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Phonological constraints are not directly phonetic

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1. Introduction[1]

The nature of the interaction between phonetics and phonology is a major area of research in linguistic theory. This paper addresses one aspect of that general line of inquiry: Do phonological constraints directly encode phonetic information? The answer developed here is that they do not. Instead, phonological constraints are expressed more abstractly, in terms of formal phonological categories.[2]

The argument is made on the basis of constraints that have the same functional basis, but distinct formal properties: ONSET and *ONSET/X (§2). If phonetic factors are projected directly onto phonological constraints, then the shared functional basis of these constraints should entail that they cannot be formally distinct. Specifically, the direct-phonetics model predicts that ONSET is actually "*ONSET/Ø," a constraint against null onsets that is the highest ranked member of the *ONSET/X family (§3). However, there is phonological evidence against equating ONSET with *ONSET/Ø. First, ONSET can be freely ranked with respect to *ONSET/X constraints, although the *ONSET/X constraints are themselves in a universally fixed relationship derived from the sonority scale (§4). Second, the behavior of glide-initial syllables in languages that avoid high-sonority onsets while also banning onsetless syllables shows that ONSET and *ONSET/X evaluate different phonological structures (§5). Each of these factors independently demonstrates that ONSET and *ONSET/X are formally distinct. Consequently, even phonetically grounded constraints like these do not encode phonetic information directly.

2. Onset constraints and their functional basis

Two types of constraints regulating syllable onsets are well established in the literature: ONSET and the *ONSET/X (*MARGIN/X) constraint family.

ONSET is a constraint requiring syllables to have onsets (Prince & Smolensky 1993, based on much previous work in syllable phonology).

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[1] I am indebted to Claire Bowern, Elliott Moreton, and members of the CLS 41 audience for helpful comments and discussion. Preliminary discussion of some of the ideas developed here can be found in Smith (2002).

[2] This result does not require the phonological grammar to be devoid of all phonetic influence. See §6 for additional discussion.

(1) ONSET Syllables have onsets

The *ONSET/X family is a set of constraints, derived from the segmental sonority scale, that assesses violations depending on the sonority of a syllable onset. The higher an onset's sonority, the less desirable, so the collective effect of the *ONSET/X constraints is to demand low-sonority onsets. *ONSET/X is based on the *MARGIN/X family proposed by Prince & Smolensky (1993), but differs in specifically excluding codas. This revision is made because the sonority restrictions on onsets and codas are different; while onsets are preferentially low in sonority, codas are preferentially high in sonority (Zec 1988; Clements 1990).

As originally conceived (Prince & Smolensky 1993: §8.1), scale-based markedness constraints like *ONSET/X refer to one sonority level per constraint (2), and have a universally fixed ranking determined by the relevant phonetic scale; in this case, it is the sonority scale (3).

(2) *ONSET/X Onsets do not have sonority level X

(3) Universally fixed ranking determined by sonority scale

*ONS/LOWV >> *ONS/MIDV >> *ONS/GLIDE >> *ONS/RHOTIC >> *ONS/LATERAL >> *ONS/NASAL >> *ONS/OBSTRUENT

More recently, it has been argued that scale-based markedness constraints should be formalized in terms of a stringency hierarchy (Prince 1997, de Lacy 2004). In this approach, the fixed ranking of (3) is replaced by a subset structure within the constraint family, as seen in (4). Stringency-hierarchy constraints are freely rankable, but each includes the "worst" category on the markedness scale, and each is progressively more stringent — banning a larger subset of the scale. For onset sonority constraints, this means that the category *lowV* is included in every *ONSET/{X,Y,...} constraint, and any constraint banning onsets of a given sonority level also bans all higher-sonority onsets.

