CHAPTER 1

PROSODY-SEGMENTAL INTERACTIONS: THE TYPOLOGY

1.0 Introduction

In the previous introductory chapter I discussed some of the problems facing OT as a radically output-oriented theory of phonology. This chapter turns to a typological survey of a phenomenon that presents a too-many-solutions problem for OT: the interaction of the prosodic and segmental components of phonology. This set of issues, not previously given a systematic treatment in OT theorizing, will prove especially insidious for the current setup of the theory, because it defies any attempts to attack it using the techniques developed for other too-many-solutions problems. In this chapter I will argue that the problem of prosody-segmental interactions diagnoses a general flaw of standard OT, because the generalization behind the typological facts is best formulated not in terms of output structures, but in terms of input-output mappings. In Chapter 2 I will show that none of the available proposals intended to deal with too-many-solutions problems is able to handle prosody-segmental interactions in a satisfactory way. I will turn to my proposal on how such generalizations can be allowed their place in the theory of phonology in Chapter 3.

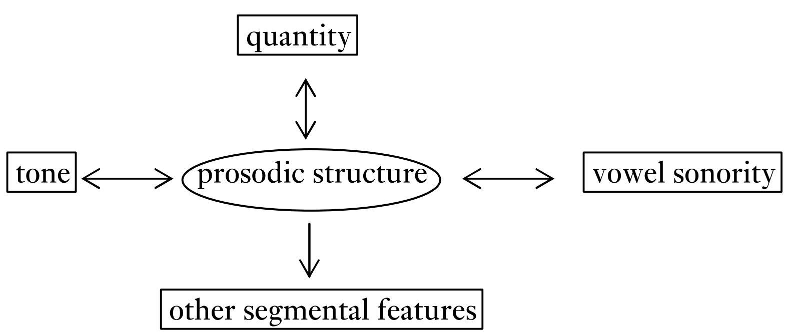
1.1 The facts

In this section I will survey the typology of the interaction between prosodic structure and segments. The crosslinguistic data will show that stress assignment rules can refer to only a very restricted set of properties in a representation. Phonological factors that may figure in stress assignment rules are limited to three general categories: quantity (vowel length and syllable weight), tone, and vowel sonority.[1] The claim I will defend in this dissertation is that all phonological stress systems can be described with reference solely to these three categories.

The reverse direction of interaction between prosody and segments is much less constrained. Prosodic structure can influence the realization of a host of segmental properties. Quantity, tone, and vowel sonority are among them, but stress can also condition the distribution of many other segmental features. In many languages, fortition and lenition of consonants is sensitive to their prosodic context. Metrical structure frequently affects the distribution of laryngeal features. Prosodic constituents can serve as domains of segmental processes such as harmony.

Apart from quantity, tone, and vowel sonority, none of the varied effects of stress on segments are observed as conditioning factors in stress assignment. Thus, the key typological claim in this chapter is that stress can influence more properties than it can be sensitive to: prosody-segmental interactions are asymmetrical. This asymmetry is given schematically below.

(1)



After surveying the typology, I will show that this asymmetry in interaction poses a general problem for OT as an output-oriented theory. I will conclude this chapter by discussing potential counterexamples to the typological generalization – cases where stress assignment appears to be sensitive to properties other that quantity, tone, and

[1] Of course, morphology can also play a role in stress assignment. I am concerned here with those factors of stress assignment which are independent of the morphological structure of words.

vowel sonority – arguing that alternative analyses that preserve the typological claim are available.

1.1.1 Bidirectional interactions

In this section I survey the three factors with which stress interacts bidirectionally: quantity, tone, and vowel sonority. In each of these cases, there are languages where stress assignment requires access to information about these categories, and there are other languages where these categories are distributed in a way that is sensitive to the location of stress (which, in turn, is assigned according to other principles).

1.1.1.1 Quantity

Metrical structure has an intimate relationship with syllable QUANTITY. The prominence of heavier syllables plays a role in stress systems in two complementary ways. On the one hand, there are languages where stress gravitates toward heavier syllables. On the other hand, there are languages where stress is assigned based on criteria other than weight, but the location of stress influences the weight distribution in the resulting form. Many languages combine features of both weight-driven stress and stress-driven weight.

Interactions of stress and weight are extremely common; perhaps a majority of the world's languages have some relationship between the two domains. Such interactions have been extensively documented and analyzed in the major theoretical works on metrical stress (Liberman 1975, Liberman and Prince 1977, Prince 1983, Halle and Vergnaud 1987, Halle and Idsardi 1995, Hayes 1981, Hayes 1995, Gordon 1999, among many others).

