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Alignment and the Syllable Coda Condition in Malay: An Optimality Account

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1.0 Introduction

It has long been observed that the basic structure of the Malay syllable is (C)V(C) (Abdullah 1974, Yunus 1980, Farid 1980), allowing only a single segment to occupy constituents of the syllable. Although Malay may have single-member codas, there is a restriction in the language which prohibits a small class of consonants from occupying the coda position. In the phonological analysis of syllable structures, the prohibition of some segments in the coda is governed by the Syllable Coda Condition (Itô 1986).

The aim of this paper is to account for the effects of the Syllable Coda Condition in Malay, and the present analysis is couched in the constraint-based approach of Optimality Theory (henceforth OT) (Prince and Smolensky 2004, McCarthy and Prince 1993a,b). The paper is organised as follows. Section 2.0 outlines briefly the statement of the problem and section 3.0 demonstrates the process of syllabification within the OT framework. The effects of the Syllable Coda Condition which are analysed in terms of alignment constraint (Itô and Mester 1994) is explored in section 4.0.

2.0 Statement of the Problem

In Itô's (1986) analysis the Syllable Coda Condition is conceived of as a negative condition ruling out particular configurations syllable-finally. Following Itô (1986), Teoh (1994) postulates the Syllable Coda Condition of Malay in (1), which states that the segments specified [-anterior] are barred from occupying the coda of a syllable.

1. $$\begin{array}{c} *\mathrm{C}]_{\sigma} \\ | \\ [\text{- anterior}] \end{array}$$

According to Teoh (1994:58), the constraint in (1) bars /č, ǰ, ɲ/[1] from codas, except in very few loan words, such as [mač] 'march' and [koleǰ] 'college' (Yunus 1980:69, Farid 1980:13). As pointed out by Teoh (1994:58), the occurrence of homorganic clusters [ɲǰ] and [ɲč] in words such as [paɲǰat] 'to climb' and [məɲčari] 'to find' is not construed as violating this constraint, because homorganic clusters are treated as partial geminates and therefore they have doubly-linked representations. By invoking Hayes's (1986) Linking Constraint, which requires that all association lines present in rules be interpreted exhaustively, the Syllable Coda Condition for Malay as stated above does not apply to doubly-linked structures.

In addition to the absence of /č, ǰ, ɲ/, there is another significant observation in the syllable coda not captured in Teoh's (1994) Syllable Coda Condition. This involves phonological alternations such as deletion and feature changing rules which affect some class of segments, namely the voiceless velar stop /k/, the voiced obstruents /b, d, g/ and the liquid /r/. As far as the Syllable Coda Condition is concerned, this phonological behaviour is more relevant, particularly in the context of the points made by Blevins (1995:228), who states that

> "Wherever possible, coda constraints should be supported by positive evidence from native and loan phonology in the form of stray Erasure, extraprosodicity, feature changing rules, or epenthesis triggered by arguably illicit coda segments. Only in such cases is there positive evidence of the systematic nature of gaps in the coda inventory".

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[1] Constraint (1) also bans /g, k, r, ŋ, h/ from syllable codas, since they are specified with [-anterior] feature in Teoh's (1994:53) feature matrix. This is inaccurate because both /ŋ/ and /h/ can occur in the coda position.

If such supportive evidence is crucial, the effect of the Syllable Coda Condition and the prohibition of /č, ǰ, ɲ/ in the coda then becomes suspicious. It is apparent that their absence in the native vocabulary is purely accidental. In what follows, I attempt to show more tangible effects of the Syllable Coda Constraint, supported by positive evidence from native and loan phonology in the form of feature changing mechanisms (i.e. feature delinking and feature spreading) and segmental deletion. These strategies are used to resolve illicit coda segments.

3.0 Syllabification in Optimality Theory

The pivotal analytical proposal of OT is that a grammar is a hierarchical ranking of well-formedness constraints. These constraints are specified by Universal Grammar, and individual grammars are constructed by imposing a language-particular ranking on those universal well-formedness constraints.

The distinguishing feature of OT with respect to other constraint-based approaches is that it allows violation of the those universal constraints. Lower ranked constraints can be minimally violated in order to assure the satisfaction of higher ranked constraints. Universal Grammar, according to McCarthy and Prince (1994) must include at least the following components:

2. CON: The set of constraints out of which grammars are constructed.
   GEN: A function defining, for each possible input *i*, the range of candidate linguistic analyses available to *i*.
   EVAL: A function that comparatively evaluates sets of forms with respect to a given constraint hierarchy Γ, a ranking of Con.

The function GEN (short for generator) will provide each input (underlying representation) with a large set of possible candidate outputs (surface representation) which is in principle infinite. The function EVAL (short for evaluation), which is embodied in a system of hierarchically ranked output constraints, will assess the well-formedness of each member of the whole candidate set. The candidate that best satisfies or least violates the constraint system is termed optimal or most harmonic, and constitutes the actual surface form attested in the language.

As mentioned, Malay is a language with a basic syllable structure (C)V(C), allowing only a single segment to occupy each syllabic constituent. Since vowels are more sonorous than consonants, they make more harmonic nuclei and less harmonic margins. In Malay only vowels are permitted in the syllable nucleus position, whereas consonants are invariably associated with the syllable margins, namely onset and coda.

As commonly accepted by most phonological theories, syllable structures are not present in the lexicon, and are derived in the course of phonological derivation. Within the OT framework, the process of syllabification is a matter of choosing the optimal output from among the possible analyses, rather than algorithmic structure building (Prince and Smolensky 2004). Syllable structure is generated in the same way as any other grammatical property by the function GEN, which produces a set of candidates with various possibilities of syllable parsing from each unsyllabified input. These possible candidates are then evaluated in parallel by the function EVAL based on a language particular constraint hierarchy. As expected, a candidate that minimally violates the constraints in the hierarchy is termed optimal and pronounced as the true output.

In early OT (Prince and Smolensky 2004, McCarthy and Prince 1993a) syllabification is construed as a process of incorporating segments into higher prosodic constituents. Phonological elements are said to be ‘parsed’ when they are associated and dominated by the appropriate node of the prosodic hierarchy (Selkirk 1980, McCarthy and Prince 1986, 1990ab), and this is controlled by a formal constraint called PARSE. As a family of constraints, PARSE provides a number of constraints that ensure parsing, such as PARSE-SEGMENT which requires that all segments must belong to moras and PARSE-μ which demands that all moras be parsed into syllables. The crucial idea about a constraint family is that a group of similar and related constraints are all built from a single broad concept (i.e. PARSE) but they are separately rankable in the hierarchy.

