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1 Introduction

This study of Vowel Harmony (VH) bears on the constraints that regulate harmonic processes. The language under consideration is Assamese (Indo-Iranian, spoken in the Eastern state of Assam in India). Vowel Harmony in Assamese has only been marginally described in the literature. Descriptive grammars by Kakati (1941) and Goswami (1982) noted how vowels of only certain qualities occurred in the presence of high vowels.

I show that [ATR] harmony in Assamese can be explained in an Optimality Theory framework by building on basic markedness and faithfulness constraints. In Assamese, [e] and [o] always emerge as a result of harmony and the occurrences of these vowels are confined to the prominent positions only. Strong positions harmonize with the trigger, and interestingly in Assamese adjacent syllables also "co-harmonize" with the strong position. To ignore the positionally determined behaviour of these mid vowels would mean an analysis devoid of significant explanatory depth. In this analysis it is proposed that it is desirable to avoid [e, o] in post-tonic positions because of the markedness of ATR/Low in that position. Furthermore, it is shown that the vowel in the post tonic position is always faithful in this kind of harmony. Casting an analysis in terms of positional licensing (Zoll 1998, Walker 2005) would not capture this essential fact.

2 The Data[1]

Assamese has eight oral vowels [i, e, ɛ a, ɔ, o, ɵ, u]. The surface representations of Assamese vowel features are shown in Table 1. The feature set which triggers change is [+High, +ATR] — /i/ and /u/, highlighted in Table 1. [+ATR] mid vowels are found only in harmony induced conditions. A harmonic [+ATR] domain is always the output domain of VH.

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[1]Data are from Kakati (1941) and Goswami (1980) and also supplemented by additional data from friends and family of the author.

	/i/	/e/	/ɛ/	/a/	/u/	/o/	/ɔ/	/ɵ/
[high]	+	-	-	-	+	-	-	+
[low]	-	-	-	+	-	-	-	-
[ATR]	+	+	-	-	+	+	-	-
[front]	+	+	+	-	-	-	-	-

Table 1:   Vowel features

(1)   Regressive assimilation: /i/ suffixation

	Root	Gloss	Suffix	Derivation	Gloss
a.	pʰédɛla	'ugly' (masc)i		pʰédeli	'ugly' (fem)
b.	gérɛla	'fat' (masc) i		géreli	'fat' (fem)
c.	sésɔr	'crawl' (masc)i		súsori	'crawl' (inf)

(2)   Occurrences of [e] and [o] in underived words

	Root	Gloss
a.	béli	'sun'
b.	pélu	'worm'
c.	tételi	'tamarind'

(3)   Occurrences of /ɛ/ and /ɔ/

	Root	Gloss
a.	tɛ́rɔ	'thirteen'
b.	bɛtɔ́n	'salary'
c.	xɔpén	'dream'

The mid vowels /ɛ/ and /ɔ/ and the high vowel /ɵ/ are the targets of leftward spreading only. There is no harmony when the potential triggers do not appear on the right.

(4)   Disharmony if the triggers are not on the right side

	Root	Gloss	Suffix	Derivation	Gloss
a.	kín	'buy'	ɛ	kínɛ	'buy'(3P Present)
b.	kín	'buy'	ɛ	kínɵ	'learn'(3P Present)
c.	bʰút	'ghost'	ɛ	bʰútɛ	'ghost' (ergative)

(5)   Non-existing Assamese words
a.   *tero
b.   *beton
c.   * poxek

(6)   The low vowel /a/ blocks [+ATR] harmony from spreading.

	Word	Gloss
a.	mɔ́dahi	'drunkard'
b.	zékari	'to shake'
c.	pɛ́tari	'covered cane basket'

(7)   The data above show that:

a.   Harmony is regressive (neither stem controlled nor dominant recessive)

b.   The harmony process always targets the vowels /ɛ/, /ɔ/ and /ɵ/ resulting in the surface realization of [e], [o] and /u/ respectively, depending on the presence of a following [+ATR, +hi] vowel.

2.1 Stress in Assamese

Main stress is assigned to the initial syllable[2]. Morphologically, stress shifts to the initial syllable under prefixation. Stress is not sensitive to affixation and the initial syllable is always the stress bearing syllable regardless of its morphological status. In a sequence of open syllables, stress assignment is in the following manner:

(8)   Stress in Assamese

a.   bɔ́ga   'white'

b.   bósori 'yearly'

Stress in Assamese is a low level event with a low pitch at the left word edge indicating prominence and the high pitch associated with the right edge of a phrasal domain. (Mahanta 2002).