Let me give a few examples of the familiar pattern. The Classical Latin stress rule is the prototypical case of weight-driven stress. The main stress falls on the penultimate syllable if it is heavy, and otherwise on the antepenultimate syllable. The basic Latin pattern can be seen, with variations, in many languages. For example, pre-classical (Plautine) Latin had a stress rule identical to Latin except that words ending in LLLH or LLLL sequences were stressed on the preantepenult. Fijian (Dixon 1988) stress rule is identical to the Classical Latin except shifted one syllable rightward: stress falls on the final syllable if it is heavy, and on the penultimate syllable otherwise. Lebanese Arabic (section 4.2.3.3) has a stress rule that is identical to Latin, with the added requirement that final superheavy (trimoraic) syllables are stressed. Languages with stress that gravitates to the beginning of the form also often have weight sensitivity: Tümpisa Shosone, for example, stresses the second syllable if it is heavy and the initial syllable otherwise (Dayley 1989). Hopi has the converse system: it stresses the initial syllable if it is heavy and the second syllable otherwise (Jeanne 1982). The list of languages with weight-sensitive stress can proceed almost indefinitely; the reader is referred to Hayes 1995 and Gordon 1999 for extensive surveys.

Stress-driven weight is also a rather common phenomenon. In many languages, stressed vowels lengthen, e.g. in Hixkaryana, Carib, and various dialects of Yupik (some of these systems are discussed in Chapter 4). Gemination is also frequently used to make stressed syllables heavy. In Latvian, which has regular initial stress, voiceless obstruents following initial stressed light syllables surface as geminates, making that syllable heavy (Kariņš 1996).

1.1.1.2 Tone

The first systematic theoretical discussion of tone-stress interactions can be found in de Lacy (2002). De Lacy's analysis, framed in Optimality Theory, posits the tonal markedness scale H 〉〉 M 〉〉 L, and a set of constraints on the relationship between stress and tone. The constraints force tones higher on the markedness scale to be preferentially aligned with metrically prominent syllables and tones on the lower end of the scale to align with non-prominent syllables. These output conditions can be satisfied in two ways: by attracting stress to tone, or by attracting tone to stress. These two patterns represent the two types of languages, those with tone-driven stress and those with stress-driven tone. De Lacy provides examples of both.

Ayutla Mixtec has a tone-driven stress generalization: stress falls on the leftmost H-toned syllable immediately followed by a L-toned syllable (de Lacy 2002: 5). Failing this condition, the leftmost H toned syllable is stressed, else the leftmost M-toned syllable followed by a syllable with a L tone, and else, by default, the leftmost syllable. De Lacy analyzes this system as a case of stress attraction to underlying tones. The alignment of the tone markedness scale with the metrical prominence of syllables results in a preference to build binary feet in such a way that the stressed syllable has a H or a M tone, and the unstressed syllable a L tone. De Lacy proposes a constraint system that generates the following harmony scale of metrical feet-to-tone alignment (2). The stress generalization can then be stated with reference to this scale: for each given form, the most harmonic possible binary foot is formed.

(2) (H́L) 〉〉 (H́H) 〉〉 (ḾL) 〉〉 (ḾM), (ĹL)

De Lacy's example of a stress-driven tone language is Lamba. In this language, H tones do not surface on the morpheme with which they are underlyingly associated, but gravitate toward metrically prominent positions, as determined by a trochaic stress system.

I have argued elsewhere that both tone-to-stress and stress-to-tone systems can coexist in the same language (Blumenfeld 2004). In the lexical phonology, Ancient Greek had a tone-to-stress system. Metrical structure was assigned by a generalization similar to the Latin stress rule, and the tonal melody HL* was associated to the metrical head of the word. Conversely, the metrical constituents built in the phrasal phonology gravitated toward the tones inherited from the lexical phonology in a stress-to-tone fashion.

1.1.1.3 Vowel sonority

Vowel quality can also interact with stress in a bidirectional fashion, an interaction that is limited to a highly constrained set of cases. Broadly speaking, the higher a vowels stands on the sonority scale (3), the more likely it is to attract stress. Likewise, the interaction can proceed in the opposite direction: unstressed vowels are shifted lower on the sonority scale, via raising or vowel reduction.

(3) ə, ɨ 〈〈 i, u 〈〈 e, o 〈〈 a

I postpone further discussion of sonority-driven stress until Section 3.6, which will be devoted to examining the typology in detail.

1.1.2 Unidirectional interactions

The three types of cases outlined above comprise only a small fraction of the typology of prosody-segmental interactions. Apart from quantity, tone, and vowel sonority, the distribution of a large number of other properties can be sensitive to metrical structure. In all such cases, the interaction takes place only in one direction: from prosody to segments.

