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Edge Asymmetries in Phonology and Morphology

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1. Introduction

Many phonological and morphological phenomena affect only one edge of a constituent – not both left and right edges. Three of the more well known cases are listed below:

(1) (a) Positional Preservation:
Underlying phonological material can resist neutralization at the left edge of a constituent, but not at the right edge.
(Trubetzkoy 1939:228*ff*, Casali 1997, Beckman 1998)

(b) Iambic Footing Asymmetry:
Iambic feet are almost always parsed from left to right – not right-to-left. e.g. [(σσ́)(σσ́)σ], *[σ(σσ́)(σσ́)].
(Hayes 1985, 1995)

(c) Prefix-Suffix Asymmetry:
Attachment of morphemes to the left edge of roots – i.e. prefixation – is marked: while every non-isolating language has suffixes, not every language has prefixes.
(Greenberg 1957, Hawkins & Gilligan 1988)

The processes in (1) show that asymmetric edge-reference is not confined to a small subpart of the grammar: it is found in both the faithfulness (1a) and markedness realms of phonology (1b) and in morphology as well (1c).

Processes which apply at only one edge present a challenge for theories of phonology and morphology which allow indiscriminate reference to both edges. In such

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theories, a variety of unattested processes are predicted to occur (e.g. resistance of neutralization at right edges, right-to-left iambs, and prefixing-only languages).

A number of researchers have addressed the problem of edge asymmetries within Optimality Theory. For example, Cohn & McCarthy (1994:50) note that left-edge alignment of PrWds with Roots is required more frequently than right-edge alignment (also see McCarthy & Prince 1993a). They express this asymmetry by constraint ranking, with ALIGN(Root, Left, PrWd, Left) outranking its right-edge counterpart. Cohn & McCarthy's approach can be adapted to explain universal edge-asymmetries by stipulating a fixed ranking: with ALIGN-L always outranking ALIGN-R, the left edge will always be favoured.

An alternative is presented by Nelson (1998). Nelson argues that asymmetries in edge reference are due to a Special-General relationship in constraint-formulation. For ANCHOR constraints, Nelson argues that there is a general constraint that refers to both edges at once and a specific one that refers to left edges alone. Significantly, there is no constraint that refers solely to right edges.

The aim of this paper is to explore another way to account for edge-asymmetries, namely by prohibiting reference to right edges entirely. So, there is no ALIGN/ANCHOR-Right or ALIGN/ANCHOR-{Left and Right}, only ALIGN/ANCHOR-Left. We dub this the 'Impoverishment' approach since it is the solution that invokes the fewest number of constraints (so CON is 'impoverished' in comparison to the other solutions).

To explore the Impoverishment approach, we push it to its logical extreme, eliminating the possibility of right-edge reference for all constraints, not just for ALIGN/ANCHOR:

(2) Edge-Asymmetry Hypothesis (EAH):
No constraint may refer to the right edge of a constituent.

The Impoverishment idea finds precedent in a great deal of recent work. In Positional Faithfulness, Beckman (1998) has argued that there are faithfulness constraints that refer to constituents at left edges, but there are no faithfulness constraints that refer to the right edge (or to both edges simultaneously).[1] Similarly, McCarthy & Prince (1993a:56) claim that right-edge referring ALIGN constraints are extremely restricted in form. Hung (1994) and Hyde (in prep.) also invoke asymmetric constraints which favour the left edge and have no right-edge-favouring counterpart.

The EAH is an extremely strong instantiation of the Impoverishment hypothesis for edges (unless edge-reference is eliminated altogether). The decision to explore such a strong hypothesis is motivated less by empirical considerations than by the methodological principle that – in general – it is best to start by considering extremes and from there determine how to moderate the idea. So, this paper can be seen as the beginnings of an exploration into whether the EAH should either be maintained, weakened (and if so, how), or discarded.

The remainder of this paper is organized around two questions: (1) "Which apparently left-edge-favouring phenomena can the EAH account for?" and (2) "Can a system without constraints that refer to right edges produce apparent right-edge effects?". In section 2, the first question is addressed by examining the asymmetric phenomena listed in (1). We show that the EAH is empirically adequate and restrictive: it both accounts for the attested facts and cannot generate unattested systems. The second

[1] Beckman does employ a more general faithfulness constraint that does not refer to edges at all, but preserves material in every position (i.e. initial, medial, final). In this way, Beckman's approach is also a 'Special-General' one, but in a more extreme way than Nelson's.

question is the focus of section 3. We argue that a limited range of right edge effects can occur even without explicit right-edge reference. Opacity, morphological constraints, and conditions on prosodic contiguity are identified as significant in this regard. Conclusions are presented in section 4.