I follow Walker (2005) in the use of the term post-tonic so as to indicate that the position of the triggering vowel is final. In some cases the syllable bearing the main stress may not be adjacent to the triggering vowel, but the adjacent syllables in between (as in (8) b.) will also undergo harmony. This analysis does not offer a foot-based solution, so the exact place of the post-tonic in metrical representations will not be considered to be of primary importance here. I also use the terms non-prominent and post-tonic complementarily, as both indicate the weak position of the triggering element.

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[2]Weight-bearing syllables attract stress as shown in (3) b. and (3)c. But weight related effects will not be discussed in this paper.

3 Positional Faithfulness vs. Positional Markedness in VH

VH has been shown to be controlled by a vowel in a strong position (qua Beckman 1997 and others). Beckman's (1997) Faithfulness constraints preserve contrasts in strong positions only and do not enforce any specific kind of unfaithfulness. They can prevent some unfaithful elements from surfacing but unlike markedness constraints, they cannot enforce restrictions on the surface output. On the other hand, positional markedness constraints can promote unfaithful candidates over faithful ones. Neutralization and allophony processes require restrictions on possible outputs. Therefore allophonic neutralization in prominent positions must be the consequence of markedness constraints specific to those positions (Kager 1999 etc.)

I will argue that in Assamese VH the motivation for regressive VH lies on a high ranked positional markedness constraint restricting the distribution of marked segments to those positions. This controls the allophonic behaviour of [e] and [o] which occur only in a prominent domain. On the other hand, a highly ranked positional faithfulness constraint on the post-tonic vowel controls the /ə/ →/u/ alternation. Note that neither /ə/ nor /u/ is allophonic. Therefore, excluding either positional markedness or positional faithfulness constraints will be insufficient as analytic tools for the harmonic alternations attested in Assamese.

The observed facts therefore, run counter to several propositions on prominent and non-prominent neutralizations proposed within OT. One of the arguments in this paper is that both positional markedness constraints and positional faithfulness constraints *can* refer to unstressed or non-prominent positions. In the compositional model of CON proposed by Smith (2004), positional constraints which refer to weak positions are supposed to be banned as they do not lead to the simplification of an OT grammar. The present work shows that a grammar may also express certain features in terms of weak positions. Work by Hyman (2001), Krämer (2003), Steriade (1994) etc. show that final positions also show faithfulness properties by resisting neutralization and also showing more contrasts (Barnes, 2002). Contrary to Beckman (1997), the present work shows that the positional faithfulness of a vowel in a non-privileged position can also determine harmony.

3.1 Agreement, Markedness and Faithfulness

The pertinent agreement constraint AGREE [ATR] and an appropriate local conjunction of markedness and faithfulness always prefer the candidate with assimilation to [+ATR] when assimilation is necessary - that is, when the vowels of a word underlyingly disagree in terms of [ATR]. The local conjunction solution correctly predicts the avoidance of the marked result. But as I will discuss later in this paper, a highly ranked positional markedness constraint is decisive whenever harmony of the allophonic neutralization kind occurs, but a positional faithfulness constraint is operational in the selection of non-allophonic kind of harmonization. In Assamese, harmony is shaped primarily by the constraint AGREE [ATR].

(9)   AGREE [ATR]: Adjacent segments must have the same [αF] value
       of a feature

In a [-ATR] harmonic domain, [-ATR] vowels do not change their underlying values. ID [ATR] can be held responsible for the vowels retaining their underlying values in the absence of any harmony inducing high vowel.

(10)   ID [ATR]: A segment in the output and its correspondent in the input
       must have identical specifications for [ATR].

Only [ATR] features are subject to alternations. In no harmonic domain do segments change their height features under harmonic conditions. One of the relevant constraints is ID [Hi] which preserves the height features of the input.

(11)   ID [Hi]: A segment in the output and its correspondent in the input
       must have identical specifications for [Hi].

However for vowels with [-ATR] values, satisfaction of the constraint inducing harmony is more important than maintaining underlying distinctions. Otherwise harmony would not be attested at all. Therefore, AGREE [ATR] is ranked above ID [ATR]. In Assamese, there are no advanced high vowels which are front. This is related to the articulatory constraint that it is marked to have retracted tongue root and feature [front] together. More specifically, an amalgamation of the two articulatory constraints in Archangeli and Pulleyblank (1994):

(12)   If [+high] then [+ATR]; if [+high] then not [-ATR]

(13) If [-back] then [+ATR]; if [-back] then not [-ATR]

The non-emergence of the vowel /ɪ/ is an effect of the undominated con-
straint which bans the occurrences of [-ATR -back] vowels, allowing for a
grammar in which the markedness constraint given below is ranked above
the harmony constraint.