With the advent of Correspondence Theory (McCarthy and Prince 1995b), the earlier faithfulness constraint of the PARSE family has been subsumed under the MAX constraint family which requires that every segment of S_1 (Input) has a correspondent in S_2 (Output). PARSE-SEGMENT is now reformulated as MAX-IO, which demands that every segment of the input must have a correspondent in the output. A process of phonological deletion is reckoned as a violation of MAX-IO[2]. Similarly, for PARSE-μ: it can be reformulated as MAX-IO-μ.

The process of syllabification is primarily an interaction of the faithfulness constraint MAX-IO and the syllable structure constraints, such as ONSET, NO CODA and *COMPLEX, which are formally defined as follows:

3. Syllable structure constraints (Prince and Smolensky 2004)
ONSET - Syllables must have onsets
NO CODA - Syllables must not have a coda
*COMPLEX - No more than one segment may associate to any one syllabic constituent (i.e onset, nucleus, coda)

For the purposes of this paper, let us consider the interaction between MAX-IO and the syllable structure constraint NO CODA. It is apparent that MAX-IO and NO CODA can be in a relation of conflict which means that there are pairs of competing candidates on which the two constraints are in disagreement. Crucially, one of the candidates (the actual output form) must emerge as optimal.

As noted, MAX-IO demands that all the input segments must appear on the surface regardless of whether the form has an illicit syllable structure, for instance a syllable with a coda. This is to ensure that all underlying segments are parsed. On the other hand, NO CODA disfavours any coda element. Since Malay is a (C)V(C) language which optionally allows codas, the relevant ranking is: MAX-IO dominates NO CODA. This conclusion is illustrated in the following tableau (syllable boundaries are marked by a period '.').

4. MAX-IO >> NO CODA - i.e. /pasti/ 'sure, certain'

/pasti/	MAX-IO	NO CODA

[2] It must be noted that the crucial difference between violating PARSE-SEGMENT and MAX-IO is that in the former case the unrealised surface segment is not deleted, but remains unparsed (marked by an angle bracket < >). This is due to Containment which forbids any deletion of input materials. In the latter case, however, this is interpreted as phonological deletion.

a. pa.ti	*!	
b. ☞ pas.ti		*

The tableau in (4) introduces some useful conventions, as follows: (i) constraints are represented in their domination order from left to right, that is the highest-ranked constraint is arranged in the leftmost column; (ii) possible candidates are listed in vertical order; (iii) constraint violation is marked by '*', and constraint satisfaction is unmarked; (iv) constraint violations accompanied by an exclamation mark '!' suggest a fatal violation which is responsible for the elimination of a candidate; (v) after a fatal violation, a loser's cells are shaded emphasising that the irrelevance of a constraint to the fate of the candidate; and (vi) the optimal candidate output is signalled by a pointing finger '☞'.

The suboptimal candidate (4a) is ruled out as it fatally violates MAX-IO. The optimal candidate (4b) eschews this violation at the expense of violating the lower-ranked NO CODA. This violation is, however, not significant since the victor has already been determined. As suggested in Optimality Theory, once a victor emerges, the remaining lower ranked constraints become irrelevant whether the sole surviving candidate obeys them or not does not affect its grammaticality.

Tableau (4) shows that faithfulness to the underlying form by parsing all the input segments leads to a violation of a syllable structure constraint. Generally, such a violation can be avoided by epenthesis, which is one way of ensuring that all the input segments are parsed, and concurrently satisfy the syllable structure constraint.

In standard OT analysis, epenthesis is governed by another faithfulness constraint called FILL (Prince and Smolensky 2004, McCarthy and Prince 1994), which states that all nodes of syllable structure must be filled by underlying segments. In the Correspondence Theoretic approach, this constraint is subsumed under the DEP constraint family which demands that every segment of S_2 (output) has a correspondent in S_1 (input). FILL is now reformulated as DEP-IO, which requires that every segment of the output must have a correspondent in the input.

DEP-IO can also be in a conflict relation with NO CODA. The latter prefers a syllable without any coda, and this can be achieved by inserting an epenthetic schwa interconsonantally. The former, by contrast, favours a nonepenthetic form, even though it has an illicit syllable structure. In Malay, DEP-IO clearly outranks NO CODA. The interaction is shown in the tableau below.

5. DEP-IO >> NO CODA

/pasti/	DEP-IO	NO CODA
a. pa.sə.ti	*!	
b. ☞ pas.ti		*

Another possible form that should be considered is [pa.sti]. In this candidate, the intervocalic consonant cluster /s/ and /t/ are both parsed to the second syllable, creating a complex structure in the onset node. Considering the available constraints developed in (4) and (5), this candidate obeys all their requirements, and thus it would be the most harmonic. However, this is not the correct surface form. It must then be the case that another constraint is crucially involved in ruling out this candidate, and this constraint must be more dominant. The relevant constraint that plays a crucial role here is *COMPLEX which bans the occurrence of clusters in any node of the syllable structure[3].

6. *COMPLEX >> NO CODA

/pasti/	*COMPLEX	NO CODA
a. pa.sti	*!	
b. ☞ pas.ti		*

Malay loan phonology offers a good piece of evidence that *COMPLEX is highly respected in the language. Borrowed lexical items containing clusters are generally resolved by schwa epenthesis and C-deletion. For example, English words like *stamp, glass, class, club, post* are realised as [sətem], [gəlas], [kəlas], [kəlap] and [pos], respectively[4].

4.0 Alignment and the Syllable Coda Condition in Malay

[3] Candidate (5b) would also violate Sonority Sequencing Generalisation (or Sonority Sequencing Principle (Selkirk 1984).

In the earlier OT analysis, the Syllable Coda Condition is governed by a formal constraint generally referred to as CODA COND and defined in prose. For example, CODA COND for Axininca Campa (McCarthy and Prince 1993a and1994) is as follows.

7. CODA-COND

A coda consonant is a nasal homorganic to a following stop or affricate

In recent OT, this constraint has been reinterpreted and reformalised in terms of an alignment statement requiring consonants to be left-aligned with a syllable (Itô and Mester 1994), as formally defined in (8) below.

8. CODA COND: Align-Left (C, σ)

The formulation in (8) generally implies that all consonants are ruled out from syllable final position. In concrete cases, however, the consonantal element referred to by means of ‘C’ in (8) is often more narrowly circumscribed by referring to Cplace, marked Cplace, major segment types (resonant, obstruents), and in this way CODA COND (8) is, properly speaking, an alignment scheme that in individual grammars is cashed in for some set of elementary alignment conditions (Itô and Mester 1994:31). For instance, CODA COND for Japanese is formalised in terms of an alignment constraint by Itô and Mester (1994) as in (9), which requires a consonantal place node to occupy the left periphery of a syllable.