In a recent survey, González (2003) lists more than seventy languages that have segmental processes conditioned by stress or metrical structure. A summary of this survey is given below in (4), with a non-exhaustive list of languages under each type of interaction. The interactions fall into two main categories: strengthening in prominent syllables and weakening in non-prominent syllables. The former type includes increased duration of consonants and VOT-related differences, such as onset gemination in stressed syllables (Senoufo) or fortition in foot-initial syllables (Yupik). Onset epenthesis (usually [ʔ]) also falls into this category. Weakening processes in non-prominent positions include the familiar English flapping case, as well as other types of lenition such as Spanish fricativization. Some languages have consonant deletion (usually ʔ or *h*) in weak positions. The most common type of strengthening/weakening alternations conditioned by prosody involves laryngeal features (voicing, aspiration, glottalization) (4)c.

(4) a. **Strengthening in prominent syllables**
- Increased duration of consonants in stressed syllables
  - Spanish, Senoufo, Urubu-Kaapor
- Fortition
  - Yupik, Maori, Squamish
- Onset epenthesis in stressed syllables
  - English, Dutch, Paipai, Huariapano

b. **Weakening in non-prominent syllables**
- Flapping
  - English, Djabugay, Senoufo
- Other lenition
  - Spanish, Nganasan, Paamese, Guyabero
- Consonant deletion
  - English, Squamish, Popoloca, Capanahua

c. **Laryngeal feature alternations**
- Voicing
  - Senoufo, Wembawemba, Wergaia, Trique
- Post-aspiration
  - English, Maori, Farsi
- Pre-aspiration
  - Icelandic, Faroese, Ingush, Toreva Hopi
- Glottalization
  - Saanich, Gitksan

In the table below I give a representative list of languages that have stress-sensitive strengthening processes. Unless otherwise noted, the source is González 2003.

(5)

English	voiceless stop aspiration	onset of σ́	
Silacayopan Mixtec	t → t^h	onset of σ́	
Toreva Hopi	C preaspiration	after σ́	
Icelandic	C preaspiration	after σ́ with a short V	
Senoufo	C→C:	onset of σ́	Mills 1984
Popoloca	C→C:	after σ́	
Latvian	voiceless stop gemination	after σ́ with short V	Kariņš 1996
Maori	voiceless stop affrication	onset of σ́	
Norton Sound Yupik	{w, j, l} → {v, z, ɮ}	foot-initial	
Guyabero	d → θ	after σ́	
Nganasan	C voicing	foot-initial	
Twana	ʔ attraction	to σ́	
Bagnere-de-Luchon French	liquid attraction	to σ́	Blevins & Garrett 1998
Dutch	ʔ epenthesis	σ́	
Paipai	ʔ epenthesis	word-initial σ́	

The table below lists a representative sample of stress-sensitive weakening processes.

(6)

West Tarangan	{g,dʒ} → {w,j}	medial unstressed σ	Nivens 1992
Djabugay	{r,d} → ɾ	V'__V	Patz 1991
Copala Trique	{d, g} → {ð, ɣ}	V'__V	
Kupia	spirantiz., flapping	V__unstrV	Christmas & id. 1975
Pattani	deaspiration	unstressed syl	Sarma 1982
Senoufo	Stop voicing	V__V	
Wergaia	Stop devoicing	unstressed σ	
Oneida	h, ʔ deletion	posttonic σ	
Southern Tati	h→∅	except onset of σ́	Yar-Shater 1969
Capanahua	ʔ deletion	weak-footed σ	
Chilean Spanish	s-deletion	unstressed σ	

As a matter of illustration, one language, Senoufo, has an unusually rich array of segmental effects of stress (Niger Congo, Gur, Ivory Coast; Mills 1984, González 2003). Stress is usually initial in this language; no secondary stress is reported. Senoufo has at least five separate processes sensitive to stress. Onset consonants are lenited in unstressed syllables, with voiceless consonants becoming voiced, and voiced consonants becoming spirantized. Conversely, onset consonants in stressed syllables are lengthened. Senoufo also has flapping of /d/ in onsets of unstressed syllables. Finally, both secondary articulation and glottalization are contrastive only in stressed syllables. These processes are summarized below.

- Onset consonants lenited in unstressed syllables
  Voiceless → voiced, voiced → spirantized (Mills 1984: 131)
- Onset consonants are longer in stressed syllables (p. 119)
- /d/ is flapped in onset of unstressed syllables (p. 96)
- Secondary articulation contrastive only in stressed syllable (p.143)
- Glottalization contrastive only in stressed syllable (p.148)

The second major type of interaction between metrical structure and segmentism is less direct. Segmental processes may require reference to metrical constituents as domains of application (Flemming 1994). Nasal harmony, laxness harmony, and height harmony have all been attested with metrical constituents serving as domains of application. For example, in Guaraní, (Gregores and Suárez 1967, Flemming 1994), [nas] spreads from a stressed vowel leftward up to the next stressed vowel. In Tudanca Spanish, final high vowels are lax, and laxness spreads leftward until it reaches the stressed syllable (Flemming 1994, Walker 2004). Examples, taken from Flemming 1994, are shown below, with capitalization indicating laxness.

