DOUBLE OPACITY IN STANDARD COLLOQUIAL BENGALI VERBS, THROUGH THE LENS OF OT-CC*

Traci C. Nagle
Indiana University

The verb paradigm in Bengali exhibits double opacity. In a chain shift involving stem vowels, mid-lax and mid-tense vowels alternate with mid-tense and high-tense vowels, respectively, in syllables immediately preceding a [+high] affix segment. In the perfective aspect, preceding a [+high] glide and also in the surface absence of that glide, the low vowel alternates with a mid-tense variant. These interacting opacity effects are explained using optimality theory with candidate chains (McCarthy 2006, 2007), and a tentative proposal is offered in the conclusion to address the unexpected raising of the [+low] vowel to [+high] in the perfective forms of bi-syllabic stems.

1. Introduction

The verb paradigm in standard colloquial Bengali (Indo-Iranian; India and Bangladesh) exhibits a number of interesting phenomena that present a challenge for phonological analysis—namely, a sometimes doubly-opaque system of vowel harmony. Under the influence of high suffix segments in the present tense and progressive forms of verbs, mid-lax and mid-tense stem vowels alternate with mid-tense and high-tense vowels, respectively—a counter-feeding opacity effect in the form of a chain shift. Yet this same alternation is seen in other verb forms (the perfective aspect, for instance) even in the absence of a [+high] suffix segment, providing evidence of counterbleeding opacity. Moreover, in non-perfective forms of the verb, a low vowel in the stem is exempt from this chain shift, but in perfective forms, the same low vowel alternates with a mid-tense variant.

A number of scholars have analyzed this system in a derivational framework, using historically informed abstract underlying representations as the triggers for the vowel alternations in the instances of counterbleeding opacity. (The Bengali language has two major registers: a "high" literary language, which today is used mostly in literature and newspapers; and a "low" colloquial language. Scholars believe that the literary register represents the language as it was spoken in an earlier era (e.g., Lahiri 2000).) While these analyses may reflect the evolution of the present-day colloquial forms from the forms spoken c. 500 years ago, it is unclear how modern learners of Bengali would infer these abstract forms in the process of acquiring the grammar (see, e.g., Lahiri 2000). This, of course, raises the question of whether the underlying representations used in many of these analyses accurately represent the lexicon of Bengali speakers. It is possible that Bengali speakers have long since restructured their grammars and posited simpler abstract underlying forms. While examination and dis-

*The author would like to acknowledge the assistance of Sumit Ganguly, Momtajul Islam, and Anupam Das in determining pronunciations and a wide variety of data for this analysis; the comments and suggestions from members of the audience at a spring 2007 presentation of part of this analysis at Indiana University; and Daniel Dinnsen and Ashley Farris-Trimble for their helpful comments on several permutations of this analysis.

IUWPL6: Phonological Opacity Effects in Optimality Theory (2008), ed. by
Ashley W. Farris-Trimble and Daniel A. Dinnsen, pp. 35-53. Bloomington, IN: IULC Publications.

cernment of actual lexical representations on the part of Bengali speakers is beyond the scope of this paper, here it is proposed that an input representation simpler than that found in historical forms can nonetheless allow the speaker to arrive at the opaque surface forms.

Moreover, the Bengali verb system has not been thoroughly analyzed under an optimality-theoretic (OT) framework. (For the principles of OT, see Prince and Smolensky 1993/2004.) Optimality theory in its classic formulation cannot explain opacity effects, but a number of revisions to the theory have been offered that can accommodate certain forms of opacity. The most recent of these, optimality theory with candidate chains, or OT-CC (McCarthy 2006, 2007), is particularly attractive in that it draws on the strength of derivational theory in explaining opacity—namely, by incorporating ordered changes between an underlying representation and the surface form. The question remains, though: How well can OT-CC explain a complex phenomenon such as the double opacity found in Bengali verbs?

This paper will demonstrate that Bengali vowel harmony can be explained in the OT-CC framework with a simpler, and perhaps more plausible, input form than has been used in prior analyses. Section 2 will present some preliminary characteristics of the Bengali verb system and explain how the data for this examination were collected. Section 3 will present the counterfeeding opacity effect (the chain shift) and will contrast an OT-CC explanation with the derivational explanations of this phenomenon that have been put forward to date. Section 4 will present the counterbleeding opacity effect, and will again contrast an OT-CC explanation with prior derivational analyses. Section 5 will present topics for future research as well as explain the limitations of the analysis presented herein.

2. The Bengali verb

The data for this study were collected as follows: all the verbs listed in the Bengali-English section of Murshid (1992) were extracted and sorted according to that dictionary's "verb pattern" conjugation schema. Representative verbs from each pattern (including monosyllabic and bisyllabic stems) were chosen to ensure that the data set included examples of each of the possible stem vowels. Gaps were filled by additional data from the glossary in Radice (2003). The sources' transliterations, and the author's IPA transcriptions, were confirmed by cross-reference with the glossary in Radice (2003) and by consultation with three native speakers. Because the native speakers all spoke the Kolkata (Calcutta) dialect, which is generally thought by native speakers to be the "standard" (referred to in the literature as "standard colloquial Bengali"), that is the dialect under examination here. This is also the dialect that has been the focus of most linguistic analysis of Bengali to date.

Although some sources count seven classes of Bengali verbs (according to their conjugation patterns), in general Bengali verb stems take two forms: monosyllabic and bisyllabic. Monosyllabic stems, samples of which are shown in (1), can be open or closed and need not have onsets (i.e., VC, CVC, or CV forms)[1]. Only a few irregular verbs fall outside these basic patterns; they will not be discussed in the present analysis.

[1] Any of the consonants represented by C in these abstract syllable forms can represent a consonant cluster or a single consonant.

