Directional constraint evaluation solves the problem of ties in Harmonic Serialism

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This paper examines the problem of tied candidates in Harmonic Serialism (Prince and Smolensky, 1993/2004; McCarthy, 2000, 2016) and presents directional constraint evaluation (Eisner, 2000, 2002) as a solution. Under standard evaluation, constraints report *how many* loci of violation a candidate contains, and as such, cannot differentiate two candidates with equal numbers of violations. Under directional evaluation, constraints report *where* loci of violation occur, and are thus able to distinguish candidates with distinct loci of violation. Alternative tie-breaking mechanisms either fail to solve ties in general or introduce unwanted typological predictions.

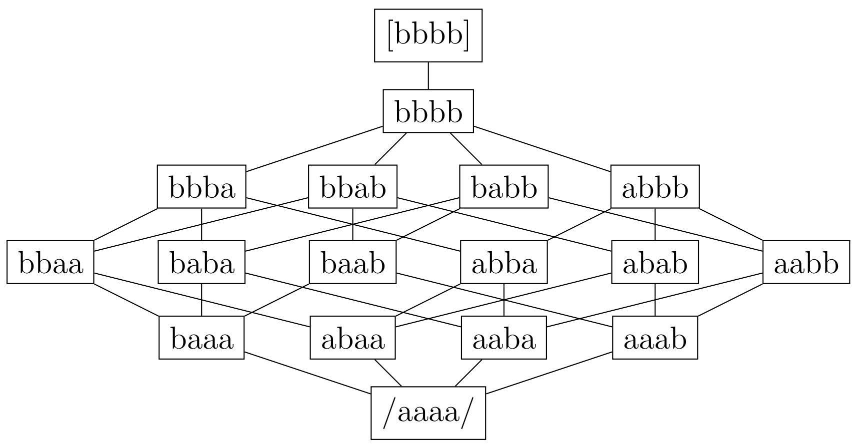
Candidates tie when they cannot be differentiated by Eval. With traditionally evaluated constraints, which count loci of violation, ties occur whenever candidates have the same number of violations. Following Pruitt's (2009) terminology, ties are either convergent or divergent. In a convergent tie, choosing between optima does not affect the ultimate output. The tableau in (1) illustrates this with a derivation mapping /aaaa/ onto [bbbb]; mappings in this paper abstract away from phonological substance because ties are a problem of Eval, not a given representation. The faithful candidate (1a) is dispreferred to the four unfaithful candidates (1b-e), which tie.

(1) /aaaa/ → [bbbb], Step 1

/aaaa/	*a	Ident
a. aaaa	W 4	L
→ b. baaa	3	1
→ c. abaa	3	1
→ d. aaba	3	1
→ e. aaab	3	1

In (1), an optimal candidate can be chosen randomly without consequence: regardless of the order in which each /a/ is changed, the derivation converges on [bbbb]. All possible derivations from /aaaa/ to [bbbb] are shown in (2), which represents harmonic improvement vertically. Every path that starts with the underlying representation (UR) /aaaa/ at the bottom, moves upward through a chain of intermediate representations, and ends with the output [bbbb] at the top, is a possible derivation.

(2)



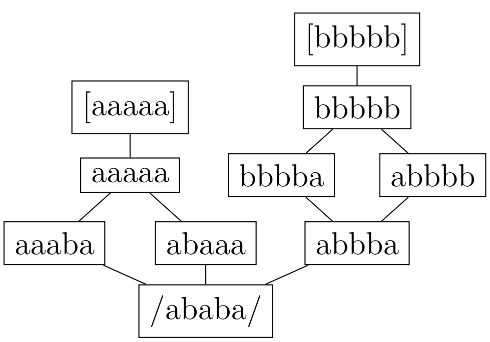
In a divergent tie, choosing between tied candidates does affect the ultimate output, creating variation. This is undesirable because there is no way to control the relative frequencies between the tied candidates (see Anttila, 2002 for critical discussion of tied candidates as a theory of variation). The tableau in (3) illustrates a divergent tie with assimilation; the markedness constraint penalizes adjacent segments that are not identical. The fully faithful candidate (3a) and the unfaithful candidates where an edge segment was changed (3b,f) are dispreferred to the other unfaithful candidates (3c-e). Because loci of violation overlap, targeting interior segments offers more harmonic improvement than targeting edge segments. Candidates (3c-e) have the same number of violations and tie.

(3) Divergent assimilation, Step 1

/ababa/	*{ab, ba}	Ident
a. ababa	W 4	L
b. bbaba	W 3	1
→ c. aaaba	2	1
→ d. abbba	2	1
→ e. abaaa	2	1
f. ababb	W 3	1

The derivational paths from this step are represented in (4). If candidates (3c,e) are chosen, the derivation converges on [aaaaa]. If candidate (3d) is chosen instead, the derivation converges on [bbbbb]. While the UR /ababa/ is only mapped onto fully agreeing outputs, the space of possible outputs grows with the length of the UR. For example, the UR /ababababa/ can surface as [aaaaaaaaa], [aaaaabbbb], [aaabbbaaa], [aaabbbbbb], [bbbbaaaaa], [bbbbbbaaa], or [bbbbbbbbb].