(7)	a.	(pÍntU)	'male calf'	b.	(pínta)	'female calf'
		(čÍkU)	'boy'		(číka)	'girl'
		se(kÁlU)	'to dry him'		se(kálo)	'to dry it'
	c.	o(rÉgAnU)	'oregano'			
		(pÓrtIkU)	'portico'			
		ra(kÍtIkU)	'rachitic'			

Flemming's analysis of this case posits left-headed stress feet serving as the domain of laxness harmony. The rationale for laxness spreading can be understood to result from a prohibition on disagreement in laxness within the stress foot.

I will discuss the Tudanca Spanish case in more detail in Chapter 3.

1.2 Too many solutions

The previous two sections established the asymmetrical nature of prosody-segmental interactions. Metrical structure interacts bidirectionally only with three properties: quantity, tone, and vowel sonority. All the other effects of prosodic structure – the various consonantal fortitions and lenitions, and the use of prosodic constituents as domains of processes – show a unidirectional influence of prosody on segments, but not the reverse.

Interaction between two phonological categories is modeled in OT with constraints that state the relationship between those two categories in the output structure. OT constraints employed to account for prosody-segmental interactions must mention the two interacting categories, the prosodic and a segmental one. A standard way of stating such constraints is to relativize a markedness constraint to a prosodic domain (Smith 2005). Such relativized constraints contain a featural markedness component that is understood to apply within a particular prosodic category. The constraint is violated whenever the material that violates the segmental part is found in the prosodic domain mentioned by the constraint.

Examples of such constraints are given below. The constraint (8)a penalizes aspirated segments in non-head syllables within a foot. I will write this constraint as ASPIRATE/σ́ below for brevity. The harmony constraint (8)b enforces agreement in the feature [nas] within a stress foot. The reduction constraint (8)c prohibits mid vowels from occupying unstressed positions.

(8) a. *[spread gl]/NONHEAD
'No aspirated segments in the weak syllable of a foot'
b. AGREE[nas]$_{\varphi}$
'All segments within a foot have the same value of the feature [nas]'
c. *MidV/NONHEAD
'No mid vowels in the weak position of a foot'

The theoretical underpinnings of such complex constraints are subject to debate. De Lacy (2002) proposes to derive constraints that regulate the relationship between stress, sonority, and tone from the formal principles of the theory of harmonic scales. Under his proposal, markedness hierarchies such as the sonority hierarchy or the tonal scale (see above) interact with prosodic markedness constraints to produce sets of composite constraints that regulate the relationship between the two domains.

Smith (2005) proposes a two-step SCHEMA-FILTER theory of constraints, where a general process of constraint building creates constraints out of elementary units according to a general constraint schema. This constraint construction mechanism is a purely formal device, without any sensitivity to the substantive content of the constraints. The set of constraints it produces are then subject to functionally-motivated filters that determine which constraints are phonetically and psycholinguistically grounded. Only the constraints that pass the functional filters are available in the grammars of natural languages.

However, no matter what the theoretical basis used to argue for the constraints, any constraint intended to express the relationship between a prosodic and a segmental property must at the very least MENTION those two properties. As a result, in the general case, for each of the prosody-segmental constraints, there are at least two logically possible repairs available, one having to do with segmental phonology, and the other with prosodic phonology. If a given form violates a segmental markedness constraint relativized to a prosodic domain, then there are at least two ways of obviating such a violation. First, one can modify the segmental structure of the form, and second, one can modify the prosodic structure. These two repairs are available for all constraints mentioning a prosodic and a segmental category.

(9) $M_{(\text{prosodic domain})}$ → (1) Fix segments
→ (2) Fix prosody

The upshot of the typological discussion above is that, in the general case, these two solutions are too many. In those cases where stress is observed to interact unidirectionally with segmentism, only the first repair in (9) – the segmental repair – is typologically observed. Segmental features such as aspiration and consonant quality can cater to prosodic preferences, but not vice versa. This asymmetry is the crux of the problem from the point of view of OT.

Let me illustrate the too-many-solutions problem with the example of stress-driven aspiration. The constraint ASPIRATE/σ́, no matter how it is formulated or grounded, mentions a prosodic category (stressed syllable), and a segmental category (aspiration). Therefore, any violation of such a constraint can lead to at least two different repairs: one that modifies the segmental property and one that modifies the prosodic property.

