

Edge Integrity in Malay Multiple Prefixes

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This paper discusses the blocking of nasal substitution at prefix-prefix boundary in Malay multiple prefixation. It has widely been observed that nasal substitution is the regular solution to resolve nasal-voiceless obstruent clusters in the language. Observation from the DBP-UKM (The Institute of Language and Literature–National University of Malaysia) corpus shows that the clusters are resolved by nasal substitution in nominal multiple prefixes only, as in /pəŋ+pər+kaja+an/ → [pə.mər.ka.ja.ʔan] ‘enrichment’. It is however blocked in verbal multiple prefixes, as in /məŋ+pər+kuat+kan/ → [məm.pər.ku.wat.kan] ‘to cause to be strong’. In previous Malay studies, the non-application of nasal substitution in verbal multiple prefixes is often considered as exceptional. In this paper, I argue that the occurrence of nasal and voiceless obstruent clusters is not an exceptional case. I propose that Malay has co-existent co-phonology, i.e. different constraint rankings for different morphological categories which mean that *NÇ is obeyed in nominal prefixes but not in verbal prefixes. The violation of *NÇ is due to a morphologically conditioned phonology constraint i.e. edge integrity that requires the integrity of the morphological constituent. By applying co-phonology, I shall show that both nominal and verbal multiple prefixes have the same set of constraints, but that they are differently ranked in the hierarchy.

Key words: nasal-final prefixes, edge integrity, nasal substitution, morphologically conditioned phonology, Optimality Theory

1. Introduction

As is generally claimed, Malay is one of the languages which do not permit nasal and voiceless obstruent clusters in their process of prefixation. It has been explained by previous Malay scholars (e.g. Hassan 1974, Omar 1981, Karim et al. 1994, Karim 1995 and many others) that nasal substitution is the regular strategy to avoid nasal and voiceless obstruent clusters from emerging in the surface representation. They claim that this process occurs when a nasal segment in the prefix assimilates to the place of articulation of the following voiceless obstruent, while the voiceless obstruent after the nasal segment is then deleted. This process can clearly be seen in the following data:

(1) Voiceless obstruent nasal substitution

- | | | |
|----|--|---------------|
| a. | /məŋ-temu-i/
ACT.PRF-meet-LOC.SUF ‘to cause to meet’ | [mənemui] |
| b. | /məŋ-potong/
ACT.PRF-cut ‘to cut’ | [məmotəŋ] |
| c. | /məŋ-kuat-kan/
ACT.PRF-strong-CAUS.SUF ‘to cause to strengthen for’ | [məŋuwatkan] |
| d. | /pəŋ-pindah-an/
NOM.PRF-migrate-NOM.SUF ‘migration’ | [pəmindahan] |
| e. | /məŋ-kunjūŋ-i/
ACT.PRF-visit-LOC.SUF ‘to cause to visit’ | [məŋundzungi] |

Besides the aforementioned scholars, nasal substitution has also been claimed by Blust (2004) as the phonological process which is applied in Malay/Indonesia when there is a sequence of nasal and voiceless obstruent. Blust (2004:82) asserts that nasal substitution applies to voiceless obstruents except for /ʃ/. The examples below show the application of nasal substitution, as exemplified by Blust. Observe that all voiceless obstruent-initial bases undergo nasal substitution except for the base that begins with /ʃ/, as in /ʃaŋkul/ → [mən-ʃaŋkul].

(2) The phonological process of nasal substitution in Malay/Indonesia (Blust 2004)

Base	Examples		
p-	pukul	mə-mukul	‘to hit’
t-	tampar	mə-nampar	‘to slap’
s-	surat	mə-ŋurat-i	‘to write’
k-	kali	mə-ŋali	‘to dig’
ʃ-	ʃaŋkul	mən-ʃaŋkul	‘to hoe’

In the analysis, Blust adds that two voiceless obstruents i.e. /f/ and /z/ (as in words like /fitnah/ → [məm-fitnah] and /ziarah/ → [mən-ziarah], respectively) have not undergone nasal substitution. These voiceless obstruents as claimed by Blust are found in loanwords only, mostly borrowed from Arabic. I am in agreement with Blust regarding the non-application of nasal substitution to these two voiceless obstruents. As discussed in Syed Jaafar (2010, 2011), there are Malay prefixed words that fail to undergo nasal substitution when there is a nasal and voiceless obstruent because the words are non-native.¹

¹ See Syed Jaafar (2010, 2011) for further discussion on how nasal substitution fails to apply to non-native words.

In what follows, I shall discuss how nasal and voiceless obstruent clusters have been treated by previous Malay scholars who have applied rule-based approaches. As proposed in rule-based analyses, in the process of prefixation to eliminate a sequence of nasal and voiceless obstruent, two rules are involved: (1) nasal assimilation, and (2) voiceless obstruent deletion, where these have to be applied in order. Below, I illustrate how these two rules apply:

(3) Nasal substitution in rule-based analyses	
Input	/məŋ-təmu-i/
1) Nasal assimilation	mən-təmu-wi
2) Voiceless obstruent deletion	mən-əmu-wi
Output	[mənəmuwi]

From the ordering of rules above, the correct output is obtained whereby nasal and voiceless obstruent clusters do not emerge on the surface. This shows that the proposed way to analyze the clusters works when the clusters occur at prefix-root boundary. As argued by Syed Jaafar (2010), nasal assimilation and voiceless obstruent deletion rules as proposed in rule-based analyses failed to account for the occurrence of nasal and voiceless obstruent clusters at prefix-root boundary in single prefixation, as shown in (4). She claims further that the occurrence of the clusters is due to the etymology of the words. Since the words are non-native, nasal substitution which is regularly applied to eliminate the clusters fails to occur. This is because non-native words are not subject to the same phonological requirements as those imposed on native words. I illustrate below an example of a non-native word which fails to undergo nasal substitution as the actual output is without nasal substitution i.e. [məm.proses]:

(4) Input	/məŋ-proses/
1) Nasal assimilation	məm-proses
2) Voiceless obstruent deletion	məm-roses
Output	*[məm.roses]

In this paper, I shall show that there is another case in the language where nasal and voiceless obstruent clusters occur, i.e. at prefix-prefix boundary in multiple prefixation apart from the above.² It is important to highlight here that nasal and voiceless obstruent

² It should be pointed out that the present study focuses only on the occurrence of nasal and voiceless obstruent clusters at prefix-prefix boundaries, i.e. in multiple prefixation. However, the occurrence of clusters in other morphological domains e.g. within roots – monomorphemic words – will not be discussed. Hence, the faithfulness constraints like LINEARITY-ROOT or

clusters at prefix-prefix boundary are not always resolved by nasal substitution. For example, the clusters somehow are resolved by nasal substitution as in nominal prefixes; e.g. /pəŋ+pər+satu/ → [pəmərsatu] NOM.PRF-VERBL.PRF-one ‘oneness’. In other examples, nasal substitution is not applied to avoid the clusters in the language as in verbal prefixes like /məŋ+pər+kənal+kan/ → [məmpərkənalakan] VERBL.PRF-NOM.PRF-know-CAUS.SUF ‘to introduce’.

A question that could be posed here is, why does nasal substitution occur in nominal prefixes, while it is blocked in verbal prefixes? As mentioned above, the occurrence of nasal and voiceless obstruent clusters in Malay single prefixation as in [məm.proses] is because the word ‘process’ is not originally a Malay word. It is therefore blocked from undergoing the regular phonological process in the language, i.e. nasal substitution. In the case of multiple prefixation, however, the blocking of nasal substitution in the verbal prefixes cannot be claimed as if they were non-native words. In multiple prefixation, the clusters occur at prefix-prefix boundaries which only involve the prefixes.

In this analysis, the inconsistency of nasal substitution at prefix-prefix boundary in multiple prefixes is analyzed as morphologically conditioned phonology alternation. As stated in Anttila (2002), morphologically conditioned phonology in OT, has been approached in two principal ways: (1) interface constraints and (2) co-phonologies. As we shall see in this paper, the morphologically conditioned phonology case of the Malay nasal substitution in its multiple prefixes is accounted for by the two principle ways through the interface constraint, i.e. edge integrity and co-phonologies ranking, whereby verbal and nominal prefixes have different constraint rankings.

2. Corpus data

In this section, I discuss what data are used to account for the topic of concern in this paper, i.e. multiple prefixes in Malay. Corpus data from tabloid and broadsheet newspapers, i.e. from *Harakah* and *Berita Harian*³ respectively, as well as from magazines and books (including academic, fiction, and non-fiction genres) were collected for this topic. As many as one million words were collected for the purpose of investigating multiple prefixation in Malay. Why corpus data? Corpus data were chosen to prove the existence of the peculiar phonological behavior of nasal and voiceless obstruent clusters in Malay grammar, which contradicts claims in previous studies

UNIFORMITY-ROOT which preserves the two segments from undergoing nasal substitution will also not be discussed.

³ The newspapers *Harakah* and *Berita Harian*, as well as magazines and books are the sources from the DBP-UKM corpus database used in this study.

regarding clusters. Additionally, corpus data were chosen because the data comprise examples of real usage of the language. As far as prefixation is concerned, the blocking of nasal substitution in a sequence of nasal and voiceless obstruents at prefix-prefix boundaries, has always been claimed to be exceptional in the language. Therefore, this paper attempts to show that this clustering is not always resolved by nasal substitution. This phonological process is somehow blocked from occurring between the clusters.

In what follows, I am going to discuss how different constraint rankings in co-phonology accounts for the blocking of nasal substitution at prefix-prefix boundaries in multiple prefixation in Malay.

3. Proposed analysis: co-phonology-based approach in OT

As previously mentioned, nasal and voiceless obstruent clusters at prefix-prefix boundary are not always resolved by nasal substitution. As observed in the DBP-UKM corpus, there are counter-examples where the clusters emerge in the surface representations. Observation from the DBP-UKM corpus shows that nasal substitution occurs only in nominal multiple prefixes, /pəŋ+pər/. It however fails to occur in verbal multiple prefixes, /məŋ+pər/.

As was also mentioned earlier, nasal and voiceless obstruent clusters are disfavored in the language; therefore, the clusters undergo nasal substitution. This phonological requirement, however, does not fully apply in multiple prefixes in Malay whereby nasal substitution is only applied in nominal multiple prefixes, while it is blocked in verbal multiple prefixes. In previous Malay studies, the blocking of nasal substitution in verbal multiple prefixes is considered to be exceptional since the regular phonological process fails to apply. In this paper, the blocking of nasal substitution in verbal multiple prefixes in Malay will not be accounted for as an exceptional case, as previous studies have claimed. There must be motivation for why the process is not fully active at prefix-prefix junctures; an adequate phonological theory can explain it. In order to overcome this, co-phonology analysis will be used to explain the inconsistency of nasal substitution that occurs in Malay multiple prefixes, as mentioned above. It must be emphasized here that this issue can be more adequately accounted for by applying the idea of co-phonology from Inkelas & Zoll (2007) rather than Anttila (2002). How Inkelas & Zoll's co-phonology accounts well for Malay data will be shortly demonstrated.