2. Asymmetric Edge-Reference

The aim of this section is twofold: (i) to examine the general implications of the EAH for constraint form (§2.1), and (ii) to examine the empirical effects of the EAH by analyzing the phenomena listed in (1) (§2.2-2.4).

2.1. Constraint Form

The EAH – stated in (2) – is a hypothesis about the form of phonological and morphological constraints. In short, if a constraint refers to a constituent edge, it will be the left, and never the right.[2] So, the EAH prohibits constraints such as ALIGN(Ft, R, PrWd, R) and *σ] (i.e. NONFINALITY – Prince & Smolensky 1993).

Apart from edge-reference, the EAH imposes no limitations on constraint form. In particular, the EAH has nothing to say about which classes of constraints may refer to edges; it is merely a condition on which edge constraints may refer to. So, the EAH does not imply that for every *F(eature) constraint there is a constraint *[$_{\alpha}$F, banning F at the left edge of constituent α. Whether certain types of constraints refer to edges at all is still a matter of empirical investigation. Similarly, the EAH does not preclude reference to properties such as headedness or constituent-membership. So, it is not relevant in determining the validity of constraints that preserve material in stressed syllables or ban features in certain constituents.

We remain agnostic about the exact formal status of the EAH. It may merely be a descriptive statement about constraints in UG, or it could be an active condition that limits constraint form (especially in the instantiation of constraint schemas – see §2.2). The sole aim of the present work is to (start to) determine whether the EAH is empirically adequate. Accordingly, we now turn to the edge-asymmetries listed in (1).

2.2. Asymmetric Faithfulness

In this section, the first of the edge-asymmetric phenomena mentioned in (1) – Positional Preservation – is examined in light of the EAH. We adopt Beckman's (1998) theory that such phenomena can be explained by employing faithfulness constraints that refer to left-edge constituents and that there are no analogous constraints that refer to right edges. We show that this asymmetry follows straightforwardly from the EAH.

Beginning with Trubetzkoy (1939), a number of researchers have pointed out that left edges are often not subject to otherwise general neutralization processes (Casali 1997, Beckman 1998). Such preservation is rarely found at right edges (Trubetzkoy 1939:237, also see §3.2, 3.3).

An example of left-edge preservation is found in Tamil. The mid vowels [ɛ] and [ɔ] are neutralized everywhere except in the leftmost syllable (Christdas 1988, Beckman 1998:§2.3.3.1): e.g. pɔrɪ "fry", *pirɔ. Beckman (1998) proposes that such position-specific preservation is due to faithfulness constraints that refer specifically to left edge constituents (i.e. the root-initial syllable, onsets (i.e. leftmost constituent in syllable)). With such constraints outranking a neutralization-causing markedness constraint (which

[2] 'Edges' are not independent elements (*cf SPE*), but are rather those nodes in a constituent C which are not preceded or followed (for 'left' and 'right' resp.) by any other nodes in C. See McCarthy & Prince (1993a) for details.

in turn outranks a general faithfulness constraint) position-specific preservation results. This is demonstrated in the following tableau. Example(1) shows preservation of mid vowels initially, contrasting with example (2) which has neutralization non-initially:

(3)

1.	/pɔrɪ/	IDENT-σ_1-mid	*MID	IDENT-mid
☞	pɔrɪ		x	
	purɪ	x!		x
2.	/pirɔ/	IDENT-σ_1-mid	*MID	IDENT-mid
	pirɔ		x!	
☞	piru			x

Various rankings of these constraints produce a variety of results, including across-the-board neutralization (*F » IDENT-σ_1-F, IDENT-F) and no neutralization at all (IDENT-F, IDENT-σ_1-F » *F). However, there is no ranking that can produce position-specific preservation without that position being the initial syllable. So, the right edge can never avoid neutralization alone, with other factors such as headedness aside (see §3 for relevant discussion).

The issue of present interest is to account for the fact that faithfulness constraints may only refer to leftmost constituents and never to right-edge elements. The EAH offers a straightforward solution to this problem: faithfulness constraints cannot refer to right edges because 'right' is not in the repertoire of edges available in constraint formation.[3]

The EAH has an additional benefit: it allows faithfulness constraints to be seen as a schema. A schema, in the sense of McCarthy & Prince (1993a), is a template with various arguments; every possible instantiation of the arguments produces a constraint (Green 1993). With the EAH, faithfulness constraints can also be seen as a schema with the following form (brackets indicate optional arguments):

(4) *FAITH*-(*XCat*$_1$ (at *edge* of *XCat*$_2$))
(i) FAITH ∈ {MAX, DEP, IDENT-F, etc.} (McCarthy & Prince 1995)

While the possible values of XCat$_{1/2}$ are disputed (Beckman 1998, Casali 1997), the important point is that the *edge* argument is limited to just 'left'. Because of this, complete instantiation of the schema will not yield any right-edge referring constraints.

