Asymmetrical Feature-Prosody Interaction in Harmonic Serialism

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1. Introduction[1]

This paper deals with the asymmetry in feature-prosody interaction noted by Blumenfeld (2006), de Lacy (2006) and Walker (2005). Prominent prosodic positions license featural contrasts and attract certain feature specifications. Nevertheless segmental features (excluding sonority) normally do not influence prosodification. Thus, in Tudanca Spanish stressed syllables attract [-ATR] (Blumenfeld 2006; Flemming 1994; Hualde 1989; Walker 2004), but there is no language where [-ATR] vowels preferentially repel or attract stress.

This assymmetry presents a problem for Classic OT (Prince and Smolensky 2004): it proves to be hard to formulate the relevant constraints in such a way that they allow for the interaction only in one direction. For example, to account for the Tudanca facts we need a licensing constraint which requires [-ATR] to be linked to stressed syllables. Classic OT predicts that this constraint can be responded to in two ways: (i) changing the [ATR] value of the stressed vowel and (ii) moving stress to a [-ATR] vowel. The second response is never attested and thus we are dealing with a *too-many-solutions* problem where the theory predicts unattested repairs (Blumenfeld 2006; de Lacy 2003; McCarthy 2008a,b; Pater 2003; Steriade 2009; Staroverov 2010; Van Oostendorp 2007; Wilson 2000).

I am going to propose a solution to this problem which allows us to correctly describe the asymmetrical feature-prosody interaction. My proposal is couched within Harmonic Serialism (Prince and Smolensky 2004; McCarthy 2006 et seq.) – an OT formalism with a derivational setup where optimization proceeds in steps and each step evaluates candidates, making minimal changes to the input. I argue that the feature-prosody interaction constraints are formulated asymmetrically, as *PS-constraints* (for previous step). They mention position in the input of the current step and therefore prosodic position cannot be modified in response to these constraints. The asymmetry in feature-prosody interaction is thus mirrored in asymmetrical constraint formulations (see Blumenfeld 2006 for a similar proposal and Staroverov 2010 for a discussion of the differences).

The paper is structured as follows. Section 2 introduces the problem based on an example pattern from Tudanca Spanish. Section 3 spells out the proposed solution and section 4 provides a way of situating my proposal within a bigger theory. Section 5 concludes.

2. The problem: attested and unattested patterns

In this section, I will illustrate the problem of feature-prosody interaction with an unattested language Tudanca' and its attested counterpart – Tudanca Spanish (see Penny 1978 for data as well as Blumenfeld (2006), Flemming (1994), Hualde (1989) and Walker (2004) for theoretical discussion and analysis).

In Tudanca stress is lexical and falls on one of the last three syllables. Word-final unstressed high

[1] For the useful discussion at different stages of the development of this paper, I am grateful to Will Bennett, Darya Kavitskaya, Shigeto Kawahara, Paul de Lacy, John McCarthy, Alan Prince, and especially Ryan Denzer-King. I would also like to thank the audiences at Rutgers Optimality Research Group, Penn Linguistics Colloquium 2009, Humdrum 2009 and WCCFL 2010 and especially Aaron Braver, Maria Gouskova, Bruce Hayes, Elizabeth Selkirk, Bruce Tesar and Rachel Walker. All errors are my own.

vowels are neutralized to [-ATR][2]. The [-ATR] feature then spreads all the way to the stressed syllable, but not further[3]. Spreading is illustrated in (1) where capitalization marks [-ATR].

(1)	ˈpinta	ˈpIntU	'calf f/m'
	ˈθudros	ˈθUdrU	'left handed m.pl/sg'
	ˈohos	ˈOhU	'eye pl/sg'
	seˈkalo	seˈkAlU	'to dry it(mass)/ to dry him'
	ahambˈraa	ahambˈrAU	'hungry f/m'
		oˈrEgAnU	'oregano'
		ˈpUlpItU	'pulpit'
		ˈkArAbU	'tawny owl'

I will adopt a slightly simplified version of the analysis of these facts in Walker (2004). On this analysis, a positional licensing constraint LICENSE-[-ATR]/σ́ in (2) (LIC-ATR for short) is assumed to be responsible for spreading. This constraint dominates the faithfulness constraint IDENT-ATR (for simplicity I omit the discussion of alternative repairs such as integrity violations here).

