

## The Rhythmic Foundations of INITIAL GRIDMARK and NONFINALITY\*

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Most of the basic constraints in metrical stress theory either lack positional restrictions or they implement positional restrictions using symmetrical directional specifications. Positional restrictions are typically absent, for example, in the familiar PARSE-SYLLABLE, FOOT-BINARITY, and \*CLASH constraints. PARSE-SYLL prohibits unfooted syllables regardless of their position, FT-BIN prohibits monomoraic feet regardless of their position, and \*CLASH prohibits adjacent stressed syllables regardless of their position. While traditional Alignment constraints do create positional restrictions, they create them using directional specifications that are typically taken to be symmetrical. If there is a constraint that aligns an object to the left, then there will also be a constraint that aligns the same object to the right.

Two of the principal constraint types in metrical stress theory stand out for their asymmetrical positional restrictions. INITIAL GRIDMARK constraints (Prince 1983) require that the initial element in a domain be stressed, and NONFINALITY constraints (Prince and Smolensky 1993) require that the final element in a domain be stressless. In this paper, I argue that the asymmetrical formulations of INITIAL GRIDMARK and NONFINALITY are justified on both typological grounds and rhythmic grounds. The typological support comes from binary patterns with clash or lapse. While there are numerous attested binary systems where the presence of a clash or lapse can be attributed to an initial stress or final stresslessness requirement, there appear to no binary systems where clash or lapse can be attributed to an initial stresslessness or final stress requirement. The rhythmic support for the asymmetrical formulations comes from the different characteristics of phonetic lengthening in initial and final syllables. Initial stress is desirable because it is compatible with the tempo acceleration at the beginning of words or phrases, and final stresslessness is desirable because it is compatible with the tempo deceleration at the end of words or phrases. An important advantage of the proposal is that it helps to explain the relative rarity of iambic systems: iambic footing is marked because it tends to result in initial stresslessness and final stress.

The constraints that I will focus on all have in common that they specify a degree of stress that should or should not occur on some peripheral category in some domain.

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The constraints are asymmetrical in that those with the general formulation in (1a,b), NONFINALITY and INITIAL GRIDMARK constraints, are crucially included in the constraint set, while those with the general formulation in (2a,b), NONINITIAL and FINAL GRIDMARK constraints, are crucially excluded from the constraint set. In both sets of definitions, *G*Cat is an entry on a particular level of the metrical grid, *P*Cat is a prosodic category, and *C*at is a grid entry or prosodic category.

- (1) Included in the Constraint Set
  - a. NONFIN(*G*Cat, *C*at, *P*Cat): No *G*Cat occurs over the final *C*at of *P*Cat.
  - b. INTGRID(*G*Cat, *C*at, *P*Cat): A *G*Cat occurs over the initial *C*at of *P*Cat.
- (2) Excluded from the Constraint Set
  - a. NONINT(*G*Cat, *C*at, *P*Cat): No *G*Cat occurs over the initial *C*at of *P*Cat.
  - b. FINGRID(*G*Cat, *C*at, *P*Cat): A *G*Cat occurs over the final *C*at of *P*Cat.

To provide examples of specific constraints that can be derived from these general definitions, the constraint set includes a NONFINALITY constraint like (3a) which prohibits stress on the final syllable of a prosodic word but not a NONINITIAL constraint like (4a) which prohibits stress on the initial syllable of a prosodic word.

- (3) Included in the Constraint Set
  - a. NONFIN( $x_F, \sigma, \omega$ ): No foot-level gridmark occurs over the final syllable of a prosodic word.
  - b. INTGRID( $x_F, \sigma, \omega$ ): A foot-level gridmark occurs over the initial syllable of a prosodic word.
- (4) Excluded from the Constraint Set
  - a. NONINT( $x_F, \sigma, \omega$ ): No foot-level gridmark occurs over the initial syllable of a prosodic word.
  - b. FINGRID( $x_F, \sigma, \omega$ ): A foot-level gridmark occurs over the final syllable of a prosodic word.

Similarly, the constraint set includes an INITIAL GRIDMARK constraint like (3b) which requires stress on the initial syllable of a prosodic word but not a FINAL GRIDMARK constraint like (4b) which requires stress on the final syllable of a prosodic word.