(1) Monosyllabic Bengali verb stems (CVC, VC, or CV)[2]

Verbal noun		Verb stem	Verbal noun		Verb stem
[kɔra]	'making'	/kɔr-/	[ot̪ʰa]	'rising'	/ot̪ʰ-/
[dækʰa]	'seeing'	/dækʰ-/	[rakʰa]	'putting'	/rakʰ-/
[ʃekʰa]	'learning'	/ʃekʰ-/	[kʰawa]	'eating'	/kʰa-/

Bisyllabic stems feature a more restricted structure: although the initial syllable of a bisyllabic stem may or may not have an onset, the second syllable of such a verb always has an onset, is invariably open, and with possibly one exception, contains the vowel [a].[3] The possible forms, then, for bisyllabic verbs are CV.Ca or V.Ca; samples are shown in (2). Many bisyllabic-stem verbs are causative forms of a monosyllabic counterpart, such as [ʃekʰano] 'teaching', the causative form of [ʃekʰa] 'learning'. One might conclude from this pattern that the [a] in the stem of the bisyllabic verbs is a causative morpheme. Yet other bisyllabic-stem verbs are not causative in meaning, and many of those do not even have a monosyllabic counterpart. Thus a conclusion that the [a] in these verb forms is a causative morpheme attached to a (C)VC stem may be inaccurate. The present analysis will assume that the [a] in these verbs is part of a bisyllabic stem; the status of this segment as well as the entire category of causative verbs will be revisited in section 5 of this paper.

(2) Bisyllabic Bengali verb stems (CVCa, VCa)

Verbal noun		Verb stem	Verbal noun		Verb stem
[kɔrano]	'causing'	/kɔra-/	[ot̪ʰano]	'lifting'	/ot̪ʰa-/
[dækʰano]	'showing'	/dækʰa-/	[kamano]	'shaving'	/kama-/
[ʃekʰano]	'teaching'	/ʃekʰa-/	[kũkɽano]	'crinkling'	/kũkɽa-/

As in many other Indo-European languages, tense, aspect, and person markers are added as suffixes on these stems. In Bengali dictionaries, the entries for monosyllabic verbs are typically headed by the nominal (deverbal noun) form (rather than the infinitive), which features the suffix [-a] (the entries for bisyllabic verbs feature the nominal suffix [-no]). This fact is important for this study because the chain shift that characterizes vowel alternations in Bengali verbs can be (and has been) interpreted either as raising or as lowering. [4]

[2] The author was unable to find, in the sources used for this study, any monosyllabic verb stems with /i/ or /u/ nuclei, indicating that if such verbs exist, they are remarkably rare.

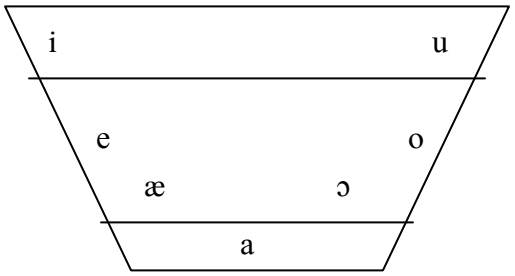
[3] The single exception unearthed by the author possibly features the vowel [o] in the second stem syllable. The verb in question is variously given as [bærano]/[berano]/[berono]. Among the three native speakers who assisted the author in determining pronunciations of the data analyzed here, there was not agreement on the "standard" pronunciation of this verb; they acknowledged, in fact, that any of those three pronunciations would be acceptable. Whether an exception to the stem pattern of bisyllabic verbs, or evidence of free or regional variation or change in progress, this verb has not been included in this analysis because of the uncertainty about its pronunciation. Without a much larger survey of the verb inventory of the language, it is unclear whether more such verbs exist in the language.

[4] The dearth of high vowels in verb stems may have influenced Dasgupta (1982) to posit a vowel-lowering phenomenon rather than a raising process as presented here and in most other (derivational) analyses of this prob-

3. Counterfeeding opacity: The chain shift

The inventory of Bengali contains seven vowels, with a place and feature distribution as shown in (3) (e.g., Chatterji 1928/1986). All but one of these seven vowels appear in verb stems; the high vowel /i/ was not found in any verb stem in the sources consulted for this analysis, and very few stems were found that contained /u/ (see note 4).

(3) The vowel inventory of Bengali



	low	high	ATR
i, u	−	+	+
e, o	−	−	+
æ, ɔ	−	−	−
a	+	−	−

These vowels, when they appear in verb stems, alternate as follows: æ ~ e, ɔ ~ o, e ~ i, o ~ u, and, less frequently, a ~ e and even a ~ i. Leaving aside these last two alternations, involving /a/, a pattern can be discerned by considering the verbal noun, present-tense, and present imperative forms. The present tense marker in Bengali is Ø; each present-tense surface form therefore comprises the verb stem plus a marker for person (there is no singular/plural marker in Bengali verbs). The forms in (4) reveal that vowel harmony in Bengali is controlled by the affix (as opposed to the root or the stem; see, e.g., Bakovic 2000). When the vowel in the suffix is [+high], the higher of the stem alternants is used; when the vowel in the suffix is [–high], the lower alternant of the stem vowel is used.

lem. His analysis, though, would require a second process to explain the a ~ e alternation (whereby [e] appears in, e.g., the perfective aspect) and the albeit limited number of verbs that feature [u] in all forms with no apparent alternations, such as [kukɽano]. Murshid (1992), an L2 learner's dictionary and not a linguistic analysis, also takes the higher alternant as underlying—an understandable approach considering the audience and the fact that, throughout any verb's paradigm, the higher alternant is much more frequent.

(4) Nominal, present tense, and present imperative forms of non-/a/ stem vowels (raised vowels are underlined)

	Affix	/kɔr-/ 'do'	/dækʰ-/ 'see'	/ʃekʰ-/ 'learn'	/oʈʰ-/ 'rise'
Nominal	/-*a* /	[kɔra]	[dækʰa]	[ʃekʰa]	[oʈʰa]
<u>Present tense</u>					
1p.	/-*i* /	[k<u>o</u>ri]	[d<u>e</u>kʰi]	[ʃ<u>i</u>kʰi]	[<u>u</u>ʈʰi]
2p. (fam.)	/-*(i)*ʃ /[5]	[k<u>o</u>riʃ]	[d<u>e</u>kʰiʃ]	[ʃ<u>i</u>kʰiʃ]	[<u>u</u>ʈʰiʃ]
2p. (casual)	/-*o* /	[kɔro]	[dækʰo]	[ʃekʰo]	[oʈʰo]
3p. (casual)	/-*e* /	[kɔre]	[dækʰe]	[ʃekʰe]	[oʈʰe]
Imperative (3p.)	/-*uk* /	[k<u>o</u>ruk]	[d<u>e</u>kʰuk]	[ʃ<u>i</u>kʰuk]	[<u>u</u>ʈʰuk]