(2) LICENSE-[-ATR]/σ́ (LIC-ATR): every [-ATR] autosegment should be linked to a stressed vowel

Tudanca has lexical stress, so I will assume that the constraint IDENT-STRESS responsible for the preservation of input prominence outranks the metrical markedness constraints as well as IDENT-ATR. In addition, a constraint responsible for word-final [ATR] neutralization is assumed to dominate faithfulness. I will not speculate about the exact formulation of this constraint and I will simply refer to it as *(+hi,+ATR)]$_{PrWd}$. The tableau in (3) illustrates the analysis of the word ˈ*kArAbU* 'tawny owl'. The last vowel of the word has to be [-ATR] because of the high-ranked neutralization constraint *(+hi,+ATR)]$_{PrWd}$. The [ATR] specification further spreads until the stressed syllable due to the licensing constraint.

(3) Analysis of Tudanca Spanish spreading in the word kÁrAbU 'tawny owl'

/ˈkarabu/	*(+hi,+ATR)]$_{PrWd}$	LIC-ATR	ID-STRESS	ID-ATR
a. ˈkarabu	*!			
☞ b. ˈkArAbU				***
c. ˈkarabU		*!		*
d. karaˈbu			*!	

In Tudanca, the presence of the marked feature in a weak position is responded to by spreading the feature up to the stressed syllable. Reranking of the constraints employed in (3) can also make the stress-shift candidate (3)d optimal. However there are no languages where a candidate like (3)d above is systematically optimal.

To illustrate the point, consider the language Tudanca' which is just like Tudanca, but with predictable stress. In this language the stress normally falls on the penultimate syllable. However, when a [-ATR] vowel occurs word-finally in the input, it attracts stress. This system results from simple reranking of the constraints in (3) and addition of well-known metrical constraints.

I will model the default penultimate stress with the ranking conditions in (4)a-b. I assume the cover-constraint HAVESTRESS to be high-ranked: this ensures that every word bears stress (cf. McCarthy 2008b for a discussion of the relevant metrical constraints). The ranking of the metrical constraints in (4)b ensures that by default every prosodic word receives a binary trochaic foot at the right edge.

[2] Hualde (1989: fn. 5) remarks that the relevant feature may be [-tense] instead of [-ATR]. The feature choice does not make any difference for the theoretical argument in this paper.

[3] Underlying /e/ and /i/ are neutralized word-finally. This neutralization makes the spreading opaque: only underlying word-final /i/ triggers spreading of [-ATR], but underlying word-final /e/ is phonetically realized the same as underlying /i/. I will not deal with neutralization and opacity here.

(4) Tudanca' rankings

a. *Stress must be present*:

HAVESTRESS >> TROCHEE, IAMB, ID-STRESS

b. *The default is one binary trochaic foot at right word edge*:

FT-BIN, ALL-FT-R >> TROCHEE >> IAMB, ID-STRESS

The tableau in (5) illustrates the default stress assignment in Tudanca'.

(5) Default penultimate stress in Tudanca'

patepate	FT-BIN	ALL-FT-R	HAVESTRESS	TROCH	IAMB	ID-STRESS
☞ a. pate(ˈpate)					*	*
b. pate(paˈte)				*!		*
c. patepate			*!			
d. patepa(ˈte)	*!					*
e. (ˈpate)pate		*!			*	*

The default footing pattern is overriden in words that fall under the pressure of featural licensing. This is guaranteed by the ranking conditions in (6).

(6) Licencing [-ATR] overrides the default in Tudanca':

LIC-ATR, IDENT-ATR >> TROCHEE

The tableau in (7) illustrates the application of this hierarchy to an input ending in a [-ATR] vowel. Here I omit the constraints FT-BIN and ALL-FT-RIGHT which are not crucially dominated. Because the licensing constraint and the faithfulness constraint are high-ranked, the inputs with word-final [-ATR] vowels surface with final stress. Thus the default trochaic pattern is interrupted in the presence of a marked feature which needs to be licensed.

