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FOOT-CONDITIONED PHONOTACTICS AND PROSODIC CONSTITUENCY

A dissertation submitted in partial satisfaction of the
requirements for the degree of

DOCTOR OF PHILOSOPHY

in

LINGUISTICS

by

Ryan T. Bennett

September 2012

The Dissertation of Ryan T. Bennett
is approved:

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Professor Junko Itô, Chair

_____

Professor Jaye Padgett, Chair

_____

Professor Armin Mester

_____

Assistant Professor Grant McGuire

_____

Dean Tyrus Miller
Vice Provost and Dean of Graduate Studies

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Abstract

Foot-conditioned phonotactics and prosodic constituency

by

Ryan T. Bennett

There has been a recurrent debate in generative phonology concerning the inclusion of hierarchical prosodic structure in phonological representations. On one side, there are those who argue that prosodic structure plays an indispensable role in the conditioning of phonological phenomena, especially stress, intonation, and segmental phonotactics. On the other side of the divide are researchers who suggest that all such phenomena yield to empirically adequate non-structural analyses, which are independently favored by criteria of theoretical parsimony.

This dissertation focuses on one aspect of the larger debate over prosodic organization: the existence of the metrical foot. In standard conceptions of phonological structure the foot is a prosodic constituent, falling between the syllable and the word, which mediates the assignment of word-level stress. The foot obviously has no role to play in non-structural theories of prosody. Such frameworks assume that stress assignment is not dependent on prosodic constituents, but is instead directly computed over segments or syllables on a metrical grid.

The evidence brought to bear on the choice of prosodic theory has, by-and-large, been drawn from the typology of attested stress patterns. Both structural and non-structural theories of stress appear capable of modelling roughly the same range of stress systems. Consequently, many of the arguments for or against foot structure have centered on the ability of each theory to express the typology of stress assignment in a compact, elegant, and predictive way. This dissertation expands the terms of the debate by examining foot-conditioned phonotactics, and to a lesser extent foot-conditioned morphology, as a window on the nature of prosodic constituency in natural language.

A major conclusion of this dissertation is that hierarchical prosodic structure must be admitted as part of phonological representations in order to capture the full range of prosodically-conditioned segmental phonotactics found in natural language. Three

case studies form the heart of this claim. Specifically, I show that Huariapano, Uspanteko, and Irish all manifest foot-dependent phonotactics that cannot be insightfully analyzed without recourse to abstract metrical structure. Importantly, these arguments go beyond claims about relative theoretical elegance: non-structural analyses simply fail to account for the relevant phonological phenomena in an explanatory way.

In arguing for a foot-based theory of stress assignment, I also make the case for a fairly traditional conception of the metrical foot. First, I contend that stress is always assigned on the basis of foot structure, and only to foot heads, though feet may be unstressed or 'covert' as well. Second, I argue that feet are always maximally binary, even in languages where stress assignment itself is ambiguous between binary and unbounded footing. Third, I propose that any given language makes use of at most one system or 'tier' of metrical organization (the UNIFORMITY OF FOOTING HYPOTHESIS). In particular, I demonstrate that the rhythmic phonology of Huariapano can and should be modeled within a single, unified system of foot structure, despite previous claims to the contrary. Along the way, I identify a novel source of phonological prominence effects: the augmentation of foot-initial syllables.

The dissertation closes with an artificial grammar study exploring how language learners acquire foot-conditioned segmental phonotactics. Given the 'hidden' character of abstract prosodic structure, foot-conditioned phonotactics pose an interesting learning problem. This is especially true given the recent rise of the view that all synchronic phonological knowledge is the result of inductive learning over phonetic regularities in the speech stream. The results of the artificial grammar study suggest that speakers of both English and Japanese were inclined to learn a stress-conditioned vowel phonotactic in terms of foot structure rather than stress *per se*. The experiment thus supports the claim that language learning is sensitive to a foot-based parsing bias that encourages the use of the foot as a general explanatory device in acquisition. These findings provide a possible explanation for why binary foot structure is found in languages lacking rhythmic, foot-based stress, and suggest that the foot may be a prosodic universal.

For the women who raised me — my mother Susanne, my
sisters Sarah and Alice, and all the rest — and for my
father, James Michael Bennett. We miss you Dad.

Acknowledgments

One of the more daunting aspects of writing this dissertation has been finding a concise way to express my gratitude to the many, many people who have helped me along the way. While I can't promise that the following acknowledgements will be brief (sorry), I hope they give a sense of the astonishing amount of support I've received over the years.

My life in linguistics began in summer 2004, in an excellent introductory class taught by Jen Nycz at New York University. From the moment we talked about $\overline{\text{X}}$-theory, I was hooked (something about abstract constituent structure, I guess). Luckily, it turned out that NYU was a wonderful place to study undergraduate linguistics. Three people at NYU deserve special recognition for their generosity during those years. John Singler, Maria Gouskova, and Lisa Davidson were always willing to offer their time and expertise, well beyond what I could have reasonably expected. Their encouragement, criticism, and guidance had a tremendous impact on me — not just in my thinking about linguistics, but also personally. For that, I am very grateful.

A seemingly endless cavalcade of people helped me navigate graduate school at UC Santa Cruz. Thanks are due, first and foremost, to the chairs of my dissertation, Junko Itô and Jaye Padgett. Junko and Jaye have always been extremely giving, both as advisors and as friends. They also managed the impressive feat of making me feel both challenged and reassured as I conducted my research. Their faith in me has made all the difference. Thanks, Junko, for helping me keep things in perspective, and for teaching me how to ride the trains in Tokyo. I am grateful to Jaye for many things, not the least for sharing the following maxim: it may be interesting, but that doesn't make it true.

Armin Mester and Grant McGuire were also kind enough to join my dissertation committee. Armin can always be counted on for an honest, insightful, and pragmatic assessment of one's work. My research has been greatly improved by his influence — thanks, Armin. Grant has made working in the Phonetics and Phonology Lab feel like a truly collaborative experience — I hope he got half as much out of our conversations as I did.

Many other people at UC Santa Cruz played major roles in my development as a

linguist, if I can be audacious enough to call myself one. Jim McCloskey's unflagging enthusiasm and trust in my work (albeit sometimes puzzling to me) has been instrumental in my success. Learning from and working with Jim has been a pleasure and a privilege. For the literal lack of better words, *go raibh míle maith agat*.

Special thanks are due to Robert Henderson and Judith Aissen for bringing me into the fold of Mayan linguistics. Robert deserves particular recognition for allowing me to reproduce some of the data and analysis from Bennett & Henderson (to appear) in Chapter 3. Having worked on that paper for almost two years, it's difficult to tell where his ideas end and mine begin; as far as I'm concerned, that's the hallmark of a truly collaborative project. Thanks for that, buddy, and for so much more.

One of the best things about having an office at Santa Cruz is that, sooner or later, Boris Harizanov will knock on your door to talk about linguistics. Carl Sagan supposedly said that if you want to make an apple pie from scratch, you must first create the universe; Boris has a similar knack for appreciating the complexity of the problems we face, and for recognizing how much fun we should have pursuing the answers. Being in a department with Mark Norris was also a joy: among other things, it was great to be around someone else who understands that doing good work in linguistics is still compatible with taking time out for the salutary practices of beer drinking and swimming.

In my first few years of grad school I learned an enormous amount about linguistics from Matt Tucker. Here's to the sunnier bogs ahead, my friend. The varsity-level phonologists at UC Santa Cruz — Abby and Aaron Kaplan, Dave Teeple, Jesse Saba Kirchner, Paul Willis, and Jeremy O'Brien — were a constant source of inspiration. When Vera Gribanova graduated from Santa Cruz, we were very lucky that she did not achieve escape velocity from Northern California. Thanks to Vera for all the good times and good advice, and for CrISP.

I'd like to thank Jorge Hankamer, Adrian Brasoveanu, Donka Farkas, and Matt Wagers for everything they've taught me, and for pushing me to do my best work. Thanks to Sandy Chung for the same reasons, despite the fact that I never got to take a class with her. While at Santa Cruz, I've had the good fortune to spend my time (free or otherwise) with friends like Scott AnderBois, Judith Fiedler, Ruth Kramer,

Anie Thompson, Nick LaCara, Oliver Northrup, Bern Samko, and Nate Arnett. I can't imagine going to grad school anywhere else, and I'm glad that I didn't have to. While Emily Elfner, Máire Ní Chiosáin, and Wendell Kimper were a bit farther east than everyone else (at least most of the time), I'm very glad that I got to know them during my tenure at Santa Cruz.

In April 2011 Maria Gouskova made an off-hand comment to me regarding segmental phonotactics in languages with iambic footing. This casual, but typically incisive remark inspired the analysis of Huariapano in Chapter 2, though it was months before I realized the impact that her suggestion had on my thinking. That makes *two* degrees in linguistics that Maria has helped me earn — thank you, Dr. Gouskova.

A panopoly of other people helped me complete and refine the research presented in this dissertation. Many of those people are thanked in individual chapters. My deepest apologies if I have left anyone out; the number of people I am indebted to surely outpaces my ability to keep track of them.

I would be remiss if I didn't thank my family, especially my mother, for everything they've given me. Words don't suffice to express how much their love and support means to me, so I'll keep it short: thanks, always.

Finally, thanks to Pedro Mateo Pedro for giving me the simplest and best advice I received about finishing my dissertation: don't worry, just keep working.

Per aspera ad astra. . .

Chapter 1

Introduction

Feets, don't fail me now!
Variously attributed to Willie Best, Stepin
Fetchit, and Mantan Moreland

This dissertation is concerned with non-accentual evidence for binary foot structure in natural language. The overarching goal of this work is to use foot-dependent phonological patterns to shed light on the nature of prosodic constituency below the word. Specifically, I will argue at length that the metrical foot is an indispensable component of phonological theory, and one that cannot be supplanted by reference to stress or segmental strings alone (*contra* Prince 1983, Selkirk 1984, Walker 1995, 1996, Gordon 2002a, Samuels 2009, van der Hulst 2009, submitted, and others). It follows from this conclusion that, despite recent suggestions to the contrary, hierarchical prosodic structure must play an integral role in the phonology of natural languages (cf. Steriade 1999, Seidl 2001, Pak 2008, Samuels 2009, Schiering, Bickel & Hildebrandt 2010, Scheer to appear). Furthermore, I provide typological and experimental evidence that at least some properties of foot structure have a universal basis: even in languages with drastically different accentual systems we find evidence for foot structure of a fairly homogeneous sort, with characteristics determined by a small, recurring set of constraints on the prosodic well-formedness of feet.

The empirical focus is on foot-conditioned segmental phonotactics, and to a lesser extent foot-conditioned tonotactics and prosodic morphology. At the core of the dissertation are three in-depth case studies exploring how foot structure conditions seg-

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mental patterns in several typologically distinct languages (Huariapano, Uspanteko, and Irish). These case studies are complemented by an artificial grammar experiment investigating whether language learners might be biased toward learning prosodically-conditioned phonotactics in foot-dependent terms. An essential finding of this dissertation is that, despite the centrality of footing in stress assignment, the binary foot should be construed as a rather general aspect of the phonological organization of words (as proposed by Liberman 1975, Hayes 1995, and others).

This work should be understand against a backdrop of three recent trends in phonological theorizing. The first such development is the move toward a radically bare-bones view of synchronic phonological knowledge, which I will call the REDUC-TIONIST TURN. This viewpoint, most closely associated with the work of John Ohala and Juliette Blevins, takes the strong position that all cross-linguistic regularities emerge from properties of language transmission and dissemination, rather than from cognitive mechanisms specific to the domain of linguistic knowledge. More succinctly, the reductionist turn denies the existence of UNIVERSAL GRAMMAR, in any form (Chomsky 1965, 1986, etc.). In reductionist models of this sort, all synchronic phonological knowledge must come from concrete, directly observable properties of the speech signal. As Blevins (2004:236) sums up the reductionist view:

> "...synchronic phonologies consist of generalizations in terms of phonological constructs extracted from the speech stream...This view of phonological knowledge as learned knowledge is at odds with many modern phonological theories which attribute a range of sound patterns to universal constraints which are part of the innate language faculty."

The existence of hierarchical prosodic structure poses a non-trivial challenge for reductionist conceptions of phonological typology and synchronic phonological knowledge. Here, I narrow the discussion to the role that the metrical foot plays in this larger debate. There are no direct phonetic correlates of foot structure. As with other units of the prosodic hierarchy (e.g. the syllable), evidence for footing is necessarily abstract and indirect — foot structure is 'hidden' structure. Nevertheless, in this dissertation I argue that foot structure is a robust part of synchronic phonological knowledge: reference to footing is needed to account for productive patterns governing the distribution of segments, as well as to explain the behavior of experimental participants learn-

ing an artificial phonological system. In other words, the mental representations of phonological objects appear to be richer than the speech stream itself.

Two questions thus present themselves for reductionist models: first, if prosodic structure is itself phonetically null, how do speakers arrive at the conclusion that their native language employs foot structure at all? And second, if typological regularities arise from properties of language transmission, what aspects of language use explain why the ontology of foot structure is fairly uniform across languages and language types?

It is true that foot boundaries may be cued by subphonemic segmental effects (e.g. Van Lancker, Kreiman & Bolinger 1988, Shaw 2007), which might provide a foothold for language learners as they acquire the prosodic system of their target language. However, such cues are clearly language-specific, and still require a process of indirect inference for the listener to uncover the phonological structure conditioning the effects in question (cf. the wide cross-linguistic variation in the phonetic realization of stress and syllable structure). More to the point, the existence of foot-conditioned, sub-segmental phonetic effects is itself a fact in need of an explanation. How does foot structure arise diachronically if, by its very nature, it has no direct, invariant phonetic correlates? And when foot structure does develop, why does it show the same core characteristics in language after language?

Blevins (2004) is herself aware of the difficulties that prosodic structure poses for radically reductionist theories of phonological knowledge. In fact, Blevins endorses a somewhat weaker version of the reductionist position, allowing for the possibility that "prosodic categories may be innate" (23). The consequences of this admission are clear: reductionist reasoning may successfully reduce the amount of innate phonological knowledge attributed to language learners, but it does not eliminate the role of universal grammar in phonological explanation.

This is not to suggest that reductionist or other functionalist accounts of prosodic structure are untenable. For example, Ohala & Kawasaki-Fukumori (1997), Steriade (1999, 2001) and Samuels (2009) offer essentially phonetic explanations for the existence of phonological phenomena that appear to be conditioned by syllable structure, and which do not require the postulation of abstract, prosodic constituents (innate or

otherwise). However, the facts laid out in this dissertation clearly delineate what aspects of foot structure must be accounted for by any theory of phonological knowledge. Taking it as given that foot structure is an active part of synchronic phonologies, any adequate phonological theory will need to explain how foot structure emerges in individual languages. Since (as I will show) the presence of foot structure in a particular language does not depend on the prior existence of phonetic stress — much less rhythmic stress — the diachronic development of foot-based phonotactics is a particularly thorny problem for reductionist modes of explanation.