9. CODA COND: Align-Left (CPlace, σ)

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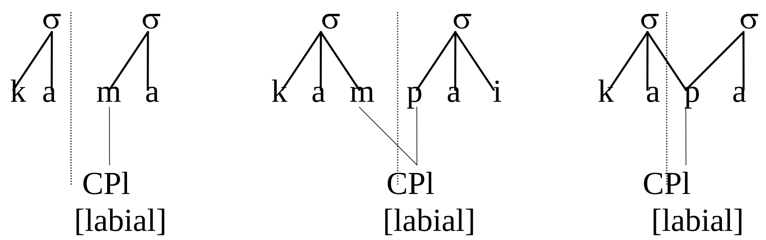
[4] It must be noted that in literary Malay, particularly under the new spelling system 1975 (Pedoman Umum Bahasa Malaysia) borrowed words containing consonant clusters are lexically preserved. However, in the old spelling system (Ejaan Sekolah), such clusters are not permitted.

CODA COND is subject to the Linking Condition (Hayes 1986, Itô 1986, 1989). Any segment which is doubly-linked to both rhyme and onset is immune to this constraint. Thus, geminates and place-linked clusters are not counted as a violation of CODA COND. Itô and Mester (1994:34) call this “noncrisp alignment”, as opposed to the “crisp” one. Consider the following representations in Japanese (Itô and Mester 1994).

10. a. kama ‘kettle’ b. kampai ‘cheers’ c. kappa ‘water imp’



The CPlace in (10a) fulfils CODA COND (9), since it is exclusively linked as a leftmost syllable daughter (“Crisp alignment”). And the CPlace in (10b) and (10c) also satisfy CODA COND, as it is linked to the left edge of the second syllable, in spite of the additional link to the preceding syllable (“noncrisp alignment”) (cf. Itô and Mester 1994).

As was mentioned, illicit coda segments are generally resolved by three different strategies namely V-epenthesis, C-deletion and feature changing mechanisms (i.e. feature delinking and spreading). For example, V-epenthesis is used to resolve CODA COND in Bedouin Arabic and Biblical Hebrew, which prohibits pharyngeal consonants in coda position (McCarthy and Prince 1993b, Itô and Mester 1994). A violation of DEP-IO is compelled by the satisfaction of CODA COND, suggesting the ranking CODA COND >> DEP-IO.

A case of C-deletion is demonstrated in the Eastern Massachusetts dialect (McCarthy 1993a). In this dialect, the consonant /r/ never occurs preconsonantally or utterance-finally. The loss of etymologic /r/ in these environments is triggered by CODA COND, and this constraint crucially dominates MAX-IO.

Other repair strategies of CODA COND violations are feature spreading and delinking. Typical cases of such mechanisms are Voicing Assimilation and Laryngeal Neutralisation (Lombardi 1995). In many languages, laryngeal distinctions are lost syllable-finally. For instance, in German voiced obstruents are devoiced syllable-finally. In this case the satisfaction of CODA COND is achieved by delinking the feature [laryngeal] of the input. The consequence of feature delinking is a violation of the IDENT-IO[F] constraint family, which demands that the correspondent of the input segment specified as [F] must be [F][5].

As far as Malay is concerned, illicit coda segments are resolved by three general strategies, namely feature delinking, feature spreading and C-deletion. These are manifested in four different phonological alternations, called Debuccalisation, Obstruent Devoicing, Nasal Assimilation and r-Deletion. To account for these, I propose that Malay requires more than one CODA COND constraint, all subsumed under the CODA COND constraint family. As suggested in Prince and Smolensky (2004), the crucial idea about a constraint family is that a group of similar and related constraints are built around a single broad concept (e.g. Faithfulness, sonority), but are still separately rankable in the constraint hierarchy.

4.1 ALIGN-STOP: Debuccalisation

The voiceless velar stop /k/ has two phonetic realisations depending on its position in the syllable structure; [k] occurs in the onset, and a glottal stop [ʔ] occupies the coda. The complementary distribution of the velar stop and glottal stop generally leads to the postulation of the former as the basic underlying form (Yunus 1980, Farid 1980, Teoh 1994). The change of the stop obstruent /k/ into [ʔ] in the syllable coda is referred to as a process of Debuccalisation[6]. Some relevant examples are listed below.

11. /saksi/ [saʔsi] ‘witness’

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[5] In the PARSE/FILL approach of earlier OT (Prince & Smolensky 1993), feature delinking is construed as a violation of a PARSE(F) constraint. In the case of laryngeal neutralisation, the relevant constraint is PARSE (Laryngeal) (cf. Lombardi 1995).

[6] It must be noted that in the Kelantan and Terengganu dialects of Malay, this rule affects all the voiceless stops /p, t, k/. Thus, the rule is more general in these dialects (see Teoh 1994, Trigo 1991).

/laksa/	[laʔsa]	‘a kind of noodle’
/sepak/	[sepaʔ]	‘to kick’
/kakak/	[kakaʔ]	‘sister’
/kapak/	[kapaʔ]	‘an axe’

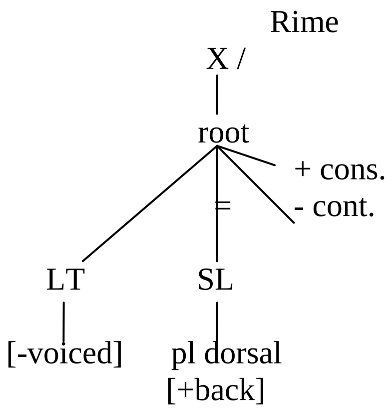
In previous studies the process of Debuccalisation is commonly known as Glottal Formation. This process occurs in many languages, such as Toba Batak (Hayes 1986b), which converts all voiceless stops in coda position to a glottal stop, and the English dialect of New York city and Scots dialects, which replace oral stop [t] to [ʔ] (Lass 1976).

Glottal Formation is formulated in Farid (1980:9) as in (12). Following Sagey’s (1986) feature representation, this rule is reinterpreted in Teoh (1994:74) as in (13) which is seen as a result of the delinking of the supralaryngeal node of the velar stop at syllable coda position, leaving only the laryngeal node linked to the root node.