## 1. Evidence from the Typology of Binary Stress Patterns

The first line of evidence supporting the asymmetrical formulations comes from the typology of quantity-insensitive binary stress patterns. In looking at these patterns, it is helpful to take as a frame of reference Prince's (1983) idea of a *Perfect Grid*, a metrical grid with neither clash nor lapse of gridmark entries – in other words, patterns with perfect binary alternation. There are four possible patterns that conform to the Perfect Grid. I will refer to the patterns in (5a,b) as the *minimal alternation* patterns, since they have the fewest stresses possible without a lapse. I will refer to the patterns in (5c,d) as the maximal alternation patterns, since they have the most stresses possible without a clash.

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(5) Perfect Grid Patterns

- |  |   |
|--|---|
| <p>a. Trochaic Minimal Alternation<br/>         óóóóó<br/>         óóóóóó<br/>         Nengone (Tryon 1967)</p>    | <p>b. Iambic Minimal Alternation<br/>         óóóóó<br/>         óóóóóó<br/>         Araucanian (Echeverria &amp; Contreras 1965)</p> |
| <p>c. Trochaic Maximal Alternation<br/>         óóóóó<br/>         óóóóóó<br/>         Maranungku (Tryon 1970)</p> | <p>d. Iambic Maximal Alternation<br/>         óóóóó<br/>         óóóóóó<br/>         Suruwaha (Everett 1996)</p>                      |

All four of the Perfect Grid patterns are attested, and they are symmetrically attested. The minimal alternation type is found in a trochaic version in Nengone, for example, and in an iambic mirror image version in Araucanian. Similarly, the maximal alternation type is found in a trochaic version in Maranungku and in an iambic mirror image version in Suruwaha.

In contrast, when we turn to departures from the Perfect Grid, focusing on departures in odd-parity forms, trochaic and iambic versions are no longer symmetrically attested. Several trochaic patterns with clash or lapse, the patterns in the left hand column in (6), are attested, but their iambic mirror images, the patterns in the right hand column in (6), are not.

(6) Clash and Lapse in Odd-Parity Forms

- | Trochaic Patterns  | Iambic Patterns   |
|--|---|
| <p>a. óóóóó<br/> <u>óóóóóó</u><br/>         Passamaquoddy (LeSourd 1993)</p>               | <p>b. óóóóó<br/>         óóóó<u>óó</u><br/> <i>unattested</i></p> |
| <p>c. óóóóó<br/>         ó<u>óóóóó</u><br/>         Garawa (Furby 1974)</p>                | <p>d. óóóóó<br/>         óóó<u>óóó</u><br/> <i>unattested</i></p> |
| <p>e. óóóóó<br/>         óó<u>óóóó</u><br/>         Piro (Matteson 1965)</p>               | <p>f. óóóóó<br/>         ó<u>óóóóó</u><br/> <i>unattested</i></p> |
| <p>g. óóóóó<br/>         óóó<u>óóó</u><br/>         Pintupi (Hansen &amp; Hansen 1969)</p> | <p>h. óóóóó<br/> <u>óóóóóó</u><br/> <i>unattested</i></p>         |

The trochaic pattern in (6a) with clash at the left edge in odd-parity forms can be found in Passamaquoddy, but there appears to be no language with the iambic mirror image pattern in (6b) where clash occurs at the right edge. The trochaic pattern in (6c) with lapse following an initial stress in odd-parity forms can be found in Garawa, but there appears to be no example of the iambic mirror image in (6d) where lapse precedes a final stress. Piro exhibits the trochaic pattern in (6e) with a lapse preceding a penultimate stress in odd-parity forms, but the iambic mirror image (6f), where a lapse follows a peninitial

stress, is unattested. Finally, Pintupi exhibits the trochaic pattern in (6g) with a final lapse in odd-parity forms, but the iambic mirror image in (6h), where there is an initial lapse, is unattested.

Notice that the trochaic cases all exhibit initial stress and final stresslessness, a configuration that is impossible in odd-parity forms without introducing clash or lapse. The unattested iambic mirror images all exhibit final stress and initial stresslessness, also impossible in odd-parity forms without introducing clash or lapse. The reason that the clashes or lapses are possible in the trochaic patterns but not in their iambic mirror images seems simply to be that departures from the Perfect Grid can be tolerated to promote initial stress and final stresslessness but not to promote final stress and initial stresslessness.

