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Towards a Compositional Treatment of Positional Constraints: The Case of Positional Augmentation

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Positional constraints — versions of constraints that are relativized to apply only to certain phonological positions, such as stressed syllables or released consonants — are frequently employed in phonological analysis. This paper argues that positional constraints, like any other family of related constraints, should be formally modeled as the output of a compositional constraint schema (such as the Generalized Alignment schema in McCarthy & Prince 1993). Specifically, the formulation of any given positional constraint should be automatically and compositionally determined by the formulation of the constraint's non-positional counterpart and the nature of the chosen position. To this end, a particular set of positional constraints, the positional augmentation constraints (markedness constraints relativized to phonologically prominent positions), are examined. A compositional constraint schema is developed that is flexible enough to extend to the many different kinds of positions and constraints involved in positional augmentation, while still determining precisely how the formulation of each general constraint is to be modified in its positional counterpart. Certain implications of the approach for another set of positional constraints, the positional faithfulness constraints, are also considered.

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1. Introduction

A fundamental postulate of Optimality Theory is that there is a universal set[1] of constraints, CON, the members of which are violable and subject to different rankings in different languages (Prince & Smolensky 1993). This basic postulate is compatible with a wide range of proposals about the nature of CON, including the view that CON is an unstructured collection of arbitrary constraints. However, as noted by Smolensky (1995) among others, many constraints can be classified together into constraint families such that the members of a particular family share a *schema*, or generalized constraint formulation. A given schema is concretely instantiated with reference to different grammatical objects to produce the different constraints in the family. For example, in the Generalized Alignment constraint family (McCarthy & Prince 1993; McCarthy 2002a), each individual alignment constraint such as ALIGN(Root, PrWd, L) is an application of the schema ALIGN(*Cat*1, *Cat2*, *Edge*) to basic phonological elements of the relevant types, in this case *root, prosodic word,* and *left edge.*

In this paper, I first argue that a good theory of CON is one that relates as many constraints as possible — ideally, all constraints — to generalized constraint schemas (§2). As a contribution toward this goal, in §3 I develop a schema for the set of *positional augmentation* constraints (Smith 2000, 2002), a class of positional markedness constraints that require phonologically prominent positions to have perceptually salient properties (hence 'augmentation,' a term inspired by Zoll 1998). One of the advantages of a schema-based theory of CON is that the formulation (=definition) of any schema-built constraint is transparently compositional, given the formulation of the schema and the identity of the basic grammatical object(s) to which the schema is applied. Thus, the schema for positional augmentation constraints developed in §3 must be general enough to extend to all attested combinations of augmentation constraints and phonologically prominent positions, while at the same time specifying for each positional constraint that it generates how the particular augmentation constraint and phonologically prominent position in question are to interact. I propose that this balance can be achieved with a schema that makes a general constraint into a positional one by embedding it in an *if-then* clause relating a phonologically prominent position to the elements contained in the *focus* (Crowhurst & Hewitt 1997) of the general constraint. Finally, §4 considers related issues and directions for further investigation.

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[1]Arguably, the universal set of constraints may be supplemented on a language-particular basis by morpheme-specific or morpheme class-specific constraints, including alignment or ANCHOR constraints (McCarthy & Prince 1993, 1995), faithfulness constraints (Benua 1997; Burzio 1994, 1997; Fukazawa 1998; Pater 2000), and perhaps structural well-formedness constraints (Pater 2000). See §2.2 for additional discussion of such constraints and how they are related to the universal constraint set CON.

2. A schema-based theory of CON

A number of researchers have developed proposals that reanalyze OT constraints in terms of simpler, independently motivated phonological elements and relations. For example, McCarthy & Prince (1993) propose that the syllable-structure constraints ONSET and NOCODA can be recast as alignment constraints, specifically, ALIGN(σ, C, L) 'syllables are left-aligned with consonants' and ALIGN(σ, V, R) 'syllables are right-aligned with vowels' respectively. Eisner (1997) argues that many constraints can be reformulated as one of two primitive relations between phonological elements, 'temporally overlaps' and 'does not temporally overlap'. There are also several proposals that decompose internally complex constraints into simpler constraints joined by logical connectors, as in the local conjunction of Smolensky (1993, 1995, 1997) or the method of constraint conjunction developed by Hewitt & Crowhurst (1996; also Crowhurst & Hewitt 1997). For example, CODACOND-PLACE 'coda Cs do not have Place features' might be replaced with the local conjunction of NOCODA and *PLACE (Smolensky 1993); the conjoined constraint [NOCODA $\&_{Seg}$ *PLACE] is violated by a consonant only if it is a coda *and* has a Place feature, just as the complex constraint CODACOND-PLACE would be. Other proposals that decompose familiar phonological constraints into conjunctions of simpler constraints include Alderete (1997), Zoll (1997, 1998), Baertsch (1998), Itô & Mester (1998), and Gafos & Lombardi (1999).

The proposals described above all share a general goal, which is to minimize the arbitrary listing of constraints in CON by formalizing certain systematic relationships that hold among constraints.

In this paper, I adopt one particular approach to systematizing CON: the use of generalized constraint schemas, in the tradition of Generalized Alignment (McCarthy & Prince 1993), to generate families of constraints with compositionally determined formulations. This section addresses various general points about constraint schemas (specific applications of the schema-based approach to positional augmentation constraints are subsequently discussed in §3). First, a model of CON using constraint schemas is outlined in §2.1, where the relationship of schemas to the compositionality of constraint formulations is also discussed. Arguments in favor of a schema-based approach to CON are then presented in §2.2, and a general solution for schemas that overgenerate is sketched in §2.3.

2.1 Constraint schemas and compositionality

The concept of a constraint schema has its origin in the Generalized Alignment treatment of alignment constraints (McCarthy & Prince 1993), as in (1); see also Smolensky (1995) on "parametrized families" of constraints. Related work includes Hayes (1999), which proposes free generation of phonotactic constraints through the unrestricted combination of basic phonological elements, but does not explicitly discuss the compositionality of the constraint formulations so generated.

(1) The ALIGN schema (Generalized Alignment; after McCarthy & Prince 1993:80)

ALIGN(*Cat*1, *Cat*2, *Edge*)

$\forall$ *Cat*1 $\exists$ *Cat*2 such that *Edge* of *Cat*1 and *Edge* of *Cat*2 coincide

*where Cat*1, *Cat*2 $\in$ *PCat* $\cup$ *GCat* (i.e., prosodic and grammatical categories)

Edge $\in$ {R(ight), L(eft)}

The ALIGN schema applies to edges and prosodic/grammatical categories to create individual alignment constraints, such as ALIGN(Root, PrWd, L) in (2) (where PrWd = Prosodic Word).

(2) ALIGN(Root, PrWd, L)

$\forall$ Root $\exists$ PrWd such that Edge=L of Root and Edge=L of PrWd coincide

A number of other constraint schemas have been proposed in the literature, implicitly or explicitly. Smolensky (1995:2) notes that "many constraints are specific instantiations of a general schema." Examples that he lists include PARSE(X), FILL(X), and constraints regulating associations between structural positions and their content.

Suzuki (1998:28) explicitly introduces his Generalized OCP system as a constraint schema, giving it the formulation in (3).

(3) The GOCP schema (Suzuki 1998:27)

***X...X**: A sequence of two *X*s is prohibited.

where *X* $\in$ {*PCat, GCat*}

"..." is intervening material

Likewise, the faithfulness (correspondence) constraints introduced by McCarthy & Prince (1995) — MAX, DEP, IDENT, CONTIGUITY, ANCHOR, LINEARITY, UNIFORMITY, INTEGRITY — are all constraint schemas, intended to be expanded into families of formally related constraints. For example, IDENT constraints can be represented as follows.

(4) The IDENT schema

IDENT-*Corr*[*Feat*] If S_1 and S_2 are strings related by the correspondence relation[2] *Corr*, $\alpha \in S_1$, $\beta \in S_2$, and $\alpha \Re \beta$, then α and β agree in their specifications for the feature *Feat*

(I.e., "corresponding segments in the *Corr* relation have identical specifications for *Feat*.")

Other constraint families that can straightforwardly be formalized in terms of schemas include *STRUCTURE (Zoll 1993; Prince & Smolensky 1993) and feature co-occurrence constraints.