(14) *[-ATR, +Hi, -back]: The feature value [-ATR] is marked in [+Hi]
      and [-Back] vowels (from Archangeli and Pulleyblank 1994)

Bringing all these assumptions together, we arrive at the following hierarchy
of constraints.

(15) ID [Hi], *[-ATR +hi –back] >> AGREE [ATR] >> *[+ATR –hi] >>
      ID[ATR]

Input: /kɔr /+/i/ 'do'+1P	ID [hi]	*[-ATR +hi -back]	AGREE [ATR]	*[+ATR -hi]	ID [ATR]
a. ☞kóri				*	*
b. kóri					
c. kóʀɪ		*!			*
d. kúri	*!				*

3.2 ATR Harmony and the Low Vowel

As already stated, the presence of the vowel /a/ does not result in vowel har-
mony. The constraint which prevents the [ATR] values of low vowels form
changing is the one below (Archangeli and Pulleyblank 1994:178)

(16) *[+ATR,+Low]: The feature value [+ATR] is marked in [+Low]
      vowels.

The non-involvement of /a/ is accounted for by a high ranked *[+ATR,
+low] constraint.

3.3 ATR Harmony in the Presence of Mid Vowels

The grounding conditions in Archangeli and Pulleyblank pertain to the fact
that tongue root advancement ([ATR]) and tongue body raising (Height) ges-

tures are articulatorily compatible, while the combination of tongue root advancement ([ATR]) and tongue body lowering ([low]) are articulatorily opposite. Their constraints of the type ATR/Low (see above in 12 and 13), prohibit the [-ATR] feature specification from co-occurring with a [-low] specification. Therefore, at this stage another feature co-occurrence constraint becomes relevant.

(17)   *[+ATR, -hi]: The feature value [+ATR] is marked in [-hi] vowels.
       (Archangeli and Pulleyblank 1994)

To ensure that this constraint restricts the inventory in the face of hypothetical inputs let us assume inputs where all vowels are [+ATR-hi]. Though a highly ranked AGREE [ATR] would try to enforce agreement, *[+ATR, -Hi] would prevent multiple occurrences of [e] and [o] in order to gain agreement in terms of [-ATR].

(18)   Hypothetical input: /tero/

Input : /téro/	ID [hi]	*[-ATR, +hi, -back]	AGREE [ATR]	*[+ATR, -hi]	ID [ATR]
a. téro				**!	
b. téro			*!	*	*
c. ☞ térɔ					**

(18) shows that the constraint *[+ATR, -hi] prohibits output occurrences of [e] and [o] and AGREE [ATR] penalizes non-harmonicity. At this stage, it is clear that it is important to agree in terms of [ATR] rather than assuming ATR/Low values.

3.4 ATR Harmony in the Presence of High and Mid Vowels

In order to evaluate an input candidate with a [-ATR] mid vowel and a [+ATR] high vowel we need to invoke the local constraint conjunction of *[+ATR -hi] and ID [ATR]. I will briefly define Local Constraint Conjunction (LCC) and its relevance here:

(19)   Definition: Local conjunction is an operation on the constraint set
       forming composite constraints:

Let C_1 and C_2 be members of the constraint set *Con*. Then their local conjunction C_1 & $_1C_2$ is also a member of *Con*
(Ito and Mester 1998:10)

For a proper violation of the local conjunction constraint, the constraints C_1 and C_2 both have to be violated. If either C_1 or C_2 are respected then the conjunction is satisfied. This constraint conjunction is ranked higher than the individual constraints C_1 and C_2. But the conjoined constraint is also higher to than some other constraints which are not C_1 and C_2. The domain of local conjunction is restricted to the segment (Lubowicz, 2002), Bakovic (2000) etc,) and both the conjoints of the conjunction also share a common argument (Bakovic 2000, Crowhurst & Hewitt 1996)

I will follow Lubowicz (2003) proposal of constraint conjunction of relevant markedness and faithfulness constraints to prevent marked vowel features from derived environments.

(20)   *[+ATR –hi] & ID [ATR]: If a segment violates *[+ATR –hi], then it must not also violate ID [ATR] and vice versa.