Interestingly, however, when the stem vowel is /a/, or when the verb stem is bisyllabic, no alternation takes place in the present tense, as shown in (5). Note in particular the forms of the verb meaning 'effect', where the underlying /ɔ/ in the stem does not raise even in the presence of a [+high] affix vowel. We can conclude from this data that not only does the low vowel /a/ not participate in vowel harmony, but it prevents the harmonization of non-low vowels that in (4) were shown to participate.[6]

(5) Nominal, present tense, and present imperative forms of monosyllabic /a/ stems and bisyllabic stems (no raising attested)

	Affix	/kʰa-/ 'eat'	/rakʰ-/ 'put'	/kɔra-/ 'effect'	/kama-/ 'shave'
Nominal	/-*a* /	[kʰawa]	[rakʰa]	[kɔrano]	[kamano]
<u>Present</u>					
1p.	/-*i* /	[kʰai]	[rakʰi]	[kɔrai]	[kamai]
2p. (fam.)	/-*(i)*ʃ /	[kʰaʃ]	[rakʰiʃ]	[kɔraʃ]	[kamaʃ]
2p. (casual)	/-*o* /	[kʰao]	[rakʰo]	[kɔrao]	[kamao]
3p. (casual)	/-*e* /	[kʰai]	[rakʰe]	[kɔrai]	[kamai]
Imperative (3p.)	/-*uk* /	[kʰak]	[rakʰuk]	[kɔrak]	[kamak]

[5] The 2nd person familiar affix appears as [-iʃ] following a consonant and as [-ʃ] following a vowel.

[6] This evidence implies one of two things. If vowel harmony is strictly local (i.e., affects only the stem vowel closest to the [+high] affix), then we can conclude only that the low vowel does not participate. If vowel harmony instead were found to affect all the non-low vowels in a stem, then we might conclude that the low vowel blocks the spread of harmony. Because of the limited syllabic templates of the Bengali verb inventory (i.e., there are never more than two vowels in a stem, and if there are two, the second one is always /a/), no positive evidence can be found in the verb paradigm to support the latter conclusion.

3.1 Derivational accounts

A number of linguists have examined this problem and have offered explanations in a derivational framework (e.g., Dasgupta 1982; Lahiri 2000; Paul 1986; Sarkar 2004). Most of the accounts reviewed for this analysis have agreed on the trigger for the transparent forms—explaining the data in (4) and (5) either as a harmonic raising of an underlying stem vowel in the context of [i] in the suffix, or as a harmonic lowering of an underlying stem vowel in the context of [e], [o], or [a] in the suffix.[7] In a derivational framework, the analysis of this chain shift is straightforward. As shown in (6), two raising rules, crucially ordered to enforce a chain shift rather than "fell swoop" raising, produce the alternations shown in (4); the lack of a rule raising a stem /a/ explains the forms that were shown in (5).

(6) Derivational account of chain shift in non-/a/ stems

/UR/	/kɔr- + o/ 'you do'	/kɔr- + i/ 'I do'	/kɔra- + i/ 'I effect'
Raising: e/o→i/u / ___C_0+[+hi]	—	—	—
Raising: æ/ɔ→e/o / ___C_0+[+hi]	—	kori	—
[PR]	[kɔro]	[kori]	[kɔrai]

3.2 An OT account

A number of analysts working in an OT framework have analyzed vowel harmony (e.g., Archangeli and Pulleyblank 2002; Bakovic 2000, 2003; Beckman 1997; Ringen and Vago 1998), but the chain shift evident in Bengali vowel harmony presents a particular challenge to OT analysis. Because chain shifts are opaque (not surface-true), OT as traditionally formulated cannot explain them. Although any of the revisions of OT that have been developed to cope with opacity could be applied to explain the data in (4) and (5), neither local constraint conjunction nor comparative markedness can address the counterbleeding opacity effect that will be presented in section 4. OT-CC, newly proposed by McCarthy (2006, 2007), can account for both counterfeeding and counterbleeding. The analysis that follows provides an opportunity to test OT-CC, particularly in a context of double opacity such as that presented here.

The constraints that prefer output candidates which exhibit vowel harmony are presumed here to be from the AGREE family (e.g., Bakovic 2000, 2003)—specifically, AGREE(high). However, the details of a chain shift require that this constraint be "exploded" further, into particular combinations of vowels that are dispreferred by AGREE(high), as defined in (7). These three markedness constraints, respectively, penalize situations in which a low, mid-lax, or mid-tense vowel surfaces in a stem syllable preceding an [i] or [u]—or indeed any [+high] segment, as will be shown in section 3.3. Because, from the standpoint of harmony, the optimal combination of successive vowels would be two identical vowels, and the least optimal would be those with the most divergent feature specifications, these ex-

[7] Although it is possible to construct a lowering rather than a raising analysis, for reasons offered in note 4, the present analysis will consider this to be a raising phenomenon.

ploded constraints are assumed to be in a fixed ranking with respect to one another, as shown in (7).

(7) Markedness constraints

*aC_0i	no [+low] stem vowel adjacent to affixal [+high] segment
*æ/ɔC_0i	no [–high, –ATR] stem vowel adjacent to affixal [+high] segment
*e/oC_0i	no [–high, +ATR] stem vowel adjacent to affixal [+high] segment
Fixed ranking	*aC_0i « *æ/ɔC_0i « *e/oC_0i

A set of faithfulness constraints, of course, would militate against any changes to the features of vowels in the input; these are defined in (8) and, in keeping with the tenets of OT, are assumed to be freely permutable. Of these, IDENT(low) will be the constraint that immunizes /a/ from raising in most contexts; as it is never violated in the data under examination, it is assumed at this point to be undominated. The ranking IDENT(low) » *aC_0i will protect /a/ from raising; the opposite ranking order for the other paired markedness and faithfulness constraints ensures raising of the other vowels.

