Furthermore, there are different predictions made by the divisions in terms of how much phonetic variation a segment can have. In (12), we could expect that /u/ can vary more freely in height than /i/ or /a/ since it is the only back vowel. In contrast, we expect that in (13) /u/ is relatively stable while /a/ may vary in frontness or backness. The the contrastivist hypothesis states that only contrastive feature participate in phonology, which guides the choice of features as well the their ordering. The contrastivist hypothesis also predicts that languages with identical inventories can have differing phonological activity. This has bearing on theories of similarity, particularly in contradicting those which posit a strict ranking of similarity relations (MacEachern, 1999).

Now that I have illustrated how hierarchical feature division functions at a small scale, we can turn to Yucatec. I have reproduced the inventory from section 2 in (14) below; sets of consonants which are subject to co-occurrence restrictions are indicated by shaded boxes.

(14) Yucatec Mayan (Bricker et al., 1998)

<table>
<thead>
<tr>
<th></th>
<th>Bilabial</th>
<th>Coronal</th>
<th>Velar</th>
<th>Glottal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stop</td>
<td>p</td>
<td>t</td>
<td>k</td>
<td>?</td>
</tr>
<tr>
<td></td>
<td>p’ b</td>
<td>t’</td>
<td>k’</td>
<td></td>
</tr>
<tr>
<td>Affricate</td>
<td>ts</td>
<td>tf’</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>ts’</td>
<td>tf’</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fricative</td>
<td>s</td>
<td>f</td>
<td>h</td>
<td></td>
</tr>
<tr>
<td>Nasal</td>
<td>m</td>
<td>n</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Approximant</td>
<td>w</td>
<td>l j</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

It seems clear that the laryngeal restriction should only apply to segments with a partner that differs only in ejectivity. I choose to capture this using the feature [constricted glottis]. Recall that the voiced bilabial stop does not participate in any laryngeal restriction despite phonetically being implosive. We might think that it does not participate because it lacks a pulmonic voiced partner; in a sense this is correct\(^1\). Additionally, we must account for why all coronals participate in the stricture harmony. Recall that both the stop /t/ and the stridents /ts, tf, s f/ participate. I have chosen to describe the relevant consonants as being specified for [delayed release]; affricated being [+del.

\(^1\)The pulmonic voiced bilabial stop [b] occurs only in Spanish loanwords and therefore I have omitted it from the inventory.
rel.] and fricatives and stops being [-del. rel.] This set of segments is at odds with the set that participates in minor place harmony since both pulmonic and ejective stridents must agree for this feature while only pulmonic coronals participate in stricture harmony. I have chosen to describe the minor place harmony using the feature [anterior], with alveolar segments being [+anterior] and postalveolar segments being [-anterior].

The diagram in (15) below illustrates a hierarchy of features for Yucatec. I only consider consonantal segments, ruling out /j, w, h, ?,/ the lateral /l/ can similarly be uniquely specified by use of the feature [+lateral]. The values for these features is not terribly important to this analysis; however, caution should be taken since potential processes may class these segments in specific ways. Later I will show that for some non-harmonic alternations in Yucatec the specifications below function well. At the top node, all of the relevant segments are grouped together. The first division is [dorsal] which results in all segments being contrastive for this feature. The next division is [labial] which only applies to [-dorsal] segments. Next the [-dorsal] segments are divided by [nasal], resulting in unique specifications for /n, m/. The remaining [-nasal] segments are further divided by [delayed release]. The [-del. rel.] segments are then divided by [continuant]. Both [+del. rel.] and [-del. rel., +cont.] segments are then divided by [anterior] to the exclusion of [-del. rel., -cont.] segments (i.e. /t, t’/). Finally, [voice] divides /b/ from the other [+labial, -nasal] segments, uniquely specifying it. The final division is [constricted glottis] which divides the relevant pairs of consonants which differ only in ejectivity.
The hierarchy proposed above classes segments together based both on value of a feature and being values for that feature. That is to say, there is a class of segments which are contrastive for [constricted glottis], namely /p, p’, t, t’, k, k’, ts, ts’, tʃ, tʃ’/. There is also a class of segments which is [-constricted glottis], namely /p, t, k, ts, tf/. Being able to reference both types of groups gives
us the ability to capture all of the alternations observed in Yucatec. Since [del. rel.] was separated before any division was made between obstruents and continuants, segments like /t/ are valued for this feature. This will help capture the fact that it participates in stricture harmony. Likewise, since [anterior] is lower than [del. rel.], /t/ is not valued for this feature. This will help capture the fact that /t/ does not participate in coronal minor place harmony.