(4) Stringency-hierarchy version of onset sonority constraints

a. *ONS/{LOWV}
b. *ONS/{LOWV, MIDV}
c. *ONS/{LOWV, MIDV, GLI}
d. *ONS/{LOWV, MIDV, GLI, RHO}
e. *ONS/{LOWV, MIDV, GLI, RHO, LAT}
f. *ONS/{LOWV, MIDV, GLI, RHO, LAT, NAS}
g. *ONS/{LOWV, MIDV, GLI, RHO, LAT, NAS, OBST}

The difference between these two formal implementations of scale-based constraints does not affect the arguments about onset constraints developed below, because in both systems, a high-ranking constraint against onsets of sonority level X implies that some constraint against all higher-sonority onsets is ranked as high or higher. For example, if the fixed-ranking constraint *ONSET/NAS in (3) is ranked higher than some constraint C, then all *ONSET/X constraints for sonority levels higher than *nasal* are ranked above C as well. Analogously, in the stringency approach, the least restrictive anti-nasal-onset constraint is the one in (4f), which also penalizes onsets of all sonority levels higher than *nasal*. For expositional simplicity, the traditional formalization in terms of a constraint family with a fixed ranking (3) is adopted in this paper, but nothing crucial depends on this choice.

Is there a functional motivation behind onset-related constraints? Several authors have argued that there is, because there is a perceptual advantage to having the speech stream consist of a modulation between low and high sonority (e.g., Ohala & Kawasaki-Fukumori 1997; Smith 2002; Gordon 2003; Wright 2004). Auditory-nerve response decays over time if a stimulus is held constant, an effect known as neural adaptation. Since different nerve fibers respond to different frequencies, the effect of adaptation is lessened when spectrally different segments alternate. In essence, a change in the spectrum of the signal causes unadapted fibers to begin responding and allows previously adapted fibers a chance to recover. (On the high perceptual salience of rapid spectral changes, see also Ohala 1992; Silverman 1995; Warner 1998.)

Thus, the functional motivation behind ONSET is the perceptual advantage gained by interspersing consonants between syllable peaks. Moreover, it follows from this that the *best* onset is a low-sonority onset, so the same functional motivation also underlies *ONSET/X.

3. Predictions under a direct-phonetics model

Models of OT phonology in which there is no formal distinction between phonology and phonetics (e.g., Flemming 1995, 2001, 2004; Jun 1995, 2004; Boersma 1998, 2003; Kirchner 1998, 2000, 2004; Zhang 2001, 2004) are referred to here as *direct-phonetics* models. Constraints in a direct-phonetics model are often formalized as constraint families whose members represent values along a continuum of some phonetic property, similar to the *ONSET/X family defined above, although generally based on a much more finely grained phonetic scale. A representative example of a direct-phonetics constraint family is Zhang's (2004) *DUR(τ_i), where τ_i ranges over duration values, and a larger value for τ_i corresponds to a higher ranking in the constraint family — i.e., longer segment durations are more strongly dispreferred. *DUR(τ_i) is formally defined as follows.

(5) The direct-phonetics constraint *DUR(τ_i) (Zhang 2004: 176-7)

a. *DUR(τ_i): for all segments in the rhyme, their cumulative duration in excess of the minimum duration in the prosodic environment in question cannot be τ_i or more.

b. If $\tau_i > \tau_j$, then *DUR(τ_i) >> *DUR(τ_j).

Adopting a direct approach to the phonology-phonetics interface arguably leads to the following implication: If constraints directly encode phonetics, then constraints with a single phonetic motivation cannot be formally distinct. Where onset constraints are concerned, this predicts that ONSET and *ONSET/X should be part of the same constraint family. Concretely, ONSET would have to be redefined as a *ONSET/X constraint on null onsets, *ONSET/Ø.

(6) *ONSET/Ø Onsets do not have sonority level Ø

Furthermore, given that the functional motivation for *ONSET/X constraints is to intersperse syllable nuclei with low-sonority onsets, this means that having no onset at all would be worse than having the most sonorous onset. Thus, *ONSET/Ø would be the highest-ranking *ONSET/X constraint. (Or, in the stringency approach to markedness scales, null onsets would be at the marked end of the onset markedness scale, so that a constraint banning non-null onsets at any sonority level would ban null onsets as well.)

The next two sections demonstrate that neither of these predictions is empirically supported. Null onsets do not occupy a fixed position in an onset-sonority markedness scale, because languages vary in how they rate null onsets in comparison to onsets of other sonority types (§4). In addition, ONSET cannot be redefined as *ONSET/Ø, because the two constraints evaluate distinct phonological structures (§5).

