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Prominence, Augmentation, and Neutralization in Phonology

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1. Introduction¹

Certain phonological phenomena, such as the lengthening of vowels in stressed syllables or the attraction of stress to heavy syllables, are best accounted for by means of markedness constraints that make specific reference to strong positions (**M/str** constraints). However, not just any markedness constraint can be relativized to strong positions. If an ordinary featural markedness constraint such as *MIDV ('output forms do not contain mid vowels') were given an **M/str** counterpart specific to stressed syllables, *MIDV/σ, the system would predict the existence of languages that have a full vowel inventory in unstressed syllables but ban mid vowels in stressed syllables — an unattested pattern.

This paper develops a theory of **M/str** constraints that correctly allows for those that are empirically attested, while ruling out problematic constraints like the putative *MIDV/σ. The basis of the proposal is the Prominence Condition, a restriction that holds of the universal constraint inventory such that the only legitimate **M/str** constraints are those that enhance prominence.

The discussion proceeds as follows. First, section 2 presents the proposal. Section 3 then gives an analysis of 'augmentation' and 'attraction' phenomena based on prominence-enhancing **M/str** constraints. Section 4 shows why constraints like *MIDV/σ, which are ruled out by the Prominence Condition, would predict unattested language types if they were assumed to be possible constraints. Finally, section 5 presents conceptual and empirical justification for the proposal.

2. **M/str** constraints and the Prominence Condition

In order to account for languages that require vowels in stressed syllables to lengthen or to bear tone, there must be **M/str** constraints like HEAVYσ/σ, 'Stressed syllables are heavy',² and HAVE TONE/σ, 'Stressed syllables bear tone' (see section 3 for exam-

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²HEAVYσ/σ is equivalent to the Stress-to-Weight Condition (Prince 1990) and is one possible imple-

ples and discussion). However, there must not be featural-markedness **M/str** constraints such as *MIDV/σ, 'Stressed syllables do not contain mid vowels' (see section 4). That is, the grammar must be allowed to include certain kinds of **M/str** constraints, but not just any logically possible **M/str** constraint.

This result is achieved with the following condition on **M/str** constraints.

(1) **The Prominence Condition**

A markedness constraint can be relativized to a strong position only if it acts to enhance the prominence of that position.

Markedness constraints (sometimes called structural constraints, phono-constraints, or well-formedness constraints) are constraints that make reference only to output forms; that is, constraints for which information about input forms, or the correspondence relation between input and output forms, is irrelevant in assessing violations. *Strong positions* are positions that show special feature-licensing abilities and resistance to "positional neutralization" by virtue of their special phonetic or psycholinguistic status (see Beckman 1998, Casali 1996, and references therein) — phonetically strong positions include syllable onsets (more accurately, released consonants), long vowels, and stressed syllables (σ); psycholinguistically strong positions include initial syllables (σ₁) and morphological roots. *Prominence* is the presence of a property, such as tone or long duration, that gives rise to a comparatively large perceptual response.

Thus, the Prominence Condition ensures that if a markedness constraint requiring property *P* to hold of output forms is relativized to one of the set of strong positions, then *P* must be a perceptually salient property. As a result, ordinary featural markedness constraints of the *STRUCTURE family, such as *MIDV or *LABIAL, which have no relationship to prominence, cannot have **M/str** counterparts. But the empirically motivated **M/str** constraints discussed in section 3, such as HEAVYσ/σ, HAVETONE/σ, and HAVESTRESS/Root, all pass the Prominence Condition, so they are legitimate constraints.

3. Phonological requirements for strong positions

This section introduces a number of phonological phenomena that motivate **M/str** constraints. First, examples of *augmentation* effects for the strong position stressed syllable are presented, as when stressed syllables are required to be heavy, to bear tone, or to have onsets (§3.1).³ The same **M/σ** constraints that account for augmentation are then shown to account for *attraction* of stress to syllables having length, tone, or low-sonority onsets, i.e., the patterns seen in what are traditionally called unbounded stress systems (§3.2). Examples of **M/str** constraints for other strong positions are given in §3.3.

mentation of the OT constraint schema or hierarchy PK-PROM (Prince & Smolensky 1993).

