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Research Article

Level Ordering and Lexical Phonology of Bangla: A Stratal Optimality Theoretic Analysis

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Abstract
This study deals with the different word formation processes in Bangla under the framework of Lexical Phonology and Stratal OT with both descriptive and theoretical goals. The study attempts a) to provide a description of the morphophonemics of Bangla that result from the concatenation of morphemes, b) to use the theory of Lexical Phonology and Morphology (Kiparsky, 1982,1985; Mohanan, 1982) and later developments in Stratal OT (Kiparsky, 2003; Bermudez- Otero and McMohan, 2006) and others.

Keywords*:* Lexical Phonology, Stratal Optimality Theory, Bangla, Rule-based account.

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1. Introduction

Bengali, also known as Bangla, is an Indo-Aryan language spoken in South Asia. The modern Bangla language is spoken by an estimated 210 million people around the world, making it the seventh most spoken language in the world[i]. It is the official language of Bangladesh, and the official language of West Bengal, and the regional language of the states of Assam and Tripura of India.

Bangla has a vast lexicon and a rich morphological system. Therefore, it is interesting to explore the word formation processes and observe the morphophonological interactions under the frameworks of Lexical Phonology and Stratal OT. We study the different word formation processes in Bangla: a) derivational processes, b) inflectional processes, and c) compounding processes. The three levels we propose for Bangla are: a) Stem Level, b) Word Level, and c) Phrase Level. The affixes have been divided into: a) Stem-level affixes and b) Word-level affixes. After establishing all the rules and constraints for stem, word and phrasal levels, we developed a preliminary LP model for Bangla.

1.1. Data Collection

The collection of data in the present study has been from**:**

a) Grammar Books, Books on the Bangla language and dictionaries ("*The Origin and Development of the Bengali Language."* by SunitikumarChatterji, and *"Adhunik Bangla Byakaran"* by Jagadish Chandra Ghosh).

b) Previous research works (Kar (2009), Sanyal (2010), Dash(2006, 2015) etc).

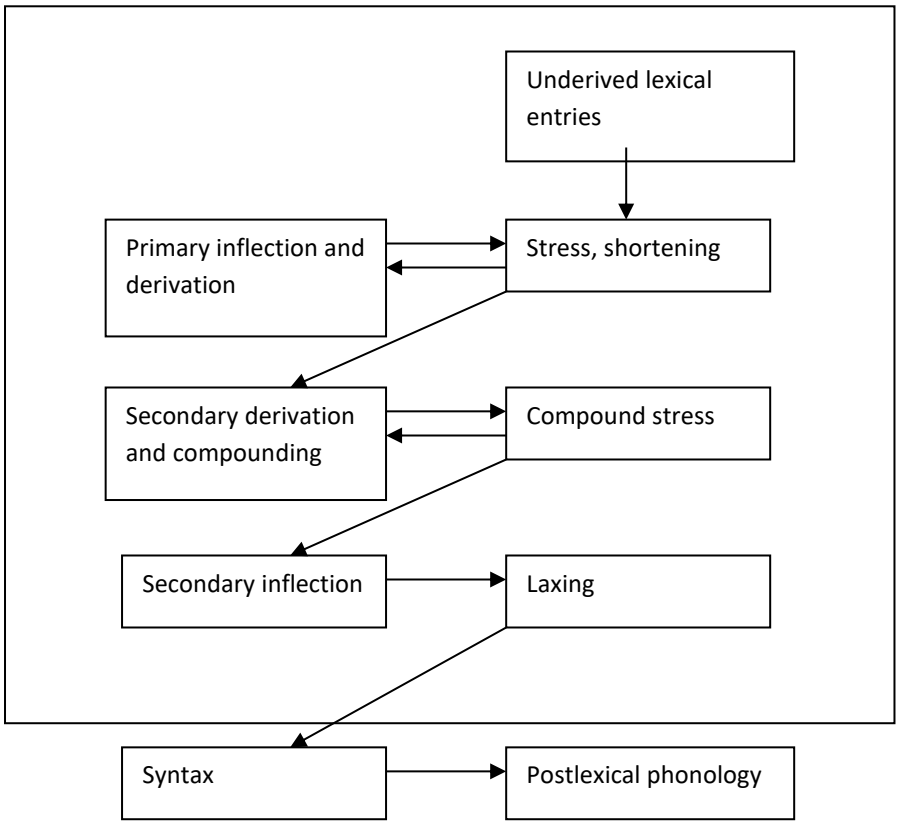
c) Online dictionaries(spokensanskrit.de dictionary[ii], Ancient Sanskrit Online[iii]).

d) Native speaker's knowledge and intuition

1.2. Lexical Phonology and Morphology

Lexical Phonology inter-orders morphology and phonology within the lexicon. In this theory, the interaction between morphology and phonology has been modelled in terms of levels of interaction in the lexicon. The lexicon consists of ordered levels (or strata), and each morphological affixation process takes place at a particular level.

Kiparsky's (1982) LP model for the English lexicon:



(1)

In Malayalam, Mohanan (1982:48) assumes that there are atleast four strata of word formation, derivational, subcompounding, cocompounding and inflectional.

According to Kaisse(1985), most lexical rules occur at Stratum I, while as one goes down towards the word level and the postlexical level, fewer lexical characteristics emerge. Pandey (1992) argues that there are instances of obligatory violation of lexical principles at the word level. The development of Optimality Theory influenced Kiparsky (2000, 2003) to develop the theory of Lexical Phonology and Morphology and Optimality Theory (LPM-OT).