(4)



This example demonstrates how ties differ in pOT and HS. Because HS is derivational, ties can occur in intermediate steps as in (3) and introduce cascading variation. In pOT, [bbbbb] is not a possible output because it is evaluated in parallel along with [aaaaa]. Both candidates satisfy *{ab, ba}, but the latter minimizes the violations of Ident, exemplifying Majority Rule (Lombardi, 1999; Baković, 2000; see Lamont, 2019 for a discussion of Majority Rule in HS), wherein the relative magnitude of two classes in the input determines the output. In HS, Eval has no lookahead capability, and so cannot disprefer candidate (3d) on the basis of its longer derivation.

The tie in (3) can be broken by including additional constraints. For example, a markedness constraint that penalizes [b] would rule out candidate (3d), as would a faithfulness constraint that penalizes the mapping /a/ → [b]. This would leave candidates (3c,e) as tied optima, and the derivation would converge on [aaaaa]. McCarthy (2009) dubs cases like (3) ties of neglect, and argues they are not a deep theoretical problem, but instead reflect an incomplete analysis. He contrasts ties of neglect with ties of principle, which resist intervention by additional constraints. In HS, ties of principle are characterized by some operation applying at different positions in the input. Two case studies of divergent ties of principle are presented in section 1. Section 2 demonstrates that directional constraint evaluation (Eisner, 2000, 2002) eliminates ties, and section 3 discusses alternative tie-breaking mechanisms.

1 The problem: Divergent ties of principle

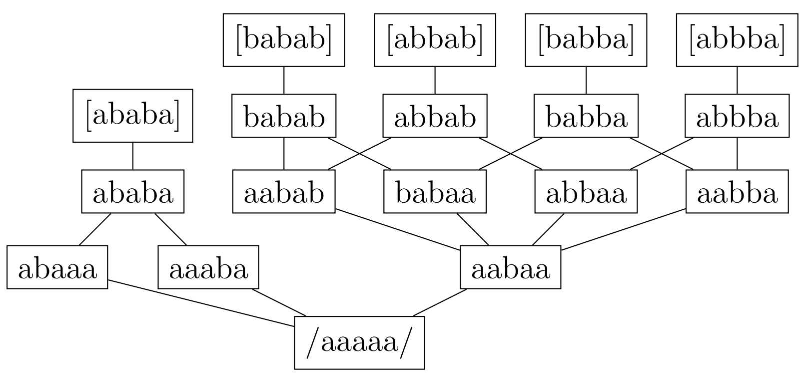
The tableau in (5) illustrates a divergent tie of principle with dissimilation; the markedness constraint penalizes adjacent segments that are both [a].[1] The fully faithful candidate (5a) and the unfaithful candidates where an edge segment was changed (5b,f) are dispreferred to the unfaithful candidates where an interior segment was changed (5c-e). It is better to target interior segments than edge segments, but there is no way to choose between interior segments. All three tied candidates were derived by mapping an /a/ onto a [b], and are only distinguished by the position at which the mapping occurred. Thus, unlike the assimilation case in (3), these candidates cannot be distinguished by penalizing a specific segment or a specific mapping.

(5) Divergent dissimilation, Step 1

/aaaaa/	*aa	IDENT
a. aaaaa	W 4	L
b. baaaa	W 3	1
→ c. abaaa	2	1
→ d. aabaa	2	1
→ e. aaaba	2	1
f. aaaab	W 3	1

The derivational paths from this step are represented in (6). If candidates (5c,e) are chosen as optimal, the derivation converges on [ababa]. If candidate (5d) is chosen instead, the derivation can converge on [babab], [abbab], [babba], or [abbba]. These four outputs would be harmonically bounded in pOT: while all five possible outputs satisfy *aa, [ababa] minimizes the violations of IDENT.

(6)



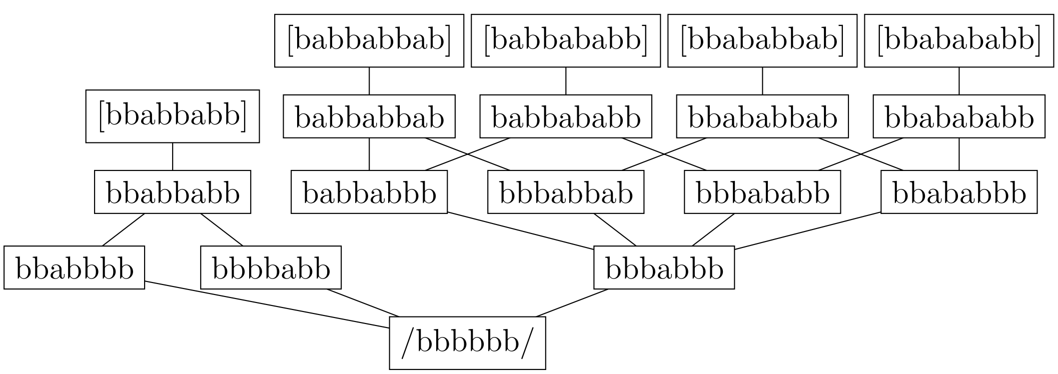
Another example of a divergent tie of principle is illustrated in the tableau in (7) with epenthesis; the markedness constraint penalizes three adjacent segments that are all [b]. The fully faithful candidate (7a) and the unfaithful candidates where an [a] was inserted close to the edge (7b-c,g-h) are dispreferred to the other unfaithful candidates (7d-f). As in (5), the tied candidates are all derived by the same mapping, which inserts [a], and are differentiated only by the location of its application.