³This use of the term *augmentation* is inspired by Zoll (1998), who observes that processes involving "augmentation of the input" can target strong positions.

3.1. Augmentation of stressed syllables

Stressed syllables are sometimes augmented with properties such as syllable weight, tone, and (low-sonority) onsets. Representative examples of stressed-syllable augmentation are given in (2); for detailed discussion and additional cases, see Smith (in prep.) and references therein.

(2) Stressed-syllable augmentation effects

- a. $\acute{\sigma}$ becomes heavy Mohawk (Michelson 1988)
- b. $\acute{\sigma}$ acquires a tone Slave (Rice 1987)
- c. $\acute{\sigma}$ epenthesizes an onset Dutch (Booij 1995)
- d. $\acute{\sigma}$ rejects a high-sonority onset Niuafou'ou (de Lacy 2000)

Phonological requirements like these are taken to be the effect of markedness constraints, which enforce phonological well-formedness. The phenomena in (2) are evidence for the existence of the following constraints.

(3) Markedness constraints specific to stressed syllables (**M/** $\acute{\sigma}$ constraints)

- a. HEAVY $\sigma/\acute{\sigma}$ For all x , if x is a $\acute{\sigma}$, then x is heavy (bimoraic).
- b. HAVETONE/ $\acute{\sigma}$ For all x , if x is a $\acute{\sigma}$, then x bears tone.
- c. ONSET/ $\acute{\sigma}$ For all x , if x is a $\acute{\sigma}$, then x has an onset.
- d. [$*\text{ONS}/X$]/ $\acute{\sigma}$ For all x , if x is a $\acute{\sigma}$, then the onset of x is not X .

(This is a $\acute{\sigma}$ -specific version of the sonority-based $*\text{ONS}/X$ markedness hierarchy, i.e., [$*\text{ONS}/\text{GLIDE}$]/ $\acute{\sigma}$ \gg [$*\text{ONS}/\text{LIQUID}$]/ $\acute{\sigma}$ \gg ... \gg [$*\text{ONS}/\text{STOP}$]/ $\acute{\sigma}$; cf. the $*\text{MARGIN}/X$ hierarchy of Prince & Smolensky 1993).

In each of the languages in (2), the relevant **M/** $\acute{\sigma}$ constraint outranks the antagonistic faithfulness constraint that would act to prevent changes in weight, tonal association, or onset structure. Also undominated is whatever constraint determines the location of stress in that language, such as an alignment constraint or a faithfulness constraint on underlying metrical structure. To ensure satisfaction of both the **M/** $\acute{\sigma}$ constraint and the stress-location constraint, faithfulness to weight/tone/onset is violated and augmentation of the stressed syllable occurs.

- (4) Stressed syllables are augmented with a prominent characteristic

Example: HEAVY $\sigma/\acute{\sigma}$, ALIGN-L($\acute{\sigma}$) >> FAITH(μ)

Input: /CVCVCVC/	HEAVY $\sigma/\acute{\sigma}$	ALIGN-L($\acute{\sigma}$)	FAITH(μ)
a. C \acute{V} .CV.CVC	*!		
b. CV.CV.C \acute{V} C		**!	
☞ c. C \acute{V} !.CV.CVC			*

➡ Result for this ranking: Stress always initial; stressed syllable lengthens

3.2. Stress attraction

If the ranking between the stress-location constraint and the faithfulness constraint in (4) is reversed, with the **M/ $\acute{\sigma}$** constraint still undominated, then a different kind of language is produced: one in which faithfulness to length, tone, or onset is maintained, so that the **M/ $\acute{\sigma}$** constraint is satisfied at the expense of the stress-location constraint. The individual syllables do not change their characteristics, but the location of stress is determined by the location of the syllables that are already prominent.