(10) ASPIRATE/σ́ → (1) Aspirate onsets of stressed syllables
→ (2) Put stress on syllables with aspirated onsets

Both repairs result in a surface structure that satisfies the constraint ASPIRATE/σ́, and thus both are predicted by OT to exist in languages. The segmental repair – aspiration attraction to stressed syllables – is observed in languages like English and Mixtec. Some of these languages are mentioned in the preceding section, and an exhaustive list is supplied in González 2003. In the tableau below in (11) I give a hypothetical example of a language with default initial stress and a high-ranking ASPIRATE/σ́, causing both the attraction of the aspiration to the initial stressed syllable from its different location in the input /pit^{h}a/, and the insertion of aspiration on the stressed syllable when it is not in the input /pita/.

(11)

		STRESS INITIAL	ASPIRATE/$\acute{\sigma}$	DEP-h	MAX-h
/pitʰa/	pítʰa		*!		
	pitʰá	*!			
☞	pʰíta			*	*
/pita/	píta		*!		
	pítʰa		*!	*	
	pitʰá	*!		*	
☞	pʰíta			*	

Tableau (11) illustrates the segmental repair of a ASPIRATE/$\acute{\sigma}$ violation – the familiar and typologically well-attested pattern of stress-driven aspiration.

The constraint can also lead to the opposite interaction – aspiration-driven stress. If ranked high enough, ASPIRATE/$\acute{\sigma}$ can cause stress to be attracted to the syllable that has onset aspiration in the underlying form. Consider again a language with default initial stress. Reranking ASPIRATE/$\acute{\sigma}$ above the stress constraint and above the faithfulness constraint militating against inserting aspiration results in a pattern where stress is attracted away from its default initial position to the syllable that has an aspirated onset in the underlying form. The following tableau (12) illustrates this case.

(12)

		ASPIRATE/$\acute{\sigma}$	DEP-h	STRESS INITIAL	MAX-h
/pitʰa/	pítʰa	*!			
☞	pitʰá			*	
	pʰíta		*!		*
	píta	*!			*

ASPIRATE/$\acute{\sigma}$ kills any candidate where a stressed syllable has no aspiration: the fully faithful candidate *pítʰa* and the aspiration-less candidate *píta*. The high-ranking faithfulness constraint DEP-h prevents a shift of aspiration from its underlying form.[2]

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[2] The choice made here in favor of the MAX-h and DEP-h constraints over constraints like IDENT[spread gl] does not affect the argument. There must be SOME faithfulness constraint regulating the input-output

The only viable candidate left is *pitʰá*, the form with a non-default stress that has been attracted to the syllable with an aspirated onset.

To illustrate that the default stress in this hypothetical language is indeed on the initial syllable it is enough to see what happens to an input without any aspiration.

(13)

			ASPIRATE/σ́	DEP-h	STRESS INITIAL	MAX-h
/pita/		pítʰa	*!			
		pitʰá		*	*!	
	☞	pʰíta		*		
		píta	*!			

Here, there is no faithfulness difference between the finally stressed *pitʰá* and the initially stressed *pítʰa* – both involve the insertion of an aspiration – and thus the stress constraints decide in favor of the default initial stress.

To summarize, the hypothetical language illustrated in tableaux (12)-(13) has the following pattern.

(14) /pita/ → *pʰíta*
/pitʰa/ → *pitʰá*

This pattern amounts to aspiration-driven stress: a system which is typologically unattested. The unwanted prediction results from the fact that the constraint ASPIRATE/σ́ only states a preferred output pattern, viz. that stress and aspiration should coincide in the same syllable, but not the derivation route by which the pattern is achieved. Both the segmental and the prosodic repairs (9) are theoretically available, but only the former is attested.

The trade-off between the two types of repair is a general property of the constraints in (8) and other similar constraints. The constraint driving nasal harmony within the

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mapping of aspiration, and whenever that constraint is ranked high enough, the unwanted pattern stress foot, AGREE[nas]$_{\varphi}$, can be satisfied either by violating the segmental faithfulness constraint – i.e. by applying harmony within the foot – or by violating a prosodic constraint (faithfulness or markedness, depending on whether stress is predictable in the system or not) by moving the prosodic domain boundary to accommodate the segments. For example, a language that makes use of such a repair strategy would have a stress system that assigns, say, penultimate default stress except in words that have a different [nas] value in the final and penultimate vowels – exactly the forms where harmony would be applicable. This hypothetical situation is illustrated below.