For a more detailed discussion of how this principle can be integrated into an account of metrical stress that accurately predicts iambic-trochaic asymmetries, see Hyde 2002. In the brief sketch presented below, the parsing structures of Hyde 2002 are retained, but the several constraints responsible for producing Perfect Grid patterns will be represented by the single constraint PERFECT ALTERNATION, which simply insists that stress maintain a regular binary alternation. In the tableaux in (7) and (8), candidates (a-d) are the attested trochaic departures from the Perfect Grid, candidates (i-l) are their unattested iambic mirror images, and candidates (e-h) are the Perfect Grid patterns.

(7)

$\sigma\sigma\sigma\sigma\sigma\sigma$	NONFIN( $x_F, \sigma, \omega$ )	INTGRID( $x_F, \sigma, \omega$ )	PERFALT
a. $\acute{\sigma} \acute{\sigma} \sigma \acute{\sigma} \sigma \acute{\sigma} \sigma$   /   /   /			*
b. $\acute{\sigma} \sigma \sigma \acute{\sigma} \sigma \acute{\sigma} \sigma$   /   /   /			*
c. $\acute{\sigma} \sigma \acute{\sigma} \sigma \sigma \acute{\sigma} \sigma$   /   /   /			*
d. $\acute{\sigma} \sigma \acute{\sigma} \sigma \acute{\sigma} \sigma \sigma$   /   /   /			*
e. $\sigma \acute{\sigma} \sigma \acute{\sigma} \sigma \acute{\sigma} \sigma$   /   /   /		*!	
f. $\acute{\sigma} \sigma \acute{\sigma} \sigma \acute{\sigma} \sigma \acute{\sigma}$   /   /   /	*!		
g. $\sigma \acute{\sigma} \sigma \acute{\sigma} \sigma \acute{\sigma} \sigma$   /   /   /		*!	
h. $\acute{\sigma} \sigma \acute{\sigma} \sigma \acute{\sigma} \sigma \acute{\sigma}$   /   /   /	*!		
i. $\sigma \acute{\sigma} \sigma \acute{\sigma} \sigma \acute{\sigma} \acute{\sigma}$   /   /   /	*!	*!	*
j. $\sigma \acute{\sigma} \sigma \acute{\sigma} \sigma \sigma \acute{\sigma}$   /   /   /	*!	*!	*
k. $\sigma \acute{\sigma} \sigma \sigma \acute{\sigma} \sigma \acute{\sigma}$   /   /   /	*!	*!	*
l. $\sigma \sigma \acute{\sigma} \sigma \acute{\sigma} \sigma \acute{\sigma}$   /   /   /	*!	*!	*

The tableau in (7) illustrates what happens when only NONFIN( $x_F, \sigma, \omega$ ) “prosodic word-final syllables are stressless” and INTGRID( $x_F, \sigma, \omega$ ) “prosodic word-initial syllables are stressed” are included in the constraint set. When NONFIN( $x_F, \sigma, \omega$ ) and INTGRID( $x_F, \sigma, \omega$ )

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dominate PERFECT ALTERNATION, the trochaic departures with clash or lapse can emerge. If PERFECT ALTERNATION were to dominate NONFIN( $X_F$ ,  $\sigma$ ,  $\omega$ ) or INTGRID( $X_F$ ,  $\sigma$ ,  $\omega$ ), then the Perfect Grid patterns would emerge. Notice that the iambic patterns with clash or lapse are harmonically bounded. They cannot emerge under any ranking. Since they are unattested, this is the desired result.

The tableau in (8) illustrates what would happen if NONINT( $X_F$ ,  $\sigma$ ,  $\omega$ ) “prosodic word-initial syllables are stressless” and FINGRID( $X_F$ ,  $\sigma$ ,  $\omega$ ) “prosodic word-final syllables are stressed” were added to the ranking. The iambic patterns with clash or lapse would no longer be harmonically bounded. They emerge when NONINT( $X_F$ ,  $\sigma$ ,  $\omega$ ) and FINGRID( $X_F$ ,  $\sigma$ ,  $\omega$ ) dominate the remaining constraints. This is not the desired result, and the best way to avoid it is to exclude NONINT( $X_F$ ,  $\sigma$ ,  $\omega$ ) and FINGRID( $X_F$ ,  $\sigma$ ,  $\omega$ ) from the constraint set.