(7) Divergent epenthesis, Step 1

/bbbbbb/	*bbb	Dep
a. bbbbbb	W 4	L
b. abbbbbb	W 4	1
c. babbbbb	W 3	1
→ d. bbabbbb	2	1
→ e. bbbabbb	2	1
→ f. bbbbabb	2	1
g. bbbbbab	W 3	1
h. bbbbbba	W 4	1

The derivational paths from this step are represented in (8). If candidates (7d,f) are chosen, the derivation converges on [bbabbabb]. If candidate (7e) is chosen instead, the derivation can converge on [babbabbab], [babbababb], [bbababbab], or [bbabababb]. As above, these four outputs are harmonically bounded in pOT, as they contain three epenthetic vowels and [bbabbabb] contains only two.

(8)



2 A solution: Directional constraint evaluation

The question of which locus of violation to apply a given operation to echoes the question in rule-based phonological theory of how to apply a rule to an input with multiple foci. Section 1 showed that random choice yields chaotic, unpredictable derivations, and outside of one hypothetical aside (Anderson, 1974:221), I am unaware of any proposals in rule-based phonology that advocate random choice. Iterative models that target foci one at a time are typically directional: rules start at one edge of an input and work their way across (Brown, 1972; Howard, 1972; Johnson, 1972; Jensen and Stong-Jensen, 1973; Cearley, 1974; Vago and Battistella, 1982). Imposing directional application on Harmonic Serialism is a principled way to break ties.

One way to impose directional application is to adopt directional constraint evaluation (Eisner, 2000, 2002; Finley, 2008, 2009; Lamont, 2019). Under directional evaluation, constraints return a violation tuple, which records the location of loci of violation relative to the input, rather than a single value reporting the total number of loci. Constraints are specified as evaluating left-to-right (⇒) or right-to-left (⇐). Like traditional constraints, directional constraints prefer candidates without violations to candidates with violations. Directional constraints further distinguish violations based on their location within candidates: under left-to-right evaluation, constraints prefer loci to be as far to the right as possible, and under right-to-left evaluation, constraints prefer loci to be as far to the left as possible.

Directional evaluation originated as a computational restriction on parallel Optimality Theory. Eisner (2000, 2002) demonstrated that if Gen is a regular relation and Con comprises only directional constraints and bounded constraints, i.e., constraints that only count up to a fixed number (Frank and Satta, 1998), pOT only produces regular mappings. Thus, directional evaluation eliminates non-regular mappings such as the Midpoint Pathology (Eisner, 1997) and Majority Rule (Lombardi, 1999; Baković, 2000). Further, Finley (2008) showed that directional constraints also avoid Sour Grapes spreading (Wilson, 2003, 2006). Adopting Eisner's restrictions in HS guarantees that each step is a regular mapping, but this does not necessarily imply that entire derivations are regular mappings. However, the non-trivial resemblance of HS with directional constraints to Johnson's (1972) linear rules, which are known to be regular mappings, suggests similar restrictiveness. Directional evaluation is also a general solution to the problem of ties. Ties of principle do not arise because candidates with different loci of violation are distinguished by the positions of their loci.

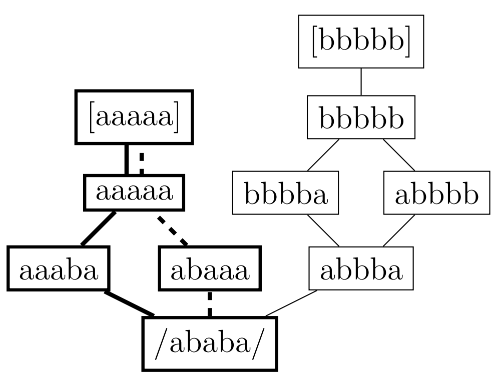
As an illustration, consider the tableau in (9). This tableau is the same as the tableau in (3), except that the markedness constraint is evaluated directionally. The markedness constraint *{ab, ba} is evaluated left-to-right, as the superscript arrow $\Rightarrow$ indicates. As such, it imposes a harmonic order on the loci of violation according to their position relative to the input. The leftmost locus [a_1b_2] is strictly worse than its successor [b_2a_3], and so on. For visual clarity, loci are shown in the tableau with indices. Whereas traditional evaluation cannot distinguish candidates with an equal number of loci, directional evaluation imposes a total harmonic order on candidates with different sets of loci. Candidates (9a,d-f) with the worst locus [a_1b_2] are strictly worse than candidates (9b-c). Notice that the total number of violations is irrelevant; candidate (9b) has three violations but is better than candidates (9d-e) which have only two violations. Candidate (9c) is chosen as optimal because candidate (9b) has an additional locus of violation [b_2a_3]. The harmonic ordering on loci determines which locus is targeted at each step. Ceteris paribus, it is always optimal to target the leftmost/rightmost locus, and candidates cannot tie. Directional evaluation guarantees the leftmost/rightmost locus is targeted, not necessarily the leftmost/rightmost violating segment. Note that left-to-right application is consistent with two theories of Con: one with parameterized constraints and *{ab, ba} is specified as left-to-right, and one with both directional versions and *{ab, ba}$^{\Rightarrow}$ dominates *{ab, ba}$^{\Leftarrow}$.