(5) Further examples of schemas

(a) The *STRUCTURE schema: **Cat*
where $Cat \in PCat \cup GCat$

(b) The feature co-occurrence schema: *[*Feat*1, *Feat*2]

Formally, a constraint schema is a function. That is, the formulation of each schema contains variables that are designated to be filled with phonological elements of a particular type, such as prosodic or grammatical categories *PCat/GCat*, features *Feat*, edges *Edge*, correspondence relations *Corr*, and so on. When a particular schema is supplied with some type-appropriate value for each of its variables, the result is an actual constraint that qualifies as a formally possible member of CON (although see §2.3 on factors that may exclude a technically well-formed constraint from actually belonging to CON). Thus, an example of an individual alignment constraint would be ALIGN(Rt, PrWd, L), as above; an individual GOCP constraint would be *[lateral]-μ-[lateral] (Suzuki 1998:82); and an individual IDENT constraint would be IDENT-IO[nasal] (McCarthy & Prince 1995:279).

In other words, each schema generates a set of constraint formulations that differ from the schema only in having the variable slots filled by arguments of the correct type. This has an important consequence: the formulation of any schema-built constraint is *compositional*, given the formulation of the schema and the specific choice of arguments for the variables. Thus, the formulation of the individual alignment constraint in (2) is transparently a combination of the formulation of the general ALIGN schema in (1) with the arguments *Cat1*=Root, *Cat2*=PrWd, and *Edge*=L.

[2]The set of possible correspondence relations over which faithfulness constraints can be defined includes the I(nput)-O(utput), O(utput)-O(utput), and B(ase)-R(eduplicant) relations (McCarthy & Prince 1995; Orgun 1995; Burzio 1994, 1997; Benua 1995, 1997; Struijke 2000; Kawahara 2002).

There are a number of advantages to a model of CON in which as many constraints as possible are related to general schemas, and as a result have formulations that are compositionally determined. These advantages are discussed in the following section.

2.2 Advantages of schema-built constraints

In various respects, a schema-based model of CON provides for a more restrictive theory of universal grammar than a model of CON with no explicit internal structure. Eisner (1997:(5)) raises several points in favor of using a restricted set of elements and relations to formulate OT constraints. He notes that this strategy reduces the space of possible constraint formulations and makes clearer predictions about what general constraint types should and should not turn up in empirical investigations of natural language. As Eisner points out, such an approach may also help identify formal similarities between superficially separate constraints.

Furthermore, a certain number of constraint schemas are actually indispensable in an empirically adequate OT grammar, because some constraints make explicit reference to individual morphemes or morpheme classes. For example, the difference between prefixes and suffixes has been argued to come from alignment constraints that cause particular morphemes to be attracted to the right or left edges of their domains, as with ALIGN(*um*, PrWd, L) in Tagalog (Prince & Smolensky 1993:§4.1; McCarthy & Prince 1993:102). Similarly, in some languages, relativized versions of general constraints apply specifically to certain morphemes or sets of morphemes (Pater 2000; Fukazawa 1998; Fukazawa, Kitahara, & Ota 1998). Constraints that refer to specific morphemes cannot possibly be included in Universal Grammar in their final form, since they include language-particular information. Thus, there must be a compositional process of constraint building for at least some constraints. Given that some constraint schemas are necessary in any case, a model of CON that relates all constraints to general schemas is more restrictive than one that allows both for schemas and for sets of constraints that are formally similar but listed arbitrarily and individually. The schemas themselves may still need to be listed, but the amount of arbitrary information in CON is reduced this way.

The adoption of a schema-based model of CON also resolves the tension between the desirability of a universal constraint set, on the one hand, and the empirical evidence in favor of alignment and other constraints that refer ro particular morphemes, on the other. If the variable *GCat* that appears in various constraint schemas can be filled, not only by universal grammatical categories such as *root* or *noun*, but also by individual morphemes or morpheme classes as stored in the lexicon of a particular language, then morpheme-specific constraints are simply the well-formed output of a constraint schema, just as truly "universal" constraints are.

Finally, as noted in the previous section, an important advantage of a schema-based model of CON is that schema-built constraints have compositional formulations. This aspect of constraint schemas allows for a formal account of why families of constraints have formulations that, despite referring to distinct grammatical elements, are systematically related. Otherwise, it would simply be an arbitrary coincidence that, for example, IDENT-IO[nasal] and IDENT-BR[voice] have nearly identical formulations.

2.3 Constraint overgeneration and constraint filters

Despite the advantages of a model of CON that generates constraints from a small set of formal relations and basic grammatical elements, there is a consequence of this approach that must be addressed. A schema-based model of CON leads to constraint *overgeneration*. That is, not all formally possible combinations of constraint schemas and basic grammatical elements actually exist as constraints. However, a solution has been proposed (Hayes 1999; Smith 2002): constraints that are inappropriately generated by otherwise well-motivated schemas can be ruled out with constraint *filters*, many of which involve functional or substantive pressures on the grammar such as those imposed by aspects of articulation and perception.

Instances of constraint overgeneration by schemas are not difficult to find. For example, Archangeli & Pulleyblank (1994:§3.1) argue that the only feature co-occurrence constraints that exist are those that are *phonetically grounded* — where the features in question are incompatible for physical (articulatory or perceptual) reasons. However, the generalized Feature Co-Occurrence schema, *[*Feat*1, *Feat*2] (5b), would generate co-occurrence constraints for all pairs of features, physically incompatible or not. Likewise, as noted above, McCarthy & Prince (1993:101) show that ONSET and NOCODA can be reformulated via the Generalized Alignment schema (1) as ALIGN(σ, C, L) and ALIGN(σ, V, R) respectively, but Eisner (1997) observes that the crucially non-existent constraints ALIGN(σ, V, L)="NOONSET" and ALIGN(σ, C, R)="CODA" are thereby also generated. Fukazawa & Lombardi (2000) raise similar criticisms about the use of constraint conjunction to derive complex constraints as described in §2.1; they argue that typologically problematic constraints like "CODACOND-VOICE" (discussed in Lombardi 2001) are incorrectly generated if CODACOND-PLACE is to be systematically derived from the local conjunction of NOCODA and *PLACE.

Addressing the problem of overgeneration in feature co-occurrence (and similar) constraints, Hayes (1999) develops a proposal that allows these constraints to be formally and freely generated, while ensuring that all extant constraints of this type are phonetically grounded in the sense of Archangeli & Pulleyblank (1994). Essentially, Hayes proposes that a constraint is phonetically grounded if it partitions the space of possible feature combinations into phonetically 'easy' and 'difficult' structures more accurately than constraints of equal or greater formal simplicity do; constraints that do not meet these criteria are excluded from CON. That is, information from outside the phonological grammar (the speaker's experiential knowledge of phonetic difficulty) is used to rule out formally possible but functionally unmotivated constraints. In Smith (2002), this approach is extended to certain other types of constraints as well. Formally, a set of *constraint filters* is incorporated into the schema-based model of CON. Each constraint filter inspects the constraints that are freely generated by the schemas and admits into CON only those formally possible constraints that meet the criteria of that particular filter, making use of articulatory, acoustic, perceptual, or other substantive information to distinguish between legitimate and impossible constraints. This Schema/Filter model can be represented as in (6).

(6) The Schema/Filter model of CON

Free constraint construction **(schemas × arguments)**	➜	Substantive **filters** block certain potential constraints	➜	CON

Crucially, the inclusion of a set of constraint filters in the model of CON is not merely an ad-hoc attempt to rescue the schema-based approach. Any model of the universal constraint set, whether or not it explicitly relates constraints to generalized constraint schemas, must address the question of functional grounding — why is it that CON includes many functionally grounded constraints, but often does not include constraints of similar formal structure that lack a substantive motivation? A model of CON that rejects constraint-building schemas in favor of an arbitrary listing of constraints may not appear to have a formal overgeneration problem, but it still offers no explanation for why the constraints included in the arbitrary list tend to reflect functional considerations. On the other hand, having filters screen potential constraints for compliance with various substantive criteria provides an explicit way of modeling the effect of functional considerations on CON.