2.0. Outline of Stratal OT (Kiparsky, 2014)

In 2014, Kiparsky developed a new form of Stratal OT, which takes on Lexical Phonology and Morphology's three ordered strata (levels): stems, words, and phrases/sentences. Lexical Phonology comprises of-a) Level 1-stem phonology and Level 2-word phonology. Each level comprises "a distinct parallel constraint system, and they interface serially".

Kiparsky (2014, 4-5) bases his theory on the following principles:

(1) a. Modularity: Grammar is organized into components that interface via their input and output representations.

b. Optimality Theory: Grammars are constituted by systems of ranked violable constraints.

(2) a. Stratification: Phonology and morphology are organized into STRATA (also known as LEVELS), each constituting a parallel constraint system.

b. Level-order

Leveling: Each of the cross-categorial domain stem, word, and phrase corresponds to a morphosyntactic and phonological stratum.

c. Cyclicity: Stems and words must satisfy the applicable stem and word constraints at every stage.

(3) Stratal OT

a. Ranking: The strata may differ in constraint ranking.

b. Correspondence theory: Each stratum is a "pure" OT system comprising Input/ Output constraints and markedness constraints.

4) There is no direct correspondence between the stem phonology and the postlexical phonology.

2.2. The Bangla Strata

In this study, the three levels we propose for Bangla are the following:

A. Stem Level

B. Word Level

C. Phrase Level

A. Stem Level Word Formation Processes

Applying these principles to Bangla, we first attempt to distinguish the stem level from the word level affixes. We know that a stem is less than a prosodic word. In Bangla, the prosodic word or the minimal word requirement is disyllabic (Vijakrishnan, 1999).

Sanyal (2010) proposes that the Bangla prosody follows trochaic foot parsing.

Stem-level affixes that attach to roots (monosyllabic forms) are the following:

i. Nominal/ Adjectival suffix [-t̪i]

ii. Nominal suffixes [-a], [-ni] and [-aru]

iii. Verbal inflectional suffixes [/-i/, /-o/, /-e/, /-lam/, /-le/, /-lo/, /-bo/, /-be/, /-be/, /-chi/, /-cho/, /-che/, /-chilam/, /-chili/, /-chilo/, /-echi/, /-echo/, /-eche/, /-echilam/, /-echile/ and /-echilo/]

We consider these to be stem-level affixes for the following reasons:

a) The derivational suffixes; [-t̪i], [-a], [-ni], [-aru] and the verbal inflectional suffixes

attach only to monosyllabic stems.

b) The rule of vowel harmony (height harmony) applies only to this stratum as seen with the addition of the suffix [-t̪i] and with the addition of verbal inflections.

B. Word Level Word Formation Processes

Word-level affixes that attach to full prosodic words are the following:

i. Derivational Prefixes [ha-], [ad^{h}-], [ni-]/[nir-]/[niʃ-], [d̪ur-/d̪uʃ-], [uC-], [sɔC-]/ [sɔm-], [ɔ-/ɔn-], [ku-].

ii. Derivational suffixes [-o], [-ik], [-uk], [-ot̪a]

iii. Nominal inflections [-i], [-ika], [-ani/-ini], [-ra/-ra/-jera], [-gulo/-guli], [-k^{h}ana/-k^{h}ana], [-ɟɔn], [-ke], [-Vr], [-t̪e].

v. Compounds (Sub- compounds and Co- compounds)

We consider these to be word level affixes for the following reasons:

a) They all attach to prosodic words. The Tatsama suffixes attach to monosyllabic roots but they are incorporated into the language after word formation processes are done in the Sanskrit lexicon. Therefore, they are taken as full prosodic words.

b) The rule of vowel harmony (height harmony) doesn't apply at this level. Rules like assimilation, consonanat deletion are applied here which are not present in Stratum 1.

C. Phrase Level Word Formation Processes

The definiteness markers [/-ʈa/, /-ʈi/, /-ʈo/] are attached at the phrasal level as they form separate words that can be moved around.

3.0. Optimality-Theoretic Analysis

Now, we propose an Optimality-theoretic account in terms of ordered constraints.

We divide all the rules into two[iv]:

a) Rules in Stratum 1.

b) Rules in Stratum 2.

6.5.1.1. Constraints and Constraint Ordering in Stratum 1

In Stratum 1, we have the following rules:

1. Vowel harmony
2. Glide insertion
3. Gemination

1. Vowel harmony

We find vowel harmony in the following cases in Stratum 1:

i. Nominal/adjectival suffix [-t̪i]

ii. Verbal inflection [-i]

The rule of vowel harmony affects the height and the ATR features of vowels. We noted that the vowel /a/is inert in the context of vowel harmony. Sanyal (2010) observed that the Bangla vowels show, "systematic qualitative alternations with respect to their prosodic position as well as the relative salience of the vowels in adjacent syllables" (Sanyal, 2010, p. 209). We shall be using some of the constraints given by her, along with some others, to account for the vowel harmony process in our data.