Second, any theory of phonology will need to explain why foot structure is relatively homogeneous across languages, while also allowing for a constrained space of cross-linguistic variation to account for attested differences in foot parsing. Third, an adequate theory of prosodic structure should account for the induction process by which language learners arrive at the conclusion that the phonology of their native language is organized into abstract metrical constituents. Lastly, all theories must account for the fact that foot structure is an active part of phonological knowledge — a mental object with psychological reality — rather than an epiphenomenal property of language change, left behind as a trace of historical development (e.g. Bach & Harms 1972). That this much is correct is suggested by the results of the experiment described in this dissertation, which finds behavioral correlates of abstract foot structure in the grammaticality responses that participants provide after learning an artificial phonological system.

Universalist modes of explanation, which assume an innate basis for foot structure, account for all of these phenomena in one fell swoop. Foot structure exists in natural languages, and in mental representations, because it is part of universal grammar. As such, the instantiation of foot structure in any particular language will be limited to a small space of variation determined by the strictures that UG places on the metrical foot. Finally, there is no induction problem because there is nothing to induce: language learners infer the presence of phonetically 'hidden' foot structure in their target language because UG leaves them no other choice. The challenge for reductionist theories is to account for this array of facts in a principled and explicit way. Failing alternative, non-nativist explanations for the same phenomena, phonolog-

ical theory must admit that abstract, phonetically null, and plausibly innate prosodic structure exists as part of synchronic phonological knowledge. This conclusion, which I maintain is essentially correct, would provide strong evidence that the phonological component of universal grammar is indeed contentful.

The second recent trend that this dissertation responds to is a move toward a highly abstract conception of the relationship between stress and structural prominence. Within the last decade, a number of authors have proposed metrical models of stress assignment that allow for mismatches between foot-internal structural prominence (i.e. headedness) and the position of stress (i.e. prominence on the grid). This development, which I will call the DENIAL OF STRUCTURE-DEPENDENCE (DSD), is perhaps best exemplified by the proposals in Hyde (2002), González (2003) and Vaysman (2009). The fundamental tenet of the DSD is that stress prominence is derivative of structural prominence, but not contingent on it. It follows from this assumption that the prominence relations defined by foot structure (the distinction between heads and non-heads) may be directly at odds with the foot-internal prominence contrasts expressed by stress: foot heads may be unstressed, and foot dependents may be stressed. The DSD is thus related (albeit somewhat indirectly) to recent claims that phonological computation is partially or even entirely divorced from phonetics (e.g. Hale & Reiss 2008).

It is my contention that the DSD is conceptually problematic, and swings the pendulum too far toward abstractness, away from a formal representation of prosodic prominence that interfaces directly and naturally with the actual phonetic properties of stress. One of the earliest and most compelling motivations for modeling stress with metrical feet is the relational character of stress itself. Stress is relative phonetic strength: stressed syllables are 'stressed' only in virtue of being more prominent, along some phonetic dimension(s), than other syllables within the same domain. This simple truth about stress receives a direct expression in foot-based, structural models of prosody. Foot heads are those syllables that are designated as the most phonologically prominent within a foot. Relative phonetic prominence, i.e. stress, is then the phonetic interpretation of this abstract, relationally-defined notion of headedness. (Note that treating stress as the phonetic implementation of abstract, structural prominence

also straightforwardly accounts for the fact that stress has no invariant cross-linguistic phonetic correlates; see the discussion in Section 1.3.1 below.)

To reiterate, stress and headedness (*contra* the DSD) are not diacritic features that freely cross-classify. If foot structure exists in natural language — and as I show in this dissertation, it undeniably does — then stress must be fully dependent on the relative structural prominence defined by feet: stress is an expression of headedness, and nothing more. More bluntly, all stressed syllables are foot heads by definition, and there is no room for variation on this point. (Importantly, this structural conception of stress still leaves open the possibility of unstressed foot heads; see Sections 1.3.2 and 1.4.1.1 below, as well as Chapters 2 and 4.)

A related claim, and one that I also dispute, is that a single language may make use of multiple systems of metrical organization. Claims of this sort generally arise in the analysis of languages that seem to require one pattern of footing for stress placement, and another for the determination of a 'rhythmic' segmental process like vowel reduction or epenthesis (e.g. Rappaport 1984, Halle & Vergnaud 1987, Parker 1994, 1998a, Aion 2003, González 2005, Blumenfeld 2006, González 2007, Vaysman 2009, etc.). I see this view as another facet of the DSD, in that it posits a species of metrical structure, specific to particular phonotactic processes, that is *in principle inaccessible* to the system of stress assignment.

While radical reductionist accounts of phonological knowledge do not countenance enough abstract prosodic structure, I argue that this version of the DSD countenances too much. Specifically, I show that the rhythmic phonology of Huariapano, previously argued to necessitate two distinct metrical tiers, can be reconciled within a single unified system of word-level prosodic organization. By extension, this reanalysis of Huariapano phonology implicitly casts doubt on the need for multiple metrical tiers in any language. I am thus advocating for a fairly conservative view of metrical structure, though one that is securely grounded in conceptual and typological arguments.

The third strand of theorizing that this dissertation challenges is represented by a somewhat loose conglomeration of views which deny prosodic hierarchy theory, either in its particulars or in its entirety. These views fall into at least the following broad

classes:

(i) Stress assignment is not foot-based

- Prince (1983), Selkirk (1984), Walker (1995, 1996), Gordon (2002a), van der Hulst (2009, submitted)

(ii) The prosodic hierarchy (including the foot) does exist, but not all levels of the prosodic hierarchy are instantiated in every language

- Green (1997), Jun (2005), Labrune (2012)

(iii) Prosodic constituents exist, but rather than being universal, they are determined on a language-by-language basis

- Schiering et al. (2010)

(iv) Prosodic constituents do not exist

- Especially Samuels (2009); less so Seidl (2001), Pak (2008), Scheer (to appear)

The authors cited above vary in the strength and specificity of their skepticism. For example, while Seidl (2001), Pak (2008) and Scheer (to appear) deny the existence of prosodic constituents at or above the level of the prosodic word ω, they appear to be relatively noncommittal regarding the need for syllables and feet. In contrast, Samuels (2009) explicitly argues for the complete abandonment of hierarchical structure in phonological theory, syllables included.[1]

The tension between these views and my own position on the universality of the foot should be clear. I find the evidence that stress assignment is foot-based to be unimpeachable, especially given the particular foot-based phonotactics discussed in this dissertation. Consequently, views (i) and (iv) are untenable, at least inasmuch as

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[1]Somewhat puzzlingly, Samuels (2009:128) suggests that stress might be assigned using bracketed grids, as in Halle & Vergnaud (1987) and Halle & Idsardi (1995). Since the theory of stress outlined in those works makes use of hierarchically arranged prosodic consituents and gridmarks (see Section 1.4.2), I fail to see how this approach to stress assignment squares with a non-hierarchical conception of phonological structure.

they refuse to acknowledge the foot *qua* hierarchical prosodic constituent. View (iii), which takes prosodic categories to be emergent in nature, provides no account of the striking cross-linguistic uniformity of foot structure. If the foot is simply emergent, why does it develop in qualitatively identical ways in languages with otherwise divergent prosodic characteristics? Unadorned, the explanatory shortcomings of view (iii) are sufficient to doubt its viability, at least as regards the foot. While the facts presented in this work speak less directly to the belief that languages can 'opt out' of particular levels of the prosodic hierarchy (ii), the observation that foot structure can be found in many languages that do not have foot-dependent stress (Chapter 3) at least suggests the existence of a positive pressure to employ all the constituents of the prosodic hierarchy.

Within this theoretical context, the dissertation arrives at five main conclusions. First, the binary foot must be included in phonological theory, either as a primitive or as a derived notion. Second, the metrical foot has more in common with higher prosodic categories than often believed, especially regarding domain-edge effects and the possibility of limited recursion. Third, foot structure in individual languages can be more flexible than predicted by strict parametric approaches to footing, particularly with respect to rhythmic type. In other words, partitioning languages into 'iambic' and 'trochaic' classes turns out to be too restrictive, because the rhythmic type of feet may be systematically non-uniform in a given language, as determined by phonological or lexical factors. Fourth, stress always coincides with a foot head, but foot heads do not always bear phonetic stress. Fifth, there is strong evidence suggesting that the foot is universally (or at least near-universally) present in natural language, and furthermore exerts an influence on the kinds of phonological generalizations posited by language learners.

1.1 Background

At least since the seminal work of Liberman (1975), it has been recognized that word-level stress can be understood as a kind of prominence relation defined over abstract,

hierarchically-organized phonological constituents.[2] These constituents are standardly known as 'feet' (Selkirk 1980), a term that deliberately harkens back to the formal devices employed in classical poetics. Liberman's theory of stress assignment, and many of the theories that followed in its wake, are 'metrical' in the sense that word-level rhythm (the 'pulse train' defined by sequences of stressed and unstressed syllables) is determined by carving words up into smaller units (i.e. feet), and then calculating various prominence relations within and between those units.[3] I will use the terms 'metrical phonology' and 'metrical theory' to refer to any phonological framework that assumes the existence of bounded, hierarchically-structured prosodic constituents (feet) residing between the syllable and the word.

While the theory of stress developed in Liberman (1975), Liberman & Prince (1977) and Selkirk (1980) has been enormously influential, it has not gone unquestioned. A number of authors have suggested that foot structure can be dispensed with as a formal device in stress theory (either entirely or in certain specific domains) without any loss of descriptive coverage or explanatory force (see Prince 1983, Selkirk 1984, Walker 1995, 1996, Gordon 2002a, van der Hulst 2009, submitted for some examples, though these papers differ in the extent to which they advocate the abandonment of foot theory). In other words, alongside the metrical, foot-based frameworks inspired by Liberman (1975), Liberman & Prince (1977) and Selkirk (1980), we find competing proposals that analyze stress placement in non-metrical terms, with little or no reliance on foot-like constituent structure.

1.1.1 The crucible of foot-conditioned phonotactics

Taking the charitable (though perhaps inaccurate) view that both metrical and non-metrical theories are equally capable of accounting for the range of stress patterns

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[2]Other early articulations of this idea can be found in Prince (1975, 1976), Liberman & Prince (1977), McCarthy (1979), and Hayes (1981).

[3]The etymological reason for using the term 'metrical' to refer to theories with sub-word prosodic constituents is the fact that the Latin source word *metrum* means both 'poetic meter' and 'object used for measuring' (cf. Spanish *medir* 'to measure'). In other words, the metrical foot 'measures out' some sub-portion of the larger word, which is then used as the basis for stress assignment. See Liberman (1975:46) for discussion.

known to exist in natural language, how might we decide between the two frameworks? At least naively, non-metrical theories seem to do better in terms of parsimony, since they require fewer abstract theoretical entities to explain the same range of empirical data. However, this conclusion depends on the assumption that the explanatory role played by foot structure is limited to patterns of rhythmic stress. This assumption turns out to be deeply flawed: foot structure influences many non-accentual grammatical patterns, and in many cases provides an underlying rationale that explains why those particular patterns are found in the first place.[4]

As Prince (1983:87-8) rightly points out, the existence of non-accentual phonological patterns making crucial reference to the foot *qua* prosodic constituent would provide compelling evidence for a metrical theory of stress assignment (and prosodic organization more generally). In a metrical theory of stress, there is little extra cost to assuming that foot structure can condition other aspects of phonology. The same cannot be said for non-metrical theories. When presented with non-accentual evidence for the foot, an adherent of non-metrical phonology has only two choices: deny that the phenomenon in question requires reference to foot structure; or admit the foot into phonological theory, thereby nullifying the argument from parsimony in favor of a non-metrical model of stress.

Non-accentual, foot-sensitive phonological phenomena do in fact exist. It was proposed early in the development of metrical theory that the foot can serve as a conditioning domain for segmental allophony (e.g. Kiparsky 1979). This claim has been buttressed in the ensuing years as additional foot-based phonological patterns have been uncovered in the languages of the world (e.g. de Lacy 2002b, Gouskova 2003, González 2003, Blumenfeld 2006, McCarthy 2008b, Vaysman 2009, among many others; see also Chapers 2-4). The existence of such phenomena clearly tilts the scales in

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[4]The term 'accentual' is intended to be neutral between stress and lexical pitch accent, since at least some lexical pitch accent systems have been analyzed using the same binary prosodic constituents proposed for stress accent systems (e.g. Tokyo Japanese, Kubozono 2008, Itô & Mester 2011b, 2012a; see also Chapter 4). That said, the existence of metrically-organized lexical pitch accent also counts as an argument in favor of metrical theory, since lexical pitch accent and word-level stress are clearly distinct phonological phenomena (see Halle & Vergnaud 1987, van der Hulst & Smith 1988, Hayes 1995, Hyman 2006, 2009 for discussion). See also Chapters 3 and 4.

favor of a metrical model of prosodic organization.

To be sure, some purportedly foot-conditioned phonological patterns are open to reinterpretation in purely stress-based, non-structural terms. In trochaic systems, for example, 'foot-initial position' is equivalent to the beginning of the stressed syllable, and 'foot-medial position' is basically synonymous with 'post-tonic position' (see also Prince 1983, Selkirk 1984, Beckman 1998, González 2003, Smith 2005b, Flack 2009, who all raise some version of this point). In the face of such systematic ambiguity, many researchers have been justifiably skeptical when presented with alleged cases of non-accentual, foot-conditioned phenomena. Still, while stress and foot structure are in many cases confounded, this ambiguity is not absolute. There are a non-trivial number of phonological patterns that can be shown to depend on abstract foot structure rather than stress *simpliciter*. Much of this dissertation is dedicated to enumerating and elucidating foot-based phonological phenomena of this sort. In many such cases non-metrical theories of prosodic organization would require additional *ad hoc* formal machinery to accommodate the same facts; as such, this dissertation also represents a sustained argument in favor of metrical phonology.

Further evidence supporting a metrical theory of stress comes from morphological phenomena that refer to the foot as a prosodic constituent. For example, many languages have templatic morphological targets (for truncation, reduplication, word minimality conditions, etc.) that appear to correspond to a well-formed metrical foot (e.g. McCarthy & Prince 1986/1996, 1990, 1993b, 1994, 1999, Poser 1990, Mester 1990, Itô & Mester 1992/2003, Itô, Kitagawa & Mester 1996). Similarly, many languages have foot-conditioned affix selection or affix placement (e.g. McCarthy 1982, McCarthy & Prince 1993a, Mester 1994, Kager 1996). The upshot, of course, is that metrical theories also fare better than non-metrical theories in accounting for foot-sensitive prosodic morphology. While the emphasis of this dissertation is on foot-conditioned phonological patterns, I will touch on foot-conditioned morphology at a number of points as well, especially when relevant for establishing the presence of foot structure in a particular language.

A central claim of this dissertation is that credible evidence for binary foot structure can be found in languages where stress is not obviously foot-dependent (so-called

'unbounded' stress systems; see Prince 1983, 1985, Hayes 1995 for discussion). These are exactly the sorts of languages that seem most amenable to a non-metrical analysis, given that the postulation of foot structure does little explanatory work within the system of stress assignment. It thus comes as some surprise that we find *non*-accentual evidence for the foot in these languages (Chapter 3). The conclusion to be drawn here is that binary foot structure is more widespread than suggested by the typology of stress patterns alone. In this light, the argument from parsimony turns out to favor a metrical theory of stress over non-metrical alternatives: a theory of prosody that takes foot structure to be a necessary prerequisite for stress actually *predicts* that non-accentual evidence for footing might be found in languages with unbounded stress.