Thus, although many details in a full theory of constraint filters remain to be worked out, the filter approach is a promising solution to formal constraint overgeneration that also addresses the important question of substantive grounding in the constraint system. (See Hayes 1999 and Smith 2002 for additional discussion; see also Fukazawa & Miglio 1998 and Fukazawa & Lombardi 2000 for a filter-type proposal for local conjunction.) For present purposes, the important point to note is that it is not necessary to abandon constraint schemas, with their many advantages, simply because they overgenerate.

In conclusion, the development of a schema-based theory of CON is a desirable goal. This conclusion establishes a research program: Any set of constraints that are formally similar should be modeled with a generalized constraint schema, defined in such a way that the formulation of every constraint built from that schema is compositionally determined. One set of constraints whose formulations are clearly systematic are the *positional* constraints — versions of markedness or faithfulness constraints that are relativized to particular phonological positions. Positional constraints are related both to the non-positional ("general") constraints from which they are formed, and also to other positional constraints, so a schema is needed to capture these relationships formally. However, given the varied nature of the positions that are eligible for relativized constraints and the wide variety of constraints that have positional versions, this is not a trivial problem. §3 now develops a schema for one class of positional constraints, the positional augmentation constraints.

3. A compositional schema for positional augmentation constraints

Positional augmentation constraints (Smith 2000, 2002) are a class of positional markedness constraints. Specifically, they are markedness constraints (of a type that act to enhance perceptual prominence) that are relativized to phonologically prominent positions. As noted above, positional augmentation constraints are prime candidates for a constraint schema, since they have systematic relationships among themselves and with their general counterparts. This section gives an overview of positional augmentation constraints (§3.1), develops a constraint schema for them (§3.2), and then examines the typology of constraints produced by the schema (§3.3).

3.1 Positional augmentation constraints

There is a set of phonologically prominent or "strong" positions that are well known for their special ability to license phonological contrasts, resisting neutralization processes that may otherwise be active in a language (Trubetzkoy 1939; Steriade 1993, 1995, 1997; Beckman 1995, 1997, 1998; Casali 1996, 1997; Padgett 1995; Lombardi 1999; Zoll 1996, 1997, 1998). The set of strong positions includes the stressed syllable ($\acute{\sigma}$), the [+release] consonant ($C_{[+rel]}$, which is often, though not always, a syllable onset), the long vowel (*V:*), the initial syllable (σ_1), and the morphological root (*Rt*). Many languages will tolerate a particular phonological contrast, such as that between voiced and voiceless obstruents or that between oral and nasal vowels, only inside one of these strong positions. Specific examples of special contrast-licensing behavior in the various strong positions can be found in the references cited above.

Although the strong positions are best known for their ability to *resist* pressures leading to neutralization, there are also cases where these positions are specifically singled out and *required* to meet certain phonotactic criteria (de Lacy 2000, 2001; Parker 2001; Smith 2000, 2002). Some examples of special requirements for strong positions are given in (7); these examples are discussed in §3.3.1 below. (Discussion of phonological requirements on the strong position Rt is postponed until §3.3.2.)

(7) Phonological requirements for strong positions

	Position	*Requirement*	*Examples*
(a)	σ́	high-sonority peak	Zabiče Slovene (Crosswhite 1999); Mokshan Mordwin (Kenstowicz 1994)
		onset	Dutch (Booij 1995), Western Arrernte (Strehlow 1942; Davis 1988; Downing 1998)
		low-sonority onset	Pirahã (Everett & Everett 1984), Niuafo'ou (Tsukamoto 1998; de Lacy 2000, 2001)
(b)	$C_{[+rel]}$	supralaryngeal place	Chamicuro (Parker 2001)
(c)	V:	high sonority	Yawelmani Yokuts (Newman 1944; Kuroda 1967; Kisseberth 1969; Archangeli 1984)
(d)	σ_1	onset	Arapaho (Salzmann 1956), Guhang Ifugao (Newell 1956, Landman 1999)
		low-sonority onset	Mongolian (Ramsey 1987), Kuman (Lynch 1983; Blevins 1994), Mbabaram (Dixon 1991), Campidanian Sardinian (Bolognesi 1998)

The phonological requirements in (7) are for the most part familiar ones. The constraints responsible for enforcing such requirements are listed in (8). Each constraint is formulated here in a way that makes its focus — its universally quantified argument (Crowhurst & Hewitt 1997) — explicit. (See §3.2 on the importance of the constraint focus.) Note that *ONSET/X (8b) and *PEAK/X (8c) are constraint subhierarchies; each subhierarchy includes one constraint per level of the segmental sonority scale in a universally fixed ranking determined by "harmonic alignment" (Prince & Smolensky 1993).

(8) Markedness constraints responsible for the requirements in (7)

(a) Requirement that a syllable onset be present:
ONSET ∀ [syllable *x*], *x* has an onset[3]
(Itô 1989; Prince & Smolensky 1993)

(b) Requirement that a syllable onset be low in sonority:
*ONSET/X ∀ [segment *a* that is the leftmost onset segment of some syllable *x*], *a* has sonority less than level X

where X is a step on the segmental sonority scale

e.g. *ONS/LOWV >> ... >> *ONS/GLIDE >> ... >> *ONS/NAS >> ... >> *ONS/VCLSOBST

(*ONSET/X is a modification of *MARGIN/X (Prince & Smolensky 1993); the combined effect of this subhierarchy is to force onsets to have low sonority)

(c) Requirement that a syllable peak be high in sonority:
*PEAK/X ∀ [segment *a* that is the head[4] of some syllable *x*], *a* has sonority greater than level X

where X is a step on the segmental sonority scale

e.g. *PK/VCLSOBST >> ... >> *PK/NAS >> ... >> *PK/HIGHV >> ... >> *PK/LOWV

(Prince & Smolensky 1993; the combined effect of this subhierarchy is to enforce high sonority in peaks)

(d) Requirement that a consonant have a supralaryngeal place specification:
HAVECPLACE ∀ [consonant *a*], *a* has a supralaryngeal place specification
(after Parker 2001)

What is special about the languages listed in (7) is that these phonological requirements do not hold across the board. Instead, they hold specifically of material in the given strong positions. For example, in Dutch (Booij 1995), stressed syllables must have onsets at all costs, even if this requires epenthesis, but unstressed syllables never epenthesize a consonant, even if this means that an unstressed syllable remains onsetless.[5]

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[3]The term *onset* here and in (8b) is intended to designate a *pre-peak segment*; that is, a constituent of the syllable that appears to the left of (and is distinct from) the syllable head.

[4]*Head* here is used transitively, in the sense of *designated terminal element* in Liberman & Prince (1977); the head segment of a syllable is the head (segment) of the head (mora) of that syllable.

[5]When the first vowel in a Dutch VV sequence is non-low, ONSET can be satisfied without recourse to epenthesis, by means of glide formation (Booij 1995; Rosenthall 1994). For example, /zeː + ən/ becomes

(9) Dutch: Onsets mandatory in stressed syllables only

(a) Onsetless unstressed syllables (Booij 1995, (22))

chaos	[xá.ɔs]	'chaos'
farao	[fára.o]	'pharaoh'

(b) [ʔ]-epenthesis in stressed syllables (Booij 1995, (22))

paella	[pa.ʔɛ́lja]	'paella'
aorta	[a.ʔɔ́rta]	'aorta'
Kaunda	[ka.ʔúnda]	'Kaunda'

This means that for Dutch stressed syllables, a markedness (**M**) over faithfulness (**F**) ranking holds, allowing the onset requirement to be successfully enforced. However, outside of stressed syllables, the reverse ranking, **F** >> **M**, holds, and as a result the onset requirement is not able to override faithfulness and force epenthesis.

There are two ways, shown in (10), to ensure that **M** >> **F** holds inside stressed syllables while **F** >> **M** holds elsewhere. **M**, in this case ONSET, could be given a σ́-specific counterpart that dominates otherwise high-ranking faithfulness (10a), allowing for special markedness requirements on stressed syllables. Constraints of this type can be called **M/str** constraints: markedness constraints relativized to strong positions. Conversely, **F**, in this case DEP ('no epenthesis'; McCarthy & Prince 1995), could be given a σ̆-specific counterpart that dominates otherwise high-ranking markedness (10b), allowing for special faithfulness in unstressed syllables; such constraints can be called **F/wk** constraints.