12. Glottal Formation (Farid 1980:9)

$k \rightarrow ʔ \ / \ \_\_\_ \ \{\#, C\}$

13. Glottal Formation (as delinking) (Teoh 1994:74)



Both these rules lack explanatory adequacy, as they only describe the phenomenon, without providing an explanation for what motivates such a rule. In our analysis, Debuccalisation is construed as a mechanical strategy to avoid the violation of the CODA COND constraint. Following Itô and Mester (1994), the CODA COND constraint for the voiceless velar stop is ALIGN-STOP, the alignment constraint requiring the velar stop /k/ to be left-aligned with a syllable, as formally defined in (14).

14. ALIGN-STOP

Align-Left (k, σ)

The constraint in (14) demands that the consonant /k/ must be an onset. One way of eschewing a violation of ALIGN-STOP is by feature delinking. The consequence of this is a violation of the featural faithfulness IDENT-IO[F] constraint family, which demands that the correspondent of the input segment specified as [F] must be [F] (Pater 2004). In the case of k ~ ʔ alternation, the relevant constraint at play is IDENT-IO[Dorsal].

It has been generally observed that Debuccalisation basically involves the delinking of the place node (McCarthy 1988). To capture this generalisation, I employ a formal constraint IDENT-IO[Place],[7] formally defined in (15).

15. IDENT-IO[Place]

The correspondent of the input segment specified as [Place] must be [Place].

ALIGN-STOP and IDENT-IO[Place] conflict with each other, and the schematic ranking in the former must dominate the latter, as the following tableau demonstrates.

16. Debuccalisation: ALIGN-STOP >> IDENT-IO[Place]

/masak/	ALIGN-STOP	IDENT-IO[Place]
a. ma.sak	*!	

[7] As noted in McCarthy & Prince (1995b), featural faithfulness can refer to distinctive features as well as feature nodes.

b. ☞ ma.saʔ		*

The failed candidate (16a) violates ALIGN-STOP, since [k] occurs in the coda position. By contrast, in the optimal candidate (16b), the coda consonant is [ʔ], and therefore ALIGN-STOP is vacuously satisfied at the expense of violating IDENT-IO[Place]. Other possibilities of feature changing strategies, such as Spirantisation, where stops become fricatives (i.e. /k/ → [x]), or Deoralisation, where oral stops become nasals (i.e. /k/ → [ŋ]), are ruled out by assuming that the IDENT-IO[Continuant] or IDENT-IO[Sonorant] are ranked higher than ALIGN-STOP.

In addition to the feature changing rules, the satisfaction of structural well-formedness can be achieved by epenthesis (i.e. overparsing) and deletion (i.e. underparsing). The price for such parsings are violations of DEP-IO and MAX-IO, respectively. Stem final epenthesis and deletion also violate ALIGN RIGHT, which is formally defined as follows:

17. ALIGN-RIGHT

Align (Stem, Right, σ, Right)

Constraint (17) states that the right edge of a stem must coincide with the right edge of a syllable. In order for ALIGN-RIGHT to be fully satisfied, the final segment of the input stem cannot be deleted (i.e. underparsed) or syllabified with an epenthetic vowel (i.e. overparsed). Deletion and Epenthesis will cause a misalignment of the leading edges of the syllable and the stem, as shown in (18). The relevant stem-edge is marked by ‘|’, the syllable boundary is indicated by a period ‘.’, and deletion is shown by ‘< >’.

18. Stem-Syllable Alignment

Input: /masak/ Output: a. *[ma.sa.< >|]

b. *[ma.sa.k|ə.]

c. [ma.saʔ|.]

<Plc>

As can be seen, the effects of C-deletion (i.e. delinking of the root node) in (18a) and V-epenthesis in (18b) have shifted the syllable edge away from the input stem edge, a clear violation of ALIGN-RIGHT. Notice that, although the stem and syllable edges coincide in the optimal form (18c), delinking is also involved: the delinking material is a feature rather than a root node. It has been argued that delinking of features would result in a violation of ALIGN-RIGHT, just as delinking of a root node does. In order for ALIGN-RIGHT to be fully satisfied, all the feature content of the input stem, as well as the root node, must have a correspondent in the output (i.e. faithfully parsed) (cf. McCarthy 1993b, Lombardi 1995).

It is apparent that ALIGN-RIGHT is a dominated constraint in this language. In this particular case, it is outranked by ALIGN-STOP. Since all the candidates in (18) violate ALIGN-RIGHT equally, this constraint does not play a crucial role here. Therefore, the elimination of (18a) and (18b) must be due to MAX-IO and DEP-IO, which militate against deletion and epenthesis, respectively. Crucially, these constraints must be ranked higher than IDENT-IO[Place].

Unlike V-epenthesis, C-deletion is visibly active in this language in order to avoid CODA COND violations (see section 4.3). In the case where deletion is favoured over epenthesis, this implies that MAX-IO must be ranked lower than DEP-IO. To account for the case under discussion, I then establish the following part of the constraint ranking: ALIGN-STOP, DEP-IO >> ALIGN-RIGHT >> MAX-IO >> IDENT-IO[Place]. The tableau in (19) clarifies the arguments I just made. For convenience, the relevant stem-edge, the syllable boundary and delinking are marked by ‘|’, ‘.’ and ‘< >’, respectively.

19. Debuccalisation

/masak/	ALIGN-STOP	DEP-IO	ALIGN-RIGHT	MAX-IO	IDENT-IO[Place]
a. ma.sak|.	*!				
b. ma.sa.k|ə.		*!	*		
c. ma.sa.< >|			*	*!	
d.☞ma.saʔ|. <Plc>			*		*

As can be seen, although the losing candidate (19a) is well-aligned constituent-wise, it incurs a fatal violation of ALIGN-STOP. Candidate (19b) is ruled out, as it fatally violates DEP-IO. Candidates (19c) and (19d) spare this violation, but both disobey ALIGN-RIGHT. Thus, they are in a tie position, and subject to evaluation by the next available constraints. MAX-IO rules out (19c) and determines (19d) as the winning candidate. A violation of IDENT-IO[Place] becomes irrelevant, since the victor has already been pronounced.

4.2 ALIGN-OBST: Obstruent Devoicing

Malay has both voiced and unvoiced obstruents in its phonemic inventory. However, native phonology demonstrates that only voiceless obstruents are permitted syllable-finally. Loan phonology inhibits the phenomenon called Obstruent Devoicing, which changes the underlying voiced obstruents /b, d, g/ into voiceless counterparts[8] (cf. Yunus 1980, Teoh 1994).