Before that, let us first consider the following examples in (5). I have classified the data into two groups according to the class derived from the multiple prefixes: (a) nominal and (b) verbal prefixes.⁴

⁴ Since the data in each group show the same pattern i.e. nasal and voiceless obstruent clusters in

(5) Multiple prefixes (from the DBP-UKM corpus)

a. Nominal prefixes

- (i) **pə-mər**-kaja-an
NOM.PRF-VERBL.PRF-rich-NOM.SUF
'enrichment'
- (ii) **pə-mər**-badan-an
NOM.PRF-VERBL.PRF-body-NOM.SUF
'organization'
- (iii) **pə-məl**-bagai-an
NOM.PRF-VERBL.PRF-various-NOM.SUF
'variety'

b. Verbal prefixes

- (i) **məm-pər**-kuwat-kan
VERBL.PRF-NOM.PRF-strength-CAUS.SUF
'to cause to strengthen for'
- (ii) **məm-pər**-luas-kan
VERBL.PRF-NOM.PRF-strength-CAUS.SUF
'to cause to broaden for'
- (iii) **mən-tər**-tadḡam-kan
VERBL.PRF-VERBL.PRF-sharp-CAUS.SUF
'to cause to sharpen for'

A generalization from the above examples can be summarized as: Nasal substitution occurs when the multiple prefixes produce a nominal prefixed word, as shown in (5a). On the other hand, when the multiple prefixes form a verbal word, as in (5b), nasal substitution is blocked.

Before the discussion begins, it is worth a brief overview of what has been done in previous studies. Works like Omar (1986), Hassan (1987), Kroeger (1988) and Pater (1999), cited in Ahmad (2005:185), concerning multiple prefixation, claim that the morphological environment of the prefix-prefix boundary is impermeable to nasal substitution. This claim is true, as shown in the above data in (5b), where nasal substitution does not occur between prefixes. However, those studies do not give any phonological explanation of why the clusters cannot undergo nasal substitution at this morphological boundary. Moreover, data such as those in (5a), where the clusters undergo nasal substitution, have been left unexplained. Considering the above examples

verbal prefixes and no nasal and voiceless obstruent clusters in nominal prefixes, I therefore present only a few of the data here.

therefore, this issue will be brought into the discussion since nasal substitution is not fully active. Therefore, we need to revise the claims made in previous studies on nasal substitution at the prefix-prefix boundary. Before I offer an OT account, let us first see how the case under discussion has been resolved in ruled-based analyses.

As mentioned in the previous section, nasal substitution is the regular phonological process which is applied to avoid nasal and voiceless obstruent clusters from occurring in the surface form, as claimed by rule-based scholars. In my opinion, the analysis to account for nasal and voiceless obstruent clusters in the language is too general. In rule-based analyses, the two rules, (1) nasal assimilation and (2) voiceless obstruent deletion, which have to be applied in order, in that the nasal assimilation rule must precede the voiceless obstruent deletion rule. Put it in another way, the rules are applied when there is a sequence of nasal and voiceless obstruent, regardless of where the sequence is. Therefore, I assume that the same rules have also been applied to explain nasal and voiceless obstruent clusters in multiple prefixation, since there is a nasal and voiceless obstruent cluster. The application of the two rules is illustrated below:

(6)	Input	/pəŋ+pər+badan+an/
	1) Nasal assimilation	pəm+pər+badan+an
	2) Voiceless obstruent deletion	pəm+ər+badan+an
	Output	[pə.mər.bada.nan]

From the above derivation, it shows that by applying the same rules, in order, to nominal multiple prefixes /pəŋ+pər/, the correct output is obtained. However, if this method of analysis were to be applied to another type of data, as we have in (5b) for verbal prefixes /məŋ+pər/, we would instead get an incorrect output, as the following derivation shows:

(7)	Input	/məŋ+pər+kuat+kan/
	1) Nasal assimilation	məm+pər+kuwat+kan
	2) Voiceless obstruent deletion	məm+ər+kuwat+kan
	Output	*[mə.mər.kuwat.kan]

The above derivation clearly shows that the two rules, taken in order, fail to account for /məŋ+pər/. The output derived from the above derivation is an output with nasal substitution. This is an incorrect output since /məŋ+pər/ does not undergo nasal substitution, as the data in (5b) show. By assuming that nasal and voiceless obstruent clusters in multiple prefixation can be resolved in the same way as in single prefixation, some previous scholars (e.g. Omar 1993, Karim 1995) have claimed that the data in (5b)

are to be considered as exceptional since the output does not obey the system of Malay grammar. Such a simple explanation has been given to account for the occurrence of nasal and voiceless obstruent clusters at the prefix-prefix boundary.

Although it has been claimed in previous studies (e.g. Hassan 1974, 1987, Omar 1986, Karim et al. 1989, 1994, Karim 1995, Ahmad 1993) that nasal and voiceless obstruent clusters are not allowed to be present in the surface form, in some cases the clusters still emerge, as in (5b), above. This paper will thus argue that Malay has a co-existent grammar which means that *NÇ is closely obeyed in one of the sub-grammars, but not in the other. By this, I claim that *NÇ is obeyed in nominal multiple prefixes, while is not in the verbal multiple prefixes in Malay.