- (5) Stress is attracted to prominent syllables

Example: HEAVY $\sigma/\acute{\sigma}$, FAITH(μ) >> ALIGN-L($\acute{\sigma}$)

Input: /CVCVCVC/	HEAVY $\sigma/\acute{\sigma}$	FAITH(μ)	ALIGN-L($\acute{\sigma}$)
a. C \acute{V} .CV.CVC	*!		
☞ b. CV.CV.C \acute{V} C			**
c. C \acute{V} !.CV.CVC		*!	

➡ Result for this ranking: Stress falls on leftmost heavy syllable

The pattern represented in (5) is precisely that found in so-called 'unbounded stress systems', in which the location of stress is determined by the location of certain prominent characteristics. Thus, under the current proposal, stress attraction ('unbounded stress') follows directly from a different ranking of the **M/ $\acute{\sigma}$** constraints that are independently needed to account for stressed-syllable augmentation effects.

Furthermore, because augmentation and attraction are driven by the same **M/ $\acute{\sigma}$** constraints, this account predicts that stress attraction should be sensitive to the same inventory of prominent properties that are involved in stressed-syllable augmentation. As shown in (6), the prediction is borne out. The properties of weight, tone, and onset sonority profile are all involved in stress attraction (cf. (2)).

- (6) Stress attraction effects
- a. Attracted to heavy σ Hindi (Hayes 1995)
 - b. Attracted to high-toned σ Serbo-Croatian (Inkelas & Zec 1988)
 - c. Attracted to σ with onsets Arrernte [Aranda] (Strehlow 1942)
 - d. Attracted to σ with low-sonority onsets Pirahã (Everett & Everett 1984)

In summary, languages with stressed-syllable augmentation effects alter input material to satisfy an **M/σ** constraint without affecting stress placement; languages with stress attraction force stress to fall on a syllable that already satisfies **M/σ**, violating the stress-location constraint but respecting faithfulness. Both phenomena are accounted for by means of markedness constraints that make specific reference to the strong position stressed syllable.

3.3. Augmentation of other strong positions

In addition to requirements that hold of stressed syllables, there are requirements on other strong positions as well, providing evidence for additional **M/str** constraints. A few examples are presented here; see Smith (in prep.) for additional discussion.

In Guhang Ifugao (Newell 1956; Landman 1999), onsetless syllables are tolerated medially, but not stem-initially. A constraint that captures this pattern is **ONSET/σ₁**, which requires initial syllables to have onsets (cf. **ONSET/σ** in (3c)).

In Campidanian Sardinian (Bolognesi 1998),⁴ liquid and glide onsets are banned from initial syllables but permitted in medial syllables. Initial liquids are banned in Korean as well, apart from recent loanwords. Patterns like these are evidence for a **σ₁**-specific version of the ***ONS/X** hierarchy, which encourages onsets of initial syllables to have low-sonority onsets (cf. **[*ONS/X]/σ** in (3d)). The **[*ONS/X]/σ₁** hierarchy can also account for many cases of domain-initial fortition, a cross-linguistically common process (for recent discussion, see Lavoie 1999 and Keating et al. to appear).

Several languages show a preference for default or floating stress to be realized on the root rather than on an affix. Examples include Chukchee (Kenstowicz 1994), Tuyuca (Barnes 1996; Smith 1998), and Cupeño (Alderete 1998). This pattern is evidence for a root-specific constraint requiring stress, **HAVESTRESS/Root**.

3.4. Summary: augmentation and attraction effects

Phonological phenomena observed in a number of languages motivate the inclusion of certain **M/str** constraints in the universal constraint set. These constraints require strong positions such as stressed syllables, initial syllables, and roots to have prominent properties like weight, high tone, or (low-sonority) onsets. When an **M/str** constraint dominates an antagonistic faithfulness constraint, the strong position will be augmented with the prominent property demanded by the **M/str** constraint. To satisfy **M/σ** constraints, an additional response is possible: stress-location constraints can be

⁴Thanks to Paul de Lacy for bringing this example to my attention.

violated instead of faithfulness constraints, leading to 'unbounded stress' or stress-attraction systems.