20.	/ǰjauab/	[ǰjawap]	'answer'
	/adab/	[adap]	'manners'
	/dekad/	[dekat]	'decade'
	/abad/	[abat]	'century'
	/ǰjag/	[ǰjaʔ]	'jug'
	/ragbi/	[raʔbi]	'rugby'

The rule of Obstruent Devoicing is formulated in Teoh (1994:53) as in (21). Notice that the voice velar stop /g/ does not change into [k], as predicted by the rule, but becomes a glottal stop instead. This must be due to the effect of ALIGN-STOP discussed earlier.

21. $$\begin{bmatrix} +\text{cons} \\ -\text{cont} \\ +\text{voice} \end{bmatrix} \rightarrow [-\text{voice}] \; / \; \underset{\substack{| \\ \text{C}]_\sigma}}{\underline{\quad\quad}}$$

[8] It should be noted that all word final voiceless stops are unreleased, which means that the contact between the lips or other relevant articulatory organs for producing stop sounds, is not exploded or completely released.

As we commented on earlier, rule (21) also lacks explanatory motivation. In our analysis, the feature changing rule of Obstruent Devoicing is triggered by the action of the CODA COND on voiced obstruents. CODA COND is formalised in terms of Itô and Mester's (1994) alignment constraint as ALIGN-OBST (Align Obstruent), which requires that the voiced obstruent segments be left-aligned with a syllable.

22. ALIGN-OBST

Align-Left (voiced obstruent, σ)

Similarly to Debuccalisation (4.1), one possibility of satisfying ALIGN-OBST is by feature delinking. In this particular case, the feature [voice] of the input is not faithfully parsed. This strategy is closely similar to Obstruent Neutralisation in German (cf. Lombardi 1995) and Coda Devoicing in Dutch (cf. Booij 1997). As mentioned, the price of the feature delinking mechanism is a violation of the featural markedness constraint IDENT-IO, particularly IDENT-IO[Voice], as in (23).

23. IDENT-IO[Voice]

The correspondent of the input segment specified as [Voice] must be [Voice].

Just like with ALIGN-STOP, other possibilities of feature changing strategies, such as stops becoming nasals (i.e. /b/ → [m]) or stops becoming fricatives (i.e. /b/ → [f]), are ruled out by the assumption that IDENT-IO[Sonorant] and IDENT-IO[Continuant] are ranked higher than ALIGN-OBST in the hierarchy.

The elimination of candidates with epenthesis and deletion at the stem edge are not the consequence of ALIGN-RIGHT, but are rather due to MAX-IO and DEP-IO. Similarly to Debuccalisation, the faithfulness constraints MAX-IO and DEP-IO must outrank the featural faithfulness constraint IDENT-IO[Voice]. The interaction of ALIGN-OBST, DEP-IO >> ALIGN-RIGHT >> MAX-IO >> IDENT-IO[Voice] is illustrated in the tableau below.

24. Obstruent Devoicing

<table>
<tr><th>/ˇjauab/</th><th>ALIGN-OBST</th><th>DEP-IO</th><th>ALIGN-RIGHT</th><th>MAX-IO</th><th>IDENT-IO[Voice]</th></tr>
<tr><td>a. ˇja.wab|.</td><td>*!</td><td></td><td></td><td></td><td></td></tr>
<tr><td>b. ˇja.wa.b|ə.</td><td></td><td>*!</td><td>*</td><td></td><td></td></tr>
<tr><td>c. ˇja.wa.< >|</td><td></td><td></td><td>*</td><td>*!</td><td></td></tr>
<tr><td>d.☞ˇja.wap|.
<Voi></td><td></td><td></td><td>*</td><td></td><td>*</td></tr>
</table>

Observe that in (20) the voiced velar /g/ surfaces as a glottal stop [ʔ], instead of the voiceless velar [k] predicted by Obstruent Devoicing. The g ~ʔ alternation is not inexplicable if we invoke the earlier CODA COND constraint of ALIGN-STOP (14). If /g/ were to become [k], this would violate ALIGN-STOP, since [k] occurs in the syllable coda position. As demonstrated in (19), the optimal way of eschewing an ALIGN-STOP violation is by delinking the feature [Place], the segment thus surfacing as a glottal stop.

Given the fact that IDENT-IO[Place] is lower ranked in the hierarchy, it is plausible for /b, d/ to become a glottal stop as well. However, this possibility can never be optimal because in addition to the IDENT-IO[Place] violation, it disobeys IDENT-IO[Voice] as well. In this situation, the two constraints do not conflict, and therefore they are not ranked with respect to each other. Putting all the constraints together yields the following set of crucial rankings: ALIGN-OBST, ALIGN-STOP, DEP-IO >> ALIGN-RIGHT >> MAX-IO >> IDENT-IO[Place], IDENT-IO[Voice].

25. Alternation of g ~ʔ

/ǰag/	ALIGN-OBST, ALIGN-STOP, DEP-IO	ALIGN-RIGHT	MAX-IO	IDENT-IO[Place]	IDENT-IO[Voice]
a. ǰag|.	ALIGN-OBST *!				
b. ǰa.g|ə.	DEP-IO *!	*			
c. ǰa.< >|		*	*!		
d. ǰak|. <Voi>	ALIGN-STOP *!	*			*
e.☞ǰaʔ|. <Plc, Voi>		*		*	*

As can be seen, the failed candidate (25d), which undergoes the regular Obstruent Devoicing strategy, is ruled out because it incurs a fatal violation of ALIGN-STOP. The optimal candidate (25e) spares ALIGN-STOP and ALIGN-OBST at the expense of violating IDENT-IO[Place] and IDENT-IO[Voc] respectively.

4.3 ALIGN-RHOTIC: r-Deletion

It has long been observed that the segment /r/ is never pronounced word finally in Malay (Yunus 1980, Asmah 1975, Farid 1980). As Yunus (1980:73) points out, “Many speakers, perhaps the majority of speakers in Malaya and Singapore, do not use [r] in word final position; neither pronunciation will make any semantic change in the word: [bəna] or [bənar] ‘true or correct’”.

To begin our analysis of the r-Deletion phenomenon, let us examine the examples in (26). Notice that when the segment /r/ is deleted, the preceding vowels will then get lengthened. This particular case of compensatory lengthening is quite common in many Malay dialects (cf. Collins 1986, Zaharani 1991). This is captured in Teoh (1994) as a process of relinking the timing X-slot to the preceding vowel. As Teoh (1994:47) points out, “/r/ deletion is seen as a delinking of the root node, thus erasing everything that it dominates leaving behind an empty X-slot. The preceding vowel then relinks to the empty X-slot thus resulting in the lengthening of the vowel”.