In OT ranking, if voiceless-obstruent nasal substitution were to emerge as the optimal output, then *NÇ must outrank any relevant faithfulness constraints. The converse state occurs if voiceless obstruents fail to undergo nasal substitution, as in (5b). As stated in the theoretical framework of OT, there are two constraints in OT: Faithfulness and Markedness.⁵ Because voiceless obstruents are retained, a relevant faithfulness constraint must be ranked higher than a markedness constraint, *NÇ. If this were to apply, a candidate without nasal substitution would be optimal. The interaction between these two constraints' rankings will generally determine the optimal output of a language, i.e. whether to choose to eliminate nasal and voiceless obstruent clusters or not. In this regard, faithfulness constraints should be ranked above *NÇ since nasal substitution does not occur in (5b).

As already noted, the language does not allow nasal and voiceless obstruent clusters in the surface representation. Therefore, voiceless obstruents following nasals regularly undergo nasal substitution. One question that can be asked here is: Is it obligatory for a sequence of nasal and voiceless obstruent to undergo nasal substitution? Or to put it another way: Must nasal substitution be applied whenever there is a nasal and voiceless obstruent cluster since the phonetic requirements are already met? To answer this question in the context of multiple prefixation, I suggest that another factor, as well as the phonetic environment, i.e. the morphological environment, is worthy of consideration. By considering both factors, I assume that nasal substitution is blocked in verbal multiple prefixes. Why is it blocked in this morphological environment? To support this, I shall then propose an EDGE-INTEGRITY constraint which requires a morphological unit to preserve its edge segments in the underlying position by keeping them at the edge of a corresponding prosodic structure in the constraint ranking.

⁵ The discussion of OT here is very brief. Readers desiring a more detailed introduction to OT can consult McCarthy & Prince (1993), Prince & Smolensky (2004), and some introductory books, such as Archangeli & Langendoen (1997) or Kager (1999).

I assume that the claim regarding nasal and voiceless obstruent clusters disfavors in the language which was made by previous studies as they were only considering the phonetic factor in multiple prefixes. Since there is a nasal and voiceless obstruent cluster, hence the solution applied to a single prefix has also been applied to multiple prefixes. Therefore they simply claim that the non-application of nasal substitution in the verbal multiple prefixes /məŋ+pər/ is an exception. Here, I shall put forward my argument about what I have claimed earlier, that nasal substitution in Malay multiple prefixation is motivated by the morphological environment factor as well as the phonetic environment factor.

OT is a theory which is able to account for a phonological process according to the morphological domain. To put it differently, unless the clusters occur in the right morphological domain, other than that, the phonological process of nasal substitution cannot be applied, even though all the phonetic requirements have been met. With the issue at hand, a morphology-phonology interface constraint is truly required to account for multiple prefixes. A faithfulness constraint called EDGE INTEGRITY is a morphologically-conditioned phonology constraint which has been used to account for cases like this. The definition of EDGE INTEGRITY can formally be defined as follows:

(8) **EDGE INTEGRITY**

A segment at the edge of a morphological constituent should be at the edge of a prosodic constituent, where the edges can be left, right, or both.

As defined, EDGE INTEGRITY requires that the morphological unit preserve its edge segments in the input by keeping them at the edge of a corresponding prosodic structure. There is a strict faithfulness constraint on the segments at the edges so that every segment at the edge of a morphological unit is protected and is immune to phonological processes.

EDGE-INTEGRITY is a constraint evaluating segment and its affiliation. The segment is said to be violating the constraint if an initial or a final segment is not affiliated with the corresponding PCat's edge. The structure in (9a) violates EDGE INTEGRITY since the final segment C_1 of $MCat_1$ is linked to $MCat_2$ and is not affiliated with $PCat_1$. Recall that the process of nasal substitution causes the two segments in the input to merge into a single segment in the output, due to the process of nasal substitution. Therefore, we see that the final segment C_1 of $MCat_1$ is also linked to the initial segment C_2 of $MCat_2$. The structure in (9b) does not violate EDGE-INTEGRITY at all, since the two segments C_1 and C_2 are at the edges of their prosodic constituents.

c. Consonant copying across words in phrases

- (i) /nun ətuk-ən/ nun nə.tu.kən ‘the eyesight is not good’
 eye dark-INF
- (ii) /tap al-an/ tap.p’a.ran ‘knowing the answer’
 answer know-INF

As illustrated in the above examples, initial vowel morphemes satisfy their onset requirement by copying the preceding consonants. Kang proposes that ‘*consonant copy is insertion of a root node to the onset of the prosodic word initial vowel with additional featural copy from the preceding consonant at the prosodic word juncture.*’ This is illustrated in the following diagram:

- (12) Diagram of consonant copy (from Kang 2002)
- $$\begin{array}{c} \text{PrWd } (\dots \text{VC})(\text{CV}\dots)_{\text{PrWd}} \text{ [in which C represents a copied root]} \\ \quad \quad \quad \vee \\ \quad \quad \quad [\text{F}] \end{array}$$

In the analysis, Kang claims that the consonant preceding the initial vowel of the following prosodic word is copied due to the ONSET constraint. Since a consonant is inserted before the initial vowel prosodic stem, so DEP-IO (13a) is ranked low in order to allow the copying of the consonant to occur.

- (13) Other constraints motivating consonant copy in Jeju dialect⁷
- a. DEP-IO – every segment in the output must have correspondent in the input
 - b. ONSET – every syllable must have an onset
 - c. STEML – Align (Stem, Left; PrWd, Left)
 - d. STEMR – Align (Stem, Right; PrWd, Right)
 (Stem = a lexical category i.e. Noun, Verb, Adjective, Adverb)

The tableau below presents the analysis proposed by Kang to explain the situation.

⁷ Please refer to Kang (2002) for details on the constraints and the OT analysis.