(7) [-ATR] vowels attract stress in Tudanca'

petepetɛ	LIC-ATR	ID-ATR	HAVESTRESS	TROCH	IAMB	ID-STRESS
☞ a. pete(peˈtɛ)				*		*
b. pete(ˈpetɛ)	*!				*	*
c. pete(ˈpɛtɛ)		*!			*	*
d. petepetɛ	*!		*			

No language like Tudanca' is attested. Furthermore, the absence of such a language represents a systematic gap in the typology, where segmental features are not able to influence prosodification. The Classic OT positional licensing and positional faithfulness constraints predict that this gap should not exist (see Jesney 2009 and Staroverov 2010 on positional faithfulness). In the next section, I will propose a solution to this problem within Harmonic Serialism.

3. PS-constraints in Harmonic Serialism

In this section, I introduce the theory of PS-constraints and show how it derives the correct result in the case of Tudanca'.

My proposal is couched within Harmonic Serialism (Prince and Smolensky 2004, McCarthy 2006 et seq.) – an OT formalism where optimization proceeds in small steps. Each step evaluates candidates making a minimal change to the step's input. The optimal minimal change (or no change at all) is selected at every step[4]. The first step is assumed to be the most harmonic fully faithful parse of the

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[4] This requirement is relaxed in the version of the theory that deals with opacity (McCarthy 2007). See Kavitskaya and Staroverov (to appear) for an exploration of PS-constraints in that theory.

input. The derivation teminates when no more harmonic improvement is possible, i.e. when the output of some step equals its input.

The serial architecture differs from the classic OT picture in that there are explicitly represented intermediate derivational steps. This opens the possibility for OT constraints to refer to the intermediate stages. This possibility can be exploited to account for asymmetrical feature-prosody interaction. In particular, I will make use of the constraints which refer to position specified in the input to the current derivational step (or, equivalently, in the previous step output). These constraints are termed *previous step constraints* (PS-constraints for short). PS-constraints are asymmetrical in that they cannot be responded to by modifying position. I propose that this asymmetrical formulation is a good fit to the observed asymmetrical typology of feature-prosody interaction.

All PS-constraints are based on a schema which compares some phonological element in the candidate output to its correspondent in the immediate input of the current step. A violation is only assigned if the immediate input element resides in a given position and the output element is marked along some dimension. For example the constraint LIC-ATR is reformulated as a PS-constraint in (8). The symbol "⮌" will be used to mark PS-constraints here. Unlike the original formulation, this constraint penalizes the marked [-ATR] autosegments which are not linked to the vowels which were stressed in the *current step input*.

(8) ⮌LIC-ATR: Assign a violation mark for every [-ATR] autosegment which is not linked to a segment *x* s. t. *x*'s correspondent in the current step input (=prev. step output) is a head of a Prosodic Word.

The asymmetrical formulation of ⮌LIC-ATR is mirrored by the possible responses to this constraint. In particular, stress shift is no longer a valid way of satisfying ⮌LIC-ATR. To demonstrate this, consider the possible Harmonic Serialism derivations which are available under the Tudanca' ranking. Let us first focus on the inputs which do not have stress specified, such as /*patepate*/ and /*petepetɛ*/. Since the violations of ⮌LIC-ATR depend on the presence of stress in the immediate input, it will not differentiate any candidates before stress is assigned. No changes in prosodic structure will occur at those pre-prosodification steps since the prosodic structure is not yet present. Next, consider the derivational step when stress is assigned (cf. McCarty 2008b and Pruitt 2008 on prosodification in Harmonic Serialism). At this step, the input /*patepate*/ will be assigned the default stress because it has no [-ATR] vowels. Crucially, the input /*petepetɛ*/ will also be assigned the default penultimate stress since ⮌LIC-ATR is not active yet.