These results also provide an implicit argument against the use of unbounded or otherwise non-binary prosodic constituents in metrical phonology. Theories that rely on unbounded feet to generate unbounded stress are at a loss to explain why some languages with unbounded stress have phonological patterns that are conditioned by bounded, binary prosodic constituents. Similarly, theories that allow for bounded, but non-binary feet (e.g. ternary or quaternary feet) predict that some languages with unbounded stress might have phonotactics that are sensitive to non-binary prosodic structure — a prediction that does not appear to be borne out.

Curiously, the same kinds of facts can be adduced for languages without any stress at all. Analogous evidence for binary foot structure can be found in some prototypical tone and pitch accent languages that lack stress entirely. There also exist intermediate cases, languages in which only some feet (but not all) are realized with phonetic stress (see Crowhurst 1996, González 2003, van der Hulst submitted for some representative examples). This suggests that the relationship between stress and footing is unidirectional: phonetic stress always entails the presence of foot structure, but not vice-versa (a point that will arise repeatedly in Chapters 2, 3, and 4).

At this point, some important conceptual questions present themselves. What explains the emergence of foot-conditioned grammatical patterns in languages without clearly foot-dependent stress? To rephrase the issue slightly, how do speakers of languages with unbounded stress (or no stress at all) arrive at the conclusion that their native language employs foot structure? The typology of foot-conditioned phonotac-

tics thus introduces a *projection problem* (Chomsky 1965, Peters 1972, Baker 1979; see also McCarthy 1981): what induces language learners to postulate rich, hidden metrical structure in words that do not provide overt phonetic evidence for that structure? The hypothesis entertained in the last part of this dissertation is that the surprising cross-linguistic prevalence of foot structure is due (at least partially) to a cognitive bias that encourages language learners to formulate implicit phonological generalizations in terms of foot structure. This hypothesis finds support in the results of an artificial grammar experiment (Chapter 4) which suggests that speakers prefer to learn prosodically-conditioned phonotactics in terms of foot structure rather than stress, even when the data is fully consistent with either formulation of the phonotactic.

For this bias to explain the attested typology of foot-based phonological patterns, it must be grounded in some innate property of human cognition, domain-specific or otherwise. The existence of such a bias then predicts — correctly, to my mind — that foot structure should be extremely common in the languages of the world, independent of the distribution of foot-based stress (see also Wilson 2006, Moreton 2008). While I leave open the possibility that foot structure is only a near-universal of natural language, it is also true that foot structure might be universally present (i.e. cognitively and linguistically real) without being equally 'visible' in all languages (Hyman 2011).

1.2   Empirical contributions

The empirical contributions of this dissertation are twofold. First, I present in-depth case studies of foot-conditioned phonotactics in three typologically distinct languages. In Chapter 2 I analyze foot-sensitive [h]-epenthesis in Huariapano (Panoan; formerly spoken in Peru). This section of the dissertation includes an empirically-motivated reanalysis of the stress system of Huariapano, as well as a novel treatment of the conditions on [h]-epenthesis. The reanalysis of [h]-epenthesis also has several empirical and conceptual advantages over extant alternatives — in particular, it only assumes a single 'tier' for metrical structure, while previous analyses have either assumed multiple metrical tiers, or have made deeply problematic claims about the relationship between footing and stress. To bolster some of the theoretical claims made in this

chapter, I present supporting data from a range of additional languages.

In Chapter 3 I present evidence for phonologically-active binary foot structure in two languages with unbounded, edge-based stress: Uspanteko (Mayan; Guatemala) and Irish (Celtic; Ireland). The discussion of Uspanteko is based on original fieldwork (a joint project with Robert Henderson), and presents a subset of the results reported in Bennett & Henderson (to appear). Three distinct phonological phenomena jointly implicate a single, right-aligned, bisyllabic foot in content words in Uspanteko: (i) constraints on stress shift in the presence of lexical tone; (ii) the interaction of stress shift and vowel syncope; and (iii) static generalizations regarding the relationship between lexical tone and vowel quality. The discussion of Irish concerns two phenomena: foot-sensitive vowel epenthesis (Green 1997, Ní Chiosáin 2000); and a pattern of plural suffix allomorphy, which I analyze as being foot-based in nature. These phenomena provide convergent evidence for a left-aligned quantity-sensitive trochaic foot in Irish.

The second empirical contribution comes in the form of an experimental study of phonotactic learning biases. The typology of foot-based phonotactics suggests that binary foot structure can be found in many languages with unbounded stress (i.e. stress that is not obviously foot-based), as well as languages that do not have stress accent at all. It thus appears that the distribution of foot-based grammatical phenomena is largely independent of the distribution of rhythmic stress. Chapter 4 asks whether the prevalence of foot-conditioned phonotactics might be due to a learning bias that encourages language learners to state phonological regularities in terms of foot structure. This chapter reports on an artificial grammar study testing this hypothesis. The discussion covers the results of an experiment conducted with native English speakers, as well as a replication of the study with native Japanese speakers, and computational modeling of both experiments.

1.3 Theoretical overview: the basics

1.3.1 The metrical foot

The metrical foot (Ft) is a prosodic constituent that intervenes between syllables (σ) and the larger prosodic word (ω) containing those syllables (e.g. Liberman 1975, Liber-

man & Prince 1977, Selkirk 1980, 1984, Hyman 1985, and many others). The core evidence for foot structure comes from patterns of rhythmic (i.e. alternating) stress. For example, in Mansi (Uralic; Western Siberia; also known as Vogul) stress is assigned to every non-final odd-numbered syllable counting from the beginning of the word (1) (Hayes 1995:100,200, Vaysman 2009, and citations there).[5]

(1)   Stress assignment in Mansi (Vaysman 2009:212-6)

a.	[sá.mɛ]	'its eye'	ɔ́σ
b.	[á.tɛ.nəl]	'its smell (ablative)'	ɔ́σσ
c.	[ó.ma.tɛ̀.nəl]	'its mother (ablative)'	ɔ́σσ̀σ
d.	[pó.ca.ɣà.nəl.nəl]	'their (dual) drips (ablative)'	ɔ́σσ̀σσ
e.	[tá.kʷə.sà.ɣa.nə̀l.nəl]	'their (dual) autumns (ablative)'	ɔ́σσ̀σσ̀σ

The distribution of stress in Mansi can be straightforwardly captured under the following assumptions:[6]

(2)   a.   Words in Mansi are subdivided into binary metrical constituents (that is, feet) consisting of two syllables each.

       b.   Construction of feet begins at the left edge of the word and proceeds rightward.

       c.   Stress is assigned to the first syllable within each foot.

       d.   The leftmost stressed syllable bears primary stress.

The foot structure corresponding to the examples in (1) is thus as in (3).

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[5]Throughout this dissertation I use periods '.' to indicate syllable boundaries, parentheses '( )' to indicate foot boundaries, and square brackets '[ ]' to indicate prosodic word boundaries. Primary stress is marked with an acute accent on the stressed vowel [V́] or with the IPA symbol ['] preceding the stressed syllable. Secondary stress is marked with a grave accent on the stressed vowel [V̀] or with the IPA symbol [ˌ] preceding the stressed syllable. Unstressed syllables are sometimes marked with a breve, [ŏ] or [V̆]. Extrametrical elements are delimited with angle brackets '⟨ ⟩'.

[6]Vaysman (2009) assumes a different, quantity-sensitive algorithm for foot construction in Mansi. See Hansen & Hansen (1969), Hammond (1986), and Hayes (1995) for discussion of Pintupi (Pama-Nyungan; Australia), a language with the same basic stress pattern as Mansi that should clearly be analyzed in quantity-insensitive terms.

(3)   Footing in Mansi

    a.   [(sá.mɛ)]   'its eye' $(\acute{\sigma}\sigma)$

    b.   [(á.tɛ)nəl]   'its smell (ablative)' $(\acute{\sigma}\sigma)\sigma$

    c.   [(ó.ma)(tɛ̀.nəl)]   'its mother (ablative)' $(\acute{\sigma}\sigma)(\grave{\sigma}\sigma)$

    d.   [(pó.ca)(ɣà.nəl)nəl]   'their (dual) drips (ablative)' $(\acute{\sigma}\sigma)(\grave{\sigma}\sigma)\sigma$

    e.   [(tá.kʷə)(sà.ɣa)(nɒ̀l.nəl)]   'their (dual) autumns (ablative)' $(\acute{\sigma}\sigma)(\grave{\sigma}\sigma)(\grave{\sigma}\sigma)$

Assumption (2a) straightforwardly explains why stress never appears on an odd-numbered final syllable (3d): placing stress on a final syllable would require the construction of a non-binary foot, as in *[(á.tɛ)(nɒ̀l)], which Mansi does not allow. The prohibition against unary feet, taken in tandem with the requirement that stress fall on the initial syllable within each foot, thus accounts for the lack of final-syllable stress. The foot-based analysis of Mansi stress therefore derives the absence of final stress from theoretical assumptions that are independently needed to account for stress placement elsewhere in the word.

While the stress system of Mansi could be successfully treated in a non-metrical framework (e.g. Prince 1983, Gordon 2002a), interactions between stress and syllable weight in other languages clearly favor a model of stress that depends on prosodic constituency. Consider the following vowel length alternations in English (often dubbed 'trisyllabic shortening', Chomsky & Halle 1968; transcriptions reflect my pronunciation).

(4)   a.   *omen* [ó͡ʊ.mɨn]   *ominous* [á.mɨ.nɨs]

        b.   *divine* [də.vá͡ɪn]   *divinity* [də.ví.nə.ɾi]

        c.   *sane*   [sé͡ɪn]   *sanity* [sǽ.nə.ɾi]

        d.   *nation* [né͡ɪ.ʃɨn]   *national* [nǽ.ʃə.nəl]

The basic generalization is that stressed long vowels (here, diphthongs) shorten to lax monophthongs when appearing in antepenultimate position. One striking fact about these alternations is that, unlike other vowel reduction processes in English, they cannot be attributed to the effects of stress alone: the vowels in question bear primary stress when realized as long and short alike.

Prince (1991), picking up on earlier insights from Myers (1987), argues that these facts provide a strong argument for binary foot structure in English. The argument that prosodic constituency is relevant for such alternations is as follows. Assume that, in general, word-final syllables are extrametrical in English nouns (where 'extrametrical' ≈ not parsed into any larger prosodic structure; see Hayes 1981, 1982, Selkirk 1984 and much subsequent work).[7] Assume further that footing in English is quantity-sensitive and trochaic (for discussion of these concepts, see Hayes 1995 and Chapter 2). The examples in (4) will thus be footed as in (5) (where H = heavy, bimoraic syllable and L = light, monomoraic syllable).

(5) a. *omen* [(óʊ̯)⟨mɨn⟩]   *ominous* [(á.mɨ)⟨nɨs⟩]
                  (H́)⟨H⟩   (Ĺ L)⟨H⟩

     b. *divine* [də(vâɪ̯n)]   *divinity* [də(ví.nə)⟨ɾi⟩]
                    L(H́)   L(Ĺ L)⟨L⟩

     c. *sane* [(sêɪ̯n)]   *sanity* [(sǽ.nə)⟨ɾi⟩]
                  (H́)   (Ĺ L)⟨L⟩

     d. *nation* [(nêɪ̯)⟨ʃɨn⟩]   *national* [(nǽ.ʃə)⟨nəl⟩]
                    (H́)⟨H⟩   (Ĺ L)⟨H⟩

The descriptive generalization can then be restated in terms of foot structure: long vowels bearing primary stress shorten when parsed together with a following light syllable into a bisyllabic foot. On this view, 'trisyllabic shortening' amounts to the avoidance of (H́ L) trochees, a well-attested phenomenon in other trochaic languages (e.g. Prince 1991, Mester 1994, Hayes 1995). Further confirmation that the process in question is sensitive to foot structure comes from words like *conic*, which manifest the same pattern of vowel shortening despite the fact that the relevant vowel is in the penult rather than the antepenult.

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[7]Most adjectival suffixes are also extrametrical in English (Hayes 1982), which accounts for the lack of final stress in *ominous* and *national* in (5). The suffix *-ic* (6) is an exception to this pattern.

(6) a. *cone* [kóʊ̯n] *conic* [ká.nɨk]

  b. (H́) (kóʊ̯n) (Ĺ L) (ká.nɨk)

Quantitative adjustments of this sort, in which the weight of a stressed syllable co-varies with properties of an adjacent unstressed syllable, provide powerful support for foot-level prosodic constituency (see especially Hayes 1981, 1995; and see Chapters 2, 3 and 4 for similar arguments from segmental phonotactics).

There are also conceptual reasons for taking stress to be metrically-organized.[8] Stress is inherently a *relational* notion: stressed syllables are stressed only in virtue of being more prominent, along some phonetic dimension(s), than other syllables within the same phonological domain. The relational nature of stress explains (among other things) why distinctions of stress in a given word are insensitive to the volume at which that word is pronounced — one can't imbue unstressed syllables with phonological stress simply by yelling, and one doesn't obliterate differences between degrees of stress by speaking quietly. Metrical approaches to stress assignment express the re-lational character of stress directly: stressed syllables are stressed in virtue of being the most prominent element within a containing foot. The location of foot-internal prominence is determined structurally, on a language-particular basis. In Mansi, for instance, the leftmost syllable within each foot is designated as the most prominent, or strong element.[9]

(7) a. [(sá.mɛ)] 'its eye'

  b. Ft

        σ_s σ_w
        △   △
        sá   mɛ

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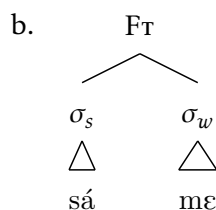
[8] See Liberman (1975), Liberman & Prince (1977), and Hayes (1995) for lucid discussion of the conceptual issues raised in this section.

[9] The notations s and w stand for 'strong member of the foot (head)' and 'weak member of the foot (dependent)' respectively. At times I also use the equivalent diacritics ʜ and ᴅ to mark foot heads and foot dependents.

Distinctions between primary stress and secondary stress fall out analogously: the foot bearing primary stress is the foot that, in virtue of its structural position, is more prominent than all other feet within the same word (in Mansi, the leftmost foot). The formal notation of foot structure, as one aspect of "a relational theory [that] defines relative prominence as a [local] feature of constituent structure" (Liberman & Prince 1977:263), thus transparently reflects the relational nature of stress itself.

In a metrical theory of stress, phonetic stress is derivative of underlying phonological structure — specifically, the hierarchical structures defined by footing, and the prominence relations defined over those feet. In such a metrical theory, it comes as no surprise that the phonetic cues to stress vary across languages. For example, phonetic vowel lengthening cues stress in the Mayan language Kaqchikel, but not in the closely related language K'ekchi (Berinstein 1979); similarly, pitch (F0) is a reliable cue to stress in English, but less so in Welsh, Czech, Polish, and other languages (Fry 1955, 1958, Cutler 2005). Even in a single language, the phonetic realization of stress can be highly variable both within and across speakers (see Cutler 2005 for a summary). It is well-known that languages may differ in how particular phonological structures are phonetically instantiated (e.g. Cho & Ladefoged 1999). But unlike segmental features (lip rounding, vowel height, etc.), stress has no inherent phonetic correlates — it is a relationally-defined structural property that may be cashed out along a variety of phonetic dimensions.[10]

Finally, the foot-based theory of stress correctly claims that the syllable is the unit of stress assignment (Hayes 1995, Ladefoged 2006): stress is defined over feet, and feet are defined over syllables. No special provision is needed to identify the syllable as the stress-bearing unit; it is a necessary consequence of the structural assumptions of metrical theory. The foot-based definition of stress therefore rules out the possibility of syllable-internal contrasts in stress placement, as the empirical facts demand (though cf. Halle & Vergnaud 1987, Cairns 2002).