(14) Constraint ranking for consonant copy

ONSET >> STEML >> EDGE INTEGRITY >> STEMR >> DEP-IO

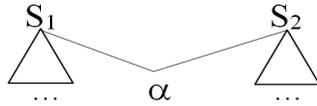
/kacuk os/	ONSET	STEML	EDGE INTEG	STEMR	DEP-IO
a. PrWd PrWd [k a c u k] [o t]		*	*	*!	
b. PrWd PrWd [k a c u k] [k'o t]		*	*		
c. PrWd PrWd [k a c u k] [o t]	*!				

The failed candidate (c) violates the higher-ranked constraint, ONSET, since there is no consonant copy in the onset position. In order to obey the higher constraint, ONSET, candidates (a) and (b) both violate STEML and EDGE INTEGRITY since the left edge of /os/ is disrupted by another segment in the surface representation. The double linking of consonant [k] in the ambisyllabic representation in candidate (a) results in the candidate violating STEMR. As claimed by Kang, the evaluation above is important, particularly the role played by the crisp alignment constraints. He claims further that the right edge of a morphological unit is often disrupted due to ONSET satisfaction. When ONSET is satisfied by a copied segment, the crisp alignment⁸ requirement at the right edge emerges (Kang 2002).

A question to ask at this point concerns the role of EDGE INTEGRITY and CRISP EDGE constraints. Since CRISP EDGE also prohibits double-linking segment as what EDGE INTEGRITY does, thus the role of CRISP EDGE needs to be clarified here. We would like to know the differences between the two and in what ways EDGE INTEGRITY could better explain the process of nasal substitution at prefix-prefix boundaries in Malay than CRISP EDGE. CRISP EDGE was first proposed by Ito & Mester (1994) to rule out any linking across the edges of prosodic categories, as exemplified below:

⁸ Interested readers can consult the cited author for details.

- (15) The prohibition of multiple linking between prosodic categories (Ito & Mester 1999:208)

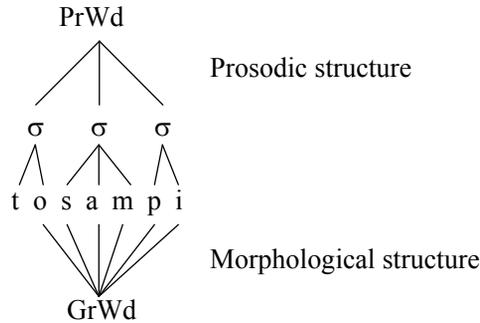


If we have a closer look at the constraint, CRISP EDGE was proposed to eliminate any linking across the edges of prosodic categories. It however does not concern with the morphological constituents of the word where the double-linking occurred. This means that doubly-linked segment which occurs either within a root or across a boundary would violate CRISP EDGE constraint. Contrast to EDGE INTEGRITY, double-linking segment across a boundary is given more attention as it interrupts the morphological constituents of the word (see the definition of EDGE INTEGRITY in (8)).

As was discussed above, EDGE INTEGRITY constraint plays a significant role in accounting for the inconsistency of nasal substitution at prefix-prefix boundaries. What is the motivation for choosing EDGE INTEGRITY rather than other related faithfulness constraints that concerned with segments standing at edges like ANCHORING and ALIGNMENT constraints? In what follows, I briefly demonstrate how those two faithfulness constraints require the segments at the edges in the inputs to be as faithful as possible in the outputs and why they are not playing a crucial role in explaining the issue under discussion.

Both constraints ALIGNMENT and ANCHORING disfavor epenthesis segment that causes the edges of the Grammatical Word (GrWd) to not coincide with the Prosodic Word (PrWd). For example, the epenthesis [t] in [tosampi] in Axininca Campa, which is to provide an onset to the initial syllable, has resulted in the left edges of the Grammatical Word and the Prosodic Word to misalign. The misaligned edge of the word [tosampi] violates Align-L which requires the left edge of the GrWd to coincide with the left edge of the PrWd. The following diagram from Kager (1999:111) gives a better picture of this:

(16) The violation of Align-L



Meanwhile, ANCHORING is a constraint that also goes against epenthesis segment, as ALIGNMENT constraint does. ANCHORING however, focuses more on the rightmost or leftmost segment of GrWd that is not coinciding with the PrWd.

The diagrams in (18) explain how the word /letkujaw/ from Diola-Fogny obey and violate ANCHOR-IO(GrWd, R) (see (17)), as shown in (a) and (b) respectively (Kager 1999:137):

(17) **ANCHOR-IO(GrWd, R)**

Any segment at the right periphery of the output GrWd has a correspondent at the right periphery of the input GrWd. ('No deletion/epenthesis at the edge.')

(18) Correspondence diagrams for obedience and violation of ANCHOR-IO(GrWd, R) (Ibid:137)



As demonstrated in the above diagrams, ANCHOR-IO(GrWd, R) focuses on the rightmost segment in the input and output. The deletion of [w] in the output has resulted in the violation of the constraint as the rightmost edge of the input has no correspondent in the output. From the above discussion, the two faithfulness constraints i.e. ALIGNMENT and ANCHORING require that the output forms must be as faithful as possible to the inputs by disallowing either segment epenthesis or deletion. The constraints however do not focus on segment coalescence, i.e. when two segments in the input merge to a single segment in the output.