The constraints that trigger the process of vowel harmony are:

i. AGREE [HIGH&ATR]: The markedness constraints AGREE [HIGH] and AGREE [ATR] locally conjoin within the domain of a foot to form the conjoint constraint AGREE [HIGH&ATR]. This constraint will incur a violation only when both its

constituents AGREE [HIGH] as well as AGREE [ATR] are simultaneously violated within the domain of a foot. (Sanyal 2010).

ii. IDENT [HIGH & ATR]: According to Sanyal(2010:162), "This constraint is formed by the local conjunction of the faithfulness constraints IDENT [HIGH] and IDENT [ATR] and incurs a violation when both its constituent constraints are simultaneously violated".

iii. Ident Back: Corresponding segments in input and output have identical values for [Back].

iv. Faith /a⁄⁄-/i/: The vowel /a/ in a stem doesn't change its features in the output. The vowel /a/ is opaque only in the context of the suffix vowel /i/. However, in the context of a vowel like /e/, the /a/ changes to /e/. e.g., /k^{h}a + -ec^{h}i/→ /k^{h}ejec^{h}i/.

i. Nominal/ Adjectival suffix [-ʈi]:

We have already discussed the changes in detail in Chapter 3. Here, we take few examples and analyse them using the framework of OT.

a. /cɔl/ → /colʈi/

Here, we see that /ɔ/→/o⁄⁄_____[-i]. /i/ is [+ATR] and /ɔ/ is a [-ATR] vowel. The suffixal vowel [-i] triggers ATR harmony and /ɔ/ is replaced by a [+ATR] vowel /o/. The [+HIGH] feature is retained. Therefore we require a constraint, AGREE[HIGH&ATR], which is very high ranked. We need another constraint IDEN[HIGH&ATR], which is higher ranked than AGREE[HIGH&ATR].

We know that /ɔ/ and /o/ share similar back and high features, both are [+BACK][-HIGH] vowels. Therefore, we have faithfulness constraint, Ident Back /ɔ/.

Tableau 1

/cɔl/ + [-ʈi]	IDENT[HIGH&ATR]	AGREE[HIGH&ATR]	Ident Back
a. /cɔlʈi/		*!	
☞b. /colʈi/			
c. /cɛlʈi/		*!	
d. /culʈi	*!		
e. /celʈi/			*!

In the above Tableau, we find that candidates (a) and (c) violate a very high-ranked constraint, AGREE[HIGH&ATR], which is a fatal violation. Candidates (d) and (e) violate the constraints IDENT[HIGH&ATR] and Ident Back, respectively, and hence are sub-optimal. So, candidate (b) emerges as the optimal candidate.

b. /oʈ^{h}/ → /uʈ^{h}ʈi/

Here, we see that o→u/_____[-i]. /i/ is [+HIGH] and /o/ is a [-HIGH] vowel. The suffixal vowel [-i] triggers height harmony and /o/ is replaced by a [+HIGH] vowel /o/. We know that /i/, /o/ and /u/ share similar ATR feature, all are [+ATR] vowels. Therefore, we require the earlier constraints, and one new constraint, AGREE [ATR], which will not allow the input to become an optimal candidate.

We know that /o/ is a [-HIGH] vowel but /u/ is a [+HIGH] vowel.

Tableau 2

/oʈʰ/ + [-ʇi]	IDENT[HIGH&ATR]	AGREE [HIGH&ATR]	Ident Back	AGREE[ATR]
a. /oʈʰʇi/				*!
☞b. /uʈʰʇi/				
c. /iʈʰʇi/			*!	
d. /ɔʈʰʇi/		*!		
e. /eʈʰʇi/			*!	

Above, we find that candidate (a) violates a constraint, AGREE[ATR] and therefore does not become the optimal candidate. Candidate (d) violates a very high-ranked constraint, AGREE[HIGH&ATR], which is disallowed in the language. Candidates (c) and (e) both violate the constraint Ident Back and, therefore, are sub-optimal in the language. So, candidate (b) emerges as the optimal candidate.

c. /barʰ/ → /barʰʇi/

We notice in this word that /a/ does not exhibit vowel harmony. So, we require a faithfulness constraint, Faith /a//-/i/, which protects /a/ from any phonological change. Apart from this, we have Ident Back as /a/ is a back vowel.

Therefore, Faith /a//-/i/ has to be higher ranked than AGREE[HIGH&ATR] and IDENT[HIGH&ATR].

Tableau 3

/barʰ/ + [-ʇi]	Faith /a//-/i/	IDENT [HIGH&ATR]	AGREE [HIGH&ATR]	IDENT [Back]
a.☞ /barʰʇi/			*	
b. /bɔrʰʇi/	*!		*	
c. /bɛrʰʇi/	*!		*	*
d. /borʰʇi/	*!			

We find that candidates (b), (c), (d) all violate a high ranked constraint, Faith /a//-/i/, and therefore they are sub-optimal. Candidate (a) violates a lower ranked constraint, AGREE[HIGH&ATR]hence emerges as the optimal candidate.

ii. Verbal inflection [-i]:

The verbal inflections, being stem level affixes, trigger vowel harmony as in the derivations discussed above. We discuss some examples here.

a. /k^{h}a/ →/k^{h}ai/

In this case, we do not find vowel harmony in the environment of the suffixal vowel /i/. The vowel /a/ remains unchanged. The constraints proposed in the earlier section will suffice to account for the verbal inflections.

Tableau 4

/k^{h}a/ + [-i]	Faith /a//-/i/	IDENT[HIGH&ATR]	AGREE[HIGH&ATR]	Ident Back
☞a. /k^{h}ai/			*	
b. /k^{h}oi/	*!			*
c. /k^{h}ɛi/	*!		*	
d. /k^{h}ɔi/	*!		*	*

Let us take another example,

b) / d̪ɛk^{h}/ →/d̪ek^{h}i/

Here, we see that /ɛ/→/e//_[-i]. /i/ is [+ATR] and /ɛ/ is a [-ATR] vowel. The suffixal vowel [-i] triggers ATR harmony and /ɛ/ is replaced by a [+ATR] vowel /e/. We require the previously used constraints to account for this change.