The virtue of the schema-based approach is that individual faithfulness constraints do not have to be listed separately in CON. Instead, all faithfulness constraints can be derived by full instantiation of a general schema, analogous to ALIGN, ANCHOR, IDENT-F, and *Feature constraints (McCarthy & Prince 1993a, 1995).

Positional Faithfulness also bears on the validity of competing edge-asymmetry hypotheses. In comparison to the Impoverishment hypothesis, expressed by the EAH, both the Fixed Ranking and Special-General hypotheses still give some status to right-edges. Under these hypotheses, there are faithfulness constraints that refer to the right edge. The restriction, though, is that there can be no right-edge preservation without left-edge preservation as well. Unlike Beckman's and the present approach, this predicts languages which resist neutralization in word-peripheral positions and not medially (e.g. a language Tamil-Prime in which mid vowels are neutralized everywhere except initially

[3] Beckman (1998:ch.1) presents a functionally-based explanation for the edge-asymmetry in faithfulness constraints. This solution does not obviously generalize to other cases where edge-reference is asymmetric, though. It is also unclear to us whether the proposal is restrictive enough; as Beckman points out (pp.1,3) there are functional factors which suggest that final syllables should be treated as prominent; hence preservation should be promoted at right edges, contrary to fact.

and finally: ✓pɛrɔ, ✓pɛtirɔ, * pɛrɔti). To our knowledge, such languages do not exist, indicating that the Impoverishment approach is the correct one. This result identifies an important difference between the Impoverishment approaches and the alternatives: with the alternatives, right edges can have at least an emergent effect on processes whereas in the Impoverishment approach, right edges can have no effect at all.

2.3. Concatenation

Greenberg (1957, 1966) observed that there is an implicational universal in affix concatenation, confirmed recently in more extensive work (Hawkins & Gilligan 1988, Bybee et al. 1990):[4]

(5) If a language has prefixes it also has suffixes, but not vice-versa.

This asymmetry results straightforwardly from the EAH. Specifically, we propose that this universal derives from conditions on the alignment of Root edges with Word edges. By the EAH, there are constraints that require the edges of a Root to coincide with the edges of the Word that contains it, with the form ALIGN(Root, *edge*, Word, *edge*) (McCarthy & Prince 1993a). However, with the EAH the only possible instantiation of the *edge* argument of this schema is 'left': ALIGN(Root, left, Word, left). When the left edge of the Root is forced to align with the left edge of the Word, no other morphemes can precede it. So, by ALIGN(Root, L, Word, L), [$_{\text{Word}}$ Root] is an acceptable morphological structure, but [$_{\text{Word}}$ prefix + Root]] is not.

Significantly, there is no constraint that requires alignment of the right edge of the Root with the Word's right edge. So, no constraint prohibits the structure [$_{\text{Word}}$Root+suffix], correctly predicting that suffixes will always surface, unlike prefixes.

In summary, the inability to refer specifically to the right edge of morphological constituents (i.e. Root, Word) is crucial in accounting for the asymmetry in affix concatenation. This follows straightforwardly from the EAH.[5]

2.4. Footing Asymmetries

Hayes (1985, 1995) has established that iambic (right-headed) feet are almost always parsed from 'left-to-right'. So, /σσσσσ/ will surface as [(σ́σ)(σ́σ)σ] and never as *[σ(σ́σ)(σ́σ)]. The exceptions to this generalization are found in languages with final main stress (e.g. Tübatulabal, Aklan, Cebuano, and Weri – Hayes 1995:263-4 and references cited therein).[6] We will show that a similar asymmetry exists for quantity-sensitive (QS) trochees: they can only be parsed right-to-left if main stress is near the right edge.

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[4] The generalization in (5) does not apply to reduplicants: Harvey (1997) observes that affix-sized reduplicants are always prefixes, not suffixes. See Harvey (1997) and de Lacy (1999) for methods of ordering reduplicants without the need for constraints that refer to right edges.

[5] This proposal raises a few issues to do with constraints on morphological concatenation. We reject the idea that affixes are designated as prefixes or suffixes by constraints such as ALIGN-L/R(affix, Stem) (Prince & Smolensky 1993, McCarthy & Prince 1993a). Instead, we assume that affix order is derived from syntactic/morphological structure. Affix order is thus already specified in the input to the phonology (Selkirk 1982). We refrain from discussing this point further as it would take us too far beyond the scope of this paper.

[6] Kager (1989) and Hayes (1995:263-5) have suggested that these languages could be analyzed as having L→R trochees with a final degenerate foot containing the main stress. While this analysis is possible, it does not rule out the R→L iamb approach. So, the constraint system presented here does not overgenerate.