(8)

$\sigma\sigma\sigma\sigma\sigma\sigma$	NONINT	FINGRID	PERFALT	NONFIN	INTGRID
a. $\acute{\sigma} \acute{\sigma} \sigma \acute{\sigma} \sigma \acute{\sigma} \sigma$ 	*!	*!	*		
b. $\acute{\sigma} \sigma \sigma \acute{\sigma} \sigma \acute{\sigma} \sigma$ 	*!	*!	*		
c. $\acute{\sigma} \sigma \acute{\sigma} \sigma \sigma \acute{\sigma} \sigma$ 	*!	*!	*		
d. $\acute{\sigma} \sigma \acute{\sigma} \sigma \acute{\sigma} \sigma \sigma$ 	*!	*!	*		
e. $\sigma \acute{\sigma} \sigma \acute{\sigma} \sigma \acute{\sigma} \sigma$ 		*!			*
f. $\acute{\sigma} \sigma \acute{\sigma} \sigma \acute{\sigma} \sigma \acute{\sigma}$ 	*!			*	
g. $\sigma \acute{\sigma} \sigma \acute{\sigma} \sigma \acute{\sigma} \sigma$ 		*!			*
h. $\acute{\sigma} \sigma \acute{\sigma} \sigma \acute{\sigma} \sigma \acute{\sigma}$ 	*!			*	
i. $\sigma \acute{\sigma} \sigma \acute{\sigma} \sigma \acute{\sigma} \sigma$ 			*	*	*
j. $\sigma \acute{\sigma} \sigma \acute{\sigma} \sigma \sigma \acute{\sigma}$ 			*	*	*
k. $\sigma \acute{\sigma} \sigma \sigma \acute{\sigma} \sigma \acute{\sigma}$ 			*	*	*
l. $\sigma \sigma \acute{\sigma} \sigma \acute{\sigma} \sigma \acute{\sigma}$ 			*	*	*

Although iambic-trochaic asymmetries have traditionally been described as directional parsing asymmetries (Kager 1993, McCarthy and Prince 1993, Hayes 1995), they actually seem to arise from the asymmetrical formulations of INITIAL GRIDMARK and NONFINALITY. Requiring initial stress and final stresslessness allows trochaic departures from the Perfect Grid to emerge but not iambic departures. Initial stress and final stresslessness are incompatible with iambic footing generally, and these requirements help to explain the relative rarity of iambic systems.

## 2. Rhythmic and Phonetic Evidence

In turning to the rhythmic and phonetic evidence for the asymmetrical formulations of NONFINALITY and INITIAL GRIDMARK, a good place to start is with Lunden’s (2006, 2007)

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insight that final stress avoidance is connected to phonetic final lengthening. A simple approach based on this connection might claim that final lengthening makes word-final syllables poor candidates for stress from a perceptual standpoint. The argument could be constructed as follows. Fry (1955), among numerous others, observes that duration is an important cue for stress, and it is reasonable to assume, perhaps as a consequence of Weber's Law, that duration due to stress is less noticeable when added to longer syllables than it is when added to shorter syllables. Since word-final syllables already have greater duration due to phonetic final lengthening, the additional duration used to indicate stress is less noticeable in final position. The result is that word-final syllables are poor candidates, from a perceptual standpoint, for stress.

There are a couple of problems, however, with an explanation given in terms of simple length differences. First, such an explanation does not actually account for NONFINALITY's positional asymmetry. Variations in vowel length, for example, are not restricted to final position. If stress avoids longer vowels in final position simply due to their additional length, then it should avoid longer vowels in nonfinal position due to their additional length, as well. Second, the idea that stress avoids longer syllables is generally inconsistent with what we know about the relationship between length and stress. Cross-linguistically, greater length attracts stress. It does not repel stress. There do not appear to be languages where stress actively avoids longer vowels, for example, in favor of shorter vowels.

Since the simple fact that final syllables tend to be lengthened cannot provide an adequate account of NONFINALITY effects, it is necessary to take a closer look at the unique characteristics of phonetic final lengthening and to compare these characteristics with the characteristics of lengthening in other positions, particularly initial position. It is well known that phonetic lengthening occurs in both initial and final syllables, but it is also well known that initial lengthening and final lengthening have different characteristics. According to Oller (1973), Wightman et al (1992), and others, some of the (variable) characteristics of final lengthening are that it typically effects all rhyme segments to some degree, it is often associated with decline in amplitude and devoicing, and it is often cumulative when multiple prosodic boundaries coincide. According to Oller (1973), Keating et al (2003), and others, some of the (variable) characteristics of initial lengthening are that it is typically limited to the initial segment, it is often associated with longer voice onset time and aspiration, and it less typically cumulative when multiple boundaries coincide.