4. Free ranking shows that ONSET is not *ONSET/Ø

This section considers two languages in which syllables with null onsets are preferred over syllables with glide onsets, or syllables with rhotic and glide onsets, respectively. These cases show that the ranking of ONSET is not fixed at the top of the *ONSET/X hierarchy, and in fact, that ONSET is not ranked in *any* fixed position with respect to *ONSET/X.

The first example is Niuafo’ou, in which a null onset is preferred to a glide onset in stressed syllables (de Lacy 2001; data from Tsukamoto 1988).

(7) Niuafo’ou null versus glide onsets

a. Glide onsets avoided in stressed syllables (*[jV, wV] if V stressed)

[i.á.te] (*[já.te])	‘yard’
[u.í.pi̥] (*[wí.pi̥])	‘whip’
[u.á.fu̥] (*[wá.fu̥])	‘wharf’

b. Glide onsets in unstressed syllables (*[i.V, u.V] if V unstressed)

[ju.ní.ti̥]	‘unit’
[wa.í.ne]	‘wine’
[wa.é.a]	‘wire’
[we.lì.ŋa.tó.ni̥]	‘Wellington’

This pattern can be analyzed as follows (based on the account in de Lacy 2001). First, the fact that glide onsets are avoided can be attributed to *ONSET/GLI, the *ONSET/X constraint against glide onsets. As for why this effect is enforced only in stressed syllables, this shows that it is actually a positional counterpart of *ONSET/GLI that is active here; namely, [*ONSET/GLI]/σ́. In general, markedness constraints that call for an increase in perceptual salience — as ONSET and *ONSET/X do by virtue of the sonority modulation that they enforce (§2) — can be relativized to prominent positions, including stressed syllables (and initial syllables, as seen in the discussion of Sestu Campidanian Sardinian below).[3]

The crucial ranking that accounts for the avoidance of glide onsets in stressed syllables is { [*ONSET/GLI]/σ́ >> ONSET/σ́, ONSET }, exemplified in (8). Here and in (9), /<i>/ is used to represent any input high front vocoid; since FAITH(μ) is ranked below all the onset markedness constraints shown in (8) and (9), it does not matter whether it is moraic /i/ or non-moraic /j/ that appears in the input.

(8) Avoidance of glide onsets in stressed syllables

/<i>ate/ ‘yard’	[*ONS/GLI]/σ́	ONS/σ́	ONS	*ONS/GLI
i. já.te	*!			*
▶ ii. i.á.te		*	**	

[3] See Smith (2002) for extended discussion of this class of positional markedness constraints, called *positional augmentation constraints* because they augment perceptual salience in prominent positions.

The fact that glide onsets are preferred to null onsets outside the stressed syllable, where [*ONSET/GLI]/σ́ is not relevant, motivates the ranking ONSET >> *ONSET/GLI.

(9) Glide onsets in other syllables

/<i>uniti/ ‘unit’	[*ONS/GLI]/σ́	ONS/σ́	ONS	*ONS/GLI
i. i.u.ní.ti̥			*!*	
▶ ii. ju.ní.ti̥				*

A second example demonstrating the independence of ONSET and *ONSET/X is the Sestu dialect of Campidanian Sardinian (Bolognesi 1998), in which null onsets are preferred to rhotic or glide onsets in initial syllables.

(10) Sestu Campidanian null onsets versus rhotic and glide onsets

a. [arːuβiu] ‘red’ < Lat. *rubeum*
[arːɔða] ‘wheel’ < Lat. *rota*
[arːaðiu] ‘radio’ < Ital. *radio*

b. [ajaju] ‘grandfather’
[ajaja] ‘grandmother’
vs. related dialects: [jaju], [jaja]

The avoidance of rhotic and glide onsets can be attributed to the effects of *ONSET/RHO and *ONSET/GLI respectively. Once again, the fact that this pattern is found only in initial syllables shows that it is a positional version of the *ONSET/X family, [*ONSET/X]/σ1 in this case, that is active. For present purposes, the crucial part of the ranking shown in (11) and (12) — making candidates with onsetless syllables better than candidates with glide or rhotic onsets — is [*ONSET/GLI]/σ1 >> [*ONSET/RHO]/σ1 >> ONSET/σ1.