(8) Faithfulness constraints

IDENT(ATR)	corresponding input and output segments must have identical values for the feature [ATR]
IDENT(high)	corresponding input and output segments must have identical values for the feature [high]
IDENT(low)	corresponding input and output segments must have identical values for the feature [low]

As discussed above, constraints couched in a traditional OT framework cannot accommodate the facts of a chain shift. As shown in tableaux (9A) and (9B), these constraints, ranked as shown, produce the attested outputs ((a) and (c), respectively). For tableau (9B), in particular, the ranking *e/oC_0i » ID(high) is the critical factor in choosing the attested output (c). Yet in tableau (9C), the same ranking produces the incorrect output—the "fell swoop" candidate (c) that raises an underlying /ɔ/ all the way to [u], rather than the attested candidate (b). Because both candidates (b) and (c) in tableau (9C) violate ID(ATR) equally, the only way to rescue candidate (b) would be to rank ID(high) above *e/oC_0i, promoting candidate (c)'s second faithfulness violation above candidate (b)'s. Yet as just discussed, that very ranking is crucial to obtaining the correct output for tableau (9B). Such ranking paradoxes show clearly that traditional OT cannot address chain shifts.

(9) Traditional OT account fails

A. /rak^h + i/ 'I put'	ID(low)	*aC$_0$i	*æ/ɔC$_0$i	ID(ATR)	*e/oC$_0$i	ID(high)
a. ☞ < ra.k^{h}i >		*				
b. < ræ.k^{h}i >	*!		*			
c. < re.k^{h}i >	*!			*	*	
d. < ri.k^{h}i >	*!			*		*

B. /oʈ^h + i/ 'I rise'	ID(low)	*aC$_0$i	*æ/ɔC$_0$i	ID(ATR)	*e/oC$_0$i	ID(high)
a. < o.ʈ^{h}i >					*!	
b. < ɔ.ʈ^{h}i >			*!	*		
c. ☞ < u.ʈ^{h}i >						*

C. /kɔr + i/ 'I do'	ID(low)	*aC$_0$i	*æ/ɔC$_0$i	ID(ATR)	*e/oC$_0$i	ID(high)
a. < kɔ.ri >			*!			
b. < ko.ri >				*	*!	
c. ☚ < ku.ri >				*		*

OT-CC provides the tool needed to fix this ranking paradox. In OT-CC, the candidates to be evaluated are not individual outputs, but rather chains that reveal the steps by which a given output candidate is "derived." To be valid, chains must meet three conditions. First, the initial member of any chain must be the fully faithful candidate[8]—indeed, a single-member chain consisting of the fully faithful candidate is valid and may be optimal under many circumstances. Second, each successive member of a chain must accumulate all of its predecessor's faithfulness violations and must add one, and only one, additional faithfulness violation (the principle of *gradualness*). And third, each successive form in a chain must represent a *harmonic improvement* over its predecessor, in terms of the ranked markedness constraints. (For further details on candidate chains, see McCarthy 2007:60-63.)

Evaluation of candidates proceeds in much the same way as hypothesized in traditional OT: markedness constraints evaluate the well-formedness of the output (i.e., the final member of a candidate chain), and faithfulness constraints evaluate that output relative to the input. The chains themselves are evaluated by a new type of constraint—a PRECEDENCE (or PREC) constraint—that outlines the circumstances under which an output candidate can and cannot violate two specified faithfulness constraints. PREC constraints follow a strict syntax (PREC[FaithA, FaithB]), referring explicitly to two faithfulness constraints in the hierarchy, and specify that any single violation of "FaithB" must be preceded in the chain by a violation of "FaithA" and must not be followed in the chain by a violation of "FaithA." (In a tableau, the assigning of faithfulness and PREC violation marks is facilitated by a line beneath each candidate chain that indicates, in order, the faithfulness violations that were incurred in producing each successive member of the chain.) By tracing the unfaithful path via which output candidates are "derived," and by dispreferring certain ordered paths, a PREC constraint can ensure that an opaque candidate such as (b) in tableau (9C) above will emerge as the optimal

[8] McCarthy points out that this fully faithful candidate need not be identical to the input, as long as it incurs no violations of the faithfulness constraints in the constraint hierarchy (McCarthy 2007:61).

candidate. Finally, a ranking metaconstraint specifies that a PREC constraint must be ranked below the "FaithB" constraint specified in its definition.[9]

The applicable PREC constraint for these data is given in (10), ranking arguments and a preliminary ranking are given in (11) and (12), and a revision of the tableaux in (9) is given in (13). In order to prevent the output predicted by (9C), this new constraint must be ranked above *e/oC$_0$i, in order to save candidate (b) in that tableau from its otherwise fatal violation of this markedness constraint.

(10) Precedence constraint

PREC(ID[high], ID[ATR])$_S$
in any segment, a violation of ID(ATR) must be preceded by a violation of ID(high) and must not be followed by a violation of ID(high)

(11) Ranking arguments:

rak^{h}i > rækʰi, rekʰi: high-ranked IDENT(low) » *aC$_0$i
effect: /a/ does not participate in vowel harmony
kori > kɔri *æ/ɔC$_0$i » IDENT(ATR)
uʈʰi > oʈʰi *e/oC$_0$i » IDENT(high)
effect: /æ/ /ɔ/ /o/ /e/ are raised in raising context
kori > kuri PREC(ID[high], ID[ATR])$_S$ » IDENT(high)
effect: no "fell swoop" raising
metaconstraint: ID[ATR] » PREC(ID[high], ID[ATR])
effect: PREC constraint decisive only for equal violators of ID[ATR]

(12) Preliminary ranking

ID(low) » *aC$_0$i » *æ/ɔC$_0$i » ID(ATR) » PREC(ID[high], ID[ATR])$_S$ » *e/oC$_0$i » ID(high)

[9] As explained by McCarthy (2007), "PREC(A, B), though it obviously *depends on* whether B is violated, must never *affect* whether B is violated. In OT, the only way to ensure this is to require that PREC(A, B) never dominate B. This requirement is formalized as the ranking metaconstraint" (p. 98).