The major difficulty for an adequate theory of the iambic footing asymmetry is that quantity-insensitive (QI) trochees do not exhibit any asymmetry: they can be left- or right-edge aligned, regardless of the placement of main stress.

In this section, we argue that both the footing asymmetries and the lack of asymmetry for QI trochees can be explained without recourse to constraints that refer to right edges (also see McCarthy & Prince 1993b:appendix 2). Constraints that refer only to the left edge and main stress provide an adequate and restrictive account of footing.

2.4.1. The Direction Asymmetries

The ALIGN constraints of McCarthy & Prince (1993a) have been extensively employed to deal with footing. These constraints are adopted here with the limitation that they cannot refer to right edges. The two instantiations of ALIGN that are most relevant are as follows (adapted from McCarthy & Prince 1993a:§3):

(6) ALIGN-Left(Ft, PrWd)
"Align the left edge of every foot with the left edge of some PrWd"
ALIGN-Left(Ft, σ́)
"Align the left edge of every foot with the main-stressed syllable."

Leaving main stress considerations aside for the moment, it is clear that the constraints can only generate iambs oriented towards the left edge: since the constraint ALIGN-L(Ft, PrWd) has no directly antagonistic competitors, left-to-right footing will always result.

Main stress complicates matters somewhat. If main stress is final and ALIGN-L(Ft,σ́) dominates ALIGN-L(Ft, PrWd), feet will be parsed from right-to-left:[7]

(7)

	/σσσσσ/	ALIGN-L(Ft, σ́)	ALIGN-L(Ft, PrWd)
☞	σ(σσ̀)(σσ́)	x x x	x x x x
	(σσ̀)σ(σσ́)	x x x x!	x x x

However, right-to-left iambs can only occur when main stress is final; when it is near the left edge, iambs can only be parsed from left-to-right:

(8)

	/σσσσσ/	ALIGN-L(Ft, σ́)	ALIGN-L(Ft, PrWd)
☞	(a) (σσ́)(σσ̀)σ	x x	x x
	(b) (σσ́)σ(σσ̀)	x x x	x x x
	(c) σ(σσ́)(σσ̀)	x x	x x x x

As shown in the tableau above, the right-to-left foot parses in (b) and (c) incur a superset of (a)'s violations. Because of this, (a) will always be produced when main stress is near the left edge no matter what the constraint ranking (i.e. (a) harmonically bounds (b) and (c)). So, the different permutations of ALIGN-FT-L and ALIGN-Ft-σ́ account for the iambic edge-asymmetry, correctly banning right-to-left iambs except when main stress is final (as in Tübatulabal, Aklan, Cebuano, and Weri).

A prediction made by the present proposal is that main stress could appear near either edge in left-to-right iambic systems: with ALIGN-L(Ft,PrWd) outranking ALIGN-

[7] All cases discussed here are systems with full parsing of well-formed feet. In other words, the constraints ||FTFORM » PARSE-σ|| outrank all the constraints mentioned in the tableaux (Prince & Smolensky 1993).

L(Ft, σ́), feet will be attracted to the left edge without regard to main stress placement. This prediction is confirmed in languages such as Araucanian, which has peninitial main stress, and Unami, where main stress falls near the right edge (see Hayes 1995:211, 265 and references cited therein).

With these constraints, the same results obtain for quantity-sensitive trochees (i.e. left headed feet with the forms ($\sigma_{\mu\mu}$) and ($\sigma_{\mu}\sigma_{\mu}$)). This correctly produces that L→R QS trochees can result with main stress near either the left or right edges (e.g. Cahuilla and Lenakel Adjs/Vs resp.). It also predicts that only languages with main stress near the right edge (e.g. Samoan) can have R→L trochees, and that otherwise R→L trochees are impossible. This result seems to be correct.[8]

One question raised by this analysis relates to main stress: without constraints that refer to the right-edge, how can there ever be final main stress at all? We do not yet have a complete answer to this question, so we merely note the existence of alternatives: Hyman (1977) argues that right-edge main stress comes about through alignment with boundary tones. Another alternative is to employ a constraint against post-main stress lapses, analogous to Hung's (1994) constraint against post-stress clashes.

2.4.2. QI Trochees and Symmetric Footing

The difficulty is in explaining why QI feet (i.e. (σ́σ)) can have any direction of foot parsing, regardless of the position of main stress.[9] As with iambs and QS trochees, a system with high-ranking ALIGN-Ft-L will allow a L→R parse of QI trochees with either leftmost or rightmost main stress. So, the problem is really why the R→L parse can have initial main stress, unlike iambs and QS trochees.