26. a. Root final /r/

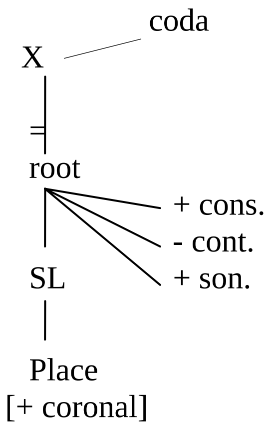
/kotor/	[kotoː]	‘dirty’
/uker/	[ukeː]	‘to carve’
/ukor/	[ukoː]	‘to measure’
/pasar/	[pasaː]	‘market’

In the previous rule-based analysis, the absence of [r] in stem final position is treated as an obligatory /r/ deletion rule by Farid (1980:16), but as an optional /r/ delinking rule by Teoh (1994:43)[9]. As shown in (27) and (28), both rules have the same structural description, that is, /r/ in coda position.

27. /r/ deletion rule (Farid 1980:16)

$$r \rightarrow \varnothing \ / \ \underline{\quad\quad} \ \{\#, C\}$$

28. /r/ delinking rule (Teoh 1994:43)



Obviously, the deletion of /r/ in the coda must be triggered by the CODA COND constraint. And again, by adopting Itô and Mester’s (1994) alignment formalism, the relevant constraint at play here is ALIGN-RHOTIC, which requires that the segment /r/ be left-aligned with a syllable.

9 Based on the previous observations of Asmah (1975), Yunus (1980) and Farid (1980), and prevalently supported by our contemporary data, I disagree with Teoh (1994) and strongly affirm that /r/ deletion word finally is obligatory.

29. ALIGN-RHOTIC

Align-Left (r, σ)

As shown in (26), the optimal way of satisfying the CODA COND constraint in (29) is by segmental deletion. This strategy is similar to the Eastern Massachusetts dialect as reported in McCarthy (1993a). Deleting the final segment of a stem incurs a violation of ALIGN-RIGHT. Crucially, for the case under discussion the hierarchical ranking is ALIGN-RHOTIC >> ALIGN-RIGHT, as demonstrated in tableau (30). Since a feature changing mechanism is not harmonic here, any possible IDENT-IO[F] constraint must be ranked higher than ALIGN-RHOTIC in the hierarchy.

30. r-Deletion: ALIGN-RHOTIC >> ALIGN-RIGHT

<table>
<tr><th>/kotor/</th><th>ALIGN-RHOTIC</th><th>ALIGN-RIGHT</th></tr>
<tr><td>a. ko.tor|.</td><td>*!</td><td></td></tr>
<tr><td>b.☞ ko.toː.< >|</td><td></td><td>*</td></tr>
</table>

Another possibility for eschewing the ALIGN-RHOTIC violation is by V-epenthesis (i.e. [ko.to.rə] . This candidate violates ALIGN-RIGHT as well, since the syllable edge and stem edge do not coincide. Thus, we have a tie situation here which must obviously be resolved by the faithfulness constraints. Deleting an input segment violates MAX-IO, and inserting epenthetic material violates DEP-IO. In the case where deletion is favoured over epenthesis, MAX-IO must be ranked lower than DEP-IO.

Considering the case under discussion, the relevant ranking to account for the phenomenon of r-Deletion is as follows: DEP-IO, ALIGN-RHOTIC, >> ALIGN-RIGHT >> MAX-IO.

31. r-Deletion

/kotor/	DEP-IO	ALIGN-RHOTIC	ALIGN-RIGHT	MAX-IO
a. ko.tor|.		*!		
b. ko.to.r|ə.	*!		*	
c.☞ ko.toː.< >|			*	*

Another important observation in the data in (26) that has not been explored thus far is the phenomenon of compensatory lengthening. As mentioned, when the coda /r/ is deleted, the preceding vowel then gets lengthened. It is common crosslinguistically that deletion of a coda consonant is always followed by vowel lengthening, such as in Latin (Ingria 1980, Bichakjian 1986), Ancient Greek (Wetzels 1986), Turkish (Sezer 1986) and Tiberian Hebrew (Lowenstamm and Kaye 1986).

Following the same interpretation of the autosegmental analysis, compensatory lengthening is construed in this study as the result of parsing the timing X-slot (possibly analysed as a mora) to the preceding vowel. Thus, we need another formal constraint that belongs to the MAX-IO constraint family called MAX-IO$_X$, which is formally defined in (32).

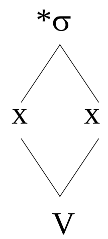
32. MAX-IO$_X$

Every X in the input must have a corespondent in the output.

Although MAX-IO and MAX-IO$_X$ belong to the same MAX-IO family, they are two distinct constraints, and therefore in principle they are separately rankable in the hierarchy. Given the facts of Malay, these two constraints never conflict, and therefore they don't need to be ranked with respect to each other.

When the timing X-slot is associated to the preceding vowel, this creates a long vowel with a doubly-linked structure. The price for this is a violation of a constraint in (33), which prohibits long vowels (cf. Rosenthall 1994).

33. No Long Vowel (NLV)



Crucially, the faithfulness constraint MAX-IO$_X$ must outrank NLV in the hierarchy. Putting all the constraints together, the relevant ranking for r-Deletion is now established as follows: DEP-IO, ALIGN-RHOTIC, >> ALIGN-RIGHT >> MAX-IO, MAX-IO$_X$ >> NLV.

34. r-Deletion and compensatory lengthening

/kotor/	DEP-IO	ALIGN-RHOTIC	ALIGN-RIGHT	MAX-IO$_X$	MAX-IO	NLV
a. ko.tor|.		*!				
b. ko.to.r|ə.	*!		*			
c. ko.to.< >|			*	*!	*	
d.☞ko.toː.< >|			*		*	*

In addition to segmental deletion, the failed candidate (34c) erases the timing-X unit as well, thus, incurring MAX-IO and MAX-IO$_X$ violations. The optimal candidate (34d) spares MAX-IO$_X$ by parsing the underlying X-element to the preceding vowel, which surfaces as a long vocoid. The satisfaction of MAX-IO$_X$ compels a violation of NLV. This violation is irrelevant, since the victor has already been determined.

4.4 ALIGN-NASAL: Nasal Assimilation

Another phonological effect of CODA COND is on nasal segments. All the previous studies affirmed that a nasal segment which forms the coda of the first syllable is always homorganic with the following onset obstruent, and this fact is captured by a very general rule called Nasal Assimilation (Farid 1980:13, Teoh 1994:101). This generalisation is true for clusters within the stem and at the prefix juncture, but not for clusters at the suffix boundary, as the following examples show.