(11) Glide onsets avoided

/jaju/ ‘grandfather’	[*ONS/GLI] /σ1	[*ONS/RHO] /σ1	DEP	ONSET/σ1
i. jaju	*!			
▶ ii. ajaju			*	*

(12) Rhotic onsets avoided

/rɔða/ 'wheel'	[*ONS/GLI] /σ1	[*ONS/RHO] /σ1	DEP	ONSET/σ1
i. rɔða		*!		
▶ ii. arːɔða			*	*

When the crucial onset-related rankings in these two languages are compared, it is clear that ONSET has no fixed universal ranking with respect to the *ONSET/X family, let alone one where it stands at the top of that family.

(13) Summary: ONSET ranking not fixed at the top of the *ONSET/X hierarchy

a. **Niuafo'ou**

*ONS LOV /σ́	»	*ONS MIDV /σ́	»	*ONS GLI /σ́	»	ONSET /σ́	,	*other* [*ONS/X]/σ́ *constraints*

b. **Sestu**

*ONS LOV /σ1	»	*ONS MIDV /σ1	»	*ONS GLI /σ1	»	*ONS RHO /σ1	»	ONSET /σ1	,	*other* [*ONS/X]/σ1 *constraints*

The stressed-syllable and initial-syllable restrictions on these patterns do not affect the main argument about how ONSET and *ONSET/X constraints are ranked with respect to one another, since in both cases the ONSET and *ONSET/X constraints in question are relativized to the *same* position (σ́ or σ1).

5. Sensitivity to different phonological structures shows that ONSET is not *ONSET/Ø

The second argument that ONSET and *ONSET/X are formally distinct constraints comes from two Australian languages that ban liquids and vowels, but tolerate glides, in word-initial position: Guugu Yimidhirr (Cape York Peninsula; Haviland 1979; Dixon 1980) and Pitta-Pitta (southwestern Queensland; Blake & Breen 1971; Blake 1979; Dixon 1980). The existence of glide-initial words in languages where both high-sonority onsets (liquids) and null onsets are banned in initial position demonstrates that ONSET and *ONSET/X are defined over different phonological structures.

5.1 Rimal onglides are not subject to *ONSET/X

The consonant inventories of Guugu Yimidhirr and Pitta-Pitta are shown in (14) and (15) respectively; consonants that are impossible in word-initial position are shaded in gray. As these charts indicate, both languages prohibit word-initial liquids (laterals as well as rhotics), but do allow word-initial glides.

Guugu Yimidhirr, unlike many Australian languages, has no general ban on initial anterior apicals; initial [d,n] are allowed. It is specifically the liquids that are impossible in initial position.

(14) Guugu Yimidhirr (chart based on Dixon 1980:162-3)

Apical		Laminal		Peripheral	
d		d̪	ɟ	g	b
n		n̪	ɲ	ŋ	m
l					
r	ɻ	j		w	

Pitta-Pitta does have the typical Australian prohibition against anterior apicals in word-initial position (dashed box in (15)), but this language also has a general ban on all initial liquids, regardless of place of articulation.[4]

(15) Pitta-Pitta (chart based on Dixon 1980:160-1)

Apical		Laminal		Peripheral	
d	ɖ	d̪	ɟ	g	b
n	ɳ	n̪	ɲ	ŋ	m
l	ɭ	l̪	ʎ		
ɾ, r	ɻ	j		w	

A ban on liquids in word-initial position motivates the following ranking for these two languages.

(16) [*ONS/RHO]/σ1 >> [*ONS/LAT]/σ1 >> FAITH

But *ONSET/X constraints are themselves in a fixed ranking determined by the sonority scale, so the ranking in (16) entails the ranking in (17). In other words, a

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[4] Blake & Breen (1971: 29) report having elicited only six liquid-initial words for Pitta-Piita, of which four are language or dialect names. The other two words begin with [ɭ] and [ɻ].

ban on word-initial liquids predicts that glides should be banned there as well, since [*ONSET/GLI]/σ1 dominates [*ONSET/RHO]/σ1 and [*ONSET/LAT]/σ1 universally. (Likewise, in the stringency approach, any constraint banning rhotic and/or lateral onsets also bans glide onsets.)