The stress assignment step in the derivation of /*petepetɛ*/ is illustrated in (9). All the candidates violate the PS-constraint ⮌LIC-ATR. Indeed, no vowel is stressed in the input in (9) and therefore any [-ATR] autosegment violates the licensing constraint since it is not linked to a vowel that was stressed in the previous step. In other words, stressing the [-ATR] vowel yields no immediate improvement on the PS-licensing constraint because the constraint only cares about what was stressed in the input.

(9) Stress assignment step: Tudanca' ranking predicts default stress even in presence of [-ATR]

Input: petepetɛ	⮌LIC-ATR	ID-ATR	HAVESTRESS	TROCH	IAMB	ID-STRESS
☞ a. pete(ˈpetɛ)	*				*	*
b. pete(peˈtɛ)	*			*!		*
c. petepetɛ	*		*!			

At the next step, there is a stressed vowel in the input and ⮌LIC-ATR can trigger assimilation if it is sufficiently high-ranked. However, the PS-constraint cannot trigger destressing or stress shift, as illustrated in (10). In this tableau, I mark the vowel that was stressed in the input of the current step with underlining. Depending on the ranking of ⮌LIC-ATR and ID-ATR either (10)a or (10)b can win. However, the pathological candidates (10)c-d both violate ⮌LIC-ATR because the presence and position of stress in the candidates is irrelevant for the PS-constraint (cf. McCarthy 2008b on whether stress shift should be considered a valid gradual step in Harmonic Serialism).

(10) Later steps on the Tudanca' ranking: no destressing or stress shifts

Prev. step output pete(ˈpe̲tɛ)	⮌LIC ATR	ID ATR	HAVE STRESS	TROCH	IAMB	ID STRESS
☞ a. pete(ˈpe̲tɛ)	*				*	
☞ b. pete(ˈpɛ̲tɛ)		*			*	
c. pete(pe̲ˈtɛ)	*			*!		*
d. petepe̲tɛ	*		*!			*

Thus even on the Tudanca' ranking it is impossible to derive the pathological pattern if we assume the PS-constraint ⮌LIC-ATR. The languages that can be described in Harmonic Serialism with the PS-licensing constraint show either no licensing effects or spreading to the stressed syllable familiar from Tudanca Spanish[5]. Note that the result illustrated above holds even if we assume that stress is present in the input. If this was the case, the derivation of the inputs with penultimate stress would simply reduce to the evaluation in (10) whereas the inputs with other vowels specified as stressed would undergo a stress shift triggered by the metrical constraints. Thus Harmonic Serialism with PS-constraints predicts that even with the Tudanca' ranking input [ATR] values cannot influence stress assignment.

The discussion of Tudanca' illustrates a crucial point: PS-constraints mentioning features and prosody generally prevent feature specifications from influencing prosodic constituency. In the next section, I will formulate a hypothesis that would allow us to generalize this result.

4. Towards a general theory of feature-prosody interaction

We have seen how PS-constraints can be used to account for the asymmetrical feature-prosody interaction in the case of Tudanca metaphony. In this section, I will propose a way of generalizing this result and accounting for the interactions which are symmetrical such as that between sonority and prosody.

In order to achieve a predictive theory of PS-constraints, one has to answer at least two important questions:

(i) For any PS-constraint, what counts as 'position' mentioned in the current step input?

(ii) What is the relation between PS-constraints and regular OT constraints?

In section 4.1 I address the first question. Section 4.2 is devoted to the discussion of the second question. Section 4.3 applies my results to sonority-prosody interaction and section 4.4 discusses the robustness of the assumed typological generalization.

4.1. Position as a prosodic concept

PS-constraints make a difference between a marked element and its position. In this section, I put forward a hypothesis about how exactly these notions are defined in a general case. According to my hypothesis, PS-constraints make this difference on the basis of the elements of the prosodic hierarchy mentioned in the constraint definition. In other words, for every PS-constraint, one needs to look at where the elements mentioned in the constraint definition belong in the prosodic hierarchy in order to understand how the constraint is formulated.

The algorithm of determining 'what is the position for a given PS-constraint' is given in (11). I hypothesize that there is so to speak a prosodic cutoff such that any elements above the cutoff will always constitute a position in the sense of PS-constraints whereas the elements below the cutoff will always be targeted by the constraints. This cutoff is at the segmental level.