This conjunction will be violated by [+ATR] outputs whose input correspondents were [-ATR]. This constraint prohibits /ɛ/ → [e] and /ɔ/ →[o] alternations as they will violate both *[+ATR –hi] and ID [ATR].

(21)   *[+ATR –hi] & ID [ATR] >> AGREE[ATR]

Input: /kin/+/ɛ/	ID [Hi]	*[-ATR, +hi, -back]	*[+ATR -hi] & ID [ATR]	AGREE [ATR]	*[+ATR -hi]	ID[ATR]
a. ☞kínɛ				*		
b. kíne			*!		*	*
c. kíne		*!	*	*	*	**
d. kínɛ		*!				*
e. kíni	*!					*

*[+ATR –hi] & ID [ATR] restrict occurrences of ATR/Low vowels which were not present in the input. But what about inputs with [e] and [o] which Richness of the Base might present in the generation of the optimal output candidate? The local constraint conjunction of *[+ATR –hi] and ID [ATR] will not effectively constrain the occurrences of [e] and [o], if presented with a hypothetical input candidate with [e] and [o] (in a non-neutralized context). This can be combined into a positional markedness constraint which prevents the occurrences of ATR/Low in a post-tonic position.

(22)   *[+ATR, -hi] / post-tonic: Do not violate *[+ATR, -hi] in a post-tonic position

This positional markedness constraint involves the compliance of articulatory and acoustically grounded factors alongwith stress related factors. Notice that this sort of licensing clearly restricts the vowel inventory for post-tonic positions relative to their ATR-ness. This is also similar to the cases of Slovene and Ojibwa (as proposed by Crosswhite, to appear) where [+ATR, -hi] does not occur in monomoraic positions and [high] and [front] do not occur in unstressed monomoraic positions respectively.

(23)   *[+ATR –hi]/pot-tonic restrict marked feature combinations

Input: /kin/+/e/	ID [Hi]	*[-ATR, +hi, -back]	*[+ATR -hi]/post-tonic	*[+ATR -hi] & ID [ATR]	AGREE [ATR]	*[+ATR -hi]	ID[ATR]
a. ☞kinɛ					*		*
b. kine			*!			*	
c. kíne		*!	*		*	*	*
d. kínɛ		*!					**
e. kíni	*!						

The constraint *[+ATR –Hi] / post-tonic restrict output patterns like /kine/ in post-tonic positions preventing the hypothetical input candidate from being the perfect correspondent of the output of this evaluation The constraint *[+ATR –Hi] & ID[ATR] is vacuously satisfied by the optimal output /kinɛ/, as it violates the low ranked conjunct ID[ATR] and not the entire conjunc-

tion. For the generation of the proper harmonic output, the locally conjoined constraint and the positional faithfulness constraint restrict the occurrences of [+ATR –Hi] in post-tonic positions.

3.5 ATR Harmony and the High Vowel /ɵ/

We have not yet assessed inputs where one of the vowels is the [-ATR +hi] vowel /ɵ/. The constraint hierarchy till now do not make any reference to the input – output correspondence of [-ATR +hi, +back] vowel /ɵ/. Under harmony, /ɵ/ always changes to /u/, an unmarked vowel which is not subject to any special feature co-occurrence constraint. The unmarked status of /u/ is also supported by the fact that /u/ is not subject to any positional restrictions in its occurrences. It is only /ɵ/ which undergoes harmony, but there are no positional restrictions in the occurrences of /ɵ/ either. In the upshot then, /u/ does not undergo any harmonic alternation to produce /ɵ/, but /ɵ/ alternates to /u/ in initial syllables. In order to prevent the emergence of a non-underlying vowel /ɵ/ which may emerge as a result of harmony, the constraints ID [ATR] and *[-ATR +hi] need to be conjoined. This constraint is defined below:

(24)   * [-ATR +hi] & ID [ATR]
       If a segment violates * [-ATR +hi] and it must not violate ID [ATR] and vice versa

The constraint *[-ATR +hi] & ID [ATR] requires an output [-ATR +Hi] vowel to have a faithful input correspondent. The domain of this conjunction is the segment and the shared argument of the constraint conjunction is the feature [ATR].