(10) Enforcing the Dutch onset-epenthesis pattern

(a) σ́-specific ONSET (**M/str**): ONSET/σ́ >> DEP >> ONSET
- In general, avoiding epenthesis is most important
- In σ́ only, the special onset requirement takes priority

(b) σ̆-specific DEP (**F/wk**): DEP/σ̆ >> ONSET >> DEP
- In general, having an onset is most important
- In σ̆ only, avoiding epenthesis takes priority

[zeːjən]. In terms of Correspondence Theory (McCarthy & Prince 1995), the input vowel in such a case has two output correspondents, a vowel and a homorganic glide. Therefore, this is not actually glide "epenthesis," since the glide is in a correspondence relation with a segment in the input; INTEGRITY ('no splitting') is violated, but DEP ('no epenthesis') is not. The crucial case, therefore, is a VV sequence where the first vowel is low, since low vowels are not permitted to form glides in Dutch. In this case, ONSET can only be satisfied if DEP is violated and actual epenthesis takes place.

The two alternatives shown in (10) are empirically difficult to distinguish, but conceptually there are reasons to prefer (10a). Namely, in order for a constraint to be relativized to a weak position, as with DEP/σ̆ above, the weak position must be formally identifiable by the part of the grammar that is responsible for producing position-specific constraints. In some cases, weak positions may be identifiable in their own right: the weak counterpart to the strong position stressed syllable would be the unstressed syllable, as here; the weak counterpart to the strong position root would be the affix. However, for other strong positions, the corresponding weak position is not something that can be identified *except as the complement of the strong position*. One such case is the "non-initial syllable," which would have to be identified by the position-specific **F** constraint in an **F/wk**-based approach to the languages in (7d). The "position" non-initial syllable can only be identified as "any syllable that is *not* the initial syllable." A grammar in which strong positions are identified and used to form positional constraints is simpler than a grammar in which strong positions are identified, weak positions are identified as the complements of the strong positions, and weak positions are used to form positional constraints. For this reason, I propose that position-specific constraints can only refer to strong positions, never to weak positions. Under this principle, **F/wk** constraints such as DEP/σ̆ are simply not available as a way to account for phonological requirements on strong positions. Instead, it is constraints such as ONSET/σ́ — markedness constraints relativized to members of the set of strong positions — that are included in CON.

The effects of ONSET/σ́ in the Dutch ranking from (10a) are exemplified in (11); as desired, onsets are mandatory in stressed syllables, but faithfulness takes priority in unstressed syllables.

(11) Enforcing onsets in stressed syllables with ONSET/σ́

(a) Onset epenthesis in stressed syllables

/paɛ́lja/	ONSET/σ́	DEP-SEG	ONSET
a. pa.ɛ́lja	*!		*
☞ b. pa.ʔɛ́lja		*	

(b) No onset epenthesis in unstressed syllables

/fárao/	ONSET/σ́	DEP-SEG	ONSET
☞ a. fára.o			*
b. fára.ʔo		*!	

Similarly, the other position-specific requirements listed in (7) are evidence for additional positional versions of the constraints in (8): [*ONSET/X]/σ́, HAVECPLACE/$C_{[+rel]}$, [*PEAK/X]/V:, ONSET/σ_1, etc. (See §3.3.1 for further discussion of these constraints.)

3.2 The M/str schema for positional augmentation constraints

As seen in the preceding section, a positional augmentation constraint is a markedness constraint that has been relativized to a member of the set of strong positions. This means that any given positional augmentation constraint has a systematic formal relationship with the general version of the markedness constraint to which it is related: the only difference between the general and specific versions of the constraint is that the specific version makes reference to a particular position. As a consequence, the formulation of each positional augmentation constraint is predictable given the general version of the constraint and the identity of the chosen strong position. In keeping with the goal of explicitly connecting related constraints through constraint schemas, it is desirable to develop a schema that builds positional augmentation constraints from their general counterparts.

However, defining a generalized schema for positional augmentation constraints is not as straightforward as for a schema like ALIGN or IDENT, where the constraints in the family all refer to the same kinds of formal element (such as prosodic/grammatical constituents and their edges, or features and correspondence relations, respectively). A schema that relates markedness constraints to strong positions must take into account an additional complication. Namely, the members of the set of strong positions differ in size and type (e.g., segment *vs.* syllable *vs.* morpheme), which means that the markedness constraints that are relevant for each of the strong positions will differ. For example, a version of ONSET that applies specifically to σ́ or σ_1 is meaningful (and attested; see (7a,d)), but one that applies specifically to V: is not, since it is syllables, not vowels, that have onsets. On the other hand, members of the *PEAK/X constraint subhierarchy — which demand that a syllable peak be high in sonority — can be relativized both to a syllable-sized position, σ́, and to a segment-sized position, V: (the peak itself); see (7a,c).

So, a schema for positional augmentation constraints must be flexible enough to allow for strong positions and general augmentation constraints of any kind to serve as its arguments, but it must allow the size or type of a given strong position to determine what markedness constraints can meaningfully be relativized to that position. I propose that what is needed is a constraint schema that places a positional restriction on some element within the *focus* of a general markedness constraint.

The concept of a constraint focus is developed by Crowhurst & Hewitt (1997; see also Hewitt & Crowhurst 1996), who describe it as follows and formalize it as in (12).

> ...every constraint has a FOCUS, which may be defined as the linguistic object upon which some condition of maximum harmony is predicated. Abstracting away from differences due to style, we recognize at the heart of any constraint a definition of a state of maximum harmony holding on some linguistic object in relation to some other linguistic object. (Crowhurst & Hewitt 1997:9)

(12) The focus of a constraint (Crowhurst & Hewitt 1997:10; emphasis added)

i. Every constraint has a unique focus.
ii. A constraint's focus is identified by the **universally quantified argument**.

Thus, for every constraint, a constraint focus can be identified. Furthermore, the remainder of the constraint can be termed the *requirement* that the constraint places on its focus. In other words, every constraint **C** has the formal structure shown in (13).

(13) **C** $\forall$ **C-foc**, **C-req** holds of **C-foc**

where **C-foc** is the focus of constraint **C**
C-req is the requirement that **C** places on **C-foc**

A schema for **M/str** constraints can now be formulated to take advantage of this universal structure in constraint formulations. The proposed schema (14) embeds the requirement of any general markedness constraint **M** inside an *if-then* statement, specifying that if a particular element from the focus of **M** is an instance of a chosen strong position, then the requirement demanded by **M** must hold of its focus.

(14) The **M/str** schema

M/str $\forall$ **M-foc**, <u>if *y* is a *str*</u>, then **M-req** holds of **M-foc**

where **M-foc** is the focus of markedness constraint **M**
M-req is the requirement that **M** places on **M-foc**
y is a variable included in **M-foc**
str is a member of the set of strong positions

This **M/str** schema has the desired ability to relativize any markedness constraint[6] to any strong position, while still compositionally generating a meaningful formulation for the relativized constraint.

For example, consider the positional augmentation constraint ONSET/σ́, discussed in §3.1 above. The general constraint ONSET has the formulation in (8a), repeated here in (15) (Itô 1989; Prince & Smolensky 1993).

(15) ONSET ∀ [syllable x], x has an onset

The focus of any constraint is the argument associated with universal quantification, so in the case of ONSET, the only element referred to within the focus is a syllable, explicitly identified in (15) with the variable x.

When ONSET becomes an argument of the **M/str** schema (14), along with a designated strong position, such as σ́, a positional constraint as in (16) is the result.

(16) ONSET/σ́ ∀ [syllable x], if x is a σ́, then x has an onset

As desired, a positional constraint constructed from the **M/str** schema "ignores" anything outside its strong position. This works because an **M/str** constraint has the logical structure of a conditional, and a conditional whose antecedent clause is false will be true regardless of the truth value of its consequent clause. So, whenever the element under scrutiny is *not* an instance of the strong position in question, the positional constraint is vacuously satisfied whether **M** actually holds or not. An unstressed syllable will never violate ONSET/σ́, even if it has no onset.