35. a. Homorganic cluster within the stem

/sampan/	[sampan]	‘boat’
/nampak/	[nãmpaʔ]	‘to see’
/pantas/	[pantas]	‘fast’
/pandu/	[pandu]	‘to drive’
/paɲǰat/	[paɲǰat]	‘to climb’

b. Homorganic cluster at prefix juncture

/məŋ+basoh/	[mə̃mbasoh]	‘wash’
/məŋ+dataŋ/	[mə̃ndataŋ]	‘come’
/məŋ+gali/	[mə̃ŋgali]	‘dig’
/məŋ+ǰilat/	[mə̃ɲǰilat]	‘lick’

c. Non-homorganic cluster at suffix boundary

/tanam+kan/	[tanãmkan]	*[tanãŋkan]	‘bury (imperative)’
/hitam+kan/	[hitamkan]	*[hitaŋkan]	‘blacken (imperative)’
/padan+kan/	[padankan]	*[padaŋkan]	‘match (imperative)’
/təkan+kan/	[təkankan]	*[təkaŋkan]	‘press (imperative)’

d. Word final nasal

/malam/	[mãlam]	‘night’
/makan/	[mãkan]	‘to eat’
/pasaŋ/	[pasaŋ]	‘to assemble’

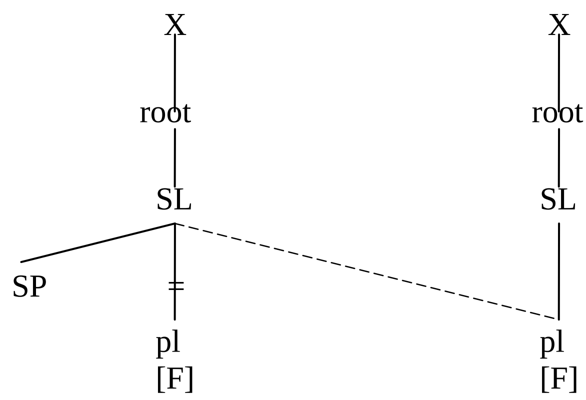
The occurrence of homorganic clusters is common cross-linguistically and is construed as the result of Nasal Assimilation. In Farid’s (1980) analysis, Nasal Assimilation is formalised as a feature changing rule as in (36). One notable comment about the formalism in rule (36) is that it is very unconstrained and cumbersome.

36. Nasal Assimilation as feature changing (Farid 1980:13)

$$[+\text{nasal}] \rightarrow \begin{bmatrix} \alpha\ \text{ant} \\ \beta\ \text{cor} \\ . \\ . \\ . \end{bmatrix} \Big/ \ \underline{\qquad} \ \begin{bmatrix} \text{C} \\ \alpha\ \text{ant} \\ \beta\ \text{cor} \\ . \\ . \end{bmatrix}$$

Within the multilinear framework (Teoh 1994), Nasal Assimilation is interpreted as a process of spreading, that is, the nasal segment gets its specification for place of articulation through linking with the following consonantal segments. This is illustrated in (37).

37. Nasal Assimilation as Spreading (Teoh 1994:101)



Notice that in (35c) Nasal Assimilation fails to apply, otherwise we will get incorrect surface forms, as indicated by the asterisk. However, given the formulations of the rules in (36) and (37), we would expect nasal assimilation to take place, because its environment is fully satisfied.

This irregular behaviour of Nasal Assimilation at the suffix boundary is not discussed in Teoh (1994). Farid (1980: 13), on the other hand, regards this as an exception, as he notes, "Nasals always appear on the surface as homorganic to a following consonant, except in cases of reduplication, or if the cluster consists of nasal plus suffix-initial consonant [kan]".

In an OT account, the irregularity of Nasal Assimilation at the suffix juncture is explainable. This process does not take place in the optimal output because the candidate in hand is not the best candidate to satisfy the constraint hierarchy.

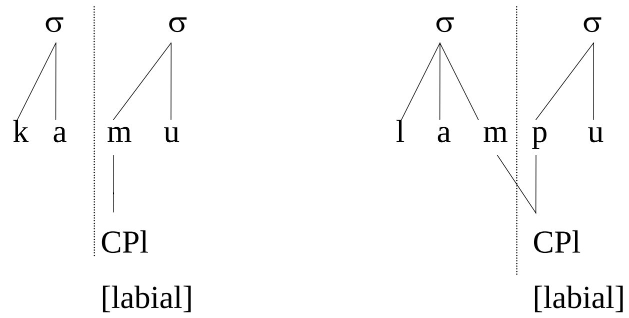
As is widely accepted, Nasal Assimilation in natural languages is triggered by the CODA COND constraint. As mentioned, in the earlier OT analysis (McCarthy and Prince 1993ab, 1994), the CODA COND for nasals is defined in prose as in (7) above. Following Itô and Mester (1994), this constraint has been reinterpreted and reformalised in terms of alignment statement, and we label it ALIGN-NASAL here.

38. ALIGN-NASAL

Align-Left (CPlace Nasal, σ)

The constraint in (38) penalises any occurrence of specified CPlace nasal in the coda. As established in the earlier version of CODA COND (Itô 1986), geminates and place-linked clusters are not counted as a violation. Itô and Mester (1994:34) call this noncrisp alignment, as opposed to the crisp one. The difference between crisp and noncrisp alignments can be seen below.

39. a. [kamu] 'you' b. [lampu] 'light'



The CPlace in (39a) fulfils ALIGN-NASAL, since it is exclusively linked as a leftmost syllable daughter ("Crisp alignment"). The CPlace in (39b) satisfies ALIGN-NASAL as well, because it is linked to the left edge of the second syllable, in spite of the additional link to the preceding syllable ("noncrisp alignment") (cf. Itô and Mester 1994).

The process of Nasal Assimilation basically involves two general procedures. First, the nasal segment loses its specified [Place] node by delinking. Second, it obtains a new [Place] node from the following consonant through spreading. The consequence of Nasal Assimilation is a violation of the featural faithfulness constraint IDENT-IO[Place] (15), which requires that the correspondent of the input segment specified as [Place] must be [Place]. A violation of IDENT-IO[Place] directly effects ALIGN-RIGHT. As mentioned, in order for ALIGN-RIGHT to be fully satisfied, all the feature content of the input stem, as well as the root node, must have a correspondent in the output (faithfully parsed) (cf. McCarthy 1993b, Lombardi 1995).