3.2 Co-occurrence restrictions in an OT framework

In standard accounts of long distance harmony, restrictions are captured using a two part system (Rose and Walker, 2004; Hansson, 2010). One family of constraints imposes a relation between similar consonants while another family of constraints forces features on related consonants to agree. This approach hinges on a computation of similarity (Frisch et al., 2004). Since I do not capture similarity by calculating shared features, but rather through natural classes and minimally different pairs, I do not need set any segments in correspondence (Mackenzie, 2009).

As was shown above, the only segments which participate in laryngeal harmony are those with a partner that minimally differs in value for [constricted glottis]. The restriction does not allow homorganic constants to differ for ejectivity within a root; furthermore, it bans ejectives from differing in place and manner. The first part of the restriction can be easily captured with a constraint like the one given in (16) below:

\[
\text{*(αCG)|[-αCG]_{root}: for segments that minimally differ in their value for [constricted glottis], differing values of [constricted glottis] are banned within a root.}
\]

The second part of the restriction can be captured by a restriction targeting [+constricted glottis] segments. As it has been observed, ejective segments within a root must be identical. The restriction in (17) below obtains identity by banning [+constricted glottis] segments from varying in other features and feature values.

\[
\text{(17) *αCG}_{\text{root}}: for segments that minimally differ in their value for [constricted glottis], differing values of [constricted glottis] are banned within a root.}
\]

---

2This constraint is a slight alteration of a similar constraint proposed by Mackenzie (2009) for the language Bumo Izo and Kalabari Ijo. She notes that her variation is similar to AGREE[F]; however, my variation is further targeted to only bar distinct specifications of [constricted glottis] for segments which differ only in their value for that feature.
(17) \( *[+CG] \text{NON-IDENTITY}_{\text{root}} \): for segments that are [+constricted glottis], all other features must be identically valued.

In Yucatec there is no evidence that \( *[+CG] \text{NON-IDENTITY}_{\text{root}} \) and \( *[^\alpha CG][-\alpha CG]_{\text{root}} \) are distinct constraints. For the purpose of this analysis I will treat them as a conjoined constraint, LARYNGEAL HARMONY, shown in (18).

(18) LARYNGEAL HARMONY: for segments that minimally differ in their value for [constricted glottis], differing values of [constricted glottis] are banned within a root; for segments that are [+constricted glottis], all other features must be identically valued.

The tableaux below illustrate that LARYNGEAL HARMONY only permits two consonant roots with single ejectives that are not homorganic with the second consonant, or roots with two homorganic ejectives. In the tableaux below, LARYNGEAL HARMONY is ranked above IO-IDENT[CG], the faithfulness constraint which penalizes changes in the value of [constricted glottis]. The tableaux in (19) shows that heterorganic consonants do not need to agree for ejectivity. The tableaux in (20) shows that homorganic consonants that contrast only in value for [constricted glottis] must be ejective; this is captured by ranking the faithfulness constraint IO-IDENT[+CG] above IO-IDENT[-CG]. This pair of constraints are value specified faith constraints. Finally, the tableaux in (21) shows that ejective consonants in a root must agree in place and manner.

(19) Heterorganic consonants

<table>
<thead>
<tr>
<th>p...k'</th>
<th>LARYNGEAL HARMONY</th>
<th>IO-IDENT[+CG]</th>
<th>IO-IDENT[-CG]</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. p...k'</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. p'...k'</td>
<td>*!</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. p...k</td>
<td>!</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(20) Homorganic consonants

<table>
<thead>
<tr>
<th>p...p'</th>
<th>LARYNGEAL HARMONY</th>
<th>IO-IDENT[+CG]</th>
<th>IO-IDENT[-CG]</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. p...p'</td>
<td>*!</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. p'...p'</td>
<td>*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. p...p</td>
<td>!</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
(21) Heterorganic ejective consonants

<table>
<thead>
<tr>
<th>p’...k’</th>
<th>LAR HARMONY</th>
<th>IO-IDENT[+CG]</th>
<th>IO-IDENT[DOR]</th>
<th>IO-IDENT[LAB]</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. p’...k’</td>
<td>*!</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. p...k’</td>
<td>*!</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. p’...k</td>
<td>*!</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>d. p’...p’</td>
<td>*!</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>e. k’...k’</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Since the restriction is not active there is no good way to decide which the direction the repair goes in. For instance in the tableaux in (20) I chose to rank constraints in a way the favors assimilation. Similarly, in (21) it is not clear if the consonant’s place and manner change or if the laryngeal quality changes. I have chosen to prefer place assimilation over [constricted glottis] dissimilation; I have also ranked IO-IDENT[DOR] > IO-IDENT[LAB] only in order to be able to choose between assimilation to labial place or dorsal place. Again, it’s not clear what sort of empirical evidence would motivate these choices. I have made them purely for expository purposes⁴.