Because the **M/str** schema simply combines any augmentation constraint with any strong position, it also generates constraints such as ONSET/V:, a version of ONSET relativized to the strong position long vowel. As noted above, this is a meaningless constraint, because it is syllables, not vowels themselves, that have onsets. **M/str** constraints such as ONSET/V: involve what may be termed a *focus mismatch* — the strong position, in this case V:, is of a type that is incompatible with every element referred to within the focus

[6]Not all markedness constraints have **M/str** counterparts that survive to be included in CON. As noted in §1, only a particular subset of markedness constraints — the augmentation, or prominence-enhancing, constraints — can have **M/str** counterparts. There is also an additional restriction on **M/str** constraints for psycholinguistically (as opposed to phonetically) strong positions. According to the proposal in Smith (2002), both of these restrictions can be modeled with substantively based constraint filters (see §2.3 on filters). The filter on **M/str** constraints for psycholinguistically strong positions, known as the Segmental Contrast Condition, is discussed in §3.3.2 below. The filter that is responsible for preventing non-augmentation constraints from having **M/str** counterparts is called the Prominence Condition; this filter is not discussed further here, but see Smith (2000, 2002).

of the constraint, which in this case includes only the syllable *x*. The focus mismatch can be clearly seen in the compositional formulation of ONSET/V: (17), as determined by the **M/str** schema.

(17) ONSET/V: ∀ [syllable *x*], if *x* is a V:, then *x* has an onset

Fortunately, including focus-mismatch constraints in CON does not lead to any problematic typological predictions. Once again, the fact that the **M/str** schema is structured as a conditional proves to be significant. In cases of focus mismatch, the antecedent clause of the constraint formulation — in (17), 'if [syllable] *x* is a V:' — will always be false. Since a conditional with an antecedent clause that is always false is itself always true, a constraint such as ONSET/V: will be (vacuously) satisfied by every output candidate. By definition, a constraint like this will never be *active on a candidate set* (that is, it will never demarcate a proper subset of the candidate set as suboptimal; Prince & Smolensky 1993). In other words, because it is always satisfied, a positional augmentation constraint involving a focus mismatch will never influence the selection of the optimal candidate for any input under any ranking. It may even be the case that a constraint filter (see §2.3 above) excludes from CON all **M/str** constraints involving a focus mismatch, but since focus-mismatch constraints are inert anyway, this is not formally necessary.

Two of the constraints from (8), *ONSET/X and *PEAK/X, are repeated here in (18). These constraints are noteworthy because they each have a focus that makes reference to more than one element, namely, a segment (identified with the variable *a*) and a syllable (*x*).

(18) Constraints with multiple elements in the focus

(a) *ONSET/X ∀ [segment *a* that is the leftmost onset segment of some syllable *x*], *a* has sonority less than level X

where X is a step on the segmental sonority scale

(b) *PEAK/X ∀ [segment *a* that is the head of some syllable *x*], *a* has sonority greater than level X

where X is a step on the segmental sonority scale

*ONSET/X and *PEAK/X have complex foci because they are constraints on *segments that have a particular structural relationship to a syllable*. Even though the constraint's requirement (**M-req**) in each case refers only to the segment (*a*), the constraint focus (**M-foc**) must also refer to a syllable (*x*) if the nature of *a* is to be appropriately specified.

The fact that the focus of each of these constraints refers to two elements predicts that strong positions compatible with *either* of the two focus elements should be able to combine with these constraints without producing a domain mismatch. For example, the following two relativized versions of *PEAK/X are predicted to be well formed (and both are attested; see (7a,c)).

(19) Positional versions of *PEAK/X

(a) [*PEAK/X]/σ́ ∀ [segment *a* that is the head of some syllable *x*],
<u>if *x* is a σ́</u>, then *a* has sonority greater than level X
where X is a step on the segmental sonority scale

(b) [*PEAK/X]/V: ∀ [segment *a* that is the head of some syllable *x*],
<u>if *a* is a V:</u>, then *a* has sonority greater than level X
where X is a step on the segmental sonority scale

Naturally, the attempt to produce a [*PEAK/X]/V: constraint in (20), in which the strong position is related to the wrong focus element, is just as much a focus mismatch as the putative ONSET/V: constraint in (17).

(20) [*PEAK/X]/V: ∀ [segment *a* that is the head of some syllable *x*],
<u>if *x* is a V:</u>, then *a* has sonority greater than level X
where X is a step on the segmental sonority scale

However, since there is one pairing of V: with an element from the focus of *PEAK/X that is not a focus mismatch, and since focus-mismatch constraints are inert, cases like (20) — where a focus mismatch arises simply because the "wrong" variable from a complex focus is related to the strong position — will not be discussed further here.

In summary, the **M/str** schema, which generates positional augmentation constraints, thus meets the criteria outlined at the beginning of §3.2. It generates all possible combinations of augmentation constraints and strong positions, taking into account positions of different sizes and augmentation constraints of different types. It also correctly allows for the fact that only some combinations of constraints and positions are meaningful, because the *if-then* structure of the schema ensures that focus-mismatch constraints are never active on a candidate set.

3.3 Predicted typology of M/str constraints

Given a set of strong positions and a set of markedness constraints, the generalized **M/str** schema (14) will freely combine them, producing a set of positional constraints. In this subsection, I examine the consequences of applying the **M/str** schema to the set of strong positions listed in (7) and the set of markedness constraints defined in (8). I show that, once we remove focus-mismatch cases and a σ_1 constraint that fails a substantively based constraint filter, there is a good match between the predicted and attested positional constraints. (Implications of the **M/str** schema for additional markedness constraints and strong positions are considered in §3.4 below.)

The strong positions from (7) are repeated here in (21), which also gives a more explicit description of the phonological configuration defining each position and a list of focus elements that are compatible with each position (i.e., that do not create a focus mismatch).

(21) Strong positions

	Position	*Defining configuration*	*Compatible focus elements*
(a)	$\acute{\sigma}$	A main-stress syllable, i.e., the head syllable of the head foot of a prosodic word	syllable
(b)	V:	A vowel associated with more than one mora	segment
(c)	$C_{[+rel]}$	A consonant that is released	segment
(d)	σ_1	The leftmost syllable whose head is affiliated with a morphological word	syllable

The position σ_1 is characterized as in (21d), with reference to the syllable head, because this position is not only prosodically but also morphologically defined (see Smith 2002:§4.4 on σ_1 as MWd-initial syllable). Morphological structure and prosodic structure are on different planes of phonological representation, so these two kinds of structure can be directly related only with reference to the segments that they share, as noted in various discussions of morphological-prosodic alignment constraints (especially McCarthy & Prince 1993:89; see also Kager 1999:11). When a morphological constituent needs to be related to a prosodic constituent, this can be done by means of the segment that serves as the head of the prosodic constituent (for a related proposal, see McCarthy 2000ab on faithfulness to prosodic heads through segmental correspondence). Therefore, σ_1 is defined here by relating the syllable and MWd aspects of this position via the segment that is the (terminal) head of the syllable.

When these four strong positions are combined by the **M/str** schema (14) with the four constraints defined in (8), the sixteen constraints given in (22) are produced. For clarity, the focus of each constraint is shown inside [square brackets] and the phonological elements referred to in the constraint foci are shown in **boldface**.