4. The need to restrict **M/str** constraints

The discussion in section 3 has introduced various prominence-enhancing **M/str** constraints to account for augmentation in strong positions. This section now returns to the Prominence Condition and demonstrates that this restriction on **M/str** constraints is necessary. First, §4.1 shows why ordinary featural markedness constraints, which do not increase prominence, must not be allowed to have **M/str** counterparts. Then, §4.2 argues that the analysis of augmentation developed above is preferable to other possible analyses. Since prominence-enhancing **M/str** constraints are necessary, but other **M/str** constraints are undesirable, a restriction like the Prominence Condition is crucial.

4.1. Unwanted **M/str** constraints

Allowing just any markedness constraint to refer to strong positions wrongly predicts that there should be languages with "reverse positional neutralization," in which weak positions license featural contrasts that are neutralized in strong positions. For example, postulating a featural **M/str** constraint like $*\text{MIDV}/\acute{\sigma}$, which bans mid vowels in stressed syllables, allows for languages with the ranking in (7).

(7) Hypothetical **M/str** constraint: $*\text{MIDV}/\acute{\sigma}$

Input: /tépo/	$*\text{MIDV}/\acute{\sigma}$	FAITH[Vht]	$*\text{MIDV}$
a. tépo	*!		**
☞ b. típo		*	*
c. típu		**!	

But languages with contrastive mid vowels only in unstressed syllables are in fact unattested. More generally, it is a characteristic of featural positional neutralization effects that they target weak positions, not strong positions (see Beckman 1998 for discussion). So constraints such as $*\text{MIDV}/\acute{\sigma}$ must not be part of the universal set of constraints.⁵

However, once the formal mechanism of combining markedness constraints with strong positions is allowed into the theory, then without any further restrictions, the option of forming an **M/str** counterpart is technically open to all markedness constraints. The Prominence Condition is needed to eliminate the possibility of unattested and undesirable **M/str** constraints like $*\text{MIDV}/\acute{\sigma}$.

⁵ Not every ranking of a constraint set that includes $*\text{MIDV}/\acute{\sigma}$ produces a grammar that allows "reverse positional neutralization" as in (5). But crucially, *some* such rankings do lead to unattested grammars. Since there is no principled way to prohibit the problem rankings, $*\text{MIDV}/\acute{\sigma}$ must not be allowed to exist.

4.2. Rejecting alternatives to M/str constraints

Another way to keep unwanted **M/str** constraints such as *MIDV/ǫ out of the constraint set, without invoking the Prominence Condition, would be to find an alternative account for augmentation and simply disallow all **M/str** constraints. However, other conceivable ways of accounting for augmentation are unsuccessful.

Since augmentation phenomena affect strong positions, an analysis of augmentation must have some way of distinguishing between strong and weak positions. Faithfulness constraints specific to strong positions (**F/str** constraints) have already been proposed to account for positional neutralization (Beckman 1998, Casali 1996): when **F/str** constraints are high-ranking, they allow their respective strong positions to resist neutralization. However, as Zoll (1998) points out, augmentation effects involve the *violation* of faithfulness in strong positions, so they cannot possibly be caused by **F/str** constraints.

Another approach to augmentation phenomena might be to use **F/wk** constraints, faithfulness constraints specific to weak positions, instead of **M/str** constraints. For example, the following constraint ranking could be used to account for obligatory lengthening in stressed syllables.

(8) Augmentation with **F/wk** constraints: **F/wk** >> **M** >> **F**

FAITH(μ)/ǫ >> HEAVYσ >> FAITH(μ)

With this ranking, faithfulness to input syllable weight in unstressed syllables has priority over the general markedness constraint banning light syllables (FAITH(μ)/ǫ >> HEAVYσ). However, since the general faithfulness constraint is ranked lowest, markedness takes priority for stressed syllables, and they are always heavy (HEAVYσ >> FAITH(μ)).