(13) OT-CC revision of (9)

A. /rak^{h} + i/ 'I put'	ID(low)	*aC$_0$i	*æ/ɔC$_0$i	ID(ATR)	PREC (ID[high], ID[ATR])$_S$	*e/oC$_0$i	ID(high)
a. ☞ < ra.k^{h}i > faithful		*					
b. < rak^{h}i, ræ.k^{h}i > <ID(low)>	*!		*				
c. < rak^{h}i, ræk^{h}i, re.k^{h}i > < ID(low), ID(ATR)>	*!			*	*	*	
d. < rak^{h}i, ræk^{h}i, rek^{h}i, ri.k^{h}i > < ID(low), ID(ATR), ID(high)>	*!			*	**		*

B. /oʧ^{h} + i/ 'I rise'	ID(low)	*aC$_0$i	*æ/ɔC$_0$i	ID(ATR)	PREC (ID[high], ID[ATR])$_S$	*e/oC$_0$i	ID(high)
a. < o.ʧ^{h}i > FFC						*!	
b. ☞ < oʧ^{h}i, u.ʧ^{h}i > < ID(high)>							*

C. /kɔr + i/ 'I do'	ID(low)	*aC$_0$i	*æ/ɔC$_0$i	ID(ATR)	PREC (ID[high], ID[ATR])$_S$	*e/oC$_0$i	ID(high)
a. < kɔ.ri > FFC			*!				
b. ☞ < kɔri, ko.ri > <ID(ATR)>				*	*	*	
c. < kɔri, kori, ku.ri > < ID(ATR), ID(high)>				*	**!		*

The tableau in (13C) illustrates how the PREC constraint eliminates the transparent candidate chain (c), whose non-chained counterpart had won in (9C), and thereby produces the attested output at the end of candidate chain (b). Although no bisyllabic-stem verbs have been presented in tableaux thus far, we can predict from the violation patterns for output candidates in (9A) and (13A) that bisyllabic stems will emerge with their second-syllable /a/ intact because the top-ranked IDENT(low) will penalize any attempts to change that /a/ to any other vowel. And with that [+low] segment in the second syllable, no context exists that would prompt a change in the vowel of the first syllable of a bisyllabic stem.

3.3 The progressive aspect

In the progressive aspect, the same vowel-raising phenomenon described above occurs, but in this paradigm, as shown in (14), the higher alternants appear even in the absence of a [+high] vowel in any suffix. As in the present tense, the stem vowel /a/ does not participate in the alternation pattern, and no alternations are seen in verbs with bisyllabic stems.

(14) Present progressive forms (raised vowels are underlined)

	Monosyllabic		Bisyllabic	
Progressive affix: /-ʧʰ-/	/kɔr-/ ‘do’	/rakʰ-/ ‘put’	/kɔra-/ ‘effect’	/kama-/ ‘shave’
1p.	[kɔ̲rʧʰi]	[rakʰʧʰi]	[kɔraʧʰi]	[kamaʧʰi]
2p. (casual)	[kɔ̲rʧʰo]	[rakʰʧʰo]	[kɔraʧʰo]	[kamaʧʰo]
3p.	[kɔ̲rʧʰe]	[rakʰʧʰe]	[kɔraʧʰe]	[kamaʧʰe]

Prior, derivational analyses have explained this puzzling data by positing a more complex progressive affix which contains a high vowel (/-iteʧ-/) which is found in the literary register discussed in the introduction to this paper. While this is a plausible historical source for the modern forms, it is unlikely that in the process of acquisition a Bengali child would infer such an underlying form. Moreover, it is unclear what phonological or morphological process would be responsible for reducing the four segments of this affix down to the final [ʧ], particularly *after* the stem vowel had been influenced by the affix’s [+high] initial vowel. Certainly learners, after restructuring their grammars to better match the forms to which they are exposed, might posit the underlying progressive affix as being /-iʧ-/, which would produce raised stem vowels in the same way as described in section 3.2. However, the phonological justification for the subsequent deletion of the initial /i/ in the affix remains unclear.

The analysis presented in section 3.2, however, can accommodate this data without positing an abstract underlying form. Importantly, note that the segment [ʧ] shares the feature [+high] with the vowels that served as triggers for harmony in the analysis thus far. Moreover, the markedness constraints defined in (7) refer only to a [+high] *segment* in the affix; they do not restrict EVAL to consideration only of affixal vowels. Thus the progressive affix [-ʧ-] triggers the same raising pattern as was seen in the present tense, and the constraints and ranking presented in section 3.2 can produce the output forms shown in (14).

4. Counterbleeding opacity: /a/ raises to [e]

The forms found in the perfective aspect of Bengali verbs complicate the analysis presented thus far by introducing a counterbleeding opacity that interacts with the counterfeeding chain shift discussed above. Moreover, the low vowel /a/ in stems seems no longer to be exempted from the raising that applies to the other vowels in the Bengali inventory. As shown in (15), *all* monosyllabic stem vowels surface higher in the perfective, and we finally see examples of the a ~ e and a ~ i alternations that were mentioned at the beginning of section 3.

(15) Present perfect forms (raised vowels are underlined)

Perfective affix: /-*jetʃʰ*-/	Monosyllabic /kɔr-/ ‘do’	/rakʰ-/ ‘put’	/kʰa-/ ‘eat’	Bisyllabic /kɔra-/ ‘effect’	/kama-/ ‘shave’
1p.	[kɔretʃʰi]	[rɛkʰetʃʰi]	[kʰejetʃʰi]	[kɔrijetʃʰi]	[kamijetʃʰi]
2p. (casual)	[kɔretʃʰo]	[rɛkʰetʃʰo]	[kʰejetʃʰo]	[kɔrijetʃʰo]	[kamijetʃʰo]

As can be seen in (15), the final /a/ in bisyllabic stems is raised to [i] in the perfective forms. This does not conform to the chain shift pattern described thus far, as it represents a “fell swoop” raising; it is hypothesized, therefore, to be subject to an additional constraint and will be discussed in the conclusion of this paper. Interestingly, though, that raising of /a/ to [i] in the bisyllabic stems licenses the same /a/-immunizing chain shift harmonization in the first syllable of those stems (note in the rightmost two columns of (15) that an /a/ in the first syllable of a bisyllabic stem does not raise in this newly derived context, but /ɔ/ does raise).[10] The forms shown in (15) exhibit double opacity: the chain shift itself, as described in section 3, and, in the monosyllabic perfective forms, chain-shift raising in the absence of any trigger.