Tableu 5

/d̪ɛk^{h}/ + [-i]	IDENT[HIGH&ATR]	AGREE[HIGH&ATR]	Ident Back
☞a. /d̪ek^{h}i/			
b. /d̪uk^{h}i/	*!		*
c. /d̪ɛk^{h}i/		*!	
d. /d̪ik^{h}i/	*!		

2. **Glide insertion:**

We find glide insertion in the following cases in Stratum 1:

i. Nominal suffix [-a]

ii. Nominal suffix [-ni]

iii. Verbal inflection [-ec^{h}i/-ec^{h}o/-ec^{h}e]

Whenever we do not find a legitimate diphthong, a glide is inserted to avoid the illegitimate V+V sequence. Apart from the previous constraints, we require the following constraints to account for the changes:

i. Onset: Syllables must have onsets. (Kager 1999)

ii. Align L: The left edge of a stem corresponds to the left edge of the prosodic word. (Kager 1999)

iii. AGREE [BACK]$_{Glide\_V}$: In a glide +vowel sequence, the glide should copy the +-[Back] feature of the following vowel.

iv. DEP-IO: Output segments must have input correspondence. ('No epenthesis') (Kager 1999)

v. MAX-IO: Input segments must have output correspondence. ('No deletion') (Kager 1999)

1. Nominal suffix [-a]:

With the addition of the nominal suffix [-a], there is insertion of a glide in this context.e.g.,

a. /ne/ → /newa/

Here, we see that there is an insertion of a glide /w/ between /e/ and /a/. This is to avoid V+V sequences and to create an onset. So, we need a constraint Onset. In Bangla, we do find onsetless syllables in the initial position. This indicates that the constraint Align L has to be higher ranked than onset. We also observe that the glide here is /w/ not /j/, as the glide /w/ share the same back feature as the following vowel /a/. Therefore, we need a constraint: AGREE [BACK]$_{Glide\_V.}$ We also use the constraints MAX-IO and DEP-IO. As there is insertion of a glide rather than deletion of a vowel, therefore MAX-IO will be higher ranked than DEP-IO.

Tableu 6

/ne/ + [-a]	Align L	Onset	AGREE [BACK]$_{Glide\_V}$	MAX-IO	DEP-IO
a. ☞/newa/					*
b. /nea/		*!			
c. /neja/			*!		*

In the above Tableau, we find that Candidates (b) and (c) violate the constraints Onset and AGREE [BACK]$_{Glide\_V}$, respectively, therefore, are banned in the language. So, candidate (a) emerges as the optimal candidate.

2. Nominal suffix [-ni]:

a. /ḍo/ → /ḍowani/

Tableu 7

/d̪o/ + [-ani]	Align L	Onset	AGREE [BACK]$_{Glide\_V}$	MAX-IO	DEP-IO
a. /d̪oani/		*!			
b. ☞/d̪owani/					*
c. /d̪oni/				*!	
d. /d̪ojani/			*!		*

Here, we find that candidate (a) violates a high-ranked constraint, Onset, and hence is disallowed in the language. Candidates (c) and (d) violate the constraints AGREE [BACK]$_{Glide\_V}$ and MAX-IO respectively, therefore are banned in the language. So, candidate (b) emerges as the optimal candidate.

iv. Verbal inflection [-ec^{h}i/-ec^{h}o/-ec^{h}e]:

a. /k^{h}a/ →/k^{h}ejec^{h}i/

Here, we see that there is an insertion of a glide /j/ between /a/ and /e/. This to avoid V+V sequences, and to create an onset. So, we need a constraint Onset. We also observe that the glide here is /j/ not /w/, as the glide /j/ share similar back feature with /e/. Therefore, we need a constraint, AGREE [BACK]$_{Glide\_V.}$ We also use the constraints MAX-IO and DEP-IO. As there is insertion of a glide rather than deletion, therefore MAX-IO will be higher ranked than DEP-IO. Another change we find here is that the root vowel /a/ changes to /e/ when followed by /e/. Earlier we saw that /i/ doesn't trigger vowel harmony in roots with /a/ vowel. Here, we see that suffixation of /e/ change /a/ to /e/.

Tableau 8

/k^{h}a/ + [-ec^{h}i]	Align L	Onset	AGREE [HIGH&ATR]	AGREE [BACK]$_{Glide\_V}$	MAX-IO	DEP-IO
a. /k^{h}ajec^{h}i			*!	*		*
b. /k^{h}eec^{h}i		*!				
☞c. /k^{h}ejec^{h}i						*
d. /k^{h}ewec^{h}i/				*!		*

In the above Tableau, we find that candidate (a) violates a very high-ranked constraint, AGREE[HIGH&ATR], and hence is disallowed in the language. Candidate (b) violates Onset and is banned. Candidate(d) violate AGREE[BACK]$_{Glide\_V}$ respectively and is therefore banned in the language. So, candidate (c) emerges as the optimal candidate.