(11) For every PS-constraint, the elements that are mentioned in the constraint definition are divided into two groups according to their place in the prosodic hierarchy. The elements at the level of segments and above it are mentioned in the previous step.

[5] My system can also derive a complete neutralization language if ⮌LIC-ATR is allowed to have an effect before stress assignment.

Thus the exact formulation of a PS-constraint follows automatically from the prosodic status of the elements that the constraint deals with. For every set of phonological elements, there is only one way in which a PS-constraint can mention these elements. The algorithm in (11) also presupposes that every PS-constraint has to mention at least two elements with different prosodic status. This accounts for the intuition that 'position' is only meaningful in comparison to something that occupies the position. In the next two sections, I will elaborate on the shape and predictions of the overall theory of PS-constraints that follows from the hypothesis in (11).

4.2. PS-constraints and regular constrains

The theory of PS-constraints aims to account for a systematic class of too-many-solutions problems. Because of this, PS-constraints need to replace their regular counterparts. If the PS-versions of feature-prosody interaction constraints coexisted with the 'classical' versions the pathological patterns would still be predicted under the rankings where 'classical' constraints outrank PS-constraints.

It is important to define the class of OT constraints which need to be reformulated as PS-constraints. The strongest possible hypothesis in this regard is that any constraint, for which the algorithm in (11) can be meaningfully applied, is a PS-constraint. In other words, whenever a constraint mentions a prosodic element and a feature, it has to be a PS-constraint. This hypothesis is formulated in (12).

(12) **Prosodically stratified constraint formulation hypothesis**

All and only the constraints that mention both subsegmental features and the units of the segmental level or higher are PS-constraints. For all such constraints the higher order prosodic units constitute position and are specified in the output of the previous step.

If (12) is assumed to be true, asymmetrical feature-prosody interaction is one of the consequences. Indeed, in this case any constraints mentioning prosody and features would have to be PS-constraints. Adjusting prosody is not a valid response to PS-constraints and hence the feature-prosody interaction constraints can only lead to featural adjustments. This applies both to the positional licensing constraints discussed in section 2 and to positional faithfulness constraints (Jesney 2009; Staroverov 2010). To sum up, the current theory relates the fact that feature-prosody interaction is asymmetrical to a theory of constraint formulation under which all feature-prosody interaction constraints have to be asymmetrical. Note also that PS-constraints find application outside the domain of too-many-solutions: Kavitskaya and Staroverov (to appear) argue that PS-constraints are needed to account for certain cases of opacity.

Another consequence of adopting (12) is that the constraints mentioning only prosodic elements (such as ONSET or FT-BIN) will not be PS-constraints.

4.3. PS-constraints and sonority-prosody interaction

Unlike segmental features, sonority values are known to be able to affect prosodification, i.e. syllable structure (Prince and Smolensky 2004) or footing (de Lacy 2006). On my account, sonority is considered a prosodic rather than a segmental feature. Following the independent evidence in McCarthy (1988) I assume that sonority values occupy root nodes. In terms of prosodic structure, this means that sonority values are at the level of segments.

Recall from (12) that PS-constraints have to mention features *below* the level of segments. Thus if we adopt the hypothesis in (12), it follows that sonority-prosody interaction constraints do not qualify as PS-constraints because they do not mention any subsegmental features. Sonority-prosody constraints are thus formulated just like Classic OT constraints and can trigger both changes in sonority values and changes in prosodic structure.

Given the theory of PS-constraints, the special status of sonority can be reduced to its place in the prosodic structure. Both the fact that sonority can affect prosody and the fact that sonority values do not participate in regular feature alternations such as spreading (McCarthy 1988) follow from the same principle on my account.

4.4. Robustness of the asymmetrical interaction and the limits on PS-constraints

In the last two sections, I have uncovered some favorable consequences of the hypothesis that all feature-prosody interaction constraints are PS-constraints. However, in some cases the hypothesis in (12) appears to be too restrictive. In this section I will discuss one such example and highlight a way to analyze it[6].