To do this, we suggest an addition to the constraint system proposed above – a constraint of the *σ́ variety relativized to the left edge of the word: *[σ́ (i.e. NONINITIALITY – Walker 1997 and references cited therein). *[σ́ is obviously irrelevant for iambic systems since stress can never be initial due to foot form. In trochaic systems, though, it produces apparent right-to-left trochees if ranked above the other constraints:

(9)

/σσσσσ/	*[σ́	ALIGN-L(Ft, PrWd)	ALIGN-L(Ft, σ́)
☞ σ(σ́σ)(σ̀σ)		x x x x	x x
(σ́σ)(σ̀σ)σ	x!	x x	x x

Due to the low rank of ALIGN-Ft-σ́, the placement of main stress is irrelevant to footing. Most significantly, R→L trochees can appear with main stress near the left edge, as shown in (9). So, with *[σ́ full symmetry of foot parsing in QI systems is achieved.

The final step in the argument is to show that *[σ́ does not affect QS trochees, or more specifically does not generate R→L QS trochees with main stress near the left edge. A glance at tableau (9) may seem to indicate otherwise: with *[σ́ outranking ALIGN-FT-L, right-to-left trochees with initial main stress result. However, this system is not a true

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[8] Wargamay has been claimed to have R→L trochees with initial stress, producing forms such as [σ(σ́σ)(σ̀σ)] (Hayes 1995:140). However, this could equally be analyzed as L→R parsing with emergent avoidance of initial stress (see below), with the ranking || PARSE-σ » *[σ́ » ALIGN-FT-L||. A crucial example that could distinguish the two analyses is /LLLH/ with the former analysis predicting [LL(LL)(H)] and the latter [L(LL)L(H)]. Unfortunately, H syllables are confined to initial position in Wargamay, and a ban on stress clash further obscures the issue. In short, Wargamay does not offer conclusive evidence for R→L trochees with initial main stress.

[9] Examples: (i) L→R footing with initial main stress: Anguthimri, (ii) L→R,final: Piro, (iii) R→L, initial: Malakmalak, (iv) R→L, final: Cavineña (Hayes 1995 and references cited therein).

R→L QS trochaic system. Instead, it has a L→R foot parse with emergent avoidance of initial stress (like Wargamay – see fn.8). The string /LHLLL/ is revealing in this regard. In a true R→L trochaic system, the parse should be [L(H)L(LL)]. In a L→R trochaic system with initial extrametricality, the parse would be [L(H)(LL)L]. As shown in the following tableau, the former parse is impossible to generate as the latter one harmonically bounds it:

(10)

/LHLLL/	*[σ	ALIGN-FT-L	ALIGN-FT-σ
☞ L(Ĺ)(ÌL)L		x x x	
L(Ĺ)L(ÌL)		x x x x	x

In short, the addition of the *[σ constraint cannot produce R→L QS trochees. The closest it can get to such a system is a L→R trochaic parse with initial extrametricality.

To relate this back to QI feet, it should now be evident that a R→L QI trochaic parse is really a L→R system with initial stress avoidance. However, in QI systems it is impossible to distinguish an apparent R→L parse from an L→R parse with initial stress avoidance due to the fact that the two systems can only be distinguished when monosyllabic and disyllabic feet intermingle. This will never happen in QI systems since all feet are uniformly disyllabic.

In conclusion, we have shown that the complex edge-asymmetries in foot-parsing can be produced without constraints that refer to the right edge. In fact, constraints with right-edge reference would be distinctly undesirable: a constraint such as ALIGN-R(Ft, PrWd) would produce unattested R→L iambs and QS trochees regardless of the position of main stress.[10]

As a final observation, we note that the analysis presented above has a precedent in McCarthy & Prince's (1993b) analysis of the iambic asymmetry; their analysis also crucially relies on the non-existence of constraints that attract feet to right edges. The analysis presented above may be seen as an extension of their idea.

3. Right-Edge Phenomena without Right Edge-Reference

The aim of this section is to show that a system without constraints that refer to right edges can still produce a limited number of apparent right-edge effects. Three devices are shown to be relevant in this regard: contiguity of prosodic constituents, constraints on morphological realization, and opacity. The subsections are organized accordingly. Section 3.1 deals with languages that relax conditions on syllable structure at the right edge of a domain, allowing more complex consonant clusters finally than medially (e.g. Cairene Arabic). We show that a notion of prosodic contiguity allows clusters only finally. In §3.2, constraints on morphological realization are shown to produce apparent instances of right-edge preservation in Javanese. In §3.3, a case of right-edge preservation in English is shown to result from an opaque interaction of constraints. In all cases, there is no need for constraints that refer to right edges. This section concludes with a discussion of the power of the various devices presented herein to produce apparent right-edge effects.