(22) Predicted positional augmentation constraints

	ONSET	*ONSET/X	*PEAK/X	HAVECPLACE
$\acute{\sigma}$	∀ [**syllable** *x*], if *x* is a $\acute{\sigma}$, then *x* has an onset	∀ [**seg** *a* that is the leftmost onset seg of some **syllable** *x*], if *x* is a $\acute{\sigma}$, then *a* has sonority < level X	∀ [**seg** *a* that is the head of some **syllable** *x*], if *x* is a $\acute{\sigma}$, then *a* has sonority > level X	∀ [**consonant** *a*], if *a* is a $\acute{\sigma}$, then *a* has a supralar. place specification
C +rel	∀ [**syllable** *x*], if *x* is a $C_{[+rel]}$, then *x* has an onset	∀ [**seg** *a* that is the leftmost onset seg of some **syllable** *x*], if *a* is a $C_{[+rel]}$, then *a* has sonority < level X	∀ [**seg** *a* that is the head of some **syllable** *x*], if *a* is a $C_{[+rel]}$, then *a* has sonority > level X	∀ [**consonant** *a*], if *a* is a $C_{[+rel]}$, then *a* has a supralar. place specification
V:	∀ [**syllable** *x*], if *x* is a V:, then *x* has an onset	∀ [**seg** *a* that is the leftmost onset seg of some **syllable** *x*], if *a* is a V:, then *a* has sonority < level X	∀ [**seg** *a* that is the head of some **syllable** *x*], if *a* is a V:, then *a* has sonority > level X	∀ [**consonant** *a*], if *a* is a V:, then *a* has a supralar. place specification
σ_1	∀ [**syllable** *x*], if *x* is a σ_1, then *x* has an onset	∀ [**seg** *a* that is the leftmost onset seg of some **syllable** *x*], if *x* is a σ_1, then *a* has sonority < level X	∀ [**seg** *a* that is the head of some **syllable** *x*], if *x* is a σ_1, then *a* has sonority > level X	∀ [**consonant** *a*], if *a* is a σ_1, then *a* has a supralar. place specification

The next chart, (23), shows how the above inventory of predicted **M/str** constraints matches the **M/str** constraints that are empirically attested. For each of the four markedness constraints in the top row, the types of elements referred to in the constraint's focus (from (22)) are indicated with the notation *foc. element*. For each of the four strong positions in the left column, the types of focus element with which it is compatible (from (21)) are indicated with the notation *matches*. **M/str** combinations involve a focus mismatch when none of the elements inside **M-foc** match the strong position; these cases are identified in (23) with shaded cells and the notation *focus mismatch*. (I assume that both $C_{[+rel]}$ and V: are compatible with the syllable-sonority constraint subhierarchies *ONSET/X and *PEAK/X, whose foci refer generally to a segment, but V: is not compatible with HAVECPLACE, whose focus refers specifically to a consonant. On the independence of *ONSET/X (*MARGIN/X) and *PEAK/X constraints from the consonant/vowel distinction, see Prince & Smolensky 1993:§8.)

Constraints that involve a focus mismatch can never have empirical effects, as shown in §3.2. However, cells that are not marked with *focus mismatch* in (23) represent constraints that can in principle have observable effects and which should, according to the basic predictions of the **M/str** schema, exist. The chart shows that seven of the predicted non-mismatch constraints are attested, while four are apparently not attested.

(23) Attested positional augmentation constraints

	ONSET *foc. element:* σ	*ONSET/X *foc. element:* seg, σ	*PEAK/X *foc. element:* seg, σ	HAVECPLACE *foc. element:* C
σ́ *matches:* σ	▸Dutch ▸Western Arrernte	▸Pirahã ▸Niuafo'ou	▸Zabiče Slovene ▸Mokshan Mordwin ▸English	***focus mismatch***
$C_{[+rel]}$ *matches:* seg	***focus mismatch***	?	?	▸Chamicuro
V: *matches:* seg	***focus mismatch***	? (→ ***focus mismatch***)	▸Yawelmani Yokuts	***focus mismatch***
σ_1 *matches:* σ	▸Arapaho ▸Guhang Ifugao ▸Hausa ▸Guaraní ▸Tabukang Sangir	▸Campidanian Sardinian (Sestu) ▸Mongolian ▸Kuman ▸Guugu Yimidhirr ▸Pitta-Pitta ▸Mbabaram	***blocked by a filter***	***focus mismatch***

In §3.3.1, I give examples and references for languages in which the attested **M/str** constraints in (23) are active. §3.3.2 addresses the remaining four constraints. I argue that [*ONSET/X]/V: becomes a case of focus mismatch when an independently necessary change is made to the formulation of *ONSET/X. I argue further that [*PEAK/X]/σ_1 is also missing for principled reasons — it is ruled out by a substantively motivated constraint filter. Finally, I show that the remaining two constraints without clear empirical support, [*ONSET/X]/$C_{[+rel]}$ and [*PEAK/X]/$C_{[+rel]}$, could only have effects under certain very limited circumstances, so it is not surprising that no languages meeting the crucial criteria have come to light. Overall, then, the predictions made by the **M/str** schema for these markedness constraints and strong positions are a good match for the attested positional augmentation constraints.

3.3.1 Attested M/str constraints

The predicted **M/str** constraints from (23) for which supporting language examples have been found are ONSET/σ́, ONSET/σ_1, [*PEAK/X]/σ́, [*PEAK/X]/V:, HAVECPLACE/$C_{[+rel]}$, [*ONSET/X]/σ́, and [*ONSET/X]/σ_1. The crucial facts that show the activity of these constraints in each language listed in (23) are described here. (See Smith 2002 for more fully developed analyses.)

The constraint ONSET (8a) demands that every syllable have an onset. In §3.1, the effects of its positional counterpart ONSET/σ́ in Dutch were described: the ranking ONSET/σ́ >> DEP >> ONSET (10a) allows onsetless syllables to surface if unstressed, but a glottal stop is epenthesized into a stressed syllable that would otherwise be onsetless (data and description from Booij 1995). Another language that exemplifies this constraint is Western Arrernte [Aranda] (Strehlow 1942; Davis 1988; Downing 1998; cf. Breen & Pensalfini 1998). In this language, stress moves from its default position if it would otherwise fall on an onsetless syllable. Here, the crucial ranking is ONSET/σ́ >> ALIGN(σ́).

Another positional version of ONSET, ONSET/σ_1, is likewise attested. Languages in which this constraint is active include Arapaho (Salzmann 1956), Guhang Ifugao (Newell 1956, Landman 1999), Hausa (Greenberg 1941), Guaraní (Gregores & Suarez 1967), and Tabukang Sangir (Maryott 1961). In these languages, onsetless syllables are generally tolerated, which motivates the ranking **F*** >> ONSET, where **F*** stands for all relevant faithfulness constraints. However, initial syllables must have onsets, which motivates ONSET/σ_1 >> $\mathbf{F_i}$, where $\mathbf{F_i}$ stands for at least one relevant faithfulness constraint. Thus, if $\mathbf{F_i}$ is DEP, then initial syllables are given onsets through epenthesis (as proposed for Guhang Ifugao by Landman 1999).

Various members of the σ́-specific version of the *PEAK/X subhierarchy are active in a number of languages. In Zabiče Slovene (Rigler 1963; Crosswhite 1999), stressed high vowels are banned and arguably surface as mid vowels, indicating that [*PEAK/HIV]/σ́ dominates IDENT, thus forcing high vowels to change their feature specifications when they occur in stressed syllables. [*PEAK/HIV]/σ́ is active in Mokshan Mordwin as well. This is a language in which stress placement is determined by syllable-peak sonority (Kenstowicz 1994), with stress avoiding high vowels (and schwa), so the relevant ranking is [*PEAK/HIV]/σ́ >> ALIGN(σ́). Different members of the [*PEAK/X]/σ́ subhierarchy are visibly active in English, where syllabic rhotics, laterals, and nasals are allowed in unstressed syllables, but laterals and nasals are banned from nuclear position in stressed syllables. The ranking motivated by this pattern is ... [*PEAK/NAS]/σ́ >> [*PEAK/LAT]/σ́ >> $\mathbf{F_i}$ >> [*PEAK/RHO]/σ́ ... .

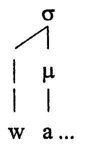
Evidence for the constraint subhierarchy [*PEAK/X]/V: is found in Yawelmani Yokuts (Newman 1944; Kuroda 1967; Kisseberth 1969; Archangeli 1984). The vowel phonology of Yawelmani is complex, famously involving derivational opacity (see Cole & Kisseberth 1996, Archangeli & Suzuki 1997, Sprouse 1997, and McCarthy 1999 for some recent discussion), but the relevant observation for present purposes is that long high vowels are banned — underlyingly high vowels become mid if they are long. This pattern motivates the ranking [*PEAK/HIV]/V: >> IDENT >> *PEAK/HIV. The V:-specific constraint against high vowels as peaks dominates faithfulness to underlying feature specifications, forcing long high vowels to change to mid. Short high vowels, which are not subject to [*PEAK/HIV]/V:, remain unchanged.

Parker (2001) describes the distribution of the glottal consonants [h, ʔ] in Chamicuro. These segments can freely appear in coda position, but they are prohibited from syllable onsets. Parker's analysis motivates the following ranking (recast in accordance with the constraint naming conventions used here): HAVECPLACE/$C_{[+rel]}$ >> IDENT >> HAVECPLACE. As Parker shows, the inclusion of high-ranking HAVECPLACE/$C_{[+rel]}$, which specifically requires onsets (i.e., released consonants) to have a supralaryngeal place specification, is crucial in accounting for Chamicuro glottals.