(17) [*ONS/GLI]/σ1 >> [*ONS/RHO]/σ1 >> [*ONS/LAT]/σ1 >> FAITH

Counter to this prediction, however, Guugu Yimidhirr and Pitta-Pitta do allow word-initial glides.

(18) Word-initial glides

a. Guugu Yimidhirr (Haviland 1979: 170-171)

[jaba]	'older brother'
[jid̪ar]	'to put'
[jugu]	'tree, wood, fire'
[waŋi]	'boomerang'
[waadal]	'to say, tell'
[wurbal]	'fog'

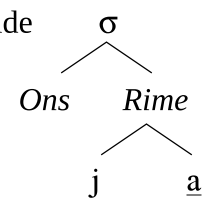
b. Pitta-Pitta (Blake & Breen 1971: 31-2, 40)

[janga]	'to tell'
[jiɭga]	'throat'
[juɖa]	'to swim'
[walga]	'child'
[wima]	'big'
[wunandi]	'gidgea'

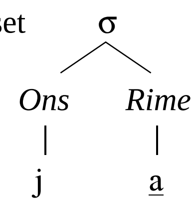
Comparing these two languages with Sestu Campidanian Sardinian, discussed in the previous section, shows that there are two subtypes of languages that ban high-sonority onsets, such as rhotics, or rhotics and laterals. One subtype also bans glides, as in Sestu, and the other subtype does not, as in Guugu Yimidhirr and Pitta-Pitta (as well as other Campidanian Sardinian dialects described by Bolognesi (1998)). These two patterns of glide behavior can be understood in connection with the fact that there are two possible syllabic positions for glides that precede the syllable peak (Kaye & Lowenstamm 1984; Davis & Hammond 1995; Harris & Kaisse 1999): onglides that are dominated by the syllable rime (19a) and true onset glides that are not (19b).

(19) Two possible positions for syllable-initial glides
(syllable heads are underlined)

a. Rimal onglide



b. True onset



Specifically, it is proposed (Smith 2002, 2003) that *ONSET/X constraints are defined so as to assess the sonority only of true onset segments (20).

(20) *ONSET/X Onsets do not have sonority level X

Formally: For every segment *a* that is the leftmost **onset** segment of some syllable σ, |*a*| < X

where |*a*| is the sonority of segment *a*
X is a particular step on the sonority scale

Given this formalization of *ONSET/X constraints, syllable-initial glides in languages that otherwise ban high-sonority onsets are tolerated because, as rimal onglides, they avoid violating *ONSET/GLIDE despite its high ranking.[5] (See Flack, to appear, for arguments that bans on initial liquids in Australian languages are due to sonority rather than to context-perceptibility or Licensing-by-Cue effects. For additional evidence that "onset" glides in languages with onset-sonority restrictions are phonologically rimal onglides, see Smith 2003.)

5.2 Rimal onglides satisfy ONSET

The second important characteristic of Guugu Yimidhirr and Pitta-Pitta is that they avoid onsetless initial syllables. Haviland (1979: 38) explicitly reports that Guugu Yimidhirr requires all words to be consonant-initial, except for two [a(:)]-initial interjections. Pitta-Pitta also avoids onsetless words in general, although

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[5] There are other potential explanations for why a language might allow glide onsets while avoiding liquid onsets. For example, one might propose that glides in syllable-initial position do violate *ONSET/GLI after all, but this constraint violation is simply compelled by a vowel-related faithfulness constraint such as IDENT[-cons] (Smith 1997) or IDENT[VPlace] (Flack, to appear) that protects glides, though not liquids, from some phonological repair strategy. Crucially, however, this kind of explanation does not extend to all cases of glide exceptionality. For example, in Iglesias Campidanian Sardinian, closely related to the Sestu dialect discussed above, initial rhotics are avoided but initial glides are not (Bolognesi 1998; Smith 2003). And in this dialect, as in Sestu, the repair for a high-sonority onset is not feature change but prothesis. So the intrinsic featural differences between vocoid glides and consonantal rhotics cannot account for all cases in which glides are exceptions to sonority-based onset restrictions, even if this is the explanation for certain cases.