3. Gemination:

We find the rule of gemination in the following suffixes:

i. Verbal inflections [-c^hi/-c^ho/-c^he]

Kar (2009), also dealt with the process of gemination in Bangla with respect to the verbal inflections and provided an OT analysis. We summarize his analysis to account for the process of germination in Bangla.

a. /k^ha/ → /k^hacc^hi/

Kar (2009:202) proposes the following constraints,

i. MAX-IO-μ: Moras (μ) in the input must have output correspondence. (Kar 2009)

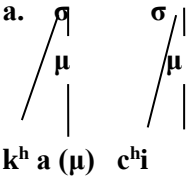
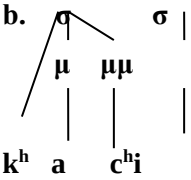
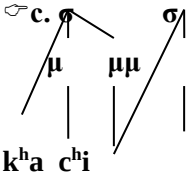
ii. NOGEM: No multiple links from a root node to a higher tier. (Hall 2003)

iii. *M/a:A syllable does not have /a/ in the margin. (Prince and Smolensky 1993)

Apart from these, he also uses Onset.

Kar (2009:203) provides the following tableau to account for gemination:

Tableau 9. (Kar2009:203)

k^h a (μ) c^hi	**Onset**	**MAX-IOμ**	***M/a**	NoGem
a. 		*!	*	
b. 	*!			
☞**c.** 				*

We find that candidates (a) and (b) violate the high ranked constraints MAX-IOμ and ONSET respectively. Hence they are disallowed in the language. Therefore, candidate (c) emerges as the optimal candidate.

Constraint Hierarchy for Stratum 1:

AlignL>>Onset>>Faith/a//_/i/>>IDENT[HIGH&ATR]>>AGREE[HIGH&ATR]>>Ident Back >>AGREE [BACK]$_{Glide\_V}$>>AGREE[ATR] >>MAX-IO>> MAX-IOμ>>DEP-IO>>*M/a>>NOGEM

3.1. Constraints and Constraint Ordering in Stratum 2:

In Stratum 2, we have the following rules:

1. Assimilation
2. Consonant deletion
3. Nasal deletion

With the addition of the derivational prefixes [ni-]/[nir-]/[niʃ-],[d̪ur-/d̪uʃ-], [uC-],[sɔC-]/ [sɔm-] and [ɔ-/ɔn-] to the stems at Stratum 2, we find,

(1) instances of place assimilation with [sɔC-]/ [sɔm-]

(2) instances of voice assimilation with [uC-]and [ni-]/[nir-]/[niʃ-]

(3) instances of consonant deletion, (a) deletion f /r/ in [ni-]/[nir-]/[niʃ-] and (b) deletion of /n/ in [ɔ-/ɔn-].

One marked difference between Stratum 1 and Stratum 2 is the repair strategy used.Stratum 1 employs the repair strategy of insertion (we noted, as in the case of glide insertion or gemination) when illicit sequences are created. On the other hand, in Stratum 2, we note the repair strategy of deletion rather than insertion. This is one clear indication of reordering of the two faithfulness constraints MAX-IO and DEP-IO. In Straum 1, MAX –IO needs to be higher ranked than DEP-IO, whereas in Stratum 2, it is vice-versa.

We first posit the constraints that we require to account for the changes,

Onset: Syllables must have onsets. (Kager 1999)

i. Align L: The left edge of a stem corresponds to the left edge of the prosodic word. (Kager 2008)

ii. *rr: /r/ + /r/ sequences are not allowed in the output. (Kar 2009)

iii. AGREE[Voice]: Agree in specification of [Voice]; one violation for every pair of adjacent obstruents in the ouput which disagree in voicing. (Lombardi 1999, Bakovic 2000).

iv. IDENT [Nasal]: Correspondent segments in input nad output have identical values for [Nasal]. (Kager 1999).

v. DEP-IO: Output segments must have input correspondence. ('No epenthesis') (Kager 1999)

vi. AGREE [Place$_{NASAL]}$

vii. MAX-IO: Input segments must have output correspondence. ('No deletion') (Kager 1999)

viii. IDENT [Place]: The specification for a place of articulation of an input segment must be preserved in its output correspondent. (Kager 1999).

ix. NÇ: No nasals plus voiceless obstruents. (Kager, 1999)

x. IDENT[Voice]: The specification for the voice of an input segment must be preserved in its output correspondent. (Kager, 1999).

1. [ni-]/[nir-][niʃ/s-]:

Here, [nir-] is the UR. We find voicing assimilation, place assimilation and consonant deletion with regard to these prefixes.

a. /ad̪^{h}ar/ → /nirad̪^{h}ar/

We do not see any change when the stem begins with a vowel. It satisfies the Onset requirement. The Onset is very high-ranked. Align L is higher ranked than Onset. There is no insertion or deletion. We will have the faithfulness constraints, DEP-IO and MAX-IO. They can be ranked in any order. But as we have deletion rules in this stratum, we keep DEP-IO before MAX-IO.

Tableau 11

[nir-] + /ad̪^{h}ar/	Align L	Onset	DEP-IO	MAX-IO
☞a. /ni.ra.d̪^{h}ar/				
b. /nir.ra.d̪^{h}ar/			*!	
c. /ni.a.d̪^{h}ar/		*!		

In the above Tableau, we find that candidates (b) and (c) violate ¸Onset and DEP-IO respectively, hence are disallowed in the language. Therefore, candidate (a) becomes as the optimal candidate.

The ranking for this analysis is:

Align L>>Onset>>DEP-IO>>MAX-IO

a. /rɔʃ/ → /nirɔʃ/

In this case, we find that there is a deletion of /r/ in order to avoid the *rr cluster. Therefore, we have a markedness constraint *rr. It satisfies the Onset requirement. Align L is higher ranked. The Onset is very high-ranked. There is a deletion of /r/. We keep DEP-IO before MAX-IO.