Returning to the tableaux in (19), [p...k’], the fully faithful output is the winner since it violates none of the markedness constraints or faithfulness constraints. In the tableaux in (20) either of the candidates which do not violate LARYNGEAL HARMONY could potentially win since it is ranked higher than any faithfulness constraint. Similarly for candidates in (21) that do not violate LARYNGEAL HARMONY.

Minor place harmony among coronal stridents is easy to capture with the contrastive features calculated above. Recall that only the segments /s,ʃ,ts,ts’,tʃ, tʃtʃ/ are specified for [anterior]. The set of consonants which are subject to the restriction is exactly those which are specified for [anterior]. We can capture the restriction with a constraint like the one in (22).

(22) *[αANT][¬αANT]root: differing values of [anterior] are banned within a root.

The tableaux in (23) below illustrates that the constraint given above rules out exactly the unattested

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⁴There are other issues with the particulars of the faithfulness constraints that need to be ironed out. For instance, the segment /k/ is not specified for any value of labial. I stress again that these constraints are only presented in order to show tableaux with a clear optimal candidate. Also note that Gallagher and Coon (2009) seem to preferentially assimilate to the first consonant in a root in their examples without clear motivation for directionality in the constraints. I have followed this convention.
root patterns in Yucatec. For any two segments that are specified for [anteriority], they must have identical values.

(23) Strident harmony

<table>
<thead>
<tr>
<th>s...tʃ’</th>
<th>*[α\text{ANT}][-α\text{ANT}]_{\text{root}}</th>
<th>IO-\text{IDENT}[+\text{ANT}]</th>
<th>IO-\text{IDENT}[-\text{ANT}]</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td>s...ts’</td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>b.</td>
<td>s...tʃ’</td>
<td>*!</td>
<td></td>
</tr>
<tr>
<td>c.</td>
<td>tʃ...tʃ’</td>
<td></td>
<td>*!</td>
</tr>
</tbody>
</table>

The same issue with directionality arises in this case. Importantly, even ejective segments participate in this harmony since they are values for [anterior]. Note that we do not need to worry about stricture harmony applying in the above case since it is sensitive to ordering.

Stricture harmony applies only to plumonic coronal segments. The set of segments specified for [delayed release] is /t, t’, ts, ts’, tʃ, tʃ’, s, ʃ/; since only the pulmonic subset participate in this harmony we must rule the glottalized variants from needing to agree in [delayed release]. Furthermore, the restriction is directional. Participating segments that follow a pulmonic affricate must agree in stricture; segments preceded by a pulmonic affricate do not need to agree in stricture. We can formalize this with a constraint like the one in (24) below.

(24) *[+\text{DEL. REL.}-\text{CG}][-\text{DEL. REL.}-\text{CG}]_{\text{root}}: for segments that are [-constricted glottis] and specified for [delayed release], a negative value of [delayed release] cannot occur after a positive value within a root.

The tableaux in (25) below illustrates that the constraint given above rules out exactly the unattested root patterns in Yucatec. The tableaux in (26) shows the interaction between strident and stricture harmony.

(25) Stricture harmony

<table>
<thead>
<tr>
<th>ts...t</th>
<th>*[+\text{DR.}-\text{CG}][-\text{DR.}-\text{CG}]_{\text{root}}</th>
<th>IO-\text{IDENT}[+\text{DR.}]</th>
<th>IO-\text{IDENT}[-\text{DR.}]</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td>tʃ...ts</td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>b.</td>
<td>ts...t</td>
<td>*!</td>
<td></td>
</tr>
<tr>
<td>c.</td>
<td>t...t</td>
<td></td>
<td>*!</td>
</tr>
</tbody>
</table>
In the second tableaux above, we see that strident harmony and stricture harmony intersect. The winning candidate in (26) agree in both anteriority and stricture. The losing candidates all violate either the constraint that enforces stricture harmony, strident harmony or a highly ranked faithfulness constraint. This tableaux also does provide evidence that positively values IO-IDENT[+F] constraints ought to be ranked above their negatively valued counterparts since violating the positive variant should prevent forms like /tʃ...tʃ/ but allow forms like /ts...ts/ when the initial affricate was [+anterior]