(9) /ababa/ → [aaaaa], Step 1

/ababa/	*{ab, ba}$^{\Rightarrow}$					IDENT
a. ababa	W	a_1b_2	b_2a_3	a_3b_4	b_4a_5	L
b. bbaba	W		b_2a_3	a_3b_4	b_4a_5	1
→ c. aaaba				a_3b_4	b_4a_5	1
d. abbba	W	a_1b_2			b_4a_5	1
e. abaaa	W	a_1b_2	b_2a_3			1
f. ababb	W	a_1b_2	b_2a_3	a_3b_4		1

The derivational path from this step is represented in (10). The thick solid line traces the derivation with left-to-right evaluation, and the thick dashed line represents right-to-left evaluation; both derivations converge on [aaaaa]. For the grammar to converge on [bbbbb], the first step would have to target the loci in the center of the candidate (9d), preserving the leftmost and rightmost loci. Because loci at the edges of the input are strictly worse than those in the center, this is impossible. Both directions of evaluation converge on [aaaaa] because the input is a palindrome; it is not true in general that left-to-right evaluation and right-to-left evaluation converge on the same output. For example, with the UR /ababab/, left-to-right evaluation produces the output [aaaaaa], and right-to-left evaluation produces [bbbbbb].

(10)



In the tableau in (9), only the markedness constraint is evaluated directionally;

the faithfulness constraint is evaluated traditionally. This reflects a theory of CON wherein all and only markedness constraints are evaluated directionally (Lamont, 2019). This theory eliminates all ties of principle between candidates that violate markedness constraints, but does not account for ties between unmarked candidates, as in the tableau in (11). I propose that ties like these are ties of neglect, not ties of principle. They are resolved by other mechanisms like positional faithfulness (Beckman, 1997, 1998; Jesney, 2011), or reflect directional pressures on prosodic structure. The latter case is exemplified by where different dialects of Arabic insert epenthetic vowels into triconsonantal clusters, mapping underlying /CCC/ onto [CiCC] or [CCiC] (Itô, 1989; Mester and Padgett, 1994; Elfner, 2009, 2016; Torres-Tamarit, 2012). [CiCC] is produced when syllables are parsed directionally from right-to-left or are left-aligned to the prosodic word. Left-to-right syllabification or right-aligned syllables produce [CCiC]. Appealing to the prosodic structure in this way obviates a directional DEP.

(11) /ab/ → [aa] ∼ [bb], Step 1

/ab/	*{ab, ba}$^{\Rightarrow}$	IDENT
a. ab	W a_1b_2	L
→ b. aa		1
→ c. bb		1

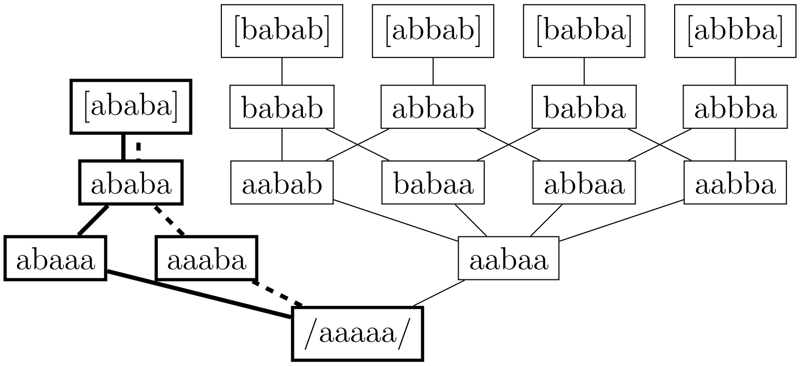
The tableau in (12) illustrates directional dissimilation; it is identical to the tableau in (5) except for the mode of evaluation. The markedness constraint is evaluated left-to-right, so the worst locus of violation is $[a_1a_2]$. Candidates (12a,d-f) with this locus are dispreferred to candidates (12b-c) without it. Candidate (12c) is chosen as optimal because candidate (12b) has an additional violation $[a_2a_3]$. Candidate (12d) is harmonically bounded by candidates (12b-c), and would be harmonically bounded by candidates (12e-f) if *aa were evaluated right-to-left.