As well as edge integrity, there are other constraints which are important to account for the case under discussion. The next constraint which is crucial for our analysis is a

markedness constraint, *NÇ. Nasal and voiceless obstruent clusters seem to be disfavored in many languages (e.g. Indonesia, Javanese, Swahili, Toba Batak, Chamorro, Kaingang, and many others, as cited in Pater 1999). Therefore, the occurrence of this cluster in the underlying representation undergoes a number of phonological processes, such as post-nasal voicing, nasal deletion, denasalization, or nasal substitution, to get rid of the clusters in the surface representation (Pater 1999). Therefore, as the formal driving force behind these phonological processes, *NÇ is used as the output constraint for such clusters. This constraint is defined as follows:

- (19) *NÇ
No nasal/voiceless obstruent sequences.

The constraint above prevents a sequence of nasal and voiceless obstruent from emerging in the surface representation. To satisfy this constraint, therefore, nasal substitution applies to break up the cluster whereby the voiceless obstruent is deleted and leaves its place of articulation with the preceding nasal.

In Correspondence Theory (McCarthy & Prince 1995), the phonological process of nasal substitution is explained as a process of merging, between the nasal segment in the prefix and the voiceless obstruent, that can be interpreted as a two-to-one mapping from input to output. In other words, two segments in the input correspond to a single segment in the output. The correspondence relationship between the input and output of a sequence of /ŋ+p/ is illustrated in (20). As can be seen, [m] in the output is obtained from two segments in the input, nasal segment /ŋ/ and place of articulation /p/.

- (20) Nasal substitution representation
- | | |
|--------|-----------------------|
| Input | η_1 p_2 |
| | \swarrow \searrow |
| Output | m_{12} |

Candidate with nasal substitution obeys the constraint, *NÇ. In OT, if a candidate satisfies a particular constraint, the candidate may violate other constraints in the hierarchy. For example, a candidate with nasal substitution obeys *NÇ, while it violates another constraint which bans nasal substitution, namely UNIFORMITY, that requires that no element of the output should have multiple correspondents in the input. This constraint can be formally defined as follows:

- (21) **UNIFORMITY** ('No Coalescence') (McCarthy & Prince 1999:296)
No element of S_2 has multiple correspondents in S_1 .
For $x, y \in S_1$ and $z \in S_2$: if $x R z$ and $y R z$, then $x=y$.

Besides the phonological requirement mentioned above, Malay requires a nasal segment occupying the coda position of a syllable to be homorganic with the following consonant. A nasal segment in the coda position assimilates to the place of articulation of the following onset consonant. This phonological requirement is stated in the constraint named NASAL ASSIMILATION (henceforth NAS ASS), as defined in (22). This constraint will be used in order to rule out any candidate without a homorganic nasal, such as [məŋpərbəsər].

- (22) **NAS ASS** (cf. Jun 1995, Padgett 1995, Boersma 1998, Pater 2001)
 A nasal must share place features with a following consonant.

As already mentioned, co-phonology is used in this study to analyze the inconsistency of nasal substitution at prefix-prefix boundary. I establish the following co-phonology rankings for Malay:

- (23) Co-phonology rankings for Malay multiple prefixation
 a. Nominal multiple prefixes co-phonology
 NAS ASS >> *NÇ >> EDGE INTEGRITY, UNIFORMITY
 b. Verbal multiple prefixes co-phonology
EDGE INTEGRITY, NAS ASS >> *NÇ, UNIFORMITY

Now I present the analysis of nominal and verbal multiple prefixes in the following tableaux by considering all the constraints discussed above:

- (24) Constraint ranking for nominal multiple prefixes
 NAS ASS >> *NÇ >> EDGE INTEGRITY, UNIFORMITY

/pəŋ ₁ +p ₂ ər+badan+an/	NAS ASS	*NÇ	EDGE INTEGRITY	UNIFORMITY
a. \varnothing pəm ₁ p ₂ ərbadanan			*	*
b. pəm ₁ p ₂ ərbadanan		*!		
c. pəŋ ₁ p ₂ ərbadanan	*!			

As discussed earlier, *NÇ must outrank any relevant faithfulness constraints in order to obtain nasal and voiceless obstruent nasal substitution. In the above tableau, we see that *NÇ is ranked higher than the faithfulness constraint, EDGE INTEGRITY. By ranking EDGE INTEGRITY below than *NÇ, the candidate with nasal substitution i.e. candidate (a) occurs as the optimal output.

(25) Constraint ranking for verbal multiple prefixes

EDGE INTEGRITY, NAS ASS >> *NÇ, UNIFORMITY

/məŋ ₁ +p ₂ ər+bəsar/	EDGE INTEGRITY	NAS ASS	*NÇ	UNIFORMITY
a. məm ₁ p ₂ ərbəsar	*!			*
b. ☞ məm ₁ p ₂ ərbəsar			*	
c. məŋ ₁ p ₂ ərbəsar		*!		

The tableau above shows that the faithfulness constraint EDGE-INTEGRITY dominates the markedness constraint, *NÇ. Because of that, candidate (a), with nasal substitution, loses due to a fatal violation of the faithfulness constraint. In contrast, candidate (b) violates the markedness constraint *NÇ, as the candidate does not undergo nasal substitution. Since the markedness constraint *NÇ is ranked beneath the faithfulness constraint, EDGE INTEGRITY, the least unmarked output is preferable to the unmarked ones. Therefore [məm₁p₂ərbəsar] emerges as the winner, not *[məm₁p₂ərbəsar]. This ranking, EDGE INTEGRITY >> *NÇ, can thus account straightforwardly for why nasal substitution does not occur in the environment of the prefix-prefix juncture.