### 3.3 Nasal place assimilation

In the preceding section I have shown how contrastive features are calculate and the simple yet empirically motivated constraints that can be formulated to account for co-occurrence restrictions in Yucatec. One of the powerful empirical predictions which the contrastivist hierarchy makes is that only contrastive features are active in the phonology. The data from Yucatec illustrates this in two ways. The first is through the exclusion of the voiced implosive bilabial stop /ɓ/. In a system that must full specify each segment, /ɓ/ would have a value of [+constricted glottis] and would therefore participate in the laryngeal co-occurrence restriction as it is currently formalized; however, using contrastive specifications we can exclude it from the set of segments which contrast
for [constricted glottis]. We can also show that the features are those needed by the phonology by examining a process other than harmony.

All nasal segments assimilate to the place of following consonants in word final position (Bricker et al. 1998). Before /b, p, p'/ nasals become /m/, before /t, t’, ts, ts’, tf, tʃ’, s, ʃ, l, j/ nasals become /n/ and before /k, k’, h, ?, w/ nasals become [ŋ]. Sequences of nasals in word final position followed by nasal onsets seem to dissimilate regressively. Below I have schematized this alternation.

\[
\begin{align*}
(27) \text{Nasal place assimilation} & \\
& a. \text{ } n \rightarrow m \_ \_ \# \{ b, p, p' \} \\
& b. \text{ } m \rightarrow n \_ \_ \# \{ t, t’, ts, ts’, tf, tʃ’, s, ʃ \} \\
& c. \text{ } N \rightarrow ñ \_ \_ \# \{ k, k’ \} \\
(28) \text{Nasal place dissimilation} & \\
& a. \text{ } n \rightarrow m \_ \_ \# \{ n \} \\
& b. \text{ } m \rightarrow n \_ \_ \# \{ m \} \\
& c. \text{ } N \rightarrow ñ \_ \_ \# \{ k, k’ \}
\end{align*}
\]

Since I have not overtly given feature specifications for /h, ?/ or /l, j/ I will not discuss them here; it is not difficult to see where [lateral] would need to be placed in the hierarchy to allow it to act like other coronal segments. We might consider the velar allophone to arise from two disjoint environments or slightly rearrange the hierarchy in order to specify /h, ?/ for [+dorsal]. In any case, we have the correct features specified to trigger assimilation to labial place for the set that triggers assimilation /b, p, p’/ are all [+labial]. Similarly, the set that trigger velar place assimilation, /k, k'/ are all [+velar]. The final set, /t, t’, ts, ts’, tf, tʃ’, s, ʃ/ all share [-velar, -labial] specifications. In the same fashion when a [+nasal] segment is followed by an identical nasal segment they must dissimilate.

4 A comparison of other approaches to similarity and identity

In the preceding section I have argued that only contrastive features should be present in segmental representations and adopted the contrastive hypothesis in claiming that the only features which the phonological system of a language operates over are contrastive features (Dresher,
2009). This approach elegantly captures similarity by reference to minimally contrasting pairs and natural classes rather than computing the number of shared features between two segments. In this section I will present a correspondence based approach, focusing on the representational issues in computing similarity and compare this to the contrastive approach (Hansson, 2010; Rose and Walker, 2004; Frisch et al., 2004). I will then present a linking based analysis and compare the claims about identity to the conclusions we can draw from the analysis presented to this paper (Gallagher and Coon, 2009).

4.1 A correspondence based approach to Yucatec

In a standard long distance approach to consonant harmony segments are put into a relation with one and other based on similarity. The relation is known as correspondence, more specifically output-output correspondence since the segments in question are both outputs of the grammar. The key to this approach is that correspondence is enforced between similar segments, with segments that are more similar having more highly ranked correspondence constraints.

Three features are subject to co-occurrence restrictions in Yucatec, [constricted glottis], [anterior] and [delayed release]. In addition, place must harmonize for [+constricted glottis] within a root. This means that four CC-CORRESPONDENCE constraints and CC-IDENT constraints are needed. The ranking of these constraints with relation to input-output feature faithfulness constraints is the bread and butter of a correspondence analysis. The CC-CORR constraints needed to capture the three harmony systems analyzed in this paper are given in (29) below and the CC-IDENT constraints are given in (30)\(^4\).