[10] A final remark: since the same facts apply to both QS trochees and iambs – R→L footing is only possible with (near-)final stress – it is still a mystery that R→L iambs are so rare while R→L trochees are quite common. We suspect that the reason has to do with an independent fact about iambic systems: they tend to avoid final stress (Hayes 1995:269). Since final main stress is necessary for R→L iambs, R→L iambs are therefore also rare. We leave the explanation of why final stress is avoided in iambic systems for future research.

One point implicit in this section is that apparent right-edge effects are not a unified phenomenon but rather are the side-effect of a variety of different processes. This situation parallels that of circumscription, which was argued to unify many different processes, including infixing, truncation, and certain types of allomorphy (McCarthy & Prince 1990, 1995). Circumscription has since been discarded, with the phenomena it purported to cover now explained by a variety of diverse processes (see e.g. McCarthy & Prince 1993a, Prince & Smolensky 1993). We envisage the same fate for apparent right-edge effects.

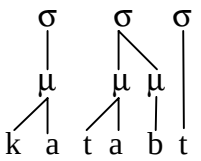
3.1. Contiguity and Right-Edge Complexity

Constraints that place conditions on the linear relationship between certain nodes can produce apparent right-effects. Specifically, a constraint that requires moras to be contiguous is shown to account for the fact that CV:C and CVCC syllables are only allowed finally in Cairene Arabic (McCarthy 1979). More generally, we argue that structural complexity is not specifically attracted to/permitted in final position; rather, medial structural complexity is ruled out by constraints requiring contiguity of prosodic nodes.

In Cairene Arabic, CV, CV: and CVC syllables can appear anywhere in the word. However, CV:C and CVCC sequences are restricted to word-final position. For example, [ka.tabt] 'I wrote' with a final CVCC syllable is acceptable, but *[tatb.ka] is not.

Following much previous work, we consider these 'superheavy syllables' to be a normal CV:/CVC syllable followed by a minor syllable (McCarthy 1979, Crowhurst 1996). A minor syllable consists of an onset consonant alone without a nucleus. The existence of minor syllables has been documented in a wide variety of languages (Shaw 1996, Bye 1997a,b), and have been shown to exist in the related Bedouin Arabic (McCarthy 2000). So, a word such as *katabt* actually has the following representation:

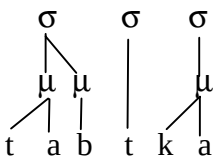
(11)



The minor syllable analysis has a number of advantages, explaining why final consonants are 'extrametrical' – i.e. they do not count for stress assignment (Crowhurst 1996).

The issue, then, is why minor syllables are allowed word-finally, but not medially or initially. To explain this we invoke a notion of moraic contiguity: moras must be strictly adjacent. In other words, non-moraified material cannot intervene between moras (μ-CONTIG). An example of an offending configuration with a medial CVCC sequence is shown below:

(12)



In this structure, the moras are separated by non-moraified material – the medial [t].[11] In comparison, the structure in (11) does not violate μ-CONTIG at all. So, μ-CONTIG is effectively a medial structural condition, allowing minor syllables only at word edges.

To account for Cairene Arabic in OT terms, *COMPLEX, which bans consonant clusters in syllabic constituents, must outrank MAX, banning deletion. MAX in turn outranks EXHAUSTIVITY, which requires prosodic nodes to be associated to nodes in immediately adjacent tiers. With EXHAUSTIVITY ranked relatively low, minor syllables will be formed to accommodate the extra C left over from avoiding C clusters. μ-CONTIG is highest ranked, preventing medial minor syllables:

(13)

	/katabt/	μ-CONTIG	*COMPLEX	MAX	EXHAUST
☞	ka.tab.t				x
	ka.tab			x!	
	ka.tabt		x!		
	/tabtka/	μ-CONTIG	*COMPLEX	MAX	EXHAUST
	tabt.ka		x!		
	tab.t.ka	x!			x
☞	tab.ka			x	

The final step in this analysis is to deal with the ban on initial minor syllables in Cairene. To account for this, we invoke a left-edge version of EXHAUSTIVITY: EXHAUSTIVITY-L requires prosodic structure at the left edge to be exhaustively parsed, effectively banning minor syllables word-initially. There can be no corresponding constraint EXHAUSTIVITY-R, due to the EAH. This seems to be a desirable result: while there are languages with minor syllables only at the right edge (e.g. Cairene Arabic), and with minor syllables in every possible position, we have not found any cases where minor syllables can appear exclusively word-initially.

The analysis presented here generalizes to a number of other cases where right edges house more complex syllable structures than in other positions. For example, Kamaiurá only allows CVC syllables word-finally (McCarthy & Prince 1993a). We consider this a sequence of a CV syllable followed by a word-final minor syllable: [CV.C#], not *[CVC#].