4.1 Derivational accounts

Other scholars’ derivational accounts diverge in the specifics of their explanations of the doubly opaque forms in (15), specifically in their proposals for the underlying affixal forms that trigger the raising. Because of the opacity in every paradigm except that of the present tense, these analyses must posit numerous abstract underlying forms that provide the triggers for raising. Many, including Lahiri (2000) and Sarkar (2004), look to the literary register for the (abstract) underlying forms of their affixes. As discussed in section 3.3, for instance, the surface form of the literary progressive affix is [-itetʃʰ-] (compared with the colloquial surface form [-tʃʰ-]) and the perfective affix is [-iatʃʰ-] (compared with the colloquial surface form [-etʃʰ-]). Some analysts posit variants of these literary forms as underlying: Paul (1986), for example, proposes that the underlying progressive affix is /-itʃʰ-/ and the perfective affix is /-ietʃʰ-/. These underlying forms nicely explain the forms of the verb /kɔr-/ ‘do’ in (15), where raising occurs even in the absence of a [+high] vowel in the surface affix. However, positing these literary affixes as underlying cannot explain the discrepancy between the forms of /rakʰ-/ ‘put’ in (15) and in (5), where a stem /a/ that was immune to the effects of the [+high] vowel in the present tense (5) loses its immunity in the presence of the same segment in the perfective aspect (15).

Another weakness of the choice of the literary affixes as underlying is the lack of a clearly defined phonological motivation for the deletion of the /ite/ and /ia/ portions of these affixes to produce the attested standard colloquial forms. One extreme case (Dasgupta 1982) provides a set of seventeen ordered rules, many incorporating two or more structural conditions, to explain these deletions and account for the surface forms. Nor does Dasgupta’s analysis take into account cyclic application of rules or their division into lexical and post-

[10] This may provide evidence that the /a/ in bisyllabic stems is in fact a causative morpheme. See section 5 for further discussion.

lexical components; it is unclear whether his analysis would withstand the application of cyclic rule ordering.

Finally, although the reliance on literary-register affixes may allow for historical continuity, such segmentally rich forms are unlikely to be posited as the input affixes by native speakers acquiring the language. Given a number of possible input forms that can produce the same output, lexicon optimization (Prince and Smolensky 1993/2004) suggests that a speaker will choose the most harmonic input form, to avoid gratuitous violations of the constraint set. Deletion of /-ite-/ in the posited perfective affix would incur, at minimum, three violations of MAX (the constraint militating against deletion of any segment in the input) and other violations of linearity constraints requiring that segments adjacent in the input be adjacent in the output. Since some deletion will be necessary to explain the counterbleeding evidence, the fewer the number of segments in the morpheme, the less deletion will be required. Thus, the next section of this paper will posit a simplified input form of the perfective affix more in keeping with the premise of lexicon optimization.

To explain the different surface forms of the underlying /a/ in verb stems, we must posit some difference in the affixal environments between the present and progressive forms shown in (5) and (14), where an /a/ in a monosyllabic stem is *not* raised, and the perfect forms shown in (15), where the same /a/ *is* raised. The partial immunization of /a/ from the harmony phenomenon is accounted for below by the postulation of a "stronger" version of the high vowel /i/ in the underlying affix—namely, the palatal glide /j/, which shares the feature [+high] with /i/ and which also surfaces in (15) in the perfective forms for stems ending in open syllables. Dasgupta (1982) also posits an underlying palatal glide for the perfective affix, as well as for nearly every other non-present-tense verbal affix in the language, including the progressive. As a result, his analysis suffers the same need for phonological acrobatics to explain the unraised surface forms of /a/ in the presence of an affixal /j/ in the progressive aspect. The palatal glide proposed here triggers harmonization even of /a/, where its counterparts /i/ and /u/ did not. A stringent formulation of constraints specifying harmony with a following /j/ and with a following /i/ or /u/ can account for the behavior of /a/.

As was shown in (15), this palatal glide surfaces in the perfect tense only intervocalically (i.e., when the stem to which it is affixed ends in an open syllable). Since a vowel always follows the /j/ in the affix, the context for deletion must be a preceding consonant segment in the stem. A constraint banning consonant+j sequences can produce this alternation in the outputs. Such a constraint may seem counterintuitive and in violation of implicational expectations, whereby a language that allows consonant clusters involving segments less sonorous than glides in the C2 position (as Bengali does—e.g., [tritijo] 'third') would be expected to allow consonant+glide clusters. Yet no such clusters surface in the language. Indeed, the evidence seems to support a blanket prohibition on any consonant+glide sequence, as the forms in (16) illustrate.

(16) Consonant + glide sequences emerge with geminate consonants in Bengali

underlying form (inferred from orthography)		surface form
/ʤonjo/	'because of'	[ʤonːo]
/biʃwɔbidjaloj/	'university'	[biʃːɔbidːaloj]

Most of these words whose orthography indicates a consonant+glide sequence are Sanskrit borrowings. According to Sarkar (2004),

> … Nor can SCB [standard colloquial Bengali] tolerate a semivowel post-consonantally, although Hindi can. In STS [semi-tatsama, i.e., partially assimilated Sanskrit loan words] lexical items, … the usual practice was to vocalize the semi-vowel and then lower it [in other words, turning the semivowel into a full vowel]. … In pronouncing TS [tatsama, i.e., unassimilated Sanskrit loan words] items, however, a speaker of SCB drops Sanskrit /w/'s and /y/'s occurring post-consonantally after a word-boundary. But if a syllable precedes such a cluster, the consonant in question would be geminated, and then the semivowel dropped (p. 145).

Thus a constraint banning consonant+j sequences seems independently motivated in Bengali.

The derivations in (17) illustrate the phenomena discussed thus far; the rightmost derivation, in particular, illustrates the counterbleeding interaction between the a-raising and the j-deletion. Here, if the j-deletion were to apply before the a-raising, the context in which the stem /rak^h-/ raises to [rek^h-] would be lost and the raising would not occur.

(17) Derivational account of counterfeeding and counterbleeding interactions[11]

/UR/	/kɔr + i/	/kɔr + ʧ + o/	/rak^h + jeʧ + i/
Raising: e/o→i/u / ___C_0+[+hi]	—	—	—
Raising: æ/ɔ→e/o / ___C_0+[+hi]	kori	korʧo	—
Raising a→e / ___C_0+j	—	—	rek^{h}jeʧi
Cj: j-deletion	—	—	rek^{h}eʧi
[PR]	[kori]	[korʧo]	[rek^{h}eʧi]

[11] Note in the perfective form (the rightmost column) an /e/ in the perfective affix /-jeʧ-/ surfaces faithfully despite preceding an affixal [i]. The AGREE markedness constraints have been defined in this analysis to apply only to stem vowels and so would not prompt raising here. However, Lahiri (2000) has proposed that this affix is derived from the Bengali verb /aʧ-/, in which case this affix may be interpreted as raised as well. The analysis of this verb form is historically and morphologically quite complex, however, and an OT analysis of its various allomorphs would be the subject of another paper. Interested readers are referred to Lahiri's analysis as a starting point.