(15) Stress in a language with high-ranking AGREE[nas]$_{\varphi}$ and a prosodic repair

a. Default penultimate

/ara/ → ára

/ãrã/ → ã́rã

b. Final in forms where harmony would otherwise apply

/arã/ → arã́

/ãra/ → ãrá

The bizarre system shown in (15), where stress assignment depends on whether the vowels in the last two syllables have the same or different [nas] specifications, is not attested.

In the general case, standard OT is plagued by a systematic too-many-solutions problem in the case of prosody-segmental interaction. The theory cannot account for any case of asymmetry between the ability of stress to condition the distribution of some segmental feature and its inability to be sensitive to that feature. OT predicts there to be systems with aspiration-driven stress, flap-driven stress, fricative-driven stress, glottalization-driven stress, and so forth. As I claimed above, none of these is attested. This unwanted typological prediction will be the subject of my proposed modification of OT in chapter 3.

Finally, let me illustrate this unwanted interaction with a syllable-based constraint, *[+voi]/CODA. Although the problem falls outside of the scope of stress-segmental interactions, it is analogous to the problems discussed so far and, I think, is an especially

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illustrated in tableau (12) results.

conspicuous example of an acute too-many-solutions problem in OT. The coda voicing constraints can be satisfied in the same two ways as any prosody-segmental constraint: by fixing the segments, or by fixing the prosody.

$$*\begin{bmatrix}+\text{voi}\\ -\text{son}\end{bmatrix} \text{ in Coda} \;\begin{cases}\nearrow \text{(1) Fix segments}\\ \searrow \text{(2) Fix prosody}\end{cases}$$

In other words, a constraint like *[+voi]/CODA can trigger two general types of repairs, one affecting the [+voi] part of the constraint and the other affecting the CODA part. More specifically, a prohibition against voiced codas could trigger any of the repairs in (16) below.

(16) a. Fix segments

Devoicing:	/abra/	→ apra
Epenthesis:	/abra/	→ abəra
Nasalization:	/abra/	→ amra
Deletion	/abra/	→ ara
Metathesis:	/abra/	→ arba

b. Fix prosody

Resyllabification:	/abra/	→ a.bra

The range of segmental repairs predicted by the theory is far greater than the attested repairs: only devoicing is attested as a response to *[+voi]/CODA. This problem need not concern us for now: it has been addressed by Steriade 2001 and used to argue for the P-map theory, to which I will come back in a later section.

What matters in this section, and what Steriade 2001 does not address, is that Standard OT predicts that for constraints like *[+voi]/CODA and other constraints of this type, languages should systematically have a choice between prosodic and segmental repairs. In the case of coda voicing neutralization, the choice is between keeping the offending syllable in the coda but satisfying the constraint by modifying the feature specification, turning the voiced *b* to a voiceless *p*. The prosodic repair would involve satisfying the prohibition of coda voicing by moving the segment out of the coda into the onset of the following syllable, which allows the language to be faithful to underlying voicing.

In the case of devoicing, the language involving prosodic repair would have the following generalization: voiceless segments that are first members of consonant clusters syllabify as codas of the preceding syllables, while voiced segments form complex onsets with following syllables.

(17) a. /apra/ → ap.ra
b. /abra/ → a.bra

This happens because the voiced but not the voiceless segments are prohibited from codas. However, if there is a difference in the syllabification of consonants based on their voicing, it goes the other way: in Icelandic and Ancient Greek, the voiced but not the voiceless segments make the preceding syllable heavy. The standard analysis of such voicing asymmetries in syllabification appeals to syllable contact: *ab.ra* is preferred to *ap.ra* because it has a smaller sonority rise across the syllable boundary.

1.3 Counterexamples

In this section I turn to some alleged counterexamples to the generalization about prosody-segmental interactions, arguing for alternative analyses. Karo stress (section 1.3.1) has been claimed by Gabas (1998) to be sensitive to the location of flaps. A small set of other onset-sensitive stress systems will be briefly discussed in section 1.3.2.

1.3.1 Stress and lenition in Karo

Karo, a Tupí language of Brazil, has been claimed to possess a stress system that directly contradicts the generalization proposed in this section. According to the description of Gabas (1998), stress assignment in Karo is sensitive to the voicing of obstruent stops, in such a way that certain types of stops are preferably located in weak positions of feet. This contradicts the proposal that only stress can cater to segments, not the other way around. In this section I will show that Gabas's analysis of Karo stress is not the only possible one, and that a different analysis that does not involve voicing-sensitive stress is not only possible but preferable.

Karo has contrastive tone (with at most one H or M tone syllable per word), contrastive nasalization, and contrastive voicing. The Karo stress rule as formulated by Gabas is as follows.