(29) a. CORR-[+CG]  
    b. CORR-[PLACE]  
    c. CORR-[+CORONAL,-CG]  
    d. CORR-[+STRIDENT]  

(30) a. CC-IDENT[PLACE]  
    b. CC-IDENT[ANTERIOR]  
    c. CC-IDENT[DELAYED RELEASE]  
    d. CC-IDENT[CG]  

\(^4\)I am borrowing the notation used by Hansson (2010); CORR-[F]: any two segments that differ only in value for [F] must be in correspondence.
The correspondence based analysis of laryngeal harmony is shown in (31) and (32). Laryngeal harmony can be enforced by ranking $\text{CORR-}[+\text{CG}], \text{CORR-}[\text{PLACE}] > \text{CC-IDENT}[\text{CG}], \text{CC-IDENT}[\text{PLACE}] > \text{IO-IDENT}[\text{CG}], \text{IO-IDENT}[\text{PLACE}]$. Note that the $\text{CORR-}[\text{F}], \text{CC-IDENT}$ and $\text{IO-IDENT}$ constraints are unranked amongst themselves.

\[
\begin{array}{|c|c|c|c|}
\hline
\text{p'...p} & \text{CORR-}[\text{PLACE}] & \text{CC-IDENT}[\text{CG}] & \text{IO-IDENT}[\text{CG}] \\
\hline
\text{a. } & \text{p'...p_x \ldots p'_x} & & * \\
\text{b. } & \text{p'...p_x \ldots p_x} & *! & \\
\text{c. } & \text{p'...p'_x \ldots p'_y} & *! & \\
\hline
\end{array}
\]

The correspondence based analysis of strident harmony is shown in (33). Minor place harmony can be enforced by ranking $\text{CORR-}[\text{STRIDENT}] > \text{CC-IDENT}[\text{ANTERIOR}] > \text{IO-IDENT}[\text{ANTERIOR}]$. The desired effect is that even consonants that differ for ejectivity must agree in anteriority.

\[
\begin{array}{|c|c|c|c|c|}
\hline
\text{p'...k'} & \text{CORR-}[\text{PL}] & \text{CORR-}[+\text{CG}] & \text{CC-IDENT}[\text{CG}] & \text{IO-IDENT}[\text{CG}] \\
\hline
\text{a. } & \text{p'...p'_{x...p'_x}} & & & * \\
\text{b. } & \text{p'...k_x} & & *! & \\
\text{c. } & \text{p'...p'_{x...p'_y}} & *! & & * \\
\hline
\end{array}
\]

Stricture harmony is a bit more tricky in Yucatec than either laryngeal or strident harmony. Briefly recall that sequences like /tS...s/ harmonize to [tS...tS] while sequences like /S...tS/ do not change. The tableaux in (34) below considers the simple case of /tS...s/, the tableaux in (35) considers the move complex case of /S...tS/. The ⊗ symbol indicates a grammatical candidate which the grammar did not select as an optimal output.
Since standard correspondence functions in only one direction regardless of consonant ordering (assimilation to one feature preferentially), we cannot capture the fact that stricture harmony is only progressive in Yucatec. Hansson (2010) offers an alternate system which can capture directionality effects in a slightly modified framework; however, the system becomes quite bloated. In comparison, the analysis which assumes contrastive features places the onus not on the system, but on the representations. It correctly predicts the harmony as observed in Yucatec.

The more similar two segments are, the more likely they are to correspond. Evidence from speech errors show that slips of the tongue occur more frequently between segments that are already highly similar Hansson (2010). The importance of similarity is undeniable in long distance harmony processes; however, few analysis of these phenomena clearly spell out how it is computed. Rose and Walker (2004) take the stance that the ranking of CC-CORRESPONDENCE constraints are universal. This hypothesis is at odds with the contrastive approach taken in this paper. The contrastive hypothesis claims that feature hierarchies may differ across languages with identical inventories. This has been shown to hold for a variety of features (Dresher, 2009). Since similarity is captured by natural classes it does not have to be the case that the same segments will be judged as similar in all languages. For instance, Chol, a Mayan language related to Yucatec, has a similar set of co-occurrence restrictions. The consonant inventory of Chol, shown below in (36), is practically identical to the inventory to Yucatec.
This inventory differs from Yucatec only in palatalizing coronal obstruents, which are not encoded phonologically according to Gallagher and Coon (2009). We might therefore expect that the co-occurrence restrictions should function over the same set of segments, even if they differ in directionality. In Chol, stridents are described being required to be totally identical within a root, as shown in the data below.