Compare the characteristics of initial lengthening and final lengthening to the characteristics of stressed syllables. According to Lieberman (1960), Beckman (1986), Gordon (2002), and others, some of the (variable) characteristics of stressed syllables are that they exhibit increased duration in the rhyme, they exhibit increased intensity in the rhyme, and they exhibit fortition, lengthening, or aspiration of the onset. The fact that stressed syllables often have a longer rhyme might make them seem more compatible with final lengthening. The fact that intensity declines in the rhyme under phonetic final lengthening but increases under stress, however, suggests that this is really not the case. The increased intensity in the rhyme and the strengthening of the onset makes stress more compatible with initial lengthening.

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One way to account for the different characteristics of initial and final lengthening would be to connect them to different types of tempo changes that might plausibly occur at prosodic boundaries. Initial lengthening is the result of a strong attack and acceleration to medial tempo, while final lengthening is the result of a deceleration from medial tempo. An initial acceleration results in strengthening of initial segments and increased intensity in initial syllables, and it is these characteristics that attract stress and justify INITIAL GRIDMARK's asymmetrical positional restriction. A final deceleration results in declining intensity in the rhyme of final syllables, and it is this characteristic that repels stress and justifies NONFINALITY's asymmetrical positional restriction.

A parallel phenomenon in music supports the interpretation of initial lengthening and final lengthening as different types of tempo changes. Gabrielson (1987, 1993) reports that early and late half measures in a musical phrase often have a slower tempo than medial half measures, with acceleration to medial tempo occurring in the early half measures and deceleration from medial tempo occurring in the late half measures. In parallel to phonetic final lengthening, the tempo change in the late half measures is typically much more pronounced and appears to be cumulative when multiple boundaries coincide.

Though asymmetrical formulations of INITIAL GRIDMARK and NONFINALITY cannot be justified by simple differences in syllable length, then, they can be justified by the different types of tempo changes that occur in initial and final position. The account need not be based solely on perceptual effects. In final syllables, stress might be avoided because the dwindling intensity accompanying a deceleration makes stress more difficult to perceive, but it might also be avoided because the intensity of stress makes it more difficult to decelerate. In initial syllables, stresslessness might be avoided because the intensity accompanying an acceleration makes stresslessness more difficult to perceive, but it might also be avoided because the lack of intensity associated with stressless syllables makes it more difficult to accelerate.

### **3. Other NONFINALITY and INITIAL GRIDMARK Constraints**

Though the NONFINALITY and INITIAL GRIDMARK constraints focused on thus far apply to peripheral syllables within the domain of the prosodic word, both formulations can also usefully apply to different peripheral elements and to larger or smaller prosodic domains. (See Hyde 2006, 2007a,b for discussion.) It is not always possible, however, to justify the asymmetrical formulations of these additional constraints based on the same rhythmic or phonetic considerations. For example, the rhythmic justification for constraints applying to the peripheral syllables of prosodic words can be extended to constraints applying to the peripheral syllables of larger domains, because the peripheral syllables of larger domains often exhibit the appropriate types of phonetic lengthening. In contrast, the appropriate types of lengthening do not appear to be associated with smaller prosodic domains, and it is difficult to connect them solidly to peripheral elements other than the syllable.

This is not to say that the rhythmic considerations discussed above never play a role in justifying the NONFINALITY and INITIAL GRIDMARK constraints that apply to smaller domains or to non-syllabic peripheral elements. Some constraints can be justified by their ability to indirectly promote initial stress or final stresslessness in the larger domains

where the appropriate types of lengthening do occur. Of those that cannot, many can be justified by alternative considerations. I briefly address these possibilities below.

### 3.1 NONFINALITY and INITIAL GRIDMARK in the Domain of the Foot

In discussing the typological justification for NONFINALITY and INITIAL GRIDMARK constraints at the level of the prosodic word in Section 1, we saw that iambic footing tends to stress the final syllable and leave the initial syllable stressless. By prohibiting final stress and initial stresslessness, NONFINALITY and INITIAL GRIDMARK promoted trochaic footing over iambic footing and helped to account for the smaller range of attested iambic patterns. Constraints that apply to the peripheral syllables of the prosodic word, then, indirectly influence the type of foot that can be used to parse a form.