(18) a. Assign stress to the syllable with H tone;
b. Else to the syllable with the nasalized vowel;
c. Else to the penultimate syllable if the final syllable begins with [b], [g], or [ɾ];
d. Else to the final syllable.

The most puzzling part of the rule is (18)c: stress appears to be sensitive to the nature of the consonant in the following. There is a general cross-linguistic preference for leniting or voicing posttonic onsets (English, Swahili, Tohono O'odham, Welsh), and Karo stress as presented by Gabas is the reverse of this posttonic lenition: stress is assigned to syllables preceding voiced consonants.

The normal situation is either like in English, where lenition takes place, or like in Russian, where lenition does not take place and the posttonic voiceless obstruents surface faithfully (19)-(20).

(19)

English			STRESS	LENITE	FAITH
/atom/	☞	á[ɾ]om			*
		á[t]om		*!	
		atóm	*!		

(20)

Russian			STRESS	FAITH	LENITE
/atom/		á[ɾ]om		*!	
	☞	á[t]om			*
		atóm	*!		

In both cases the STRESS family of constraints outrank the segmental faithfulness and markedness constraints, the ranking between which determines whether the posttonic *t* is flapped or not. The high-ranking STRESS ensures that the stress assignment rule is not affected by the segmental properties of adjacent consonants.

In Karo, however, the stress constraint seems to be ranked below the markedness constraint. As the following examples show, stress is assigned to the final syllable unless the onset of the final syllable is a flap, in which case stress is penultimate. As the tableau below illustrates, the segmental faithfulness and markedness constraints must outrank the stress assignment constraints in order to ensure that stress is sensitive to the nature of the final syllable onset.

(21) a. /parat/ → [páɾat] 'curimba'
b. /pako/ → [pakó] 'pacu'

(22) a. IDENT-C 'No feature change on Cs'
b. *D/HEAD 'No weak Cs in stressed syllables'
c. FINALSTRESS 'Stress is word-final'

(23)

			*D/HEAD	IDENT-C	FINALSTRESS
parat	☞	páɾat			*
		paɾát	*!		
		patát		*!	
		pátat		*!	*
pako		págo		*!	*
		páko			*!
	☞	pakó			
		pagó	*!	*	

Is this a counterexample to the central generalization that stress does not cater to segmental phonology like stress-sensitive lenition?

In the remainder of this section I will argue against Gabas's assumption that voicing, not stress, is contrastive. A better analysis takes stress to be partially unpredictable, and derives lenition as conditioned by stress. As a result, Karo is not a counterexample to the generalization on stress-segmental interaction, but simply a language like English, Welsh, etc., with a process of posttonic lenition.

The inventory of Karo, as Gabas presents it, is as follows.[3]

(24)						
stops:	p	t	c	k	ʔ
	b			g	
liquids		ɾ			
fricatives					h
approximants	w		y		

Gabas's description unambiguously implies that voiced and voiceless stops do not contrast in onsets of unstressed syllables; however, Gabas does not use this crucial fact for the analysis of voicing and stress. The list of environments where voiced and voiceless stops occur is given below.

[3] Because there is no [d], [ɾ] can be grouped with the voiced stop series. I will assume that [ɾ] derives from *d* under pressure of an independent constraint.

(25) a. Voiceless stops occur everywhere except intervocalic onsets of unstressed σs

V__V́ (in this position voiceless stops are lengthened)
ʔ__V
#__V
V__#

b. Voiced stops occur intervocalically

V__V

In onsets of stressed syllables, voiced and voiceless stops contrast. In all other positions, their distribution is predictable: voiced stops occur when intervocalic, and voiceless stops occur elsewhere. The contrast in voicing in onsets of stressed syllables can lead to EXCEPTIONS to the stress rule (18)c. In the following examples, voiced stops in onsets of final syllables do not cause the stress to be penultimate: it is irregularly final, in contradiction to (18)c.

(26)	acibéʔ	'raiz'
	koɾé^{b}m	'também'
	pagó^{d}n	'amigo'

Some of the occurrences of voiced stops in onsets of stressed syllables do not generate exceptions to (18)c, because the (18)a or (18)b clauses preclude it.

(27) a. koɾét 'jacu' [stress assigned to V with H tone]
|
H

b. wakə̃́ỹa 'cutia' [stress assigned to nasal V]
morĩ́ỹa 'miçanga'

Furthermore, Karo has a "morphophonemic" process of stop lenition that is sensitive to stress, which Gabas claims to apply across morpheme boundaries. It applies intervocalically before unstressed vowels, and lenites word-initial voiceless stops to voiced stops when not immediately followed by stress.