(37) Chol strident identity

a. sos ‘gizzard’
   tsats ‘sartinde’
   faʃ ‘stain’
   tfʃʃ ‘older sister’

b. *sots
   *tfʃʃ
   *tfʃʃ
   *ʃʃʃʃ

I analyze the proposed total identity as two overlapping co-occurrence restrictions. Namely, anterior harmony and stricture harmony, as in Yucatec. Where Chol differs is that stricture harmony is bidirectional rather than strictly progressive. The disjunction between these restrictions are observable in ejective stridents; like in Yucatec, only pulmonic affricates trigger stricture agreement, but both ejective and pulmonic affricates trigger anteriority harmony. Interestingly, while /tʃ/ participates in stricture harmony in Yucatec, the analogue /tʃ/ does not participate in stricture harmony in Chol. This differing activity can be easily captured by dividing [delayed release] after [strident], as shown below.
Under this analysis we do not need to reformulate or reorder any constraints. We have excluded /t̪/ from stricture harmony simply by removing it from the set of segments which are contrastive for [delayed release]. I take this case, in conjunction with the Yucatec analysis, as evidence that similarity is a function of contrastive specifications rather than a measure of shared features (Frisch et al., 2004).

### 4.2 A linking based approach to Yucatec

In the linking analysis proposed by Gallagher and Coon (2009), only one identity constraint is needed, similar to MacEachern (1999)’s proposal. The LINK-CC family of constraints functions essentially the same way as CORR-CC and are based on computations of similarity. Setting aside issues of similarity, which I have previously discussed, only one constraint holds for linked consonants, IDENTITY. This constraint simply states that any two linked consonants must be identical. The IDENTITY constraint is ranked under LINK-CC and above feature faithfulness in order to obtain total identity between linked consonants.

For Chol, since stricture harmony gives rise to total identity, Gallagher and Coon (2009) are able to use linking to account for it. In Yucatec, stricture harmony is unidirectional and therefore the same challenges which are posed to a standard correspondence analysis are present for linking.
As far as I know there is no ordering analysis that utilized linking. It may be the case that linking can only function in cases that are adirectional. If this were true then we should question why a process is captured by linking in one language while it is only partial identity in another when we can already differentiate the two by reference to directionality/lack of directionality.

**Identity** captures part of the laryngeal harmony system of Yucatec. Namely it can capture the fact that ejective segments must be identical; it does not seem to be able to capture the fact that when a root contains two homorganic consonants they must have the same value for [constricted glottis]. This portion of the harmony is not present in Chol and therefore the analysis is less problematic for that language. For Yucatec a second constraint would still be needed to prevent differing values of [constricted glottis] for homorganic segments.

Gallagher and Coon (2009) argue that a single constraint inducing total identity more cleanly captures the nature of the laryngeal harmony system of Chol than multiple feature identity constraints as in the standard correspondence approach modeled above. This argument is motivated by the claim that no language exist which make use of only one of the feature identity constraints and that they must therefore pattern as a set. While it may be true that Gallagher and Coon (2009) have identified languages which do not appear to make use of individual feature identity constraints, they also considered fully specified inventories. As a future goal, a contrastive analysis of those systems may show that there are indeed single feature motivations. With the Gallagher and Coon (2009) proposal in mind, one expects to find languages which only make use of total identity constraints and no additional harmony systems. They additionally claim that harmony that is not total identity must be local spreading.

In this section I have examined alternate approaches to Yucatec consonant harmony processes. In particular I examined how a correspondence based system can use feature identity and how similarity is computed in such a system. I showed that languages with practically identical inventories can have differing phonological activity. I examined a linking based analysis of Yucatec identity and proposed that linking suffers from the same faults as correspondence, namely that it is not driven by a clear notion of similarity.
5 Conclusion

In this paper I have presented and argued for contrastive feature specifications as a measure of identity in consonant harmony in Yucatec. I compared my approach with a standard correspondence approach and a linking based approach, focusing on metrics of similarity and the status of total identity.

My proposal follows the work of Mackenzie (2009) in attempting to place some of the burden of phonology on representations rather than mechanisms. To this end, I have proposed an analysis that does not require any special relation to be established between segments by the grammar. Rather this relationship of similarity is captured by natural classes and minimally differing feature sets. I also argue against the claim that total identity is a process independent from partial feature identity on the grounds that partial identity constraints gang up to for total identity, and if formulated correctly may not pose issues for typology. On the other hand, I question if systems with only total identity can be found.

References