Tableu 12

[nir-] + rɔʃ	Align L	Onset	*rr	DEP-IO	MAX-IO
a. /nir.rɔʃ/			*!		
b. /ni.rə.rɔʃ/				*!	
☞c. /ni.rɔʃ/					*

Above, we find that candidates (a) and (b) violate ¸*rr and DEP-IO respectively. Therefore, candidate (c) becomes as the optimal candidate.

The ranking for this analysis is:

Align L>>Onset>>*rr>>DEP-IO>>MAX-IO

b. /pap/ → /niʃpap/

We find that there is voicing and place assimilation. /r/(voiced) is replaced by /ʃ/(voiceless), which gets its voicing from /p/(voiceless). Therefore, AGREE[Voice] is highly ranked. The place feature of /r/ (alveolar) is retained in /ʃ/. Therefore, we need a constraint Ident [Place], which can be ranked after DEP-IO and MAX-IO.

Tableau 13

[nir-] + pap	IDENT [Place]	AGREE[Voice]	DEP-IO	MAX-IO
a.☞/niʃ.pap/				
b. /nip.pap/	*!			
c. /niṭ.pap/	*!			
d. /nik.pap/	*!			
e. /ni.rə.pap/			*!	
f. /nir.pap/		*1		

Above, we find that candidates (b), (c) and (d) violate Ident [Place], hence are disallowed in the language. Candidates (e) and (f) violate DEP-IO and AGREE[Voice] respectively, and are not possible in the language. Therefore, candidate (a) becomes as the optimal candidate.

ii. [dur-/duʃ-]:

In these prefixes, we find voice and place assimilation.

/d̪ɔʃa/ → /d̪urd̪ɔʃa/

1. We find the same changes happening to with the prefix**[**dur_/duʃ_]:

Tableau 14

[d̪ur-] + /d̪ɔʃa/	IDENT [PLACE]	AGREE[Voice]	DEP-IO	MAX-IO
☞a. d̪ur.d̪ɔ.ʃa				
b. d̪uʃ.d̪ɔ.ʃa		*!		
c. d̪u.d̪ɔ.ʃa				*!

d. d̪ub.d̪ɔ.ʃa	*!			
e. d̪ug.d̪ɔ.ʃa	*!			

We observe that candidates (d) and(e) violate IDENT[Place] and are not allowed. Candidate (b) and (c) violate AGREE[Voice] and MAX-IO, respectively, and hence are disallowed in the language. Therefore, candidate (a) becomes as the optimal candidate.

/cinta/ → /d̪uʃcinta/

We find that there is voicing and place assimilation. /r/(voiced) is replaced by /ʃ/(voiceless), which gets its voicing from /c/(voiceless).

Tableau 15

[d̪ur-] + cinta	IDENT [Place]	AGREE[Voice]	DEP-IO	MAX-IO
a. d̪ur.cin.ta		*!		
☞b. d̪uʃ.cin.ta				
c. d̪u.cin.ta				*!
e. d̪up.cin.ta	*!			
f. d̪ut.cin.ta	*!			

Above, we find that candidates (a) violates ˌAGREE[Voice] and is not possible in the language. Candidate (c) violate MAX-IO, hence is disallowed in the language. Candidates (e) and (f) both violate Ident [Place] and are banned in the language. Therefore, candidate (b) becomes as the optimal candidate.

The ranking for this analysis is:

[uC-]:

In this prefix, we find the rule of voicing assimilation.

a. /piɽɔn/ → /uʈ̪piɽɔn/

We find that there is voicing assimilation. When the stem is voiceless /p/, the prefix becomes voiceless /ʈ̪/. Therefore, AGREE[Voice] ranks higher than IDENT[Voice].

Tableau 16

[uʈ̪-] + piɽɔn	IDENT [Place]	AGREE[Voice]	IDENT[Voice]	DEP-IO	MAX-IO
☞a. uʈ̪. piɽɔn					
b. ud̪. piɽɔn		*!	*		
c. up.piɽɔn	*!				
d. uc. piɽɔn	*!				

Above, we find that candidates (c) and(d) violate Ident [Place], hence are disallowed in the language. Candidate (b) violate AGREE[Voice], and is banned in the language. Therefore, candidate (a) becomes as the optimal candidate.

/gɔmon/ → /uɖgɔmon/

Tableu 17

[uʈ-] + gɔmon	IDENT [PLACE]	AGREE[Voice]	IDENT[Voice]	DEP-IO	MAX-IO
☞a. uɖ. gɔmon			*		
b. uʈ.gɔmon		*!			
c. uɻ.gɔmon	*!		*		
d. ug.gɔmon	*!		*		

We find that candidates (c) and(d) violate, IDENT [Place] hence are disallowed in the language. Candidate (b) violate AGREE[Voice], and is banned in the language. Therefore, candidate (a) becomes as the optimal candidate.

4. [sɔN-]/ [sɔm-]:

The rule of place assimilation is applicable here.

a. /man/ → /sɔmman/

In addition to the constraints proposed earlier, we need additional constraints IDENT [Nasal] and AGREE [Place$_{NASAL]}$. The constraint IDENT[Nasal] is required as the nasal feature is unchanged/retained in the output. The only change is one of place as per the following consonant. So, AGREE [Place$_{NASAL]}$ is required.