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[10]See also Trubetzkoy (1939), Bollinger (1958), Beckman (1998), de Lacy (2002b), Smith (2005b) on stress and phonological prominence.

1.3.2 Non-accentual evidence for footing

A recurring theme in this dissertation is that many prosodically-determined, but non-accentual phonological regularities can only be adequately explained within a metrical view of prosodic structure. The reason for this is simple: footing may have ramifications for word-level phonology that are wholly independent of the conditioning effects of stress. The truth of this claim is made particularly clear by the fact that foot-based phonological patterns are sometimes observable even in the total absence of phonetic stress. That is, some foot-conditioned segmental patterns are in fact insensitive to stress, though the general correlation between stress and foot structure can sometimes give the spurious suggestion of stress-conditioning.

By way of illustration, in this section I outline three phonological patterns that implicate abstract foot structure as a conditioning factor. The goal is to demonstrate (by ostension) how to identify a truly foot-based phonotactic pattern. One basic heuristic proves useful in this regard: whenever the phonological properties of a particular syllable depend on the properties of an adjacent syllable, we may be dealing with a foot-based phonological pattern. This is especially true when the phenomenon in question is sensitive to stress, syllable weight, or syllable count. There are of course other indications that foot-based conditioning might be at play in a given phonological pattern — rhythmicity, disyllabic bounding, prosodically-influenced alternations in segmental strength, etc. — but I mostly postpone discussion of these additional clues until Chapters 2 and 3, where they become especially relevant.

1.3.2.1 Stress assignment in Kiriwina

Kiriwina is an Austronesian language spoken in the Trobriand Islands. Stress assignment in Kiriwina has two striking properties: first, it is sensitive to vowel sonority; and second, this sensitivity depends on the sonority of the *post-tonic* syllable rather than the sonority of the stressed vowel itself. The following presentation draws on de Lacy (2004, 2007); see those publications for more in-depth analysis, and Kenstowicz (1994, 1997), de Lacy (2002b), Kiparsky (2008) for further discussion of sonority-driven stress.

Default stress in Kiriwina falls on the final syllable if heavy (8), otherwise on the

penult (9). As de Lacy (2004, 2007) points out, this system of stress assignment implicates the presence of a quantity-sensitive trochaic foot falling as close as possible to the right edge of the word.

(8)   Stressed heavy ultimas

    a.   [i.ki(ˈum)] 'he did secretly'

    b.   [tau(ˈau)] 'hey, men!'

(9)   Stressed penults in words ending in a light ultima

    a.   [(ˈpeu)la] 'strong'

    b.   [i.koi(ˈsu.vi)] 'clear throat'

A remarkable fact about this system of stress assignment is that stress will retract to the antepenult if and only if doing so would derive a bisyllabic trochee with a low-sonority high vowel [i u] in its weak branch (10).

(10)   a.   [(ˈmi.gi)la] 'the face'

       b.   [(ˈla.mi)la] 'outrigger log'

       c.   [(ˈme.gu)va] 'white magic'

       d.   [la(ˈsi.ku)la] 'pull canoe'

       Cf.

       e.   [bo(ˈna.ra)] 'shelf (in house)'

       f.   *[(ˈbo.na)ra]

       g.   [i.gi.bu(ˈlu.i)] 'he is angry at'

       h.   *[i.gi(ˈbu.lu)i]

Example (10a) demonstrates that the sonority of the stressed vowel itself is not at issue in sonority-driven stress shift. The shifted form [(ˈmi.gi)la] and the non-shifted form *[mi(ˈgi.la)] both bear stress on the high vowel [i]. The crucial distinction between the two alternative parses is that the shifted form [(ˈmi.gi)la] has a low-sonority [i] in the weak branch of the foot, while the non-shifted form *[mi(ˈgi.la)] has a high-

sonority [a] in the same structural position. Example (10g) further demonstrates that antepenultimate stress is prohibited when leaving stress in its default, penultimate position would already result in a foot containing a low sonority vowel in its weak branch.

While these facts technically constitute accentual evidence for the foot, it is notable that the sonority of the stressed vowel itself is not the determining factor for non-default stress assignment in Kiriwina. As with 'trisyllabic shortening' in English (4), the fact that properties of the stressed syllable co-vary with properties of the post-tonic syllable provides excellent evidence for the claim that stress is assigned within a metrical constituent, i.e. that stress assignment is foot-based in nature.

1.3.2.2   Lenition in Ibibio

Ibibio is a Niger-Congo language spoken in southern Nigeria. While Ibibio makes abundant use of lexical tone, Ibibio words do not bear phonetic stress of any sort. Nevertheless, there is convergent evidence for trochaic foot structure in the language. Evidence for footing in Ibibio can be found in Harris & Urua (2001), Akinlabi & Urua (2003) and Harris (2004). Here, I focus on the argument from lenition, as outlined in Harris & Urua (2001) and Harris (2004).

Ibibio exhibits a process of lenition in which the non-geminate stops /p t k/ become lenited [β ɾ ɣ] in intervocalic position (11).[11]

(11)   a.   [díp] 'hide'
         b.   [díβé] 'hide oneself'

         c.   [bèt] 'push'
         d.   [bèɾé] 'push oneself'

         e.   [fʌ́k] 'cover'
         f.   [fʌ́ɣɔ́] 'cover oneself'

However, not all intervocalic stops are subject to this process of lenition. Root-initial

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[11] The symbols [β ɾ ɣ] represent "frictionless continuants or 'tapped approximants'" rather than their literal IPA values (Harris 2004:16).

stops are exempt, and surface unchanged even when appearing between vowels.

(12) a. [ú-táŋ] 'plaiting'
      b. *[ú-ɾáŋ]

      c. [ú-kʌ́p] 'covering'
      d. *[ú-ɣʌ́p]

      e. [í-bàt-tá] 'she/he is not counting'
      f. *[í-βàt-tá]

Harris & Urua (2001) and Harris (2004) propose that the resistance of root-initial stops to lenition can be understood if (i) lenition only occurs when the relevant [VCV] sequence is contained within a single foot, and (ii) all roots begin with a left-aligned trochee. These assumptions jointly derive the contrast in (13).

(13) a. [(fʌ́.ɣɔ́)] 'cover oneself'
      b. *[(fʌ́.kɔ́)]

      c. [ú(kʌ́p)] 'covering'
      d. *[ú(ɣʌ́p)]

Further evidence for the foot-based analysis of Ibibio lenition comes from the fact that lenition is sensitive to the *distance* between the root-initial syllable and the target stop. For example, lenition applies to the onset consonant of the negative suffix when it attaches to a monosyllabic, vowel-final root (14). However, lenition is inhibited in the very same suffix when it is affixed to a disyllabic, vowel-final root (15).

(14) a. [séé-ɣé] 'not look'
      b. [dáá-ɣá] 'not stand'

(15) a. [sà.ŋá-ké] 'not walk'
      b. *[sà.ŋá-ɣé]

  c. [dáp.pá-ké] 'not dream'

  d. *[dáp.pá-ɣé]

  e. [fáá.ŋá-ke] 'not argue'

  f. *[fáá.ŋá-ɣe]

Under the assumption that all roots begin with a trochee, [séé-ɣé] will be footed [(séé.ɣé)], which correctly predicts the application of lenition (there is independent evidence that Ibibio prefers (CVX.CV) trochees in certain circumstances; see Harris & Urua 2001, Akinlabi & Urua 2003, Harris 2004). Similarly, the footing [(dáp.pá)ké] correctly predicts that lenition should fail to apply in (15), precisely because lenition in Ibibio is foot-bounded in nature.[12]

  This case of foot-conditioned allophony is particularly compelling given that Ibibio does not have phonetic stress prominence. As a result, reanalyzing foot-bounded lenition as a stress-conditioned phonotactic (the typical strategy in non-metrical frameworks) is simply not an option.

1.3.2.3 Iambic lengthening Kashaya Pomo

Kashaya is a severely endangered Pomoan language spoken by fewer than 50 people in Northern California. Data in this section is taken from Buckley (1994b) (with modified transcriptions); see also Buckley (1992, 1994a, 1997, 2009) and Buckley & Gluckman (2012).

  Footing in Kashaya is iambic. As in many iambic languages, if the head of a foot

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[12]Vaysman (2009:188) offers an alternative, non-metrical analysis of the Ibibio facts. In her view "a voiceless stop lenites after a prominent syllable," where 'prominent' is shorthand for 'initial in the prosodic word' (or perhaps 'initial within the root'). An obvious shortcoming of this analysis is that it provides no explanation for why the syllable following a ω/root-initial syllable should be a position targeted by lenition. On the foot-based analysis of Ibibio, the ω/root-initial syllable and the syllable that follows form a prosodic constituent; lenition then boils down to the fact that foot dependents are prosodically weaker than other unstressed syllables, and often host a reduced or otherwise altered set of segmental contrasts (e.g. Kager 1989, Gouskova 2003, Blumenfeld 2006, McCarthy 2008b, Norris 2010, Itô & Mester 2011a; Chapters 2-4). See also Harris & Urua (2001), Harris (2004), Downing (2004) and Hyman (2011) on foot-based positional asymmetries concerning possible segmental constrasts in a range of African languages.

is an open [CV] syllable, the vowel of that syllable undergoes lengthening (16). The result is an alternating, rhythmic pattern of vowel lengthening (which is inhibited in final syllables (16b), another common phenomenon; Buckley 1998).

(16) Iambic lengthening in Kashaya

   a. UR: / mo-mul-icʔ-enʔ-icenʔ-i /

   b. SR: [(mo.<u>mú꞉</u>)(li.<u>cʔe꞉</u>)(du.<u>ce꞉</u>)du]

   c. Gloss: 'keep running all the way around (singular)'

   d. UR: / mo-ht-mul-icʔ-wacʔ-wacʔ-ijicʔ-ʔ /

   e. SR: [(móh)(ti.<u>mu꞉</u>)(licʔ)(wacʔ)(wa.<u>cʔi꞉</u>)(jiʔ)]

   f. Gloss: 'keep running all the way around (plural)'

   g. UR: / nʔa-mac-qa-wacʔ-ijicʔ-me=ʔ /

   h. SR: [(da.máchʰ)(qa.<u>wa꞉</u>)(cʔi.jicʔ)(meʔ)]

   i. Gloss: 'Keep coming in here! (plural)'

Vowel length is otherwise contrastive in Kashaya (e.g. [ʔihja] 'wind' vs. [ʔihja꞉] 'bone'), and iambic lengthening fully neutralizes underlying length contrasts (Buckley 1994b:172).

The twist here is that stress is non-iterative in Kashaya: any given word contains at most one stress peak, normally on the leftmost foot (though there are predictable exceptions).[13] Nevertheless, the rhythmic character of vowel lengthening clearly points toward a foot-based analysis, as does the fact that stress will fall on a lengthened vowel if it is the head of the first foot in the word. Iambic lengthening in Kashaya is therefore foot-dependent, but separable from the conditioning effects of surface phonetic stress.

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[13]As far as I know, Buckley does not specify how stress is cued phonetically in Kashaya. Since vowel length is contrastive in the language, I would guess that pitch and intensity are indicators of stress prominence (see also Buckley & Gluckman 2012).

A further issue is that feet may cross word boundaries in Kashaya. Consequently, stress must be assigned at the phrasal level rather than the word level. Despite this, it is clear that iambic lengthening is a word-level process: while footing may change between the word and phrase levels, the vowel length distributions resulting from word-level iambic lengthening are retained. See especially Buckley (1997).

Very similar points can be made for the Panoan language Capanahua (Chapter 2). Capanahua has a rhythmic process of coda [ʔ] deletion which applies in even-numbered syllables, counting from left-to-right (Loos 1969, González 2003). On the assumption that [ʔ] deletion occurs in the weak branch of the foot (González 2003), this process implicates iterative, left-to-right, trochaic footing. However, as in Kashaya, only the leftmost foot bears phonetic stress in Capanahua. The rhythmic deletion of coda [ʔ] is therefore plausibly foot-based, but independent from phonetic stress itself.

1.3.2.4   Summary

In this section I have presented three qualitatively different examples of phonotactic patterns conditioned by the presence of abstract metrical structure. The intent was to provide some convincing cases of foot-dependent segmental phenomena, thereby setting the scene for Chapters 2 and 3, in which I argue for a foot-based treatment of morpho-phonological phenomena in a number of other languages. The next section is dedicated to explicating two theories of prosodic constituency that are consistent with the basic claims of this dissertation: prosodic hierarchy theory, and simplified bracketed grid theory.

1.4   Two metrical frameworks

1.4.1   Prosodic hierarchy theory

Prosodic hierarchy theory was inaugurated by Elisabeth Selkirk in a series of articles in the late 1970s and early 1980s (e.g. Selkirk 1978, 1980, 1986). Selkirk's early proposals were subsequently developed and extended by other authors; a partial list of influential work in this tradition includes Selkirk (1984), Hyman (1985), Nespor & Vogel (1986), Pierrehumbert & Beckman (1988), Hayes (1989, 1995), Inkelas (1990), Selkirk (1996), Ladd (2008) and various papers by Junko Itô and Armin Mester (e.g. Itô & Mester 1992/2003, 2009, 2010, 2012a,b).

While prosodic hierarchy theory has various incarnations, all research in this framework shares two basic assumptions: first, that phonological representations are structured into hierarchically-composed prosodic constituents; and second, that these

prosodic constituents are stratified into discrete PROSODIC CATEGORIES, or 'levels'. These categories are organized further into a PROSODIC HIERARCHY, which defines a set of ordering relations over the different constituent types. Speaking somewhat imprecisely, these relations express the relative 'size' of different prosodic constituents: a prosodic category C^a is composed of only those categories C^b such that $b \leq a$ on the hierarchy (i.e. domains at level C^a contain only domains of level C^a or smaller). This is known as the assumption of LAYEREDNESS (Selkirk 1996 and references cited there).

(17)   LAYEREDNESS:
    *$[_a\ [_b\ ]\ ]$, $b > a$ on the prosodic hierarchy

A fairly standard statement of the prosodic hierarchy is given in Figure 1.1, in which the utterance (υ) occupies the topmost level of the hierarchy and the mora (μ) (or segment) stands at the lowest level.[14] The strongest version of the theory assumes that these categories are universal (e.g. Vogel 2009; see also Chapters 2-4), though as discussed earlier in this chapter, there is some variation on this point in the literature.

A simple example utterance, parsed into the prosodic levels in Figure 1.1, is provided in (18).