Minor syllables can also help explain some cases of apparent right-edge preservation. For example, glottalized stops in Tojolabal are neutralized in codas everywhere except word-finally: e.g. [pʔotoʔ], *[pʔokʔ.toʔ] (Lombardi 1994). We propose that word-final consonants actually appear in minor syllables: *[pʔo.to.tʔ]. Since the final C is not in a coda, it is not subject to neutralization.

Conditions on prosodic contiguity may also explain other cases of right-edge prosodic complexity. For example, it is well-known that contour tones are often permitted only at the right edge of words (e.g. Odden 1995). In such cases, a tonal contiguity constraint, requiring 'head' tones to be adjacent could rule out medial contours, but not final ones.[12]

In short, structural complexity at the right edge does not indicate the activity of constraints that refer to the right edge. Conditions on medial structure coupled with constraints on left edges can produce apparent right-edge effects.

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[11] This analysis does depend to some extent on the syllable structure assumed. For this model of the syllable see Hyman (1985), Perlmutter (1995), and Hayes (1995:53*ff*).

[12] By 'head' tone we mean either the tone associated to the head mora or one of the members of a complex tone, depending on one's assumptions about contour tones (see Yip 1995 for discussion).

3.2. Morphological Realization and Right-Edge Preservation

The aim of this section is to show that conditions on morphological realization can produce cases of apparent right-edge resistance to neutralization.

In Javanese, non-low vowels are almost always lax in closed syllables (Dudas 1976). The exception to this generalization is found in final syllables, where both tense and lax vowels can appear. When tense vowels are present, though, they mark the morphological category 'Elative'. In the examples below, the form on the left is the plain adjective and the form on the right is the corresponding Elative.

(14)

Adjective	Elative	
alʊs	alus	'refined, smooth'
abɔt	abut	'heavy, hard'
aŋɛl	aŋil	'hard, difficult'

Thus, contrast in closed syllables in Javanese is richer in final position than elsewhere. In §2.2 preservation of positional contrast was claimed to result from faithfulness constraints that referred specifically to the position in question. So, in the present case such constraints would have to refer specifically to the syllable at the right edge of the word, contra the EAH.

However, the observed pattern can be explained by other means. Instead, we relate it to the need to faithfully parse the exponent of the Elative, which is evidently [+tense].[13] The crucial constraint is MORPHREAL, which requires some exponent of a morpheme to be present in the output form (Prince & Smolensky 1993). So, if the Elative morpheme is not realized as [+tense], MORPHREAL is violated, as shown in example (1) below. In the morphologically simple case, MORPHREAL fails to have any effect, so producing neutralization (example 2):

(15) || MORPHREAL » *V[+tense]C]$_\sigma$ ||

1	/alus+[+tense]$_{elative}$/	MORPHREAL	*V[+tense]C]$_\sigma$	IDENT[tense]
a. ☞	alus		x	
b.	alʊs	x!		x
2	/alus/	MORPHREAL	*V[+tense]C]$_\sigma$	IDENT[tense]
a.	alus		x!	
b. ☞	alʊs			x

If the Elative morpheme's [+tense] feature is unparsed, as in candidate (1b), the Elative has no visual surface exponent, so violating MORPHREAL. This overrides the general pressure to neutralize vowels in closed syllables, as in example (2).

The alternative to this analysis is not only unnecessary, but undesirable: if right-edge faithfulness were invoked, tense vowels in final syllables should appear in every morphological class, not just in the Elative. So, analyses that fail to invoke a morphological constraint fail to capture this aspect of the Javanese system.

[13] The reader will observe that the output of the elative is subject to a constraint which renders the tense vowel [+high], regardless of the [±high] specification of the input. We ignore this detail in our analysis.

3.3. Opacity and Right-Edge Preservation

In this section, we argue that opacity coupled with contiguity requirements can also produce apparent right edge preservation.

In many English dialects, the possibilities of contrast amongst the short vowels of unstressed open syllables are richer finally than medially (Chomsky and Halle 1968: 74*ff*, Halle & Mohanan 1985:59–62). The dialect of one of the authors (New Zealand English) is a rather extreme example, but illustrates the point well:

(16) Short medial vowels: /ə/
Short final unstressed vowels: /i ə u o/ e.g. *city*, *builder*, *jujitsu*, *judo*.