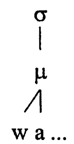
The constraint subhierarchy [*ONSET/X]/$\acute{\sigma}$ is seen at work in Niuafo'ou (Tsukamoto 1988; de Lacy 2000, 2001) and in Pirahã (Everett & Everett 1984; Everett 1988; Davis 1988). In Niuafo'ou, glide onsets can appear in unstressed syllables (in loanwords). However, when a stressed syllable would otherwise surface with a glide onset, the glide vocalizes, even though this creates hiatus. Thus, /jate/ 'yard' surfaces as [i.á.te]. de Lacy (2000, 2001) argues for a ranking that is equivalent (terminological differences aside) to [*ONSET/GLI]/$\acute{\sigma}$ >> ONSET >> *ONSET/GLI. In Pirahã, when overriding factors such as vowel length are held constant, stress is attracted to syllables with low-sonority onsets, specifically, those with voiceless obstruents. This shows that almost the entire [*ONSET/X]/$\acute{\sigma}$ hierarchy — specifically, [*ONS/LOV]/$\acute{\sigma}$ >> [*ONS/MIDV]/$\acute{\sigma}$ >> [*ONS/GLI]/$\acute{\sigma}$ >> [*ONS/RHO]/$\acute{\sigma}$ >> [*ONS/LAT]/$\acute{\sigma}$ >> [*ONS/NAS]/$\acute{\sigma}$ >> [*ONS/VOIOBST]/$\acute{\sigma}$ — crucially dominates ALIGN($\acute{\sigma}$), forcing the stress to fall on a syllable with a voiceless-obstruent onset when one is available. (Since Pirahã has no sonorant consonant phonemes (Everett & Everett 1984), only [*ONS/VOIOBST]/$\acute{\sigma}$ has directly observable effects, but the constraints in the [*ONSET/X](/$\acute{\sigma}$) hierarchy are universally ranked according to the sonority scale.)

The σ_1-specific version of the *ONSET/X subhierarchy is also attested. Where constraints in this subhierarchy are active, initial syllables are forced to have onsets that fall below a certain level of sonority. One such language is the Sestu dialect of Campidanian Sardinian (Bolognesi 1998), in which initial syllables may not begin with either glides or rhotics, motivating the ranking ... [*ONS/GLI]/σ_1>> [*ONS/RHO]/σ_1>> $\mathbf{F_i}$ >> [*ONS/LAT]/σ_1 ..., where $\mathbf{F_i}$ is arguably DEP. Other languages with similar rankings include Mbabaram (Dixon 1991), which also bans rhotic onsets, and Mongolian (Poppe 1970; Ramsey 1987), Kuman (Trefry 1969; Lynch 1983; Blevins 1994), Guugu Yimidhirr (Dixon 1980:162-3), and Pitta-Pitta (Dixon 1980:160-1), which ban lateral as well as rhotic onsets. These last five languages actually allow glide onsets, even though glides are even higher in sonority than the banned rhotics or liquids. However, a proposal is presented in Smith (2002:§4.2, in prep.) that these languages have "nuclear onglides" (24b), pre-peak glides that are syllabified under a mora node, and that the [*ONSET/X]/σ_1 constraints apply specifically to "true onset" glides (24a), direct daughters of the syllable node (assuming syllable structure as in Hayes 1989 or McCarthy & Prince 1986).

(24) (a) True onset



(b) Nuclear onglide



Thus, the formulation of *ONSET/X constraints is to be amended as follows, to distinguish syllable-initial non-peak segments that are true onsets from those that are syllabified under a mora node.

(25) *ONSET/X ∀ [segment *a* that is the leftmost **non-moraic** onset segment of some syllable *x*], *a* has sonority less than level X

where X is a step on the segmental sonority scale

The new formulation in (25) also changes the status of the unattested [*ONSET/X]/V:; this constraint is now another case of focus mismatch. In §3.3.2, I address this and the three other unattested constraints from (23).

3.3.2 The residue

There are four constraints in (23) that remain unexemplified: [*ONSET/X]/V:, [*PEAK/X]/σ_1, [*ONSET/X]/$C_{[+rel]}$, and [*PEAK/X]/$C_{[+rel]}$. In this subsection, I argue that the first two are actually excluded from CON on principled grounds, and that the latter two could only be active in a language with certain very specific properties, suggesting that their lack of attestation is an accidental gap.

As discussed in the previous subsection, the presence of glide onsets in languages that otherwise ban high-sonority onsets motivates a change in the formulation of *ONSET/X constraints so that they evaluate only true structural onsets (25). Given this change, the positional version [*ONSET/X]/V: now has the formulation in (26).

(26) [*ONSET/X]/V: ∀ [segment *a* that is the leftmost **non-moraic** onset segment of some syllable *x*], if *a* is a V:, then *a* has sonority less than level X

where X is a step on the segmental sonority scale

With this independently motivated reformulation of *ONSET/X, the **M/str** constraint [*ONSET/X]/V: becomes another case of focus mismatch. No segment can simultaneously be non-moraic and bimoraic, so once again the antecedent clause of the conditional statement is always false, making the whole conditional always true. Since [*ONSET/X]/V: is satisfied by every candidate under every ranking, it will never be active.

On the other hand, the next unattested **M/str** combination, [*PEAK/X]/σ_1, does not involve a focus mismatch; the focus of *PEAK/X includes reference to a syllable (8c, 18b), so relativization to σ_1 should be possible. The demand that would be made by the relativized subhierarchy — that initial syllables have high-sonority peaks — does not seem particularly implausible. Nevertheless, the fact that no languages have been identified in which [*PEAK/X]/σ_1 is active turns out to be part of a larger pattern.

The strong position σ_1, like another strong position, the root (Rt), has special phonological status for psycholinguistic reasons, whereas $\acute{\sigma}$, $C_{[+rel]}$, and V: are strong positions for phonetic reasons (Beckman 1998; Steriade 1993, 1995, 1997). Beckman (1998:1) proposes that psycholinguistically strong positions are those that "bear the heaviest burden of lexical storage, lexical access and retrieval, and processing." A review of psycholinguistic studies in Smith (2002:§4.3) supports the somewhat more specific claim that psycholinguistically strong positions are important in early-stage word recognition, when a preliminary set of lexical entries is selected for further comparison with the auditory input signal. The initial syllable, which exerts a disproportionately strong influence over which lexical entries are deemed similar enough to the incoming signal to be activated, and the root, which affects how the contents of the lexicon are organized and/or accessed, thus qualify as psycholinguistically strong positions (and are crucially distinguished from $\acute{\sigma}$, which is important in later stages of word recognition and speech processing but not in this early stage).

The fact that σ_1 and Rt are strong positions for psycholinguistic reasons predicts that there should be a particular functional pressure on these positions. Nooteboom (1981) and Taft (1984) have argued that speech processing is more efficient when positions that are especially important in (early-stage) word recognition are given as large a number as possible of phonological contrasts to draw from. So if a language is to have a particular contrast at all, it is advantageous to have it in psycholinguistically strong positions. Thus, there is a functional pressure on σ_1 and Rt to resist neutralizing the kinds of phonological contrasts that are used in determining "similarity to the incoming signal" for the purposes of activating a preliminary set of lexical entries.[7] However, since segmental contrasts are more influential in early-stage word recognition than prosodic contrasts such as stress and possibly tone (Cutler 1986; Cutler & van Donselaar 2001; Cutler & Chen 1997; Walsh Dickey in prep.; cf. Cutler & Otake 1999), the anti-neutralization pressure is particularly acute for segmental contrasts.

A constraint filter that formalizes this functional pressure, the Segmental Contrast Condition, is proposed in Smith (2002:§2.4.1, §4.3). The Segmental Contrast Condition examines any **M/str** constraint relativized to a psycholinguistically strong position to see whether satisfaction of the constraint would entail the neutralization of a segmental contrast.

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[7]See Beckman (1998), Casali (1996) on the consequences of this functional pressure for positional *faithfulness* constraints.