(12) /aaaaa/ → [ababa], Step 1

/aaaaa/	*aa$^{\Rightarrow}$					IDENT
a. aaaaa	W	a_1a_2	a_2a_3	a_3a_4	a_4a_5	L
b. baaaa	W		a_2a_3	a_3a_4	a_4a_5	1
→ c. abaaa				a_3a_4	a_4a_5	1
d. aabaa	W	a_1a_2			a_4a_5	1
e. aaaba	W	a_1a_2	a_2a_3			1
f. aaaab	W	a_1a_2	a_2a_3	a_3a_4		1

The derivational path from this step is represented in (13). At each step, the leftmost or rightmost locus is targeted, and derivation converges on [ababa] whether *aa is evaluated left-to-right or right-to-left. In rule-based phonology, direction of application is related to opacity (Kenstowicz and Kisseberth, 1977:chapter 5); a mapping may be transparent when a given rule is applied in one direction and opaque when it is applied in the opposite direction. This is often because applying the rule backwards skips foci it would have targeted. For example, applying the rule a → b / _a to the UR /aaaaa/ left-to-right yields [bbbba] and applying it right-to-left yields [ababa]. This is not the case for directional constraint evaluation. Because removing more loci of violation results in more harmonic improvement, there is no motivation to skip over loci, and derivations only produce transparent mappings.

(13)



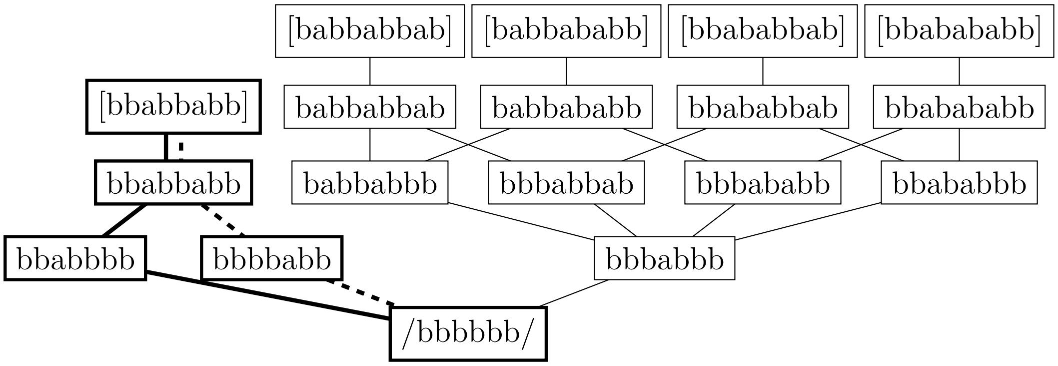
The tableau in (14) illustrates directional epenthesis; it is otherwise identical (7). The markedness constraint is evaluated left-to-right, and candidates (14a-b,e-h) with the leftmost locus [$b_1b_2b_3$] are dispreferred to those without it (14c-d). In the optimal candidate (14d), the epenthetic [a] removes multiple loci. Note that because positions are defined relative to the input, epenthesis does not affect the indices of loci.

(14) /bbbbbb/ → [bbabbabb], Step 1

/bbbbbb/	*bbb$^{\Rightarrow}$					Dep
a. bbbbbb	W	$b_1b_2b_3$	$b_2b_3b_4$	$b_3b_4b_5$	$b_4b_5b_6$	L
b. abbbbbb	W	$b_1b_2b_3$	$b_2b_3b_4$	$b_3b_4b_5$	$b_4b_5b_6$	1
c. babbbbb	W		$b_2b_3b_4$	$b_3b_4b_5$	$b_4b_5b_6$	1
→ d. bbabbbb				$b_3b_4b_5$	$b_4b_5b_6$	1
e. bbbabbb	W	$b_1b_2b_3$			$b_4b_5b_6$	1
f. bbbbabb	W	$b_1b_2b_3$	$b_2b_3b_4$			1
g. bbbbbab	W	$b_1b_2b_3$	$b_2b_3b_4$	$b_3b_4b_5$		1
h. bbbbbba	W	$b_1b_2b_3$	$b_2b_3b_4$	$b_3b_4b_5$	$b_4b_5b_6$	1

The derivational path from this step is represented in (15). Under either direction of evaluation, the derivation converges on [bbabbabb]. All other outputs require targeting the center of the input in the first step, which is impossible.

(15)



3 Alternative tie-breaking mechanisms

The previous section demonstrated that directional constraint evaluation solves the problem of ties. Loci of violation are harmonically ordered, as are candidates with different loci. Effective tie-breaking mechanisms must be able to distinguish loci by position; this is the only property that is guaranteed to distinguish loci. This section discusses two other mechanisms with this property, gradient alignment and distance-based scaling, and their shortcomings as general solutions to the problem of ties.