4.2 An OT analysis

An OT analysis of these interactions must incorporate into the constraint set given in section 3 some additional constraints. A markedness constraint must license the raising of /a/ when the following syllable contains a /j/, and another (as described in the preceding section) must militate against any consonant+j sequences. The conflicting faithfulness constraints are IDENT(low), which is already in the constraint set presented in section 3, and MAX, which militates against any deletion of input segments. Finally, a set of OT-CC precedence constraints will specify that the deletion of the /j/ (i.e., the violation of MAX) must occur after any raising (i.e., the violation of an IDENT[feature] constraint) licensed by the markedness constraints. These new constraints are presented in (18), ranking arguments for them are presented in (19), and a ranking is given in (20).

(18) Constraints

Markedness

*Cj	no consonant adjacent to [j]
*aC_0j	no [+low] stem vowel adjacent to affixal [j][12]

Faithfulness

MAX	input segments have output correspondents (i.e., no deletion)

Precedence

PREC(ID[ATR], MAX)$_S$
: in any segment, a violation of MAX must be preceded by a violation of ID(ATR) and must not be followed by a violation of ID(ATR)

PREC(ID[high], MAX)$_S$
: in any segment, a violation of MAX must be preceded by a violation of ID(high) and must not be followed by a violation of ID(high)

PREC(ID[low], MAX)$_S$
: in any segment, a violation of MAX must be preceded by a violation of ID(low) and must not be followed by a violation of ID(low)

(19) Ranking arguments

$k^hejetʃ^hi$ > $k^hajetʃ^hi$: *aC_0j » ID(low)

effect: /a/ does participate in vowel harmony before /j/

koretʃi > korjetʃi: *Cj » MAX

effect: /j/ is deleted after a consonant

[12] Note that this constraint is just another "exploded" instantiation of AGREE(high), and that because [j] is also [+high], the markedness constraints given in (7) will also penalize any non-high vowels adjacent to an affixal [j].

koretʃi > kɔretʃi: PREC(ID[feature], MAX)$_S$ » ID(feature)
effect: raising happens before j-deletion
metaconstraint: MAX » PREC(ID[feature], MAX)$_S$
effect: PREC constraint is decisive only for equal violators of MAX

(20) Ranking

*aC$_0$j » *Cj » MAX » PREC(ID[ATR], MAX)$_S$, PREC(ID[high], MAX)$_S$, PREC(ID[low], MAX)$_S$ » IDENT(low) » *aC$_0$i » *æ/ɔC$_0$i » IDENT(ATR) » PREC(ID[high], ID[ATR])$_S$ » *e/oC$_0$i » IDENT(high)

Because they all interact with MAX in the same way, it will be assumed that all three of these new PREC constraints are equally ranked with respect to one another. Moreover, because when /a/ does raise, it raises to [e] instead of to [o], a high-ranked IDENT(round) constraint will also be assumed, as will a high-ranked DEP constraint (ranked above *Cj) that rules out an epenthetic repair of a marked consonant+j sequence.

The integration of these new constraints into the preceding analysis is shown in the remaining tableaux, each of which omits some constraints that are not decisive for the particular form under investigation. Tableau (21) shows the opaque result of the PREC constraint's mandate that raising occur prior to j-deletion; without the PREC constraint, candidate chain (c) would have emerged as optimal because of candidate chain (d)'s violation of the low-ranked IDENT(high).

(21) Non-/a/ vowels in monosyllabic closed stems raised before deletion of affixal /j/

/oʈʰ-jetʃʰ-i/ 'I have risen'	*Cj	MAX	PREC(ID[high], MAX)	*e/oC$_0$i	ID(high)
a. <oʈʰ.je.tʃʰi> <faithful>	*!			*	
b. <oʈʰjetʃʰi, u.ʈʰje.tʃʰi> <ID(high)>	*!				
c. <oʈʰjetʃʰi, o.ʈʰe.tʃʰi> <MAX>		*	*!		
d. ☞ <oʈʰjetʃʰi, uʈʰjetʃʰi, u.ʈʰe.tʃʰi> <ID(high), MAX>		*			*

Tableau (22) shows that the ranking of the positional markedness constraint *aC$_0$j above its less stringent counterpart *aC$_0$i exposes stem /a/ to the raising process. Here too, the relatively high ranking of *æ/ɔC$_0$i ensures that when that stem /a/ is raised, it takes two "steps" to [e] rather than the expected one step to [æ].

(22) /a/ raised in monosyllabic open stems when affixal /j/ appended

/k^{h}a-jetʃ^h-i/ 'I have eaten'	*aC$_0$j	ID(low)	*aC$_0$i	*æ/ɔC$_0$i	ID(ATR)	PREC (ID[high], ID[ATR])$_S$	*e/oC$_0$i
a. <k^{h}a.je.tʃ^{h}i> <faithful>	*!		*				
b. <k^{h}ajetʃ^{h}i, k^{h}æ.je.tʃ^{h}i> <ID(low)>		*		*!			
c. ☞ <k^{h}ajetʃ^{h}i, k^{h}æjetʃ^{h}i, k^{h}e.je.tʃ^{h}i> <ID(low), ID(ATR)>		*			*	*	*

Tableau (23) shows a verb with a stem that contains both /a/ and a coda consonant, thereby triggering both the a-raising and j-deletion constraint sets and showing how they co-operate to eliminate a number of valid candidate chains in favor of the attested ouput.