Obviously, the inapplicability of Nasal Assimilation at the suffix boundary is the consequence of satisfying ALIGN-RIGHT. Thus, the ranking is ALIGN-RIGHT >> ALIGN-NASAL. As mentioned, although ALIGN-STOP and ALIGN-NASAL belong to the same CODA COND family, they are distinct constraints, and therefore they can be separately ranked in the constraint hierarchy. Tableau (40) gives a clear illustration why an assimilated candidate fails to emerge as the winner. Since ALIGN-OBST is irrelevant here, it is not represented in the tableau.

40. ALIGN-NASAL violation at the suffix juncture

<table>
<tr><th>/tanam+kan/</th><th>DEP-IO</th><th>ALIGN-RIGHT</th><th>ALIGN-NASAL</th><th>MAX-IO</th><th>IDENT-IO[Place]</th></tr>
<tr><td>a. ta.na.< >|kan</td><td></td><td>*!</td><td></td><td>*</td><td></td></tr>
<tr><td>b. ta.na.m|ə.kan</td><td>*!</td><td>*</td><td></td><td></td><td></td></tr>
<tr><td>c. ta.naŋ|.kan
<Plc></td><td></td><td>*!</td><td></td><td></td><td>*</td></tr>
<tr><td>d.☞ta.nam|.kan</td><td></td><td></td><td>*</td><td></td><td></td></tr>
</table>

The assimilated candidate (40c), which has a multiple-linked structure survives ALIGN-NASAL, in compliance with a noncrisp alignment. The delinking of the [Place] node of the underlying nasal /m/, however, fatally violates ALIGN-RIGHT. The optimal candidate (40d) is featurally faithful to the input, but it disobeys the dominated CODA COND constraint ALIGN-NASAL.

The hierarchical ranking in (40) also accounts for the preservation of the specified feature [Place] of the nasal segment word finally. This is illustrated in tableau (41).

41. ALIGN-NASAL violation word finally

<table>
<tr><th>/tanam/</th><th>DEP-IO</th><th>ALIGN-RIGHT</th><th>ALIGN-NASAL</th><th>MAX- IO</th><th>IDENT-IO[Place]</th></tr>
<tr><td>a. ta.na.< >|</td><td></td><td>*!</td><td></td><td>*</td><td></td></tr>
<tr><td>b. ta.na.m|ə.</td><td>*!</td><td>*</td><td></td><td></td><td></td></tr>
<tr><td>c. ta.nã|.
<Plc></td><td></td><td>*!</td><td></td><td></td><td>*</td></tr>
<tr><td>d.☞ta.nam|.</td><td></td><td></td><td>*</td><td></td><td></td></tr>
</table>

Observe that candidate (41c) undergoes Debuccalisation, not C-Deletion. As noted, Debuccalisation is a process that involves delinking of the Place node. As illustrated in (16), /k/ debuccalises into a glottal stop in order to avoid a violation of the CODA COND constraint ALIGN-STOP. In this particular case, when a nasal segment loses its [Place] node of articulation, it leaves behind a nasal element [nasal] (i.e. a nasal lacking a point of articulation). This nasal element is then docked into the preceding vowel deriving a nasalised vowel.

Nasal Debuccalisation is a very productive rule in some of the Malay dialects as a strategy used to get rid of word-final nasals (cf. Teoh 1994, Trigo 1991). The effect of Debuccalisation is a violation of ALIGN-RIGHT as well as the featural faithfulness constraint IDENT-IO[Place]. The Debuccalised candidate (41c) cannot be better than the optimal candidate (41d), which preserves the specified [Place] node of the nasal segment.

On the other hand, at the prefix juncture, the nasal segment in the coda of the first syllable is always homorganic with the following onset obstruent of the second syllable. The application of Nasal Assimilation suggests that ALIGN-NASAL must be obeyed by the candidate in order to emerge as the optimal output.

In previous studies the C-final prefix in (35b) is represented with nasal segment which is not specified for the feature node [Place] (cf. Teoh 1994, Kroeger 1988). This consonant gets its [Place] node from the following obstruent through spreading. It has been argued that underspecification is unnecessary in the analysis of OT (Prince and Smolensky 2004, Itô, Mester and Padgett 1995). As Itô, Mester and Padgett (1995) point out, “Since there is no sequential phonological derivation in Optimality Theory, there is no sense in which (parts of) the phonological derivation could be characterised by underspecification”. Following this assumption, I construe the nasal-final prefix in Malay as fully specified in the lexical representation, and as represented as a dorsal nasal /ŋ/, since this segment appears before V-initial stems (cf. Farid 1980).

Nasal Assimilation applies at the prefix boundary, and this suggests that a process of delinking is taking place here. However, this has no effect on ALIGN-RIGHT, since the effected segment occurs at the left edge of the stem. In this case, ALIGN-RIGHT is vacuously satisfied by an assimilated candidate. By employing the same ranking hierarchy in (41), the effect of Nasal Assimilation at the prefix boundary is demonstrated in tableau (42) below.

42. ALIGN-NASAL satisfaction at the prefix juncture

/məŋ+basoh/	DEP-IO	ALIGN-RIGHT	ALIGN-NASAL	MAX-IO	IDENT-IO[Place]
a. məŋbasoh			*!		
b. məŋəbasoh	*!				
c. məbasoh				*!	
d. ☞məmbasoh <Plc>					*

The alignment constraint ALIGN-RIGHT is irrelevant in this prefixal environment, and therefore it is vacuously satisfied by all the candidates. Candidate (42a) gets its [Place] node by default and surfaces as a velar nasal [ŋ]). The cluster is not homorganic, and therefore it is ruled out by ALIGN-NASAL. The failed candidates (42b) and (42c) spare ALIGN-NASAL at the expense of violating the faithfulness constraints DEP-IO and MAX-IO, respectively. Candidate (42d) incurs no such violation and is pronounced the victor.

5.0 Conclusion

Although Malay may have single-member codas, there is a restriction in the language which prohibits a small class of consonants in that position. This prohibition is due to the syllable structure constraint CODA COND. I have reinterpreted and reformalised this constraint in terms of Itô and Mester's (1994) alignment constraint. I have argued that Malay has four constraints subsumed under the CODA COND constraint family, namely, ALIGN-STOP, ALIGN-OBST, ALIGN-RHOTIC and ALIGN-NASAL. These constraints are distinct, and therefore they are separately ranked in the constraint hierarchy.

Illicit coda segments have been tackled by three different strategies - feature delinking, feature spreading and root node delinking. The effects of CODA COND constraints ALIGN-STOP, ALIGN-OBST, ALIGN-RHOTIC and ALIGN-NASAL are represented in four phonological phenomena called Debuccalisation, Obstruent Devoicing, r-Deletion and Nasal Assimilation, respectively.

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