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[14]While Figure 1.1 illustrates a reasonably orthodox view of the prosodic hierarchy (at least given the present state of the field), a number of modifications to this structure have been proposed. For example, Nespor & Vogel (1986) and Vogel (2009) (among others) have argued that the CLITIC GROUP constitutes an independent level of the hierarchy. Similarly, various analyses of Japanese prosody (e.g. Poser 1984, Pierrehumbert & Beckman 1988) assume a separation between 'major' and 'minor' phonological phrases (though cf. the battery of recent work by Itô and Mester disputing this claim). Some researchers have advocated the elimination of the utterance as a distinct category (e.g. Itô & Mester 2012b; see also Kawahara & Shinya 2008), or for treating the mora as a property of syllables rather than a true prosodic unit (e.g. Itô & Mester 1992/2003, Lunden 2006). The existence of such debates does not in any way indicate that practicioners of prosodic hierarchy theory are in disagreement about the foundational assumptions of the framework.

υ   Utterance
|
ιP   Intonational Phrase
|
ϕP   Phonological Phrase | Interface categories |
|
ω   Prosodic Word
|
- -
|
Ft   Foot
|
σ   Syllable | Rhythmic categories |
|
μ / X   Mora / Segment

Figure 1.1: The prosodic hierarchy (Selkirk 1980, 1984, Hyman 1985, *et seq.*)

(18)   Prosodic structure of a simple utterance in prosodic hierarchy theory

    a.   When Pancho died, Lefty fled north.

    b.

Within a structure like (18), the usual graph-theoretic notions of constituency, containment, (immediate) domination, precedence, etc. hold (see Partee, ter Meulen & Wall 1990 and Carnie 2010; more on this in a moment).

A major goal of prosodic hierarchy theory is to account for the fact that the prosodic

domains found in a given utterance (marked by pauses in speech, tonal excursions, and other phonetic phenomena) may be only partially isomorphic to the syntactic structure underlying that utterance (Chomsky & Halle 1968, and many, many others in its wake). For example, a complex noun phrase like *the house that Maria built* contains (under standard assumptions) a richly-articulated structure of syntactic constituents: $[_{DP}$ the $[_{NP}$ $[_{NP}$ house] $[_{CP}$ that $[_{VP}$ $[_{DP}$ Maria] built]]]]. While the prosodic realization of this noun phrase will vary by context, it is clear that the surface phonological form of such strings will always contain less constituent structure than the underlying syntax. Consider, for instance, the fact that no fluent, discourse-neutral production of *the house that Maria built* would contain a strong prosodic break between *the* and *house*, despite the presence of a major syntactic boundary in that position.

Prosodic hierarchy theory accounts for such mismatches between prosodic and syntactic constituency by assuming that syntactic structures are mapped onto prosodic domains that have their own organizing logic. This mapping ensures that there will be some correspondence between prosodic and syntactic constituents; the existence of independent conditions on prosodic structure explains why the isomorphism between syntax and prosody is only partial. In particular, purely phonological constraints on the form of prosodic domains — e.g. a preference for binary branching (Itô & Mester 1992/2003, Elfner 2012) — may disrupt the mapping from syntax to prosody, leading to incongruencies between the two levels of structure. Within this view of the relation between syntax and prosody, Itô & Mester (2012b) draw a useful distinction between the 'interface categories' ω, ϕP, ιP, and υ — which are partially determined by a mapping from morpho-syntactic constituents to prosodic domains — and the 'rhythmic categories' Fт, σ, and perhaps μ, which are purely phonological in character (see also Selkirk 1984, 1986 and Chapter 2). (Note that the distinction between 'rhythmic' and 'interface' categories is only conceptual, and does not have any status within the theory itself.)

It should be stressed that the category labels in Figure 1.1 and (18) are not just convenient descriptors for prosodic domains of different sizes. On the contrary, the categories of the prosodic hierarchy are taken to be formal primitives that phonological computation can refer to. For instance, languages are free to impose conditions on

the well-formedness of feet (Fᴛ) or prosodic words (ω) that they do not also impose on phonological phrases (ϕP). Similarly, different 'interface categories' may be subject to different mapping principles: it is generally assumed that prosodic words (ω) correspond to terminal nodes (or morphological words) in the syntax; phonological phrases (ϕ) correspond to maximal projections (full xᴘs); and intonational phrases correspond to full clauses (basically cᴘs, though perhaps only those carrying illocutionary force; see Bennett, Elfner & McCloskey in prep).

Selkirk (1996) (building on Selkirk 1984, Inkelas 1990, Itô & Mester 1992/2003, and related work) suggests that prosodic structure is built in accordance with four 'constraints on prosodic domination'. These constraints are given in (19).

(19)   Constraints on prosodic domination (C^n = a prosodic category of level n)

   a.   Inviolable constraints:

      (i)   Lᴀʏᴇʀᴇᴅɴᴇss:
            No C^a dominates a constituent C^b, $b > a$ (e.g. no σ dominates a Fᴛ)

      (ii) Hᴇᴀᴅᴇᴅɴᴇss:[15]
            Any C^a must dominate a constituent C^{a-1}, unless C^a is the lowest level of the prosodic hierarchy (e.g. each ω dominates at least one Fᴛ).

   b.   Violable constraints:[16]

      (i)   Exʜᴀusᴛɪᴠɪᴛʏ:
            No C^a immediately dominates a constituent C^b, $b < a - 1$ (e.g. no ω immediately dominates a σ)

---

[15]Somewhat counter-intuitively, this definition of Hᴇᴀᴅᴇᴅɴᴇss actually allows for prosodic constituents without any head at all: it is satisfied by a configuration in which a constituent of level C^a contains only non-heads of level C^{a-1} (e.g. a foot containing only unstressed, non-head syllables). It is, one hopes, an empirical question as to whether this loophole is desirable. See Crowhurst (1996) for related discussion.

[16]In this dissertation I use the Pᴀʀsᴇ(π) family of constraints (Prince & Smolensky 1993/2004) to generate the effects of Selkirk's (1996) Exʜᴀusᴛɪᴠɪᴛʏ condition. See Itô & Mester (2009) for discussion of some differences and similarities between these two ways of enforcing exhaustive parsing. Similarly, I use constraints of the form *Rᴇᴄuʀsɪᴏɴ(π) to implement Selkirk's NᴏɴRᴇᴄuʀsɪᴠɪᴛʏ condition.

(ii) NonRecursivity:

No C^a immediately dominates a constituent C^b, $a = b$ (e.g. no Ft immediately dominates another Ft)

Constraints (19ai-ii) are taken to be inviolable, almost definitional conditions on the well-formedness of prosodic structures. Taken togther, they express the core intuition behind the strict layer hypothesis of Selkirk (1984) and Nespor & Vogel (1986). Informally, the strict layer hypothesis amounts to the claim that prosodic structure always consists of a series of 'nested' prosodic constituents, embedded in such a way as to respect the ordering relations defined by the prosodic hierarchy.[17] Somewhat more precisely, (19ai-ii) ensure that each constituent in a prosodic representation will dominate at least one constituent lower on the hierarchy, and no constituents higher. More simply, the nesting of prosodic constituents always begins at the top level of the hierarchy, and moves uniformly downward.

In a sense, layeredness simply expresses the claim that there *is* a prosodic hierarchy, and as far as I know no one has ever successfully disputed this facet of the theory (though see Seidl 2001 and Pak 2008 for some different views). The case for treating headedness (19aii) as an inviolable stricture has been made by McCarthy & Prince (1986/1996), Itô & Mester (1992/2003), McCarthy (2008b), Itô & Mester (2009), and others (more on this below, and in Chapters 3 and 4). But what of Exhaustivity (19bi) and NonRecursivity (19bii)? I follow Selkirk (1996), Truckenbrodt (1999), and related work in assuming that these conditions represent 'soft' preferences regarding the form of prosodic structure — in other words, they amount to violable constraints on prosodic representations. Indeed, in Chapter 2 I argue at length that footing in the Amazonian language Huariapano is sometimes recursive, though non-recursive footing is demonstrably the preferred parsing strategy in the language (see also Itô &

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[17]Formally:

(i) The strict layer hypothesis (Selkirk 1984):

A category of level C^a in the prosodic hierarchy immediately dominates a (sequence of) categories of level C^{a-1}.

Mester 2007, 2009, 2010, 2012a,b, Ladd 2008). Along similar lines, In Chapter 3 I claim that the metrical systems of Irish and Uspanteko employ non-iterative footing: all words contain at most one (maximally bisyllabic) foot. As a consequence, words of three or more syllables necessarily violate Exhaustivity to some degree. It follows then that NonRecursivity and Exhaustivity (unlike Layeredness and Headedness) must be violable conditions on prosodic structure. These are fairly uncontroversial assumptions within current phonological theorizing, so I won't justify them in any greater detail here.

Finally, it should be mentioned that the four conditions in (19) are not intended to be an exahustive listing of constraints governing prosodic structure. Many other constraints help shape the form of prosodic domains, including constraints on the positioning of constituents and on the properties of domain-internal structure. Some of these additional constraints are addressed in the next section, where I discuss the place of the foot in prosodic hierarchy theory.

1.4.1.1   The foot in prosodic hierarchy theory

Within prosodic hierarchy theory the foot is taken to be an autonomous structural category, just like any other level of the hierarchy. In other words, the foot is an irreducible primitive of the theory. The foot stands in a hierarchical relationship with the other prosodic categories listed in Figure 1.1. Most importantly, feet are constructed over syllables (Selkirk 1980, Hayes 1995; cf. Halle & Vergnaud 1987, Cairns 2002), and subsequently parsed into a larger, containing prosodic word (ω).[18]

One property that distinguishes the foot from other prosodic categories is its relational character (see Section 1.3.1 and elsewhere in this chapter).[19] Each foot contains at least one syllable designated as the head, or most phonologically prominent ele-

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[18]In principle, a foot could be parsed directly into a phonological phrase (ϕP) or intonational phrase (ιP) while still respecting the core tenets of prosodic hierarchy theory. At the moment no clear examples of this sort of parse come to mind, though I suspect that large discourse particles (such as English *like* or Spanish *como* [ˈko.mo]) might fit the bill.

[19]This might be too strong: in order to capture the difference between head and non-head feet — i.e., between primary and secondary stress — it may be necessary to conceive of the prosodic word (ω) as a relational category as well.

ment within that foot. Any other syllables within the foot are considered weak, or non-prominent. Standard versions of prosodic hierarchy theory assume that feet are maximally bisyllabic, so a given foot consists of at most one strong syllable and one weak syllable.[20] This assumption is bolstered further in Chapters 3 and 4, where I argue that binary footing is more widespread than the typology of 'binary', alternating stress patterns would suggest (see also Vaysman 2009).

It bears mentioning that the bisyllabic upper-limit on foot size is a second property that distinguishes the foot from the other levels of the prosodic hierarchy. In particular, it is generally accepted that the 'interface' categories may freely contain n-ary branching structures, as in illustrated in (18) (though there is arguably a preference for binarity at all levels of the hierarchy; Itô & Mester 1992/2003, Selkirk 2011, Elfner 2012). This is surely not an accident, though it is outside the scope of the present work to pursue the interesting question of why binarity constraints seem to be more stringent at the level of the foot than at other levels of the prosodic hierarchy.

A third property of foot structure is EDGE-TROPISM: feet tend to cluster at one or both edges of a containing prosodic word (McCarthy & Prince 1993a, Hayes 1995, Gordon 2002a, etc.). There are various ways that edge-tropism is cashed out in prosodic hierarchy theory. In derivational formulations, edge-tropism results from a parameter setting that causes iterative foot construction to begin at one edge of the prosodic word (e.g. Hayes 1981, 1995, Hammond 1986). In optimality-theoretic instantiations of the theory, edge-tropism is a response to surface constraints enforcing alignment between feet and prosodic word edges (McCarthy & Prince 1993a, Gordon 2002a, Pruitt 2010, Hyde 2012, etc.). In this dissertation I assume that phonological computation, proceeds under a system of ranked and violable constraints, as in classic Optimality Theory (Prince & Smolensky 1993/2004). This theoretical choice is partly one of convenience, but also partly one of principle, as I discuss in Chapters 2 and 3.

So far unmentioned is the relationship between footing, headedness, and stress. In opposition to some recent work on footing (e.g. Hyde 2002, González 2003, Vaysman 2009), I take the strong view that stress is always assigned to foot heads, and never

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[20]See Liberman & Prince (1977), Selkirk (1978, 1980), Hayes (1981, 1995), Prince (1985, 1991), McCarthy & Prince (1986/1996), Kager (1989), Rice (1992, 2007), Hewitt (1994), Mester (1994) and Vaysman (2009) for extensive discussion of foot binarity.

to foot dependents (i.e. never to the weak syllable of the foot). However, since there are languages without stress that nonetheless provide convincing evidence for phonologically active foot structure (e.g. Ibibio, Section 1.3.2.2; see also Chapter 4), it must be the case that unstressed foot heads are permissible phonological objects as well. Taken together, these observations lead me to the following proposal, which I dub the STRESS-HEADEDNESS HOMOMORPHISM:

(20)   **Stress-headedness homomorphism**:
        All stressed syllables are foot heads, though not all foot heads are stressed.

    a. $\acute{\sigma} \rightarrow \sigma_{\text{H}}$
    b. $\sigma_{\text{H}} \nrightarrow \acute{\sigma}$

A fuller justification of this view is provided in Chapter 2; for now, it suffices to point out that this is the most restrictive conception of foot-based stress assignment consistent with the empirical facts considered so far.

Finally, if the levels of the prosodic hierarchy are given *a priori*, as in the strongest version of the theory, then it follows that foot structure should be a prosodic universal (provided that HEADEDNESS is indeed inviolable). In Chapters 3 and 4 I explore this possibility in greater detail, and argue that the foot may well be a universal primitive of prosodic structure, as predicted by the strongest version of prosodic hierarchy theory.

To summarize, in prosodic hierarchy theory stress is always assigned within the foot, a maximally binary constituent intervening between the syllable (σ) and the prosodic word (ω). Futhermore, I take the restrictive view that only foot heads may bear phonetic stress, though unstressed foot heads are structurally licit as well (the STRESS-HEADEDNESS HOMOMORPHISM; see Chapter 2 for futher discussion).

Throughout this dissertation I will be operating more-or-less within the confines of prosodic hierarchy theory, using the terms, notation, and definitions set out in this section. However, my use of this framework should not be construed as a full-throated endorsement of the theory in its particulars (though as it happens, I do in fact endorse it). The core goal of the dissertation is to provide evidence bearing on the need for, and properties of, foot-like prosodic constituents in formal theories of natural language phonology. Except where explicitly indicated, the claims I make in this work

are in principle compatible with any number of theories that include abstract metrical structure as part of their explanatory apparatus. In the following section I discuss an alternative to prosodic hierarchy theory — simplified bracketed grid theory — which also satisfies that basic requirement.

1.4.2 Simplified bracketed grid theory

The discussion of simplified bracketed grid theory (or SBG) in this section follows the presentation in Halle & Idsardi (1995). That article updates the proposals made in Idsardi's 1992 MIT dissertation, which was itself a reformulation of the metrical system set out in Halle & Vergnaud (1987). While some refinements to SBG have been offered since 1995, as far as I know the architectural assumptions of that framework have remained basically fixed over the last two decades.

SBG follows work like Liberman (1975), Liberman & Prince (1977), Hayes (1981), Prince (1983), Selkirk (1984), and many others in assuming that stress is assigned on the basis of a metrical grid. Example (21) provides a grid-based representation of the dactylic stress pattern of *Winnipesaukee*. Level 0 gridmarks indicate segments (or perhaps, syllables) with the potential to bear stress.[21] Level 1 gridmarks are assigned to those segments that actually bear some degree of stress. Lastly, Level 2 gridmarks signal the position of primary stress.