Gradient alignment constraints penalize misalignment between two morphological/phonological objects, and quantify the violation according to the number of intervening units (McCarthy and Prince, 1993; Hyde, 2012). They are effective tie-breakers because they distinguish objects by their position. Alignment naturally serves this purpose within the realm of serial prosodification (Pruitt, 2010, 2012; Torres-Tamarit, 2012). However, alignment does not naturally extend into other contexts. The tableau in (16) illustrates the use of alignment to break ties between different epenthesis sites; angled brackets ⟨⟩ demarcate a prosodic word and misalignment is quantified over segments. The alignment constraint penalizes segments that intervene between an [a] and the left edge of the prosodic word, and breaks the tie between candidates (16d-f). Candidate (16d) is optimal because its epenthetic [a] is closer to the left edge of its prosodic word than the epenthetic [a] in candidates (16e-f).

Using alignment constraints as tie-breakers requires including in Con constraints Align(α, L/R, β, L/R), where α is defined over all phonological objects and β is some morphological or phonological category. In order to be a general solution to ties, β must be some domain that encapsulates all possible α. This is because when β is absent, the alignment constraint is vacuously satisfied, and ties are not broken. β cannot be defined morphologically because there is no guarantee that any morphological category is present in all candidates. β can also not be defined phonologically in a theory of HS with gradual prosodification (Elfner, 2009, 2016; Pruitt, 2010, 2012; Torres-Tamarit, 2012, 2014). The example above assumes that a prosodic word was built prior to epenthesis: /bbbbbb/ → ⟨bbbbbb⟩ → ⟨bbabbbb⟩ → ⟨bbabbabb⟩ → [⟨bbabbabb⟩]. However, if epenthesis occurs first, then the tie is not broken, because all candidates vacuously satisfy the alignment constraint. It is infeasible to require prosodification to occur before segmental processes because there are a number of cases where prosodification is crucially ordered after segmental processes (Elfner, 2009, 2016; Torres-Tamarit, 2012, 2014). Further, as a reviewer points out, candidates containing multiple instances of β pose additional problems to this approach. Thus, while alignment constraints can in principle be used as tie-breakers, they impose too many unrealistic restrictions to be effective in general.

(16) Alignment as tie-breaker

⟨bbbbbb⟩	*bbb	Dep	Align([a], L, PrWd, L)
a. ⟨bbbbbb⟩	W 4	L	L
b. ⟨abbbbbb⟩	W 4	1	L
c. ⟨babbbbb⟩	W 3	1	L 1
→ d. ⟨bbabbbb⟩	2	1	2
e. ⟨bbbabbb⟩	2	1	W 3
f. ⟨bbbbabb⟩	2	1	W 4
g. ⟨bbbbbab⟩	W 3	1	W 5
h. ⟨bbbbbba⟩	W 4	1	W 6

Another way to distinguish violations by position is to adopt distance-based scaling (Inkelas and Wilbanks, 2018) within Serial Harmonic Grammar (Legendre, Miyata, and Smolensky, 1990; Pater, 2012, 2016). Under this proposal, violations are scaled by their distance from the left or right edge of a candidate. As the tableau in (17) illustrates, scaling violations is an effective tie-breaker. Candidates (17b-f) all remove one locus of violation of *a, but are differentiated by which loci remain. Because loci at the left edge incur the highest penalty, it is optimal to target the leftmost locus (17b). In this example, the markedness constraint is scaled while the faithfulness constraint is held constant. Equivalently, the weight of the markedness constraint can be held constant while the faithfulness constraint is scaled linearly in the left index.

(17) Distance-based scaling as tie-breaker, $f(x) = 2x$, Step 1

/aaaaa/	*a f(right-index)	Ident 5	$\mathscr{H}$
a. aaaaa	$-f(5) - f(4) - f(3) - f(2) - f(1)$		−33
→ b. baaaa	$-f(4) - f(3) - f(2) - f(1)$	−1	−25
c. abaaa	$-f(5) - f(3) - f(2) - f(1)$	−1	−27
d. aabaa	$-f(5) - f(4) - f(2) - f(1)$	−1	−29
e. aaaba	$-f(5) - f(4) - f(3) - f(1)$	−1	−31
f. aaaab	$-f(5) - f(4) - f(3) - f(2)$	−1	−33

While an effective tie-breaker, distance-based scaling has the disadvantage of producing unattested windows of faithfulness.[2] The tableau in (18) illustrates the fourth step of the derivation begun by the tableau in (17). Because the weight of the markedness constraint falls while the weight of the faithfulness constraint remains constant, there is an index beyond which repairs cannot be made, similar to the catching up pathology discussed by O'Hara (2016). The derivation converges after changing the leftmost three segments: /aaaaa/ → baaaa → bbaaa → bbbaa → [bbbaa].

(18) Word-final window of faithfulness with a linear scale, $f(x) = 2x$, Step 4

bbbaa	*a f(right-index)	IDENT 5	$\mathscr{H}$
→ a. bbbaa	$-f(2) - f(1)$		-6
b. bbbba	$-f(1)$	-1	-7
c. bbbab	$-f(2)$	-1	-9

If, following Inkelas and Wilbanks (2018), non-linear scaling functions are allowed, then windows of faithfulness can occur inside words. This effect is illustrated in the tableau in (19). The weight of *a is scaled quadratically, and dips below the weight of IDENT at the third segment. Employing distance-based scaling as a tie-breaker thus has the disadvantage of significantly embiggening the typology.