The analysis of co-phonology above could satisfactorily explain the issue of inconsistency of nasal substitution in Malay multiple prefixes. The issue could be solved by ranking the verbal and the nominal multiple prefixes differently. The difference in ranking is due to the morphologically conditioned phonology factor which means the phonological process i.e. nasal substitution is determined by the morphological factor i.e. verbs and nouns have different phonological process where verbs in Malay multiple prefixes are usually more faithful to their input positions than the nouns, to satisfy the faithfulness constraint i.e. EDGE INTEGRITY, as discussed above. As verbal multiple prefixes are more faithful to the inputs, this faithfulness constraint dominates the markedness constraint, *NÇ. Different from the nominal multiple prefixes, EDGE INTEGRITY is ranked beneath *NÇ, as the outputs are not faithful to the inputs since nasal substitution applies. The distinction of how a nasal and voiceless obstruent cluster is resolved requires the grammar of Malay to have two constraint rankings; i.e. one which allows the occurrence of the clusters, while the other one does not.

With regard to the above, single constraint ranking or so-called indexed constraint theory (according to which the proposed idea is a single constraint ranking used to describe the grammar of the entire language⁹ (Alderete 1999, 2001, Ito & Mester 1999, 2003)) would certainly fail to account for the inconsistency of nasal substitution in

⁹ Indexed constraint and co-phonology theory have formally been discussed by Inkelas & Zoll (2005, 2007), Pater (2009), Downing (2006, 2008) and many others. Readers may consult these scholars' works for more discussion.

multiple prefixes in Malay. I briefly demonstrate below how indexed constraint theory fails to solve the problem under discussion:

- (26) Indexed constraint analysis: single constraint ranking
 NAS ASS >> *NÇ >> EDGE INTEGRITY, UNIFORMITY

Let us employ the above constraint ranking which is proposed for nominal multiple prefixes, as demonstrated above to account for both nominal and verbal multiple prefixes in Malay. We see in the following tableaux that this constraint ranking could only yield the right output for nominal prefixes, but not for verbal prefixes, as *[məmərbəsar] is not the correct output.

- (27) Indexed constraint ranking: NAS ASS >> *NÇ >> EDGE INTEGRITY, UNIFORMITY

/pəŋ ₁ +p ₂ ər+badan+an/	NAS ASS	*NÇ	EDGE INTEGRITY	UNIFORMITY
a. ☞ pəm ₁₂ ərbadanan			*	*
b. pəm ₁ p ₂ ərbadanan		*!		
c. pəŋ ₁ p ₂ ərbadanan	*!			
/məŋ ₁ +p ₂ ər+bəsar/				
a. ☞ məm ₁₂ ərbəsar			*	*
b. ☹ məm ₁ p ₂ ərbəsar		*!		
c. məŋ ₁ p ₂ ərbəsar	*!	*		

The same results yields if the constraint ranking for verbal multiple prefixes in (25) above is used to account for both prefixes. The constraint ranking would not be able to account for nominal multiple prefixes. The following tableaux give a better picture of this:

- (28) Indexed constraint ranking: EDGE INTEGRITY, NAS ASS >> *NÇ, UNIFORMITY

/məŋ ₁ +p ₂ ər+bəsar/	EDGE INTEGRITY	NAS ASS	*NÇ	UNIFORMITY
a. məm ₁₂ ərbəsar	*!			*
b. ☞ məm ₁ p ₂ ərbəsar			*	
c. məŋ ₁ p ₂ ərbəsar		*!		
/pəŋ ₁ +p ₂ ər+badan+an/				
a. ☹ pəm ₁₂ ərbadanan	*!			*
b. ☞ pəm ₁ p ₂ ərbadanan			*	
c. pəŋ ₁ p ₂ ərbadanan		*!	*	

It is now clear that indexed constraint analysis is not an adequate theory to account for the problem under discussion since it proposes a single constraint ranking for the whole grammar. As stated in Inkelas & Zoll (2007:143), variation cannot be described using indexed constraints theory as the patterns in variation occur in identical contexts. The result shows that by employing a single constraint ranking, the right output from one of the two multiple prefixes could only be obtained. In other words, one constraint ranking could not account for the inconsistency of nasal substitution occurring in multiple prefixes in Malay.

In addition to co-phonology and indexed constraint theories, there is another approach to variation: Partially Ordered Grammar (Anttila 1997, Anttila & Cho 1998 and many others). A Partially Ordered Grammar is a binary relation (= set of ordered pairs) which is not reflexive, asymmetric, and transitive (Anttila 2007:526). Based on the idea proposed in the Partially Ordered Grammar, we see whether this theory of variation can adequately account for the inconsistency of nasal substitution in Malay multiple prefixes. To begin the analysis, we posit the following optimality theoretic constraints:

(29) Relevant Constraints:

*NÇ	Avoid a sequence of nasal and voiceless obstruent
EDGE INTEGRITY	No nasal substitution
NASAL ASSIMILATION	Allow a sequence of homorganic nasal and voiceless obstruent
UNIFORMITY	No coalescence

As was mentioned earlier, verbal multiple prefixes are more faithful to the inputs than nominal multiple prefixes are. This means that nasal substitution is more common in nominal multiple prefixes /pəŋ+pər/ than verbal multiple prefixes /məŋ+pər/. Therefore, a fixed ranking to solve this problem is *NÇ >> EDGE INTEGRITY. I exemplify the following tableaux based on this ranking to demonstrate the constraint violation pattern:

(30) The constraint violation pattern

/pəŋ ₁ +pər ₂ +badan+an/	NAS ASS	*NÇ	EDGE INTEGRITY	UNIFORMITY
a. pə ₁ m ₁ p ₂ ər ₂ badanan		*		
b. pə ₁ m ₁₂ ər ₂ badanan			*	*
/məŋ ₁ +pər ₂ +bəsar/				
a. mə ₁ m ₁ p ₂ ər ₂ bəsar		*		
b. mə ₁ m ₁₂ ər ₂ bəsar			*	*