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[21] I do not see how to reconcile Halle & Idsardi's (1995) stance that stress is a property of single segments with the ample phonetic and phonological evidence that stress is a property of entire syllables (see e.g. Hayes 1995:Ch. 3.9 and references there). Somewhat cryptically, Halle & Idsardi remark that "In Koya only the head of a syllable [i.e. a vowel] is capable of bearing stress. Elements within syllables other than heads can also be stress-bearing in some languages" (407). Since they do not provide concrete examples of such languages, or any references to consult on the matter, I remain suspicious of the validity of these claims. It may be that Halle & Idsardi are conflating 'stress' and 'pitch accent' here, since some languages with pitch accent systems do allow syllable-internal contrasts in pitch placement.

(21)   SBG representation of *Winnipesaukee* [wì.nə.pə.sá.ki] with prosodic domains
         omitted

```
Level 2                             *
Level 1        *                    *
Level 0        *        *        *        *        *
           w   ì  . n   ə  . p    ə  . s  á  . k   i
```

The representation of stress in SBG is in fact more complex than (21) suggests, because
SBG assumes that the grid on which stress is assigned is carved up further into abstract
metrical constituents. Like prosodic hierarchy theory, SBG assumes that words are
subdivided into prosodic domains that partially determine the position of stress. SBG
further claims that stress is only assigned to those segments (or syllables) that are
the heads of a privileged prosodic domain (again as in prosodic hierarchy theory).
However, the two frameworks part ways when it comes to the *origin* of the prosodic
domains governing stress placement. In SBG, prosodic constituents like the foot are
not primitives of the theory: they are derived domains, generated by the application of
parameterized rules that insert prosodic boundaries into phonological representations.

The calculation of stress placement in SBG begins with a determination of poten-
tial stress-bearing segments. The mechanism used for this calculation is projection
(Goldsmith 1976, 1990, Halle & Vergnaud 1980, 1987, etc.). In practice, projection is
simply the process of placing a Level 0 gridmark above those segments that are eligible
to be the head of a stress domain (basically over every vowel). Gridmark projection is
also involved in determining the position of stress peaks and for calculating degrees of
stress — more on this in a moment.

SBG assumes that all languages with stress accent make use of the projection prin-
ciple in (22), which identifies vowels (or other 'syllable heads') as potentially stressable
elements.

(22)   Line 0 mark projection:
         Project (i.e. assign) a line 0 element for each syllable head.

To illustrate, I will reproduce the derivation of the Maranungku word [wé.le.pè.ne.màn.ta]
'kind of duck' as it is given in Halle & Idsardi (1995). (Stress in Maranungku falls on

every odd-numbered syllable counting from the beginning of the word; the leftmost stress is the primary stress.)

(23) Line 0 mark projection for Maranungku [wé.le.pè.ne.màn.ta]

Level 0   *   *   *   *   *   *
w e . l e . p e . n e . m a n . t a

The next step is to determine which vowels will actually bear stress, i.e. to determine which Level 0 gridmarks will be dominated by a Level 1 gridmark. In many languages, particular kinds of syllables show a special affinity for stress: this is frequently true of heavy syllables like [CVV] or [CVC], but there are also languages in which stress is attracted to syllables containing a high-sonority vowel nucleus or a particular tone (see de Lacy 2002a, 2004, 2007 and work cited there). To capture such patterns, SBG assumes that the following parameter may or may not be active in particular languages:

(24) Syllable boundary projection parameter:

Project the $\left\{ \begin{array}{c} \text{left} \\ \text{right} \end{array} \right\}$ boundary of *certain syllables* onto Line 0.

If Maranungku had quantity-sensitive stress (it does not), this parameter might place a prosodic boundary at the left edge of the closed penult [man].[22]

(25) Syllable boundary projection for pseudo-Maranungku [wé.le.pè.ne.màn.ta]

a. Project the left boundary of CVC syllables onto Line 0.

b.
Level 0   *   *   *   * ‖   *   *
w e . l e . p e . n e . m a n . t a

The effect of the syllable boundary projection parameter is to ensure that certain syllables will be at the edge (left or right) of a containing prosodic domain. Since stress is

---

[22]For simplicity of exposition, I follow van der Hulst (2009) in assuming that boundary projection in SBG inserts a non-directional boundary marker '‖' rather than a left '(' or right ')' constituent bracket as in Halle & Idsardi (1995). Consequently, it was necessary to modify the definitions of some of the parameters mentioned in this section. Nothing much hinges on this, but see those two papers for discussion of this point.

assigned to the leftmost or rightmost element in a given domain (see (30) below), this parameter can be used to ensure that syllables with certain properties will always bear stress in surface forms. Like all parameters in SBG, the syllable boundary projection parameter may or may not be active in a particular language. When this parameter is inactive (as in real-life Maranungku), stress placement will necessarily be quantity-insensitive.

The second parameter responsible for the insertion of prosodic domain boundaries is the edge-marking parameter (26).

(26) Edge-marking parameter:

Place a boundary to the $\left\{ \begin{array}{c} \text{left} \\ \text{right} \end{array} \right\}$ of the $\left\{ \begin{array}{c} \text{left} \\ \text{right} \end{array} \right\}$-most element in the string.

This parameter serves one basic purpose: it guarantees that syllables at the edges of a word will also be at the edge of a prosodic domain, which makes them eligible to be prosodic heads (i.e. stressed). In the case of Maranungku, the edge-marking parameter places a boundary after the final syllable. (I will explain shortly the effect that this boundary has on stress placement in the language.)

(27) Edge-marking for Maranungku [wé.le.pè.ne.màn.ta]

    a.   Place a boundary to the left of the left-most element

    b.

      Level 0   *   *   *   *   *   * ‖
               w e .l e .p e .n e .m a n .t a

The third parameter exploited by the SBG is the iterative constituent construction parameter (28).

(28) Iterative constituent construction parameter (ICC):

Insert a boundary for each pair of elements, moving from $\left\{ \begin{array}{c} \text{left-to-right} \\ \text{right-to-left} \end{array} \right\}$

This parameter is the SBG answer to the foot binarity condition of prosodic hierarchy theory: by placing a boundary after pairs of elements, the ICC creates binary prosodic

domains, deriving alternating stress in those languages that have rhythmic stress systems. For Maranungku, application of the rule defined by this parameter places a boundary after every even-numbered Level 0 gridmark (i.e. vowel), as in (29).

(29)   ɪᴄᴄ for Maranungku [wé.le.pè.ne.màn.ta]

    a.   Insert a boundary for each pair of elements, moving from left-to-right.

    b.

Level 0	*		*	‖	*		*	‖	*		*	‖
	w	e	.l	e	.p	e	.n	e	.m	a	n	.t	a

The fourth parameter central to the SBG theory of stress is the head-location parameter (30). This parameter determines whether the head of a given constituent will fall at its right or left edge — in other words, it is roughly the SBG analog of the distinction between iambic and trochaic foot-types in prosodic hierarchy theory.

(30)   Head location parameter:

    Project the $\left\{ \begin{array}{c} \text{left} \\ \text{right} \end{array} \right\}$-most element of each constituent onto the next line of the grid.

In Maranungku, the setting of this parameter places a Line 1 grid mark above the leftmost gridmark in each prosodic domain on Line 0.

(31)   Head location parameter for Maranungku [wé.le.pè.ne.màn.ta]

    a.   Project the leftmost element of each constituent onto the next line of the grid.

    b.

Level 1	*				*				*			
Level 0	*		*	‖	*		*	‖	*		*	‖
	w	e	.l	e	.p	e	.n	e	.m	a	n	.t	a

The joint effect of the ɪᴄᴄ and the head location parameter is to place stress on every other syllable (in Maranungku, on odd-numbered syllables). These two parameters thus replicate the foot-based implementation of alternating stress found in prosodic hierarchy theory. For Maranungku, this amounts to constructing quantity-insensitive,

bisyllabic trochaic feet from left-to-right.

To return a promisory note made earlier, the role of the edge-marking parameter in this system becomes clear when we consider stress assignment in monosyllabic words. The ICC only targets pairs of gridmarks, so it does not apply to monosyllables. Since, by assumption, stress can only be 'projected' in the presence of at least one prosodic boundary '‖', some other mechanism is needed to place the requisite boundary on either side of a monosyllabic word. That mechanism is edge marking, which in Maranungku derives an output like (32) (Maranungku does allow monosyllabic content words; Hayes 1995:200).

(32)   Edge-marking and monosyllables in Maranungku

    Level 1   *
    Level 0   *   ‖
            σ

The edge-marking parameter is also used to account for 'default-to-{same/opposite} edge' patterns in unbounded, quantity sensitive stress systems — see Halle & Idsardi (1995) for exemplification.

An important elaboration of the SBG system concerns the construction of prosodic domains at different levels of the grid. In SBG, metrical parameters may be set differently for each grid level. For example, assume that the parameter settings for Level 1 constituents are the same as for Level 0 constituents, except that the ICC is 'turned off' for Level 1. This results in leftmost primary stress, as in (33).

(33)   Primary stress assignment in Maranungku: leftmost

    Level 2   *
    Level 1   *   *   *   ‖
    Level 0   *   * ‖ *   * ‖ *   * ‖
          w é .l e .p è .n e .m à n .t a

If the value of the head location parameter was set at RIGHT rather than LEFT for Level 1, the result would be a system just like Maranungku, except with primary stress being rightmost rather than leftmost. Notice that the edge-marking parameter is again relevant at Level 1 of the grid, where it provides metrical structure for an otherwise unorganized row of gridmarks (albeit structure of a rather trivial sort).

To summarize: in SBG, stress is assigned on the basis of a constituentized metrical grid. Prosodic constituency is determined by the application of parameterized rules that build prosodic domains on each level of the grid, and by the mechanism of gridmark projection.[23]

1.4.2.1 Some differences between SBG and prosodic hierarchy theory

It should be observed here that the notion of 'constituent' employed in SBG is rather different from the understanding of this term as used in prosodic hierarchy theory and elsewhere in linguistics. Constituents in SBG can be 'open', or unbounded on one end. For example, the first two syllables of [wé.le.pè.ne.màn.ta] (33) count as a 'constituent' in this theory because they are bookended on the right by a prosodic boundary, i.e. [wé.le ‖], even though there is no corresponding closing boundary on the left side of this string. As such, the term 'constituent' is somewhat misleading in SBG, and we might do better to think of these unpaired boundary symbols as the endpoints of abstract prosodic domains that primarily serve to delimit the application of rules manipulating gridmarks (see van der Hulst 2009 for more on this issue).

The preceding discussion of constituency leads directly to another major schism between SBG and prosodic hierarchy theory. Unlike prosodic hierarchy theory, SBG admits non-binary, potentially unbounded prosodic structures in the set of domains conditioning stress placement. While a preference for binary domains is enforced by the ICC (28), this is only a preference, not an absolute. For instance, Halle & Idsardi (1995) propose a metrical representation like (34) for some words in Koya. Notice that this representation contains both unary and ternary prosodic domains, as well as 'open constituents' on Lines 0 and 1.

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[23]SBG makes use of a number of additional mechanisms which I do not discuss here. These are so-called 'avoidance constraints' (i.e. output constraints that can block the application of metrical rules) and gridmark removal, or 'conflation'. See Halle & Vergnaud (1987), Halle & Idsardi (1995), Crowhurst (1996) for details.

(34) Stress assignment in some Koya words (L = light syllable, H = heavy syllable)

```
Level 2        *
Level 1   ‖    *      *                    *
Level 0   ‖    *  ‖   *      *      *  ‖    *      *
               L      H      L      L      H      L
```

The empirical evidence for unbounded metrical structure of this sort is slim, and appears to be limited to facts regarding the integration of clitics into word-level stress domains (see Halle & Vergnaud 1987, Halle 1990, Halle & Kenstowicz 1991, Halle & Idsardi 1995, van der Hulst 2009). As argued by McCarthy & Prince (1986/1996), Beckman (1998) and Vaysman (2009), there seems to be no evidence whatsoever for unbounded feet in the realms of prosodically-conditioned morphology or segmental phonotactics (though cf. Flemming 1994; see also Prince 1985). While the point of this dissertation is not to advocate for or against SBG, in Chapter 3 I show that some languages with edge-based, non-iterative stress placement still assign stress within a bounded, binary foot. Since languages with this stress pattern are most naturally modelled in SBG using unbounded domains rather than binary domains (35), this counts as something of a point against the SBG account of stress assignment.

(35) Non-rhythmic, edge-based stress in SBG using unbounded domains

```
Level 2        *
Level 1   ‖    *
Level 0   ‖    *      *      *      *
               σ      σ      σ      σ
```

Another important distinction between the 'constituents' of SBG and the categories of prosodic hierarchy theory has to do with labelling. In prosodic hierarchy theory, prosodic domains are labelled according to the level of the hierarchy that they belong to; phonological computation can then make reference to these labels, and can (for example) place conditions on feet that it does not place on other prosodic categories. In SBG, there are no 'feet' as such: prosodic domains are unlabeled, non-primitive objects, which exist only as the output of rules that derive prosodic groupings for the purposes of stress placement.

    Finally, unlike prosodic hierarchy theory, SBG is committed to BOTTOM-UP CON-

structionism. It is a 'bottom-up' theory in the sense that the calculation of primary stress on Line 2 is contingent on the prior determination of Line 1 gridmarks (see also Chapter 4). Less formally, in order to know where primary stress falls in SBG, one must first calculate the position of *all* stress peaks in the word. This is a straightforward consequence of the fact that SBG is a derivational, rule-based framework (though there are rule-based frameworks in which primary stress placement is largely independent from the location of secondary stresses, e.g. van der Hulst 2009, submitted). In contrast, constraint-based implementations of prosodic hierarchy theory have no such commitment to bottom-up constructionism. An OT model of prosodic computation, for instance, actually predicts the existence of 'top-down' effects in which the position of primary stress partially shapes the position of stress elsewhere in the word (see Prince & Smolensky 1993/2004, Crowhurst & Michael 2005, McCarthy, Pater & Pruitt to appear for useful discussion).

In my estimation, prosodic hierarchy theory deals with many of the phonological phenomena surveyed in this dissertation in a more natural and straightforward way than SBG. That said, SBG is an important alternative to prosodic hierarchy theory, and one that is in principle consistent with the basic claims I make regarding prosodic constituency in the chapters that follow.

Chapter 2

Rhythmicity, prominence, and the uniqueness of footing

In this chapter I argue for a conception of the metrical foot that is both conceptually restrictive and structurally flexible. A central claim of this chapter is that foot structure is unique: languages make use of no more than one system of metrical organization in their phonological components. However, foot structure is also flexible, in that any single language may exploit a diversity of different foot types, as conditioned by countervailing morphological or phonological factors.

Evidence for this view of foot structure comes from interactions between stress and segmental phonotactics in a range of languages. The bulk of the chapter is dedicated to a case study of Huariapano, a language that has been claimed to motivate multiple, co-existing systems of metrical structure. I contend here that such a conclusion is at best premature: the phonology of Huariapano can be successfully modeled without recourse to a distinct, autonomous metrical system over and above the footing needed for stress placement. We begin with Huariapano.