there is some disagreement among sources as to the precise characterization of the pattern. Sources agree that [a] in the word-initial syllable is always preceded by a consonant (Blake & Breen 1971: 25; Blake 1979: 187), which may be a glide, as seen in (18b). But the status of word-initial [i] and [u] seems to be under dispute. Blake & Breen (1971: 32) describe Pitta-Pitta as showing variation between [ji] and [i] and between [wu] and [u] in word-initial position, which suggests at least that high vowels and homorganic glide-vowel sequences are not phonologically contrastive. However, in a later publication, one of these authors describes Pitta-Pitta quite differently (Blake 1979: 187), stating that "...glides occur initially, but not before their vocalic counterparts. We do not hear [yi] and [wu] in word-initial positions. *i* and *u* occur initially but not *a*." On the other hand, Dixon (1980: 160) includes Pitta-Pitta in a discussion of languages requiring a word-initial consonant. So it may be that Blake (1979) is emphasizing a lack of *contrast* between [ji]/[i] and [wu]/[u], because the glides are predictable (if phonetically variable) in that context, and is simply choosing to phonemicize these structures as /i/ /u/. Or, it may be that word-initial [i] [u] really are the surface forms that appear in Pitta-Pitta, perhaps because an OCP constraint against homorganic glide-vowel sequences dominates ONSET, leading to avoidance of homorganic glides. But what is important for the discussion at hand are these two points: First, we know that ONSET is high-ranking in Pitta-Pitta, because when homorganic glides are not at stake — when the initial syllable contains [a] — then onsetless syllables are not tolerated. Second, even if Pitta-Pitta turns out to be too problematic as an example, the argument in the remainder of this section can be made on the basis of the clear case of mandatory onsets in Guugu Yimidhirr.

The existence of a ban on initial onsetless syllables in Guugu Yimidhirr and (apparently) Pitta-Pitta is important because it shows that glide-initial syllables — which are permissible — must not violate ONSET. That is, rimal onglides (19a) satisfy ONSET just as well as true onset glides (19b) would. This means that ONSET must be defined in such a way as to be satisfied by any segment that precedes the syllable peak, regardless of the syllable position of that segment (21).

(21) ONSET Syllables must have onsets

Formally: For all syllables σ, $a \neq b$

where a is the leftmost segment dominated by σ
b is the head segment of σ (Smith 2002)

To summarize the discussion in §5, we find that rimal onglides are *not* relevant for *ONSET/GLIDE. Otherwise, initial glides would be banned along with liquids, since glide onsets are even higher in sonority than liquids are. On the other hand, rimal onglides *are* relevant for ONSET. If this were not the case, then glide-initial syllables would be banned along with vowel-initial syllables in word-initial position. This means that ONSET and *ONSET/X have different formal definitions, referring to different aspects of syllable structure. As a consequence, it cannot be the case that ONSET is equivalent to *ONSET/Ø.

6. Conclusions

Adopting a direct-phonetics model entails that ONSET should be formalized as the highest-ranked member of the *ONSET/X family, "*ONSET/Ø". However, the attempt to reformulate ONSET as *ONSET/Ø fails on two grounds: The ranking of ONSET is not fixed at the top of the *ONSET/X family, and ONSET and *ONSET/X evaluate distinct phonological structures. From this, we conclude that ONSET and *ONSET/X are formally distinct, and thus that the mapping from phonetics to constraints is indirect.

It is important to note, however, that a direct-phonetics model is not the only way to instantiate a phonetically motivated phonological grammar. The claim that phonological constraints are distinct from the phonetic factors on which they may be based is compatible with proposals in which phonological constraints are formal, symbolic objects, but the constraint set is nevertheless subject to functionally grounded restrictions. For example, it may be the case that phonetic information is used to rank, or motivate for inclusion in the universal constraint set, constraints that are stated over formal phonological categories (Archangeli & Pulleyblank 1994; Hayes 1999; Steriade 2001; Smith 2002). For additional evidence that the effect of phonetics on phonology is indirect or symbolically mediated, see, among others, Gerfen (2001); Gordon (2004); Flack (to appear).

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