(25)   High ranking * [-ATR +hi] & ID [ATR] in high vowels

Input : /gɵl/+ u'stir' 1P	ID [hi]	* [-ATR +hi] & ID [ATR]	AGREE [ATR]	ID [ATR]	* [-ATR +hi]
a. gélu			*!		*
b. ☞ gúlu				*	
d. gélɵ		*!		*	**
e. gúlɵ	*!			*	*

This conjunction of markedness and faithfulness constraints prevent the oc-

currence of the marked segment /ə/ in derived environments. Under harmonic conditions, vowels which are underlyingly specified as [-ATR, +hi] but emerge as [+ATR +hi] will violate this constraint. It is not only important to agree in terms of the feature [ATR] but also to maintain the input value of the [-ATR +hi] vowel /ə/. The candidate /gələ/ agrees in terms of the relevant feature, but violates the constraint conjunction which requires the input-output correspondence of the vowel /ə/, a costly requirement, and therefore it is doomed to fail. But we have not yet addressed the crucial input where the potential undergoer of harmony occurs on the right side of the domain. The local conjunction * [-ATR +hi] & ID [ATR] does not say anything about the inertness of /ə/ when it appears to the right.

The constraint which regulates the non-underlying occurrences of /u/ has to be different from the constraint restricting [e] and [o]. The difference lies essentially in the nature of their distribution, i.e., [e] and [o] are allophonic while /u/ is not. Therefore, apart from the constraint regulating marked feature combinations in post-tonic positions, note that the other constraint which regulates the post-tonic vowel from changing its feature specification is a faithfulness constraint preserving input vowels in post-tonic syllables.

(26) ID [ATR]/post-tonic: Feature specifications for [ATR] remains unchanged in post-tonic syllables

ID [ATR]/post-tonic is a positional constraint which cannot prevent the emergence [e] and [o] in unstressed syllables primarily because /u/ and /ə/ enjoy a distributive freedom which [e] and [o] do not.

(27) ID [ATR]/post-tonic determines /ə/→ /u/ alternations

Input : /pʰur/+ /ə/ 'travel' 1P	ID[ATR] /post tonic	*[-ATR +Hi] & ID[ATR]	AGREE [ATR]	ID [ATR]
a. ☞ pʰúrə			*	
b. pʰə́rə		*		*
c. pʰúru	*!			*
d. pʰə́ru	*!	*	*	*

4 Other Approaches to Weak Triggers in VH

Walker (2005) analysis of Veneto shows that the primacy of the weak trigger is accounted for by a positional licensing constraint which associates the quality of the post-tonic vowel to that of the stressed vowel. The specific constraint is as below:

(28)   LICENSE([+high] post-tonic, stressed syllable): [+high] in a post-tonic syllable must be associated to the stressed syllable

This is apparently due to the perceptually threatened property of the harmony triggering segment /i/. I show that such a constraint is not necessary, because harmony in such situations can be independently derived from the positional faithfulness of the vowel in the weak position. The final vowel's incorrigible faithfulfulness to its underlying value is facilitated by its primary nature. The feature high is phonologically 'primary' (Stevens & Keyser 1989) and a phonological account retreating to the supposedly perceptual markedness of /i/ does not provide us with an adequate explanation. Harmony is triggered by the vowel in a weak position either because certain marked feature combinations are prohibited in post-tonic positions or because of the faithfulness of the triggering segment. The constraint ID High/post-tonic can also account for the Veneto data. Under the circumstances it is the faithfulness of the weak trigger which determines the direction of assimilation. In Veneto and Grado, stressed /e, o/ raise to /i, u/ and this can be independently derived from very simple constraints, as shown below:

(29)   ID[high]/post-tonic >> AGREE[high] >> ID [hi]

Input : bevi	ID[High]/post-tonic	AGREE[high]	ID [hi]
a. bévi		*!	
b. ☞ bívi			*
c. béve	*!		

This shows that a contextual faithfulness of the vowel in a weak position can also effectively restrain the mal-formed output occurrences.

The present work and numerous other studies in the literature have pointed out that the traditionally prioritized strong positions are not always respected in assimilatory processes. The results obtained in Walker (2005)

can be easily derived from independent principles suggesting that features in weak positions may be unyielding to alternation because of their primary nature rather than 'perceptual markedness'. Walker (2005) shows that raising in the stressed syllable is the outcome of a multiplicity of factors relating to perceptual markedness of the unstressed high vowel as well as avoidance of unstressed syllable lowering. However, there are no phonologically marked non-peripheral vowels which asymmetrically control harmony from an un-stressed position. If peripheral high vowels are proven to be perceptually more marked, then how do we understand the non-triggering status of pho-nologically marked vowels? In short, is there any correlation at all between perceptually marked and phonologically marked? I propose that before these questions are properly answered, any analysis presupposing the perceptual markedness of /i/ is better abandoned.

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