2.1 Huariapano

Huariapano is an extinct Panoan language, spoken in the Peruvian Amazon until the death of its last known speaker in 1991 (Parker 1994, Loos 1999).[1] The phonology

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[1] Huariapano is now officially known as Panobo (Ethnologue code PNO). Other common designations include Wariapano and Pano. Since all major works on the phonology of this language use the name

of Huariapano is of interest for metrical theory because it exhibits two 'rhythmic' phenomena: rhythmic secondary stress, and rhythmic epenthesis of coda [h]. Both of these processes are plausibly foot-based; however, previous work on Huariapano has argued that the feet needed to determine rhythmic stress are distinct from the feet needed to determine the distribution of coda [h] epenthesis (Parker 1994, 1998a,b; see also González 2003, 2005, Blumenfeld 2006, González 2007, Vaysman 2009). In this chapter I demonstrate that the phonology of Huariapano can and should be analyzed without resorting to 'disjoint' metrical tiers of this sort. By rethinking the prosodic motivation behind rhythmic [h] insertion, the account developed here successfully reconciles the distribution of stress and coda [h] epenthesis within a single system of metrical footing. The core claims of this reanalysis are (i) that the choice of foot type (iambic or trochaic) is fairly flexible in Huariapano, both within and across words; (ii) that foot-initial position counts as a phonologically prominent position, independent of the location of stress within the foot; and (iii) that Huariapano exploits recursive footing as a last-resort strategy to achieve exhaustive parsing of syllables into feet.[2]

2.2 Phonology of Huariapano

This section provides a brief overview of syllable structure and stress in Huariapano. For a more detailed discussion of Huariapano phonology, see Parker (1994, 1998a,b), which are the sources for the data and basic descriptive generalizations presented here.

2.2.1 Segmental inventory

The vowel inventory of Huariapano is provided in Table 2.1. Note that the vowel [ï] corresponds to IPA [ɯ]. The surface form of underlying /o/ varies between [o], [u] and [ʊ]. Huariapano also had fifteen phonemic consonants, which are provided in Table 2.2.

Huariapano, I adopt it here as well.

[2]Steve Parker generously provided comments on an earlier version of this chapter, for which I thank him. He does not necessarily agree with the conclusions and analysis I arrive at here.

i　　　　ï

　　　　　o

　　　　a
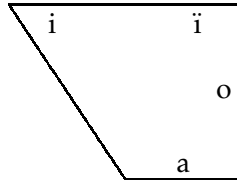
Table 2.1: Huariapano vowel inventory (Parker 1994, 1998a,b)

	Labial	Alveolar	Alveopalatal	Retroflex	Palatal	Velar	Laryngeal
Stop	p	t				k	
Affricate		tˢ	t͡ʃ				
Fricative	β	s	ʃ	ʂ			h
Nasal	m	n					
Trill		r					
Glide	w				j		

Table 2.2: Huariapano consonant inventory (Parker 1994, 1998a,b)

See Parker (1994, 1998a,b) for more detailed description of the segmental phonetics of Huariapano.

2.2.2 Syllable structure

Syllable structure in Huariapano is maximally [CGVC] (where [G] = glide) and minimally [V]. Surface glides are arguably derived from underlying vowel sequences. Licit codas are nasals, glides, or sibilant fricatives [s ʃ ʂ] (where [ʂ] is the retroflex alveopalatal fricative). Coda [h] is also permitted, but is not phonemic in that its distribution is non-contrastive and largely predictable.

Content words in Huariapano are minimally [CVC] or [CVː]. Vowel length is non-contrastive: apart from [CVː] words, where vowel length is clearly a reflex of a prosodic minimality condition, long vowels are unattested.

Coda nasals in Huariapano can undergo a variable process of nasal coalescence,

in which a /VN/ rime is realized as a single nasalized vowel [Ṽ]. These fused [Ṽ] sequences are notable for their chimerical nature: for purposes of stress placement they behave as closed [ṼN] rimes, but for purposes of coda [h] epenthesis they behave as open [Ṽ] (see Sections 2.2.3 and 2.2.4 for details). Vowel nasality is not contrastive in Huariapano, which is atypical for a Panoan language (Shell 1965, Loos 1999, González 2003).

2.2.3   Stress placement

2.2.3.1   Primary stress

When the final syllable is open [(C)(G)V] (i.e. a light, monomoraic syllable), primary stress falls on the penult.[3]

(1) a. [á.tˢa] 'manioc'
     b. *[a.tˢá]

     c. [wín.ti] 'oar, paddle'
     d. *[win.tí]

When the final syllable is closed [(C)(G)VC] (i.e. a heavy, bimoraic syllable), primary stress falls on the ultima. Primary stress in Huariapano is thus quantity-sensitive.

(2) a. [ja.wíʃ] 'opossum'
     b. *[já.wiʃ]

When a word ends in two closed, heavy syllables, primary stress again falls on the ultima.

(3) a. [hon.tˢís] 'claw; fingernail'
     b. *[hón.tˢis]

The basic pattern of primary stress assignment can thus be summarized as follows:

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[3]The transcriptions given here are changed slightly from Parker (1994, 1998a,b) to better match IPA standards.

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(4)   Primary stress in Huariapano: stress the ultima if heavy, otherwise the penult.

    a.   /...σ H/   →   [...σ H́]
    b.   /...σ L/   →   [...σ́ L]

There are some lexical exceptions to regular primary stress assignment. A number of words ending in a light, open syllable bear irregular final syllable stress.

(5)   a.   [uʃ.tá] 'garbage'
    b.   [jo.β̃í] 'witch'

Exceptional forms of this sort are a statistical minority: in Parker's corpus, 25% of bisyllabic nouns and adjectives ending in a light syllable have exceptional final stress as in (5) (Parker 1994, 1998a). There are no verbs with exceptional final stress Parker (1998a:5-6,19-21).[4]

    An even smaller number of words show exceptional antepenultimate stress.

(6)   a.   [β̃í.ma.na] 'face (noun)'
    b.   [ríʃ.ki.ti] 'whip (noun)'

Only twelve words of this sort are attested in Parker's corpus. There are no attested words in Huariapano with pre-antepenultimate primary stress, though given the small number of exceptional forms to begin with, this gap may be accidental.

    Primary stress therefore has the potential to be surface-constrastive in Huaria-pano, though stress assignment is largely regular and carries a very small functional load.

2.2.3.2 Secondary stress

Unlike primary stress, secondary stress in Huariapano is entirely quantity-insensitive (Parker 1998a, McGarrity 2003). There are two distinct patterns of secondary stress

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[4]There are some apparently inexplicable cases of irregular final stress as well. For example, the plural suffix /-kain/ → [-kã̃j] sometimes bears stress in final position and sometimes does not (Parker 1994:101-2,107, Parker 1998a:28). This variability does not seem to depend on the number or weight of the preceding syllables. I assume [-kã̃j] counts as heavy when it bears final stress, and as light otherwise.

assignment. In the first pattern, secondary stress is assigned to every odd-numbered syllable counting from the beginning of the word. As (7c) shows, secondary stress is inhibited on syllables adjacent to primary stress. This is because Huariapano absolutely prohibits stress clash in surface forms.

(7)   Regular secondary stress: odd-numbered syllables, counting from left

    a.   [mà.na.páj.ri] 'I will wait'

    b.   [jò.mï.rà.no.s̠í.ki] 'he is going to hunt'

    c.   [jò.mï.rà.no.s̠ih.ká̰j̃] 'they will hunt'

    d. *[jò.mï.rà.no.s̠ìh.ká̰j̃]

This is the most frequent pattern of secondary stress in Huariapano, occurring in ~66% of eligible words in Parker's corpus (Parker 1998a). Following Parker (1994, 1998a), I will therefore refer to the pattern in (7) as 'regular' secondary stress assignment.

The other attested pattern of secondary stress in Huariapano targets every *even-numbered* syllable counting from the beginning of the word.

(8)   Irregular secondary stress: even-numbered syllables, counting from left

    a.   [a.rì.βah.káŋ.ki] 'they repeated'

    b.   [hɨ.màŋ.ko.ʃó] 'species of ant'

    c.   [βis.mà.noh.kò.no.s̠í.ki] 'I forgot'

I will call this pattern of stress assignment 'irregular' secondary stress, again following Parker (1994, 1998a). It occurs in ~34% of the relevant words in Parker's corpus (Parker 1998a). Since odd-syllable and even-syllable secondary stress are both fairly common, it might be more accurate to distinguish between 'major' and 'minor' patterns of stress assignment in Huariapano. With that point noted, in this chapter I will continue to use the terms 'regular' and 'irregular' to separate the two systems of rhythmic stress placement.

2.2.4 Coda [h] epenthesis

The segment [h] has a narrowly circumscribed distribution in Huariapano. Onset [h] is only permitted word-initially.[5] Word-initial [h] is phonemic: it contrasts with [∅] and with other consonants.

(9)   Word-initial phonemic [h]

    a.   [há.na] 'tongue'

    b.   [ká.na] 'macaw'

    c.   [á.no] 'paca rodent (*Coelogenys fulvus*)'

Coda [h] is permitted in Huariapano, but it must satisfy a number of phonotactic constraints.[6] Furthermore, whenever coda [h] is permitted in the language, it is obligatory. This provides an initial indication that coda [h] might always be the result of a phonological process of epenthesis.

    The restrictions on coda [h] are as follows. First, coda [h] is only allowed before a voiceless obstruent.

(10)   Coda [h] only allowed before voiceless obstruents

    a.   [poh.ʂój] 'I open'

    b.   *[po.ʂój]

    c.   [ka.móʂ] 'species of venomous snake'

    d.   *[kah.móʂ]

In this respect, coda [h] resembles a species of preaspiration (as first pointed out by Parker 1998a).

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[5]There are no known prefixes in Huariapano (Parker 1994, 1998a), and other Panoan lanugages are entirely suffixing (Loos 1999). The distribution of onset [h] is therefore ambiguous between word-initial and root-initial position.

[6]Parker (1994, 1998b) reports that coda [h] can take on the place of articulation of a preceding high vowel, especially in rapid speech (e.g. [iç.tú.ri] 'hen', [pix̤.tá] 'wide'). I abstract away from this detail in all transcriptions.

Second, coda [h] only appears in syllables that do not already contain a coda consonant. This restriction is entirely expected, given that complex codas are disallowed in Huariapano.

(11)   Coda [h] may not co-occur with a tautosyllabic coda

    a.   [βoʂ.ká] 'head'

    b. *[βoh̲ʂ.ká]
    c. *[βoʂh̲.ká]

Third, coda [h] never appears in word-final syllables. This too is expected if coda [h] is akin to preaspiration: assuming that coda [h] is licensed by a following voiceless obstruent (within the same word), it follows that word-final coda [h]s should be illicit, since they have no licensing obstruent.

(12)   Coda [h] never appears in word-final syllables

    a.   [nïh̲.tḯ.no] 'day (locative)'
    b. *[nïh̲.tḯ.noh̲]   (X word-final coda [h])

Fourth, and most important, is the fact that the distribution of coda [h] is *rhythmic*. Coda [h] appears in all eligible odd-numbered syllables, counting from the left. As example (13) shows, when coda [h] is allowed to appear in an odd-numbered syllable, it *must* appear there.

(13)   Coda [h] allowed in odd-numbered syllables (counting from the left)

    a.   [βì.naj.níh̲.kã̃j] 'they are looking, searching'   (✓ 3rd σ coda [h])
    b. *[βì.naj.ní.kã̃j]

    c.   [pàh̲.tˢaj.níh̲.kã̃j] 'they are washing'   (✓ 1st, 3rd σ coda [h])
    d. *[pà.tˢaj.ní.kã̃j]

However, coda [h] never appears in even-numbered syllables, even when all other phonotactic restrictions on [h] are satisfied.

(14) Coda [h] banned in even-numbered syllables (counting from the left)

 a. [pi.ní.kã�] 'they are eating'

 b. *[pi.níh̲.kã̃j]   (X 2nd syllable coda [h])

The distribution of coda [h] in Huariapano is thus 'rhythmic' in the sense that it targets every-other syllable within a word. This is of course strikingly similar to the distribution of secondary stress in Huariapano, which also targets alternating syllables, and also counts from the left edge. This distributional parallelism between coda [h] and secondary stress will form the crux of the analytical issues addressed in this chapter.

Despite the commonalities between secondary stress and coda [h], it is clear that stress itself does not condition the appearance of [h], at least not directly. Coda [h] may appear in both stressed and unstressed syllables alike, and is insensitive to different degrees of stress.

(15) Coda [h] insensitive to stress distinctions

 a. [nïh̲.tí.no]   (unstressed coda [h])

 b. [pàh̲.tˢaj.níh̲.kã̃j]   (stressed coda [h], [ó] and [ò])

Finally, coda [h] is prohibited in word-initial syllables that also bear primary stress. Neither of these conditions are sufficient on their own to interfere with the appearance of coda [h], as the examples in (16) demonstrate. The underlying generalization seems to be that word-initial syllables bearing primary stress are somehow too prominent to license coda [h] (see Parker 1998a, de Lacy 2001).

(16) Coda [h] cannot appear in word-initial syllables with primary stress

 a. [ní.tï] 'day'

 b. *[níh̲.tï]   (X coda [h] in initial syllable, [ó])

 c. [pàh̲.tˢaj.níh̲.kã̃j]   (✓ coda [h] in initial syllable, [ò])

 d. [poh̲.ʂój] 'I open'   (✓ coda [h] in initial syllable, [ŏ])

 e. [pàh̲.tˢaj.níh̲.kã̃j]   (✓ coda [h] in non-initial syllable, [ó])

To summarize, coda [h] is only permissible in Huariapano if it satisfies the following phonotactic restrictions:

(17)   Conditions on coda [h]

   a.   PREASPIRATION CONDITION:
         Coda [h] must appear before a voiceless obstruent.

   b.   SIMPLEX CODA CONDITION:
         Coda [h] cannot co-occur with a tautosyllabic coda consonant.

   c.   NON-FINALITY CONDITION:
         Coda [h] cannot appear in word-final syllables (follows from (17a) and (17b)).

   d.   RHYTHMICITY CONDITION:
         Coda [h] only appears in odd-numbered syllables, counting from the left.

   e.   NON-MAXIMAL PROMINENCE CONDITION:
         Coda [h] cannot appear in word-initial syllables that also bear primary stress.

An important point is that coda [h] appears wherever these conditions are met, even multiple times within a single word. In other words, the distribution of coda [h] is non-contrastive, predictable, and rule-governed: if coda [h] can appear in a particular syllable, it necessarily surfaces there.[7] For this reason, I follow Parker in assuming that coda [h] is always epenthetic rather than underlying. Alternations like (18) are thus due to a productive phonological process of coda [h] epenthesis.

(18)   a.   [pàj.ri.ráh̠.kã͏̃j] 'still; yet (they)'
        b.   [pàj.ri.rá.naj] 'still; yet (we)'

If alternations like (18) were instead due to deletion, we would have no account of why words like *[pàj.ri.rá ̲.kã͏̃j], which lack coda [h] in an eligible syllable, are systemati-

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[7]Barring some exceptional forms; see (20) and Section 2.4.6.

cally unattested in Huariapano. Another argument for an epenthetic treatment of coda [h] is that coda [h] appears in assimilated loanwords from Spanish, in which there is no plausible source consonant for an underlying coda [h].