Unfortunately, the **F/wk** approach to augmentation fares no better than the **M/str** account, because exactly the same kind of problem arises. Allowing featural **F/wk** constraints like FAITH[Vht]/ǫ predicts reverse positional neutralization when they are ranked as in (9).

(9) Unwanted **F/wk** constraints

FAITH[Vht]/ǫ >> *MIDV >> FAITH[Vht] → mid V in ǫ only (unattested)

Furthermore, the **F/wk** approach raises additional questions, such as how faithfulness constraints can make reference to weak positions (which may not be available to the grammar in the way that strong positions, being phonetically or psychologically important, are). An analysis of augmentation based on **M/str** constraints remains the most attractive option.

5. Justification for the proposal

This section addresses some remaining questions concerning the Prominence Condition, confirming that all attested **M/str** constraints do enhance prominence (§5.1) and examining the place of prominence-enhancing **M/str** constraints in a broader theory

of markedness (§5.2).

5.1. Empirical justification: onsets enhance syllable prominence

The Prominence Condition states that only prominence-enhancing **M/str** constraints can exist, where *prominence* is defined as the presence of a property that produces a comparatively large perceptual response. If the Prominence Condition is the correct way to distinguish between the empirically attested **M/str** constraints in section 3 and the problematic, unattested constraints in section 4, then all properties called for by the attested **M/str** constraints must actually be prominent properties.

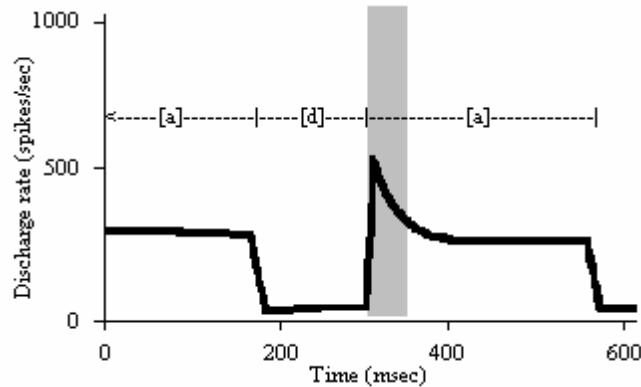
For many of the **M/str** constraints in section 3, the Prominence Condition is clearly met; it is widely accepted that characteristics such as weight, tone, and stress are perceptually prominent. However, the relationship between the Prominence Condition and the **M/str** constraints calling for onsets (or for low-sonority onsets) is less obvious — CV syllables are certainly less marked than onsetless syllables, but that does not entail that syllables with onsets are more prominent than those without. This section presents data from neural response patterns to support the claim that having an onset, and specifically a low-sonority onset, does in fact enhance the perceptual response to a syllable.

Given a constant auditory stimulus such as a tone or a vowel-like sound, auditory-nerve fibers do not discharge at a constant rate. There is an initial response at the onset of the stimulus, followed by a decay in response rate known as *adaptation*. Adaptation has a physiological origin, because it is apparently caused by depletion of the neurotransmitter that stimulates the auditory-nerve fibers (R. Smith 1979). However, it also plays a role in speech perception:

[A]daptation enhances spectral contrast between successive speech segments. ... [A] fiber adapted by stimulus components close to its CF [characteristic frequency] is less responsive to subsequent stimuli that share spectral components with the adapting sound. On the other hand, stimuli with novel spectral components stimulate 'fresh,' unadapted fibers, thereby producing an enhanced response. (Delgutte 1997:510)

Therefore, interspersing consonants (syllable onsets) between vowels gives the peripheral auditory system time to recover from adaptation, allowing enhanced response for each new vowel (syllable) in the string, as seen in (10).

(10) Neural response to synthesized [ada] (adapted from Delgutte 1997:531)



Adapted from a post-stimulus time histogram for a high-spontaneous nerve fiber (CF=1800 Hz). The stimulus is a synthesized sequence [ada] (with equal intensity in both syllables). The shaded bar indicates the time interval occupied by the CV formant transitions, so its left edge marks the point of consonantal release.