In what follows, I am going to show that the inconsistency of nasal substitution in multiple prefixes in Malay cannot be captured by positing the fixed ranking $*N\zeta \gg$ EDGE INTEGRITY. From this fixed ranking, we get the following factorial typology which fails to produce the desired typological pattern:

(31) The factorial typology

	pəŋ+pər+badan+an	məŋ+pər+bəsar
$*N\zeta \gg EI \gg NA \gg UNI$	pəmərbadanan	məmərbəsar
$NA \gg UNI \gg *N\zeta \gg EI$	pəmpərbadanan	məmpərbəsar
$*N\zeta \gg NA \gg EI \gg UNI$	pəmərbadanan	məmərbəsar
$*N\zeta \gg UNI \gg EI \gg NA$	pəmərbadanan	məmərbəsar
$UNI \gg *N\zeta \gg NA \gg EI$	pəmpərbadanan	məmpərbəsar
$NA \gg *N\zeta \gg UNI \gg EI$	pəmərbadanan	məmərbəsar
$UNI \gg NA \gg *N\zeta \gg EI$	pəmpərbadanan	məmpərbəsar
$UNI \gg *N\zeta \gg EI \gg NA$	pəmpərbadanan	məmpərbəsar
$NA \gg *N\zeta \gg EI \gg UNI$	pəmərbadanan	məmərbəsar

Given the above factorial typology pattern, none of the ranking produces the right outputs. The rankings above show that both prefixes could not have different outputs, i.e. one with nasal substitution and one without. To put it in another way, one fixed ranking produces outputs with one pattern only, i.e. either with or without nasal substitution. Hence, the analysis of Partially Ordered Grammar could not be a better solution to account for the inconsistency of nasal substitution in Malay multiple prefixes. Since the fixed ranking $*N\zeta \gg$ EDGE INTEGRITY could not hold for both verbal and nominal multiple prefixes, the ranking thus fails to produce the desired factorial typology pattern.

The analysis of multiple prefixes above proves the fact that EDGE INTEGRITY provides us with a means to account for the problem of phonological opacity which arises from the interaction of phonological process (i.e. nasal substitution) and morphological domain (i.e. prefix-prefix juncture). This constraint which requires that the segments at the edges of a morphological word should be at the edge of a prosodic word at both edges has blocked nasal substitution from occurring at prefix-prefix boundary. This morphology-phonology interface constraint, which is found in OT and is used as a research tool to account for any morphologically-conditioned phonology issues, is absent in previous approaches, such as rule-based and non-linear autosegmental analyses. Thus, it is impossible to say that these previous approaches can perform the analysis correctly as OT does. Moreover, due to the morphological domain, nasal and voiceless obstruent clusters at the prefix-prefix juncture cannot undergo the regular process, nasal substitution.

4. Conclusion

It is clear from the above discussion that nasal and voiceless obstruent clusters at the prefix-prefix juncture in Malay are not fully resolved by nasal substitution. The clusters at this morphological boundary permitted to emerge in surface representation as the edges of a morphological word are preserved by the faithfulness constraint called EDGE-INTEGRITY. As we saw in rule-based analyses, since there is a nasal and voiceless obstruent cluster between the first and second prefix, it has been resolved by nasal substitution, as this is the way in which this cluster is resolved at the prefix-root boundary. This solution however only works for nominal multiple prefixes, but not for verbal multiple prefixes. To deal with this matter, I have argued that although there is a nasal and voiceless obstruent cluster, which means the phonetic environment is met and can thus be resolved by nasal substitution, the morphological environment must also be considered as a factor conditioning the clusters to undergo nasal substitution. By considering the phonetic and morphological environments, I have further claimed that nasal substitution is blocked between prefixes. As shown above, the problem occurring in Malay multiple prefixation could satisfactorily be explained by adopting co-phonology analysis rather than other theories of variation like Partially Ordered Grammar or Indexed Constraint theories.

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馬來語多重前綴的邊緣完整性

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本文探討馬來語的多重前綴加接，在前綴之間的邊界對鼻音替代規律的阻擋現象。學界對該語言廣泛的觀察認為，鼻音替代規律是解決鼻音與無聲子音音串普遍使用的方法。從 DBP-UKM (The Institute of Language and Literature–National University of Malaysia) 語料庫的觀察顯示，鼻音替代規律只針對出現在名詞性多重前綴的音串，如 /pəŋ+pər+kaja+an/ → [pə.mər.ka.ja.ʔan] ‘豐富’。然而，此規律卻在動詞性多重前綴加接時受到阻擋，如 /məŋ+pər+kuat+kan/ → [məm.pər.ku.wat.kan] ‘使成為強壯’。先前對馬來語的研究常將鼻音替代規律未能應用在動詞性多重前綴加接的情形視為例外。在本文中我將論證鼻音與無聲子音音串在這種情況下的出現並非例外。我提出馬來語有並存的共同音韻，亦即對不同的構詞範疇有不同的制約排序，而 *NÇ 制約的遵守只針對名詞前綴，而非動詞前綴。對 *NÇ 制約的違反是由於受制於構詞的音韻制約，亦即對完整構詞成分需具備邊緣完整性的要求。透過應用共同音韻，我指出名詞性與動詞性兩種多重前綴具有相同的制約組，但在階層中卻有不同的地位。

關鍵詞：鼻音結尾前綴，邊緣完整性，鼻音替代規律，受制於構詞的音韻，
優選理論