(19) Word-internal window of faithfulness with a quadratic scale, $f(x) = 2(x-3)^2$

aabaa	*a f(left-index)	IDENT 5	$\mathscr{H}$
→ a. aabaa	$-f(3)$		0
b. aaaaa		-1	-5

4 Conclusion

Tied candidates are problematic in any Optimality Theoretic framework, as they create uncontrollable variation. Directional constraint evaluation (Eisner, 2000, 2002) presents a general solution to the problem of ties, and does so in a way that is consistent with existing work on iterative processes. It is effective in its role as a tie-breaker without introducing other problems that come with relying on gradient alignment or distance-based scaling as tie-breakers.

References

Anderson, Stephen R. 1974. *The organization of phonology*. New York: Academic Press.

Anttila, Arto. 2002. Variation and phonological theory. In *The handbook of language variation and change*, ed. by J. K. Chambers, Peter Trudgill, and Natalie Schilling-Estes, 206–243. Malden, MA: Blackwell Publishing.

Baković, Eric. 2000. Harmony, dominance and control. Doctoral dissertation, Rutgers, The State University of New Jersey.

Beckman, Jill N. 1997. Positional faithfulness, positional neutralisation and Shona vowel harmony. *Phonology* 14:1–46.

Beckman, Jill N. 1998. Positional faithfulness. Doctoral dissertation, University of Massachusetts Amherst.

Brown, E. W. 1972. How to apply phonological rules. In *Research Laboratory of Electronics progress report no. 105*, 143–146. Cambridge, MA: MIT.

Cearley, Alvin. 1974. The only phonological rule ordering principle. In *Papers from the parasession on natural phonology*, ed. by A. Bruck, R. A. Fox, and M. W. LaGaly, 30–42. Chicago: Chicago Linguistic Society.

Eisner, Jason. 1997. What constraints should OT allow? Ms. Rutgers Optimality Archive 215. roa.rutgers.edu.

Eisner, Jason. 2000. Directional constraint evaluation in Optimality Theory. In *Proceedings of the 18th International Conference on Computational Linguistics*, 257–263.

Eisner, Jason. 2002. Comprehension and compilation in Optimality Theory. In *Proceedings of the 40th Annual Meeting of the Association for Computational Linguistics*, 56–63.

Elfner, Emily. 2009. Syllabification and stress-epenthesis interactions in Harmonic Serialism. Ms., University of Massachusetts Amherst. Rutgers Optimality Archive 1077. roa.rutgers.edu.

Elfner, Emily. 2016. Stress-epenthesis interactions in Harmonic Serialism. In *Harmonic Grammar and Harmonic Serialism*, ed. by John J. McCarthy and Joe Pater, 261–300. London: Equinox Publishing.

Finley, Sara. 2008. Formal and cognitive restrictions on vowel harmony. Doctoral dissertation, Johns Hopkins University.

Finley, Sara. 2009. Directionality in vowel harmony. In *University of Rochester working papers in the language sciences*, ed. by Heike Lehnert-LeHouillier and Alex B. Fine, volume 5, 69–88.

Frank, Robert, and Giorgia Satta. 1998. Optimality Theory and the generative complexity of constraint violability. *Computational Linguistics* 24:307–315.

Howard, Irwin. 1972. A directional theory of rule application. Doctoral dissertation, Massachusetts Institute of Technology.

Hyde, Brett. 2012. Alignment constraints. *Natural Language & Linguistic Theory* 30:789–836.

Inkelas, Sharon, and Eric Wilbanks. 2018. Directionality effects via distance-based penalty scaling. In *Proceedings of the 2017 Annual Meeting on Phonology*, ed.

by Gillian Gallagher, Maria Gouskova, and Sora Heng Yin. Washington, D.C.: Linguistic Society of America.

Itô, Junko. 1989. A prosodic theory of epenthesis. *Natural Language & Linguistic Theory* 7:217–259.

Jensen, John T., and Margaret Stong-Jensen. 1973. Ordering and directionality of iterative rules. *Papers in linguistics* 6:66–90.

Jesney, Karen. 2011. Positional faithfulness, non-locality, and the Harmonic Serialism solution. In *NELS 39: Proceedings of the 39th Annual Meeting of the North East Linguistic Society*, ed. by Suzi Lima, Kevin Mullin, and Brian Smith, 403–416. Amherst, MA: Graduate Linguistics Student Association.

Johnson, C. Douglas. 1972. *Formal aspects of phonological description.* The Hague: Mouton.

Kenstowicz, Michael, and Charles Kisseberth. 1977. *Topics in phonological theory.* New York: Academic Press.

Kimper, Wendell. 2011. Locality and globality in phonological variation. *Natural Language & Linguistic Theory* 29:423–465.