If so, then the filter checks to see whether satisfaction of the constraint would highlight the left edge of the initial syllable (because this would facilitate the location of word boundaries in running speech, a difficult task in processing; see, e.g., Taft 1984, Cutler & Norris 1988, and Norris, McQueen, & Cutler 1995). **M/str** constraints on psycholinguistically strong positions that neutralize segmental contrasts without helping to demarcate the left edge of σ_1 are blocked from inclusion in CON.

The Segmental Contrast Condition thus predicts that ONSET/σ_1 and [*ONSET/X]/σ_1 are legitimate **M/str** combinations, because even though they refer to segmental properties in a psycholinguistically strong position, they do aid in left-edge demarcation. As seen in §3.3.1, these constraints are attested. On the other hand, the Segmental Contrast Condition blocks [*PEAK/X]/σ_1 (as well as many constraints relativized to the position Rt). Thus, the lack of attestation of any members of the [*PEAK/X]/σ_1 subhierarchy is a meaningful gap, with its basis in the importance of psycholinguistically strong positions for early-stage word recognition.

The two remaining unattested **M/str** combinations, [*ONSET/X]/$C_{[+rel]}$ and [*PEAK/X]/$C_{[+rel]}$, are not focus-mismatch constraints, like [*ONSET/X]/V:, and they are not plausibly excluded by a constraint filter, as with [*PEAK/X]/σ_1. They are predicted to be legitimate constraints. However, it turns out that each of these cases could have observable effects only under very specific circumstances, so the lack of actual language examples is understandable.

[*ONSET/X]/$C_{[+rel]}$ is a constraint subhierarchy whose members demand that the leftmost non-moraic segment of a syllable be low in sonority if it is an instance of the strong position $C_{[+rel]}$. But the leftmost non-moraic segment of a syllable will nearly always be a released consonant anyway. So in most languages, [*ONSET/X]/$C_{[+rel]}$ will assign exactly the same violation marks as general *ONSET/X. Only in a language where the leftmost non-moraic segment is not always released (one such case might be an obstruent-obstruent onset cluster, as argued for example by Steriade 1997) could the effects of [*ONSET/X]/$C_{[+rel]}$ and general *ONSET/X be distinguished. Since languages with a contrast between released and unreleased onset consonants are fairly rare in the first place, I have not found a language with such a contrast that actually does distinguish between these two constraint families.

The [*PEAK/X]/$C_{[+rel]}$ subhierarchy demands that if a syllable peak consists of a released consonant, that peak must be high in sonority. The effects of [*PEAK/X]/$C_{[+rel]}$ could be distinguished from those of general *PEAK/X only in a language that makes a distinction between consonantal syllable peaks that are released and consonantal syllable peaks that are not released. I have not yet found a language that makes this distinction, let alone one in which the two kinds of consonantal peaks have different sonority requirements.

In summary, the four **M/str** combinations in (23) that remain unattested include one that is properly reclassified as another case of focus mismatch; one that is excluded by a substantively based constraint filter; and two whose absence is plausibly an accidental gap because they would potentially be active in only very limited circumstances. Therefore, the predictions made when the **M/str** schema (14) is applied to the four strong positions in (7) and the four constraints in (8) are a good match for the empirically attested **M/str** constraints.

3.4 Concluding remarks on the M/str schema

This section has presented an initial exploration of a schema-based approach to positional augmentation constraints. Attention was restricted to a subset of augmentation constraints and a subset of strong positions. Under these conditions, the **M/str** schema presented in (14) gave good results. Obviously, further exploration of the predictions of this schema, when more constraints and positions are considered, is necessary. Preliminary results are promising, however. For example, although the root is prevented by the Segmental Contrast Condition (§3.3.2) from having positional versions of augmentation constraints on segmental properties, there is a Rt-specific version of a constraint calling for stress, a prosodic property. Languages that provide evidence for this HAVESTRESS/Rt constraint include Tuyuca (Barnes 1996; Smith 1998) and Tahltan (Alderete & Bob 2001). Another position to consider is the foot head or secondary-stress syllable, which can be classified as a strong position on the basis of its ability to resist vowel neutralization. An example of augmentation in this position is found in Sukuma, where foot-heads attract tones (Kang 1997). Thus, the kinds of augmentation constraints that are attested outside the set explored in §3.3 also appear to involve combinations of constraints and positions that are predicted by the **M/str** schema to be compatible.

4. Future directions

This paper is one step toward the goal of developing a complete schema-based treatment of positional constraints. The next step in this endeavor will be a schema-based approach to another major class of positional constraints: those responsible for positional neutralization. Here, I make a few preliminary remarks on an interesting difference in the role of the position in positional neutralization as opposed to positional augmentation.

The term *positional neutralization* is used to refer to cases in which a phonological contrast is licensed in strong positions but neutralized in weak positions (Trubetzkoy 1939; Steriade 1993, 1995); in a sense, positional neutralization is the inverse of positional augmentation. A familiar example of this kind of pattern is a language, such as Russian, that permits contrastive mid vowels in stressed syllables but not in unstressed syllables. Several different theoretical approaches have been taken to positional neutralization: positional faithfulness, which uses faithfulness constraints relativized to strong positions in order to protect contrasts there (Beckman 1998; Casali 1996); positional markedness, which uses markedness constraints relativized to weak positions in order to enforce neutralization there (e.g., Steriade 1997, Kager 1999); and COINCIDE constraints, which require particular contrasts to fall inside strong positions if they are to appear at all (Zoll 1996, 1997).

If the positional faithfulness approach is taken, the constraints involved in positional neutralization effects have the formal structure **F/str** — they are independently attested faithfulness constraints that have been relativized to members of the set of strong positions. Obviously, there is a close formal similarity between such constraints and positional augmentation (**M/str**) constraints. Therefore, it would be worth considering the replacement of the **M/str** schema with an even more general schema, **C/str**, that is able to relativize any augmentation constraint *or* any faithfulness constraint to a member of the set of strong positions.

However, an examination of the kinds of positional faithfulness constraints that have been proposed shows that the role of the strong position in the formulation of an **F/str** constraint is not the same as that in an **M/str** constraint. For example, the **F/str** constraints discussed in Beckman (1998) include the following. (These constraints have been rephrased to match the **M/str** schema as closely as possible; explicit formalization of correspondence relations has also been suppressed for clarity).

(27) Some examples of **F/str** constraints

(a) IDENT[voice]/$C_{[+rel]}$ ∀ [segment *a*], <u>if *a* is a $C_{[+rel]}$</u>, then *a* and its correspondent have the same value for [voice]
(Beckman 1998:23)

(b) IDENT[nasal]/σ́ ∀ [segment *a*], <u>if *a* is contained in a σ́</u>, then *a* and its correspondent have the same value for [nasal]
(Beckman 1998:131)

The relationship in (27a) between the strong position $C_{[+rel]}$ and the focus of the general constraint IDENT[voice], which refers to a segment, is similar to the position-focus relationships seen in §3 for positional augmentation constraints: the two elements related by the positional constraint are of the same type. However, the strong position σ́ in (27b) is *not the same size* as the element in the constraint focus, which is again a segment. Thus, the role of the position in an **F/str** constraint is to delimit a *domain within which* the constraint must be satisfied. This is formally quite different from the role of the position in an **M/str** constraint, which is to identify an *object with respect to which* a constraint must hold.

If **M/str** constraints were like **F/str** constraints in this regard, then a constraint such as HAVECPLACE/σ́, which would ban glottal consonants from any position within a stressed syllable, would no longer be a focus mismatch. So far, however, this and similar constraints seem not to be attested. Thus, it appears that **M/str** constraints and **F/str** constraints do not share a unified schema, because the role of the strong position in the two types of constraints is different. This difference may turn out to be related to the functional basis of **F/str** and **M/str** constraints respectively: Steriade (1993, 1995, 1997) argues that in many cases, the resistance of strong positions to positional neutralization processes has its basis in the strong perceptual cues that are found in the various strong positions. Smith (2000, 2002) argues that strong positions undergo positional augmentation (and do not specifically undergo other kinds of phonological processes) because augmenting a strong position with a perceptually salient property is a case of "making the strong stronger". Thus, there may be a principled reason for why a strong position serves as the domain for contrast licensing, but as the object of processes that increase perceptual salience.

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