Itô (1986) describes a family of constraints known as Coda Conditions (CODACOND for short). These constraints penalize certain segmental features in the coda. An interesting property of such conditions is that geminate consonants and homorganic NC clusters often satisfy the relevant constraints even if the given feature occurs in the coda part of the cluster.

Interestingly, CODACOND can be responded to by moving the consonant out of the coda, i.e. by epenthesizing a vowel in order to place the relevant feature in the onset. For instance, in Ponapean, syllables can be closed by a consonant that is either part of a geminate or part of a homorganic NC cluster. Non-homorganic clusters are resolved by epenthesis, as in /kitik-men/ → kitikimen 'rat' (see Itô 1986 and Rehg and Sohl 1981 for a full description of cluster resolution patterns). Other relevant cases include Axininca Campa (Itô 1986; McCarthy and Prince 1993), Japanese (Itô 1986) and Tiberian Hebrew (Itô and Mester 1994; McCarthy and Prince 1993; Prince 1975).

These cases are problematic from the point of view of the restrictive theory of PS-constraints. The constraint CODACOND mentions both the features below the level of segments and a prosodic position (coda). Hence if (12) is correct, CODACOND has to be a PS-constraint. However, PS-constraints cannot trigger modifications of prosodic structure and thus the languages mentioned above would not fall under the generalization of ⮌CODACOND if it was a PS-constraint.

This indicates that the hypothesis in (12) might need further refinement. Whether a given constraint is a PS-constraint or not might depend on the type of the constraint as well as the elements mentioned in the definition. Itô and Mester (1994) argue that the CODACOND constraints are best analyzed as alignment constraints – a class of constraints that have been outside of the scope of this paper. We may tentatively assume that all alignment constraints are not formulated as PS-constraints. This issue requires further investigation based on the typology of alignment.

5. Conclusion

Features can be attracted to certain prosodic positions and licensed in those positions, but prosody is never adjusted to accommodate certain segmental features (Blumenfeld 2006; de Lacy 2006; Walker 2005). Harmonic Serialism provides a novel way of accounting for this asymmetry. In particular, in the serial theory it is possible to formulate the constraints which specify the relevant position in the output of the previous step. I argued that these new PS-constraints correctly derive the restricted typology of feature-prosody interaction. Importantly, PS-constraints also find motivation outside of the domain of too-many-solutions problems. Thus, Kavitskaya and Staroverov (to appear) argue that these constraints need to be employed to account for certain cases of opacity.

I have put forth the Prosodically Stratified Constraint Formulation hypothesis (12) concerning the precise definition of PS-constraints and their relation to regular constraints. According to this hypothesis, the nature of the constraint depends on the elements of the prosodic heirarchy mentioned in the constraint definition. Whenever a constraint mentions both subsegmental features and units of the segmental or higher level it is a PS-constraint. For all such constraints the higher order prosodic units constitute position and are checked against the output of the previous step. This hypothesis coupled with the independently motivated assumptions about the prosodic status of sonority accounts for the bidirectional interaction of sonority and prosody. I have also outlined some phenomena which may require a refinement of this hypothesis.

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[6] The example in this section does not appear to be the only one. For some other relevant examples, I am grateful to Will Bennet, Maria Gouskova, Bruce Hayes, John McCarthy and Rachel Walker. I have to leave the full analysis of these other examples for future research.

My theory is close in spirit to that of Blumenfeld (2006): the asymmetrical interactions between features and prosody are modelled via asymmetrical constraint formulations. However, PS-constraints are more principally restricted than the implicational constraints of Blumenfeld (2006) in that they only assure the special status of position. In addition, the implicational constraints are better suited to account for the cases when deletion is among the attested repairs (see Staroverov 2010 for discussion).

To make the current proposal even more general all phonological objects would have to be split into those that interact with prosody and those that do not. I have explored a way of employing this split for segmental features and sonority. It remains to be seen how the restrictive theory of PS-constraints applies in other domains, such as, for example, the interaction between tone and prosody.

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