Tableau 18

[sɔm-]+ man	IDENT[NASAL]	AGREE [PLACE$_{NASAL]}$	DEP-IO	MAX-IO
☞a. sɔm.man				
b. sɔn.man		*!		
c. sɔ.man				*!
d. sɔb.man	*!			

Here we see that candidates (b) and (c) violate ,AGREE [Place$_{NASAL]}$ and MAX-IO respectively, and are not possible in the language. Candidate (d) violate IDENT[Nasal], hence is disallowed in the language. Therefore, candidate (a) becomes as the optimal candidate.

b. /git/ →/soŋgit/

We find that the nasal shares the same place feature with the following consonant of the stem. Therefore, we require a constraint, AGREE [PLACE$_{NASAL]}$. We place DEP-IO before MAX-IO, as deletion is allowed in this stratum. We also see that the nasal feature of the prefix is retained in the output. Therefore, we require a constraint, IDENT[NASAL], which is higher ranked.

Tableau 19

[sɔm-]+ git	IDENT[Nasal]	AGREE [PLACE$_{NASAL}$]	DEP-IO	MAX-IO
a. sɔm.git		*!		
☞b. sɔŋ .git				
c. sɔ.git				*!
d. sɔɟ.git	*!			

We find that candidate (a) violates, AGREE [PLACE$_{NASAL}$] and is not possible in the language. Candidates (c) and (d) violate MAX-IO, and IDENT[Nasal] respectively, hence are disallowed in the language. Therefore, candidate (b) becomes as the optimal candidate.

5. [ɔ-/ɔn-]:

We find the rule of nasal deletion, in these prefixes. The UR is [ɔn-].

/cena/ → /ɔncena/

The constraint, AGREE [Place$_{NASAL}$] used in the last section is not required here, as there is no nasal place assimilation observed here.

We observe that /n/ (voiced) gets deleted when followed by a voiceless consonant. We require the markedness constraint *NC̥, which will not allow voiceless consonants after nasals. IDENT [Nasal] is also required, as we do not see any other consonant replacing the prefixal nasal sound. MAX-IO is higher ranked as there is a deletion of /n/.

Tableau 20

[ɔn-] + cena	*NC	IDENT [Nasal]	DEP-IO	MAX-IO
a. ɔn.ce.na	*!			
☞b. ɔ.ce.na				*
c. ɔp.ce.na		*!		
d. ɔ.nə.ce.na			*!	

Candidate (a) violates *NC̥ and is not possible in the language. Candidates (c) and (d) violate IDENT[Nasal] and DEP-IO respectively, hence are disallowed in the language. Therefore, candidate (b) becomes as the optimal candidate.

Constraint Hierarchy for Stratum 2:

AlignL>>Onset>>*rr>>NC̥>>IDENT[Nasal]>>AGREE[Place$_{NASAL]}$>>IDENT [Place] >> AGREE[Voice]>>IDENT [Voice]>>DEP-I>>MAX-IO

4.0. Level Ordering:

Based on the three Stratums that we have posited,we examine how rules apply in different levels or cycles. The stem level suffixes are at Stratum 1. There is no cyclic application noted. A Stratum 1 suffix can feed a Stratum 2 operation. The derivational suffix [_a] feed the cocompounds. For example, we cannot have */cɔlp^{h}er/ but we can have a compound word like / have /cɔlap^{h}era/ 'moving around'. This clearly shows that the derivational suffix has to attach first to form the compound, it is not attached after compound formation.

(2).

UR	Morphological Process	Stratum	Phonological change
[cɔl] & [p^{h}er]			
[cɔl]a] &[p^{h}er]a]	Derivation	Stratum 1 Cycle 1	No change
[cɔla] +[p^{h}era] [cɔlap^{h}era]	Compounding	Stratum 2 Cycle 1	No change

In Stratum 2, we have different cycles:

We find that the nominal inflections can feed other affixation and compounding processes.

a. In /haputi/, */haput/ is not possible but /puti/ is possible. Therefore, the feminine marker attaches before the prefix:

(3).

UR	Morphological Process	Stratum	Phonological change
[put]		Stratum 2	
[[put] +- i] [put]i]	Nominal Inflection	Stratum 2 Cycle 1	No change
[ha+[put]-i] [ha[[put]-i]]	Prefixation	Stratum 2 Cycle 2	No change

c. In a sub -compound like /gajeholud/, the nominal inflectional case marker [_e] attaches to the first word and then the compound is formed. */gaholud/ is not possible.

(4).

UR	Morphological Process	Stratum	Phonological change
[ga]		Stratum 2	
[ga]+-e] [ga]je]	Nominal Inflection	Stratum 2 Cycle 1	Glide insertion
[ga](j)e]+holud̪] [[[ga](j)e]holud̪]	Compounding	Stratum 2 Cycle 2	No change

b. Even in sub-compounds like, /rɔkt̪omak^{h}a/ ‘drenched with blood’, we find that the suffix [-a] has to be attached first, to allow the compound formation. /rɔkt̪omakha/ is possible but */rɔkt̪omak^{h}/ is not possible.

(5).

UR	Morphological Process	Stratum	Phonological change
[mak^{h}]		Stratum	
[mak^{h}]+-a] [mak^{h}]a]	Derivation	Stratum1 Cycle 1	No change
[rɔkt̪o+ [mak^{h}]a] [[rɔkt̪o[mak^{h}]a]	Compounding	Stratum2 Cycle 1	No change

Therefore, we can conclude that the inflectional suffixes can feed sub and co-compounds and the derivational suffix [-a]^{v} can feed both sub and co-compounds in Bangla.

c. [-t̪a] and the prefixes both can feed each other:

In Bangla, we can have both [ɔb^{h}ɔdro] and [b^{h}ɔdrota] and also [ɔb^{h}ɔdrota].