At the time of release into the second [a], this nerve fiber shows some recovery from adaptation. The response rate there, at approximately 500 sp/sec, is larger than the response rate observed where adaptation has set in (i.e., the portion of the neural response to the first [a] that is shown,⁶ and the response to the second [a] after about 350 ms).

Furthermore, if CV syllables are more prominent than V syllables because the onset consonant provides a contrast to the vowel (thereby allowing the peripheral auditory system time to recover from adaptation), it follows that syllables with low-sonority onsets are even more prominent than syllables with high-sonority onsets. A low-sonority onset such as a voiceless stop is maximally distinct from a vowel, and so would provide the best opportunity for recovery from adaptation.

Thus, there is evidence from neural response patterns that syllables with onsets, and further, those with low-sonority onsets, are prominent. The Prominence Condition, which holds that only prominence-enhancing **M/str** constraints exist, is therefore consistent with all observed cases of augmentation discussed above.⁷

5.2. Conceptual justification: the nature of markedness constraints

The Prominence Condition has been motivated by typological patterns, to account for why strong positions are never the specific targets of neutralization (by means of **M/str** constraints) unless enhancement of prominence is the result. There is also con-

⁶ Responses to other stimuli by the same nerve fiber indicate that the initial response rate for the first [a], before adaptation, was probably between 500 and 700 sp/sec (Delgutte 1997:531).

⁷ This discussion is not intended to propose that markedness constraints make direct reference to neural response patterns, but rather, that the neural response patterns discussed above provide the functional grounding for onset-related **M/str** constraints. See Silverman (1995) for another application of neural response patterns to phonological markedness.

ceptual justification for this kind of restriction.

It has often been observed that there is more than one kind or dimension of markedness. Some markedness constraints, such as those of the *STRUCTURE family, are ultimately grounded in a "least effort" or "ease of articulation" principle. But another class of markedness constraints calls for the co-occurrence of mutually enhancing properties. For example, Stevens & Keyser (1989) argue that certain feature co-occurrence patterns are marked because they give rise to conflicting cues in the acoustic signal — e.g., prototypical obstruents have no low-frequency energy, because sonorants do; voicing an obstruent adds low-frequency energy to the signal; so voiced obstruents are marked. Restating Stevens & Keyser's (1989) claim in OT terms, there is a markedness constraint requiring obstruents to be voiceless, because voicelessness makes obstruents more like prototypical obstruents.

The **M/str** constraints that satisfy the Prominence Condition, and therefore act to enhance the prominence of strong positions, fall into this second group of markedness constraints. These legitimate **M/str** constraints require a strong position, which by definition is already prominent along some phonetic or psycholinguistic dimension, to become even more prototypically prominent by acquiring another kind of prominent characteristic. **M/str** constraints that did not act to enhance prominence, such as the putative *MIDV/ǫ, would if anything make strong positions less distinctive by stripping away potential contrasts without adding to the salience of the position.

Thus, **M/str** constraints as restricted by the Prominence Condition are conceptually justified in that they belong to an already recognized class of markedness constraints: those that call for mutually enhancing characteristics.

6. Conclusions

Augmentation effects are driven by markedness constraints that are relativized to strong positions. But allowing just any markedness constraint to have an **M/str** counterpart wrongly predicts that featural contrasts can be banned from strong positions but preserved in weak positions. In order to account for why only augmentation-driving **M/str** constraints occur, this paper has proposed and justified a Prominence Condition on **M/str** constraints: **M/str** constraints are legitimate only if they act to enhance the prominence of the strong positions that they target. Featural neutralization that does not enhance prominence is thus excluded from singling out strong positions. The Prominence Condition is conceptually plausible, in that markedness constraints often encourage linguistic objects to have prototypical attributes, and requiring a strong position to be augmented makes an intrinsically prominent position become even more prominent.

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