Lamont, Andrew. 2019. Majority Rule in Harmonic Serialism. In *Supplemental Proceedings of the 2018 Annual Meeting on Phonology*, ed. by Katherine Hout, Anna Mai, Adam McCollum, Sharon Rose, and Matt Zaslansky. Washington, D.C.: Linguistic Society of America.

Legendre, Géraldine, Yoshiro Miyata, and Paul Smolensky. 1990. Harmonic Grammar: a formal multi-level connectionist theory of linguistic well-formedness: an application. In *Proceedings of the 12th annual conference of the Cognitive Science Society*, 884–891. Hillsdale: Erlbaum.

Lombardi, Linda. 1999. Positional faithfulness and voicing assimilation in Optimality Theory. *Natural Language & Linguistic Theory* 17:267–302.

McCarthy, John J. 2000. Harmonic Serialism and Parallelism. In *NELS 30: Proceedings of the North East Linguistic Society 30*. Vol. 1, ed. by Masako Hirotani, Andries Coetzee, Nancy Hall, and Ji-Yung Kim, 501–524. Amherst, MA: Graduate Linguistics Student Association.

McCarthy, John J. 2009. Knotty ties. Ms., University of Massachusetts Amherst. `http://blogs.umass.edu/comphon/files/2019/09/Knotty-ties.pdf`.

McCarthy, John J. 2016. The theory and practice of Harmonic Serialism. In *Harmonic Grammar and Harmonic Serialism*, ed. by John J. McCarthy and Joe Pater, 47–87. Sheffield: Equinox Publishing.

McCarthy, John J., and Alan Prince. 1993. Generalized alignment. In *Yearbook of morphology*, ed. by Geert Booij and Jaap van Marle, 79–153. Dordrecht: Kluwer.

Mester, Armin, and Jaye Padgett. 1994. Directional syllabification in Generalized Alignment. In *Phonology at Santa Cruz Vol. 3*, ed. by Jason Merchant, Jaye Padgett, and Rachel Walker, 79–85. Santa Cruz, CA: Linguistics Research Center: University of California, Santa Cruz.

O'Hara, Charlie. 2016. Harmony in Harmonic Grammar by reevaluating faithfulness. In *NELS 46: The Proceedings of the 46th Meeting of the North East Linguistics Society*. Vol. 3, ed. by Christopher Hammerly and Brandon Prickett, 71–84. Amherst, MA: Graduate Linguistics Student Association.

Pater, Joe. 2012. Serial Harmonic Grammar and Berber syllabification. In *Prosody matters: Essays in honor of Elisabeth Selkirk*, ed. by Toni Borowsky, Shigeto Kawahara, Mariko Sugahara, and Takahito Shinya, 43–72. London: Equinox Publishing.

Pater, Joe. 2016. Universal grammar with weighted constraints. In *Harmonic Grammar and Harmonic Serialism*, ed. by John J. McCarthy and Joe Pater, 1–46. Sheffield: Equinox Publishing.

Prince, Alan, and Paul Smolensky. 1993/2004. *Optimality Theory: Constraint interaction in generative grammar*. Malden, MA: Blackwell Publishing.

Pruitt, Kathryn. 2009. Two types of ties (some notes). Ms., University of Massachusetts Amherst. `http://blogs.umass.edu/comphon/files/2019/09/Ties-in-HS.pdf`.

Pruitt, Kathryn. 2010. Serialism and locality in constraint-based metrical parsing. *Phonology* 27:481–526.

Pruitt, Kathryn. 2012. Stress in Harmonic Serialism. Doctoral dissertation, University of Massachusetts Amherst.

Riggle, Jason, and Colin Wilson. 2005. Local optionality. In *NELS 35: Proceedings of the North East Linguistic Society 35*, ed. by Leah Bateman and Cherlon Ussery, 539–550. Amherst, MA: Graduate Linguistics Student Association.

Torres-Tamarit, Francesc. 2012. Syllabification and opacity in Harmonic Serialism. Doctoral dissertation, Centre de Lingüística Teòrica.

Torres-Tamarit, Francesc. 2014. Phonology-morphology opacity in Harmonic Serialism: The case of /s/ aspiration in Spanish. In *Variation within and across*

Romance Languages: Selected papers from the 41st Linguistic Symposium on Romance Languages (LSRL), Ottawa, 5–7 May 2011, ed. by Marie-Hélène Côté and Eric Mathieu, 39–62. Amsterdam: John Benjamins.

Vago, Robert M., and Edwin L. Battistella 1982. Rule application in phonology. Ms., Queens College and The Graduate Center The City University of New York.

Wilson, Colin. 2003. Analyzing unbounded spreading with constraints: marks, targets and derivations. Ms., University of California, Los Angeles.

Wilson, Colin. 2006. Unbounded spreading is myopic. Ms., University of California, Los Angeles.

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[1]All the cases in this paper were verified using the script available at `https://github.com/aphonologist/hs-ties`

[2]The proposal by Riggle and Wilson (2005) to cleave constraints into multiple position-specific constraints also predicts windows of faithfulness. Their model was

proposed to account for local optionality in pOT, which, as Kimper (2011) demonstrates, can be modeled in HS without any special machinery.