This seems like a *bona fide* case of right-edge contrast preservation. Accordingly, it seems that faithfulness constraints that refer to rightmost syllables should be invoked to account for it (see §2.2). Even so, we will argue that the greater variety of contrast seen finally in English is not due to specific right-edge preservation but instead to an opaque process of tenseness assimilation and glide deletion. As background to the proposal, a rather typical English vowel inventory is presented below, focussing on the tense-lax distinction:

(17) English vowel system (tenseness distinctive)

Lax/Short			Tense/Long	
ɪ		ʊ	ij	uw
ɛ	ʌ	o	ej	ow
æ	a	ɔ	aa	ɔɔ

To account for the relation between tenseness and length, we adopt the view that the 'long' or 'tense' vowels are really diphthongs consisting of vowel followed by a [+high] glide. With the exception of the [+low] vowels /aa/ and /ɔɔ/, the other 'long' vowels are segmentally complex. Tenseness is a function of adjacency to the glide.[14]

This offers an explanation for the contrast found in final short vowels. We propose that such vowels come from an vowel + glide (/j/ or /w/) sequence. So, in final position the system is underlyingly /ɪj ə ɪw əw/. The reason that these sequences end up as /i ə u o/ on the surface is due to an opaque interaction: the vowel is assimilated to the glide in terms of tensing, then the glide is deleted: /ɪj/ → [ij] → [i].

This opaque interaction can be modeled using Sympathy Theory and Cumulativity (McCarthy 1999, 2000). Two constraints that are crucial are ASSIM "A vowel followed by a glide must be [+tense]" and *GLIDE, which bans glides. Their interaction is shown in the following tableau:

(18)

	/hæpɪj/	ASSIM	*GLIDE	❀SYM	IDENT[tense]	✯MAX-C
a.	hæpɪj	x!	x	∞x's		✓
b. ❀	hæpij		x!		x	✓
c.	hæpɪ			∞x's!		x
d. ☞	hæpi			x	x	x

[14] In OT, Richness of the Base means that the phonological system must deal with the possibility of input long vowels. In the present analysis, input long vowels will be neutralized to short ones (due to ||NOLONGV » MAX-μ||). Similarly, tense short vowels will be neutralized to lax unless they assimilate to glides (see below).

This alternation does not take place word-internally because word-internal deletion is banned by the faithfulness constraint I-CONTIG: 'No skipping' (McCarthy & Prince 1995: 371).[15]

So, the richer system of contrast in short vowels in final open syllables results from an opaque vowel-glide interaction in tandem with a condition on medial contiguity (I-CONTIG). The patterns do not necessitate the postulation of faithfulness constraints which pick out right-peripheral syllables.

3.4. Limitations on Right-Edge Effects

The processes invoked in the preceding sections can only produce a limited array of right-edge effects, nothing like the range of structural attraction and preservation found at left edges. Contiguity effects, for example, can only affect the extreme right edge of words. While contiguity can preserve underlying material and so has an effect analogous to right-edge faithfulness, its scope is extremely limited, affecting only the rightmost segment in a word. This compares to left-edge preservation, which may affect an entire syllable, not just a single peripheral segment. The same can be said of right-edge structural effects. With minor syllables and contiguity, right edges can house an extra consonant, allowing consonant clusters at right edges but not medially; the same is true of tone. However, structural complexity can only occur at the extreme right edge. There can be no cases, for example, where the onset of a final syllable is more complex than any other onset. In comparison, structural effects at left edges can affect more than just peripheral segments. For example, complex codas can be banned except in the initial syllable (Beckman 1998).

Opacity has limitations similar to contiguity since it relies on contiguity to limit its effects to final position; so, any opaque interaction resulting in preservation can only effect an element at the extreme right edge of a domain. Similarly, morphological conditions have extremely limited effects, only being able to apply when the morpheme is present in the input; they do not allow right-edge preservation in every circumstance.

In short, the processes presented in this section do not make the present theory isomorphic with one that employs right-edge reference. They have an extremely limited array of effects, consistent with the idea that the right edge is not as significant for phonological phenomena as the left edge.

4. Conclusions

The purpose of this paper was to explore the consequences of a particularly strong hypothesis about the ability of constraints to refer to edges:

(19) Edge-Asymmetry Hypothesis (EAH):
No constraint may refer to the right edge of a constituent.

The preceding sections have examined some empirical consequences of the EAH: it avoids several pathological predictions in the realms of faithfulness, markedness, and morphology (§2), but still allows a limited range of right-edge effects (§3) – a desirable result.

Of course, it is far too early to come to any conclusions about the adequacy of the EAH; the present work is only a small step towards exploring its effects. Whatever the ultimate fate of the hypothesis, it is clear that any adequate theory of phonology and

[15] Inputs with final /i/ cannot map onto surface [i] since tensing can only come about through assimilation to a glide. Instead, we suggest that input [i] maps onto output [ə]. Formally, this is an Input–Output chain-shift since input /i/ maps onto output [ə] but input /ɪj/ and /ij/ map onto output [i] (see Bye in prep. for discussion).

morphology must recognize the pervasiveness of asymmetric edge-reference and seriously address the issue.

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