(6).

UR	Morphological Process	Stratum	Phonological change
[b^{h}ɔd̪r]		Stratum	/o/ insertion, lexical reconstruction
[ɔn-+ [b^{h}ɔd̪ro]	Prefixation	Stratum 2	Nasal deletion

[ɔb^{h}ɔɖro]		Cycle 1	

Below we see that it is not necessary to have prefixation first and the suffixation of /ʈa-/. A word like [b^{h}ɔdroʈa] is also possible.

(7).

UR	Morphological Process	Stratum	Phonological change
[b^{h}ɔɖr]		Stratum	/o/ insertion, lexical reconstruction
[b^{h}ɔɖro]+ʈa] [b^{h}ɔdɖroʈa]	Derivation	Stratum 2 Cycle 1	No change

Finally we present the table below, which shows that prefixation and [-ʈa/] suffixation, both can feed each other.

(8).

UR	Morphological Process	Stratum	Phonological change
[b^{h}ɔɖr]		Stratum	/o/ insertion, lexical reconstruction
[b^{h}ɔɖro]+ʈa] [b^{h}ɔɖro] ʈa]	Derivational Suffixation	Stratum 2 Cycle 1	No change
ɔ-+[b^{h}ɔɖro]+ʈa] [ɔ[b^{h}ɔɖro]ʈa]]	Prefixation	Stratum 2 Cycle 2	No change

Stratum 1 requires no ordering.

Based on the above observations, we present the following ordering at Stratum 2:

Cycle 1: Verbal nominal suffix [_o]

Cycle 2: Nominal inflections

Cycle 3: Compounds

Cycle 4: Prefixes

Cycle 5: Adjectival nominal suffix [_oʈa]

C. Post lexical Word level:

The classifiers [/_ʈa/, /ʈi/, /ʈo/].

4.1. Bangla LP Model:

Based on our analysis, we propose the following LP Model for Bangla:

(9)

Stratum 1 Stem-to-word affixes: [[X]Stem + Affix]Word	Tadbhava Verbal adjectival suffix [-ṯi] Verbal nominal suffixes [-a], [-ni/] and [_aru] Verbal Inflections [-i/, /-o/, /-e/, /-c^hi/, /-c^ho/, /-c^he/, /-e-c^hi/, /-e-c^ho/, /-e-c^he/,/-l-am/,/-l-e//-l-o/, /-c^hilam/, /-c^hile/,/-c^hilo/,/-e-c^hilam/,/-e-c^hile/, /-e-c^hilo//-bo/,/-be/, /-bo]	Rules Vowel harmony Diphthongization/ Glide insertion Gemination ConstraintHierarchy: AlignL>>Onset>>Faith/a//_/i/>>IDENT[HIGH&ATR]>>AGREE[HIGH&ATR]>>IdentBack>>AGREE[BACK]$_{Glide\_V}$>>AGREE[ATR] >>MAX-IO>>MAX-IOμ>>*M/a>>NOGEM>>DEP-IO
Stratum 2 Word-to-word affixes: [[X]Word + Affix]Word Word-to-word affixes: [[X]Word + Word]Word	Tadbhava and Tatsama Cycle 1: Verbal nominal suffix [-o] Cycle 2: Nominal inflections Gender [_i, _ika/_ni] Number [-ra/-era/-(j)era] and Case suffixes Cycle 3: Compounds Cycle 4: Prefixes Cycle 5: Adjectival nominal suffix [-oṯa]	Nasal deletion Consonant deletion Assimilation(Place and voice) ConstraintHierarchy:AlignL>>Onset>>*rr>>NC̥>>IDENT[Nasal]>>AGREE[Place$_{NASAL]}$>>IDENT[Place]>>AGREE[Voice]>>IDENT [Voice]>>DEP-IO>>MAX-IO
Stratum 3 Word # Word	Nominal inflection: Definiteness marker [-ṭa/ -ṭi/ -ṭo/]	

To conclude, Stratum 1 is the stem level, where vowel changes are noted and the repair strategy used is insertion. Stratum 2 is the word level where consonantal changes are observed and the repair strategy is deletion. The crucial reordering that is required between Stratum 1 and Straum 2 is that of MAX-IO and DEP-IO. In Stratum 1, MAX-IO>>DEP-IO whereas in Stratum 2, DEP-IO>>MAX-IO. Stratum 3 is the phrasal level, where no phonological changes are observed.

5.0. Scope and Possible Areas of Study in Future:

The results of this research work would be valuable to different morphophonological studies in Bangla. Studies can be carried out in OT phonology account for stress assignment in Bangla with regard to cycles and levels of affixation, affixation with regard to the loanwords in Bangla, Gemination at stem boundaries in Bangla and a lot of other areas.This work work can also provide some scope for Bangla syntax, since inflections are triggered by rules of Syntax. Overall the analysis and results of this study would be beneficial for the future works in Bangla linguistics and its applied areas.

Notes

[i]https://en.wikipedia.org/wiki/Bengali_language

[ii]http://spokensanskrit.de/

[iii] https://lrc.la.utexas.edu/

[iv] We do not have any post lexical rule, at Stratum 3 (Phrasal Level)

[v] This conclusion is strictly based on the data which we have provided for this research. More data will provide a clearer picture of the derivational suffixes which feed compounding and which do not.

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