The relationship between foot-type and the status of word-peripheral syllables can also be exploited from the opposite direction. Initial stress and final stresslessness are promoted, indirectly, by constraints that discourage iambic footing or encourage trochaic footing. The NONFINALITY and INITIAL GRIDMARK constraints in (9), which apply to peripheral syllables in the domain of the foot, both have this effect.

- (9) a.  $\text{NONFIN}(x_F, \sigma, F)$ : No foot-level gridmark occurs over the final syllable of a foot.  
 b.  $\text{INTGRID}(x_F, \sigma, F)$ : A foot-level gridmark occurs over the initial syllable of a foot.

$\text{NONFIN}(x_F, \sigma, F)$  prohibits stress over foot-final syllables, discouraging iambic footing, and  $\text{INTGRID}(x_F, \sigma, F)$  requires stress on foot-initial syllables, encouraging trochaic footing. Since both constraints prefer trochees to iambs, both promote footing that typically stresses word-initial syllables and leaves word-final syllables stressless. The result is desirable from the standpoint of the rhythmic and phonetic considerations discussed above, because the tempo acceleration in word-initial syllables is more compatible with stress, and the tempo deceleration in word-final syllables is more compatible with stresslessness.

If we change the peripheral elements specified in the foot-level constraints from syllable to mora, the same indirect justification applies in some contexts but not in others.

- (10) a.  $\text{NONFIN}(x_F, \mu, F)$ : No foot-level gridmark occurs over the final mora of a foot.  
 b.  $\text{INTGRID}(x_F, \mu, F)$ : A foot-level gridmark occurs over the initial mora of a foot.

$\text{INTGRID}(x_F, \mu, F)$  requires stress on foot-initial moras. Since it always prefers trochees to iambs, it can be indirectly justified in much the same way as the syllabic version.  $\text{NONFIN}(x_F, \mu, F)$ , however, which prohibits stress over foot-final moras, does not necessarily prefer trochees to iambs. Although it does discourage iambs with a light final syllable, as in (11a), iambs with a heavy final syllable, as in (11b), are just as acceptable as trochees.



When the final foot is monosyllabic or iambic, the effect of  $\text{NONFIN}(x_\omega, F, \omega)$  can be justified in terms of the deceleration found in word-final syllables.  $\text{NONFIN}(x_\omega, F, \omega)$  prevents a particularly prominent stress from occupying a syllable with a deceleration.

When the final foot is trochaic, however, the effect of  $\text{NONFIN}(x_\omega, F, \omega)$  cannot be justified in this way. If the primary stress were to occur over a final trochee, it would still not occur over the final syllable, so  $\text{NONFIN}(x_\omega, F, \omega)$  would not actually help primary stress to avoid a deceleration. There appears to be no other obvious alternative for grounding the effect of  $\text{NONFIN}(x_\omega, F, \omega)$  in this case (other than the fact that it makes the right prediction). Lunden (2006, 2007) mentions the possibility that final trochaic feet might be marked because phonetic final lengthening would create an LH trochee. Extending this idea, an LH trochee with primary stress might be especially marked. This does not seem especially plausible, however. Final trochees are *very* common, and final trochees with primary stress are fairly plentiful, as well.

In my view, this mixed result is not necessarily cause for despair. If the effects of a constraint are motivated in one context, this motivation may be sufficient for it to be implemented in a more general form in the grammar, and we might expect to see its effects in other contexts, as well. It may not be necessary for a constraint to be motivated in every context in which it applies.

### 3.3 NONFINALITY and INITIAL GRIDMARK in the Syllable Domain

The last type that I will mention here are NONFINALITY and INITIAL GRIDMARK constraints applied to the domain of the syllable.

- (15) a.  $\text{NONFIN}(x_F, \mu, \sigma)$ : No foot-level gridmark occurs over the final mora of a syllable.
- b.  $\text{INTGRID}(x_F, \mu, \sigma)$ : A foot-level gridmark occurs over the initial mora of the syllable.