(28) /p, t, k/ → [b/w, ɾ, g] / V__V[-accent]

(29) a. /e-penaoy/ → [ebenaóy] 'você dançou'
/e-tati/ → [eɾatí] 'te trouxe'
/e-kuruʔcu/ → [eguruʔcú] 'minha saliva'
b. /e-pəgat/ → [epə́gat] 'te queimou'
/i-toy/ → [itóy] 'viu alguém'
/e-kɨgat/ → [ekɨ́gat] 'te pegou'

Gabas treats stops as contrastive in voicing throughout, even thought they only contrast in onsets of stressed syllables. This misses the connection between their distribution, the morphophonemic alternations, and the placement of stress: these three facts are treated as independent of each other on Gabas's analysis, missing the generalization that they all reflect the same preference for leniting posttonic stops. Instead of assuming that the process (28) is limited to derived environments, I propose that it applies across the board, and that stress is partially unpredictable. My reanalysis is summarized below.

(30) a. Stress rules (18)a or (18)b are still in place.[4]
b. If (18)a or (18)b are not applicable, stress is unpredictably either penultimate or final.
c. The lenition rule (28) applies across the board.

The underlying forms and derivations according to this reanalysis are shown below. The tableau is given in (33).

(31) a. /pátat/ → [páɾat] 'curimba'
b. /pakó/ → [pakó] 'pacu'
c. /acibéʔ/ → [acibéʔ] 'raiz'

The analysis requires the following lenition constraint.

(32) *T/NONHEAD 'lenite in weak position'

[4] (18)b could be improved if nasalized Vs are treated as underlying VN sequences (there are no surface codas except [ʔ]). Stress is then assigned to Vs with H tone, else to closed syllables.

(33)

			FAITH STRESS	MAX[voi]	*T/NONHEAD	DEP[voi]	FINALSTRESS
pátat	☞	páɾat					*
		paɾát	*!				
		patát	*!	*			
		pátat		*!	*		*
pako		págo				*!	*
		páko			*!		*
	☞	pakó					
		pagó				*!	
acibéʔ	☞	acibéʔ					
		acipéʔ		*!			
		acíbeʔ	*!				*
		acípeʔ	*!	*	*		*

There is a problem, however: the unpredictably penultimate/final distinction in stress only exist in forms whose final syllable has a stop onset (Gabas p.c.). In all cases where there is no stop involved, the final syllable is accented.

(34) a. kɔyɔ́ 'juriti'
b. yaʔɔ́ 'calango'
c. maní 'macaxeira'

This is not predicted by my analysis, because FAITHSTRESS is high-ranked, and there is no constraint that would prevent stress from mapping faithfully in *acibéʔ* but not in #*máni*.

However, this is not a problem that is unique to my reanalysis: on Gabas's analysis, the existence of exceptions like *acibéʔ* but not #*máni* is also accidental. In an OT implementation of Gabas's proposal, FAITHSTRESS must also be high-ranked in order to ensure that *acibéʔ* surfaces faithfully.

(35) Gabas's system

Input		Candidate	FAITH STRESS	MAX[voi]	*D/HEAD	DEP[voi]	FINALSTRESS
acibéʔ	☞	acibéʔ			*		
		acipéʔ		*!			
		acíbeʔ	*!				*
		acípeʔ	*!	*			*
mani	☞	maní					
		máni					*!
máni		maní	*!				
	(☞)	máni					

Despite the problem of not accounting for the absence of exceptions like #*máni*, the reanalysis of the Karo stress system shows that it is not necessary to treat it as segment-sensitive. The reanalysis that takes stress rather than voicing to be unpredictable fares better in that it expresses the connection between three facts that were unrelated in Gabas's analysis: the distribution of voiced/voiceless stops, the 'morphophonemic' rule of stop voicing, and the stress placement rule.

1.3.2 Onset-sensitive stress

In a small class of languages, stress is sensitive to the presence or absense of onsets on the initial syllable (Davis 1988, Goedemans 1997, González 2003). Such systems include Aranda, Banawá, Iowa-Oto, and typically have the following stress generalization: stress is assigned to the initial syllable unless it is onsetless, in which case stress falls on the second syllable. In other words, stress is repelled from the initial onsetless syllables.

Second, in at least one language, Alyawarra, there is a variation on this pattern: stress is repelled not only from onsetless syllables, but also from glide-initial syllables (Goedemans 1997: 4). The Alyawarra type may be treated on a par with the Aranda type if the glides can be argued to be in the syllable nucleus rather than in the onset.

This small and constrained set of cases does not present a serious counterexample to the generalization that stress can only be sensitive to quantity, tone, and sonority. As

Goedemans (1997) has shown, these systems can be analyzed using the constraint ALIGN(FT, ONS), calling for feet to be left-aligned with a syllable onset. I will not further discuss these onset-repelling systems in this thesis.