(23) /a/ raised in monosyllabic closed stems when affixal /j/ appended and then deleted

/rak^h-jetʃ^h-i/ 'I have put'	*aC$_0$j	*Cj	MAX	PREC(ID [feature], MAX)			ID(low)	*æ/ɔC$_0$i	ID(ATR)	*e/oC$_0$i
				lo	ATR	hi				
a. <rak^h.je.tʃ^{h}i> <faithful>	*!	*								
b. <rak^{h}jetʃ^{h}i, ræk^h.je.tʃ^{h}i> <ID(low)>		*!					*	*		
c. <rak^{h}jetʃ^{h}i, ræk^{h}jetʃ^{h}i, rek^h.je.tʃ^{h}i> <ID(low), ID(ATR)>		*!					*		*	*
d. ☞ <rak^{h}jetʃ^{h}i, ræk^{h}jetʃ^{h}i, rek^{h}jetʃ^{h}i, re.k^{h}e.tʃ^{h}i> <ID(low), ID(ATR), MAX >			*			*	*		*	
e. <rak^{h}jetʃ^{h}i, ra.k^{h}e.tʃ^{h}i> <MAX>			*	*	*!	*				

5. Conclusion

The analysis presented in this paper proposes a simplified underlying input representation for the progressive and perfective affixes than that proposed by the historically dependent derivational analyses that have addressed the vowel chain shift in Bengali verbs to date—a representation more in keeping with the tenets of lexicon optimization. Markedly fewer abstract underlying forms and an OT-CC analysis were used to predict all but one of the phenomena evidenced in the present, progressive, and perfective Bengali verb paradigms. That unexplained phenomenon is the raising of stem-final /a/ in bisyllabic stems to /i/ in the perfective forms, as was shown in (15). This cannot be controlled solely by the markedness and faith-

fulness constraints presented in sections 3 and 4, for the PREC(ID[high],ID[ATR])$_S$ constraint would rule out such a "fell swoop" raising of /a/ to /i/. Clearly a raising of that bisyllabic stem-final /a/ simply to [e] would not be ruled out by any markedness constraint banning [e] before a glide, for that very sequence occurs in the optimal /k^{h}a-jetʃ^h-i/→ [k^{h}e.je.tʃ^{h}i] mapping shown in tableau (22).

This surprising mapping may be attributable to the augmentation of positionally salient prosodic constituents, as proposed by Smith (2002). As discussed in section 2, many of these bisyllabic stems occur in causative verbs, which differ from their non-causative counterparts by a single segment: the stem-final /a/. The distinguishing of this segment through enhancement of its perceptual prominence (in this case, assigning it the highest or lowest sonority position of the Bengali vowel scale, i.e., [a] or [i]) would avoid perceptual confusion between the causative and non-causative forms of the same root verb, such as [koretʃ^{h}e] and [korijetʃ^{h}e]. If we assume that the *aC$_0$j and *æC$_0$i constraints are active in banning the faithful causative form *korajetʃ^{h}e and the single-step raised output of /a/ in *koræjetʃ^{h}e, two other options are available for the output of /a/: [e] and [i]. Were the causative form to raise /a/ to [e], the pair of non-causative and causative forms would be [ko.re.tʃ^{h}e] and [ko.re.je.tʃ^{h}e], two forms that would be difficult to distinguish unless the stress were shifted to emphasize the second or third syllable of the causative form. As shifting of word-level stress away from the first syllable is not permissible in Bengali (Chatterji 1928/1986), another option to enhance the distinction between the two forms would be to augment the underlying /a/ vowel in the causative form by raising it as much as possible, to the perceptually distinct [i].

A thorough presentation of this or any other explanation for the /a/ to [i] mapping would have to be the subject of another paper, but we can imagine how the effect of such a positional augmentation process would feed the analysis presented in section 4. If we consider what has been presented here as a stem-final /a/ in bisyllabic verbs to be a separate (causative) morpheme, then it too, once raised, would trigger stem-vowel raising. Augmentation of /a/ to [i] would therefore expose a non-/a/ vowel in the first syllable of a causative verb stem to raising. This process might then apply via analogy to the non-causative bisyllabic-stem verbs to produce the same raising effect.

In addition to developing an explanation for the perfective forms of bisyllabic-stem verbs, further paths of research include the extension of this OT analysis to all tenses and aspects of Bengali verbs (in particular to the future tense forms, which also feature raising of stem vowels in the absence of any surface trigger), and an investigation of vowel alternations in other word classes, particularly nouns. As shown in this paper, however, an OT analysis promises a streamlined explanation of the numerous opaque and transparent outputs that comprise the Bengali verb paradigms.

References

ARCHANGELI, DIANA, and PULLEYBLANK, DOUGLAS. 2002. Kinande vowel harmony: Domains, grounded conditions, and one-sided alignment. Phonology, 19.139–88.

BAKOVIC, ERIC. 2000. Harmony, Dominance, and Control. Unpublished doctoral dissertation, Rutgers University, New Brunswick.

—. 2003. Vowel harmony and stem identity. ROA-540, Rutgers Optimality Archive, http://roa.rutgers.edu/.

BECKMAN, JILL N. 1997. Positional faithfulness, positional neutralization, and Shona vowel harmony. Phonology, 14.1–46.
CHATTERJI, S. K. 1928/1986. A Bengali Phonetic Reader. Calcutta: Rupa & Co.
DASGUPTA, PROBAL. 1982. Phonology and the Bangla verb. Indian Linguistics, 43.17–28.
LAHIRI, ADITI. 2000. Hierarchical restructuring in the creation of verbal morphology in Bengali and Germanic: Evidence from phonology. Analogy, Levelling, Markedness: Principles of Change in Phonology and Morphology, ed. by Aditi Lahiri, 71–123. Berlin: Mouton de Gruyter.
MCCARTHY, JOHN J. 2006. Gen, Eval, and Phonological Opacity. Paper presented at PhonologyFest, Indiana University, Bloomington.
—. 2007. Hidden Generalizations: Phonological Opacity in Optimality Theory. London: Equinox.
MURSHID, GHULAM. 1992. Bengali-English-Bengali Dictionary. London: Ruposhi Bangla Ltd.
PAUL, J. 1986. Bangla verb morphology: A reconsideration. Indian Linguistics, 47.73–79.
PRINCE, ALAN, and SMOLENSKY, PAUL. 1993/2004. Optimality Theory: Constraint Interaction in Generative Grammar. Malden, MA: Blackwell.
RADICE, WILLIAM. 2003. Teach Yourself Bengali. Chicago: McGraw-Hill.
RINGEN, CATHERINE O., and VAGO, ROBERT M. 1998. Hungarian vowel harmony in optimality theory. Phonology, 15.393–416.
SARKAR, P. 2004. Segmental Phonology of Standard Colloquial Bengali. Unpublished doctoral dissertation, University of Chicago.
SMITH, JENNIFER. 2002. Phonological Augmentation in Prominent Positions. Unpublished doctoral dissertation, University of Massachusetts, Amherst.