$\text{NONFIN}(x_F, \mu, \sigma)$  prohibits stress over syllable-final moras, and  $\text{INTGRID}(x_F, \mu, \sigma)$ , referred to in Hyde 2007a as *FIRSTMORA*, requires stress over syllable-initial moras. Though neither constraint can be justified in terms of the tempo changes in word-peripheral syllables, both are amply justified by other considerations.

As demonstrated in Hyde 2006, 2007b,  $\text{NONFIN}(x_F, \mu, \sigma)$  has much the same effect as familiar constraints like *PEAK PROMINENCE* (Prince and Smolensky 1993) and *STRESS-TO-WEIGHT* (Hammond and Dupoux 1996, and numerous others) in that it prefers stressed heavy syllables to stressed light syllables. If stress cannot occur on the final mora of a syllable, then a syllable must have two moras, must be heavy, to carry a stress. The preference for stress to occur on heavy syllables is well-known – it plays a particularly important role in producing quantity-sensitive unbounded stress patterns – but it is also well-motivated by perceptual considerations. As discussed in Gordon 2002, 2005, heavy syllables have more perceptual prominence than light syllables, making them more natural candidates for positions in which stress can be realized.

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$\text{NONFIN}(x_F, \mu, \sigma)$  also has an additional motivation, one that it shares with  $\text{INTGRID}(x_F, \mu, \sigma)$ , in that it typically positions stress on the most sonorous part of the rhyme. Both constraints discourage stressed codas in closed syllables –  $\text{NONFIN}(x_F, \mu, \sigma)$  by pushing stress away from the end of the rhyme and  $\text{INTGRID}(x_F, \mu, \sigma)$  by placing it at the beginning – and they both discourage stress on the second vowel of a diphthong, the vowel that is typically less sonorous. Even in rhymes containing a long vowel, the beginning of the rhyme (after a consonant) is the most prominent part from a perceptual standpoint (Smith 2003, Gordon 2005), and the two constraints both encourage stress to occur in this position. Both constraints, then, appear to be well-motivated, though it is not the same type of motivation available for the versions discussed above.

### **4. Conclusions**

The asymmetrical formulations of *INITIAL GRIDMARK* and *NONFINALITY* constraints can be justified on typological grounds, but they can often be justified on rhythmic or phonetic grounds, as well. The paper began by examining the two constraints,  $\text{NONFIN}(x_F, \sigma, \omega)$  and  $\text{INTGRID}(x_F, \sigma, \omega)$ , that apply to peripheral syllables within the domain of the prosodic word. These two constraints were shown to be crucial in predicting a typology of binary stress systems that respects well-known iambic-trochaic asymmetries, and I argued that they helped to explain the relative rarity of iambic systems generally. I then argued that the asymmetrical formulation of the two constraints was also motivated on rhythmic grounds.  $\text{INTGRID}(x_F, \sigma, \omega)$  requires stress in a position that often exhibits a tempo acceleration, and  $\text{NONFIN}(x_F, \sigma, \omega)$  prohibits stress in a position that often exhibits a tempo deceleration.

Since *INITIAL GRIDMARK* and *NONFINALITY* offer general formulations from which a number of specific constraints with useful applications might be derived, I also examined constraints that applied to different peripheral elements and to different prosodic domains. We saw that some of these additional constraints can be justified indirectly by the same tempo considerations as the original constraints but that others had to be justified by alternative phonetic considerations. In some contexts, however, a constraint might have no obvious justification other than its usefulness in producing the desired predictions (which is fairly significant justification on its own.)

In terms of future research, the attempt to ground very general (and very useful) constraint formulations like *INITIAL GRIDMARK* and *NONFINALITY* raises a number of questions for the relationship between phonology and phonetics. The first question is whether or not every specific constraint derived from a general formulation must be independently motivated in every relevant context in order for us to expect to see its effects. Based on the discussion of  $\text{NONFIN}(x_\omega, F, \omega)$  in Section 3.2, this appears not to be the case, but additional examples are necessary to support this conclusion. The second question is the meaning of the situation where different rhythmic or phonetic considerations must be used to motivate different specific constraints derived from a general formulation. The default assumption would seem to be that formally related constraints should be motivated by the same phonetic or rhythmic considerations, at least if the intimate relationship between phonetic considerations and the formulation of specific phonological constraints that is often assumed actually exists. Although the evidence presented here suggests that the relationship may be somewhat looser, additional examples would be necessary to support this conclusion, as well.

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