(19) a. [mah̲.t͡ʃé.te] 'machete'
      b. *[ma.t͡ʃé.te]

      c. Cf. Spanish [ma.t͡ʃé.te]

There are nevertheless a few cases where coda epenthesis fails to apply, despite satisfaction of the conditioning criteria in (17).

(20) Lexical exceptions to coda epenthesis

      a. [t͡ʃu.ʃí.kï] '(he/it) dried up'
      b. *[t͡ʃuh̲.ʃí.kï]

      c. [ʂo.tó.ki] 'we sent'
      d. *[ʂoh̲.tó.ki]

Words with exceptional non-epenthesis are a clear minority in Huariapano. In Section 2.4.6 I will argue that most cases of exceptional non-epenthesis can be attributed to facts about morphological structure, as speculated by Parker (1994).

2.3   Disjoint footing in Huariapano?

The earliest formal account of Huariapano phonology is presented, with some slight variations, in Parker (1994, 1998a,b) and González (2007) (see also González 2003, 2005, McGarrity 2003). For reasons that will become clear, I refer to this analysis as the DISJOINT FOOTING ANALYSIS of Huariapano (or DFAH, for short). Sections 2.3.1 and 2.3.2 lay out the DFAH. In Section 2.4 I propose an alternative, single-tier account of coda [h] epenthesis in Huariapano, which I then subsequently defend.

2.3.1 Stress placement

The DFAH assumes that primary stress in Huariapano is assigned to a right-aligned, quantity-sensitive moraic trochee. This assumption explains (i) why primary stress is, in most cases, limited to a word-final two syllable window, (ii) why default primary stress is on the penult in words ending in two light syllables, and (iii) why primary stress shifts to word-final heavy syllables.

(21)   Primary stress in DFAH: right-aligned moraic trochee

    a.   [pó.a] 'potato'   [(ĹL)]

    b.   [kóʂ.ni] 'beard'   [(ĤL)] or [(Ĥ)L]

    c.   [ʂa.βín] 'bee'   [L(Ĥ)]

    d.   [hon.tˢís] 'claw; fingernail'   [H(Ĥ)]

Secondary stress, in contrast, is quantity-insensitive: stress placement is determined by counting syllables, without any reference to their phonological weight. In the regular pattern of secondary stress, stress falls on the first syllable and every other syllable that follows (as constrained by the avoidance of stress clash). Since initial stress is most simply accommodated with a left-aligned trochaic foot, the DFAH assumes that regular secondary stress results from parsing iterative, quantity-insensitive syllabic trochees from left to right.

(22)   Regular secondary stress in DFAH: L → R syllabic trochees

    a.   [mà.na.páj.ri] 'I will wait' $\overrightarrow{(\grave{\text{L}}\text{L})}$(ĹL)

    b.   [jò.mï.rà.no.ʂih.kə́j̃] 'they will hunt' $\overrightarrow{(\grave{\text{L}}\text{L})(\grave{\text{L}}\text{L})}$L(Ĥ)

    c.   [wà.nï.ki.ráŋ.ki] 'they have returned' $\overrightarrow{(\grave{\text{L}}\text{H})}$L(ĤL)

Irregular secondary stress differs minimally from the regular pattern: stress is assigned to every even-numbered syllable counting from the left, rather than every odd-numbered syllable. In Huariapano, this is extensionally equivalent to counting even-

numbered syllables, right-to-left, from the position of primary stress.

(23)   Irregular secondary stress: $[\sigma\grave{\sigma}\sigma\grave{\sigma}\sigma\acute{\sigma}]$

    a.   Counting L → R from left edge:
       $[\ \overrightarrow{\sigma_1\grave{\sigma}_2\sigma_3\grave{\sigma}_4\sigma_5\acute{\sigma}}\ ]$

    b.   Counting R → L from primary stress:
       $[\ \overleftarrow{\sigma_5\grave{\sigma}_4\sigma_3\grave{\sigma}_2\sigma_1}\ \acute{\sigma}\ ]$

The DFAH exploits this equivalence: irregular secondary stress is taken to be exactly like regular secondary stress (that is, quantity-insensitive and trochaic), but with a non-default right-to-left direction of parsing.

(24)   Irregular secondary stress in DFAH: R → L syllabic trochees

    a.   [βis.mà.noh.kò.no.ʂí.ki] 'I forgot'   L$(\overleftarrow{\grave{L}L})(\grave{L}L)(\acute{L}L)$

    b.   [ʄi.nà.ko.ʂón] 'spider'   L$(\overleftarrow{\grave{L}L})(\acute{H})$

    c.   [mi.βòm.bi.rá.ma] 'you (plural)'   L$(\overleftarrow{\grave{L}L})(\acute{L}L)$

The DFAH thus assumes that lexical items can vary in the direction of parsing for secondary stress; barring some sporadic exceptions, any other parameters of stress assignment remain fixed across all lexical items.

2.3.2   Coda [h] epenthesis

Recall that coda [h] epenthesis is rhythmic: it applies to all eligible odd-numbered syllables, counting from the left. Descriptively, then, coda [h] epenthesis targets exactly the same syllables as default secondary stress assignment (setting aside other phonotactic restrictions on where [h] may appear). Furthermore, in even-parity words with default secondary stress and penultimate main stress, [h] epenthesis occurs in a subset of the stressed syllables.

(25)   Epenthesis sometimes coincides with stress (L$_h$ = σ with coda [h] epenthesis)

   a.   [pàh̲.tˢaj.níh̲.kã�] 'they are washing' $\overrightarrow{(\grave{\text{L}}_h\text{H})}(\acute{\text{L}}_h\text{L})$

   b.   [jò.mï.ràh̲.ka.tíh̲.kã̃j] 'they hunted' $\overrightarrow{(\grave{\text{L}}\text{H})}\overrightarrow{(\grave{\text{L}}_h\text{H})}(\acute{\text{L}}_h\text{L})$

Given the striking fact that the rhythmic conditions on coda [h] epenthesis are identical to those governing secondary stress assignment, a natural conclusion is that the two processes are sensitive to exactly the same metrical structure — namely, left-to-right syllabic trochees.[8] This analysis has the further virtue of explaining why epenthesis is rhythmic, and why it occurs at all: coda [h] insertion converts open [CV] foot heads into closed [CVh], thereby rendering them bimoraic in accord with the cross-linguistic preference for heavy stressed syllables (i.e. the Stress-to-Weight Principle; see discussion in Gouskova 2003). Since the feet that determine the locus of coda [h] epenthesis are assumed to be syllabic trochees (like the feet that determine secondary stress), it falls out immediately that epenthesis will only target odd-numbered syllables. For these reasons, the DFAH draws the plausible conclusion that coda [h] epenthesis occurs in the heads of trochaic feet, assigned left-to-right in a quantity-insensitive fashion.

Despite the clear appeal of this account, on its own it is too simplistic to capture the full range of empirical facts in Huariapano. In particular, there are many words in which stress and [h] epenthesis do not coincide. For example, epenthesis and stress diverge when primary stress falls on the ultima rather than the penult.

(26)   a.   [jò.mï.rà.no.ṣih̲.kã́j] 'they will hunt' $\overrightarrow{(\grave{\text{L}}\text{L})(\grave{\text{L}}\text{L})}\text{L}_h(\acute{\text{H}})$

   b.   [nah̲.ká] 'manioc beer' $\text{L}_h(\acute{\text{L}})$

Mismatches also occur in odd-parity words. Clash avoidance (or, the avoidance of degenerate feet) can block stress assignment on an odd-numbered syllable. Such syllables are nonetheless targeted by epenthesis.

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[8]See Section 2.4.8 for further arguments that coda [h] epenthesis in Huariapano really does depend on foot structure.

(27) a. [jò.mï.ra<u>h</u>.ká.no] 'let's go hunting' $\overrightarrow{(\grave{\text{L}}\text{L})}\text{L}_h(\acute{\text{L}}\text{L})$

b. [ma<u>h</u>.tˢó.te] 'broom' $\text{L}_h(\acute{\text{L}}\text{L})$

c. [ma.nàŋ.ki<u>h</u>.ká.si] 'I will speak to you' $\text{L}\overleftarrow{(\grave{\text{H}}\text{L}_h)}(\acute{\text{L}}\text{L})$

The most dramatic mismatches between stress and epenthesis are found in words with irregular secondary stress. Words in this class bear secondary stress on every even-numbered syllable. This has no effect on coda [h] epenthesis, which is restricted to *odd*-numbered syllables in all lexical items, regardless of the location of stress.

(28) a. [ra<u>h</u>.kï.t͡ʃa.í.ki] 'it is scary' $\text{L}_h\overleftarrow{(\grave{\text{L}}\text{L})}(\acute{\text{L}}\text{L})$

b. [i<u>h</u>.kàʂ.t͡ʃaŋ.ká.ti] 'you would shake with fear' $\text{L}_h\overleftarrow{(\grave{\text{H}}\text{H})}(\acute{\text{L}}\text{L})$

These facts rule out the possibility of any direct correspondence between stress and coda [h] epenthesis: mismatches include both cases where coda [h] epenthesis fails to apply in an otherwise eligible stressed syllable (27)-(28) and cases where it applies in unstressed syllables (26)-(28).

We are thus faced with a conundrum: coda [h] epenthesis in Huariapano appears to be foot-based, but the feet required to determine the locus of epenthesis are not isomorphic to the feet that determine surface stress assignment. This conundrum leads to the central proposal of the DFAH; namely, that the phonology of Huariapano makes use of two distinct, and disjoint, metrical tiers. One of these tiers determines stress assignment, while the other determines the location of coda [h] epenthesis.

(29) **Central proposal of the DFAH (to be rejected)**
There are *two distinct metrical tiers* active in the phonology of Huariapano:

(i) A **prominence tier** for stress assignment (syllabic trochees, direction is lexically-determined)

(ii) A **'rhythmic' tier** for coda [h] epenthesis (syllabic trochees, always left-to-right)

These tiers are 'metrical' in the sense that they are each governed by familiar constraints on hierarchical prosodic structure. Both tiers evince rhythmic alternations (due to syllabic binarity, clash avoidance, etc.), and they both show evidence of head prominence (stress assignment to heads on the prominence tier; quantity sensitivity for primary stress placement; augmentation of prosodic heads with coda [h] on the rhythmic tier). Under the DFAH, then, words in Huariapano are parsed into metrical consitituents in two different phonological 'dimensions': stress feet '( )' on the prominence tier, and epenthesis feet '{ }' on the rhythmic tier.

(30)   Disjoint footing in Huariapano

  a. Stress feet and epenthesis feet coincide (L → R secondary stress)

   (i) [pàḥ.tˢaj.níḥ.kã̃j] 'they are washing'

   (ii) Stress footing: $\overrightarrow{(\grave{\text{L}}_h\text{H})}(\acute{\text{L}}_h\text{L})$

   (iii) Epenthesis footing: $\overrightarrow{\{\grave{\text{L}}_h\text{H}\}\{\acute{\text{L}}_h\text{L}\}}$

  b. Stress feet and epenthesis feet do not coincide (R → L secondary stress)

   (i) [ha.jà.jiḥ.káŋ.ki] '(they) possessed, had'

   (ii) Stress footing: $\text{L}\overleftarrow{(\grave{\text{L}}\text{L}_h)}(\acute{\text{H}})\text{L}$

   (iii) Epenthesis footing: $\overrightarrow{\{\text{L}\grave{\text{L}}\}\{\text{L}_h\acute{\text{H}}\}}\text{L}$

2.4 Towards a unified account of Huariapano

The DFAH does a very good job of accounting for the empirical facts regarding stress and [h] epenthesis in Huariapano. Conceptually, however, the apparent need for a 'rhythmic' tier governing coda [h] epenthesis is both mysterious and dissatisfying. For one, the proposed rhythmic tier has no phonological consequences apart from epenthesis itself — there is no further evidence for such a tier in Huariapano, and thus no independent language-internal justification for assuming its existence. There is also

no language-external, typological justification for a 'disjoint' tier specifically governing epenthesis (though cf. Halle & Vergnaud 1987:66, Blumenfeld 2006:§3.6.2, and Vaysman 2009 on other cases of putative mismatch between stress and prosodic structure). To the best of my knowledge, Huariapano is the only attested language with a pattern of rhythmic epenthesis that diverges from rhythmic stress assignment. The empirical motivation for an epenthesis-specific tier is thus limited to fairly parochial properties of Huariapano. Given that assuming disjoint, process-specific tiers constitutes a fairly drastic amendment to metrical theory, we should be loathe to take such a step until all other analytical avenues have been exhausted (a point that Parker 1998a would appear to be in agreement with).

The third conceptual problem with the DFAH has to do with the geometry of the proposed rhythmic tier. It is generally assumed that phonological tiers are 'projected' from features, segments, tonemes, or prosodic units like the syllable (Goldsmith 1976, 1990, Halle & Vergnaud 1980, 1987, Hyman 1985, etc.). But the rhythmic tier governing epenthesis under the DFAH does not obviously project from anything at all. An obvious possibility is that the rhythmic tier projects from syllables; however, since secondary stress assignment also operates over groups of syllables, this amounts to the otherwise unmotivated assumption that a single phonological unit can project multiple, ontologically identical tiers. The essential problem is that the proposed rhythmic tier is *process*-specific rather than *object*-specific, which distinguishes it from the tiers that plausibly organize vowel features, tones, and other phonological primitives. Within a larger theory of phonological geometry, then, there is no grounding for an epenthesis-specific tier.

In this chapter, I defend an alternative analysis of Huariapano that avoids these conceptual pitfalls. The analysis begins with the conservative assumption that metrical structure is unique: any individual language can make use of at most one system of metrical parsing. As such, metrically-organized stress cannot co-exist with an independent, disjoint metrical system operating within the same language. I will call this assumption the UNIFORMITY OF FOOTING HYPOTHESIS.

(31) **Uniformity of footing hypothesis (ᴜꜰʜ):**

Within a single language, there are no mismatches between the metrical feet needed for stress assignment and the feet needed to explain foot-sensitive segmental processes.

As discussed in Section 2.7, the strongest form of the ᴜꜰʜ may be too restrictive. In particular, we might expect to find disjoint metrical systems in tonal languages, because tones may be metrically parsed on an independent tier, apart from any constituent structure defined over segments or prosodic units (e.g. Weidman & Rose 2006, Green, Davis, Diakite & Baertsch 2009 on Bamana; see Section 2.7). With this caveat in mind, for the time being I will assume that the ᴜꜰʜ, as stated in (31), holds without exception in natural language.

The ᴜꜰʜ is clearly at odds with the disjoint footing analysis of Huariapano. After all, the ᴅꜰᴀʜ was itself motivated by the apparent impossibility of reconciling rhythmic stress with rhythmic coda [h] epenthesis under a single metrical parse. As it turns out, a unified account of rhythmic phenomena in Huariapano *is* possible under the ᴜꜰʜ, provided that we're willing to make two general assumptions: first, that footing in Huariapano is more flexible than assumed by the ᴅꜰᴀʜ; and second, that rhythmic coda [h] epenthesis is foot-based and prominence-sensitive (as in the ᴅꜰᴀʜ), but is *not* the result of a pressure to augment foot heads (*contra* the ᴅꜰᴀʜ).

Before presenting my account of Huariapano, I should mention that some of the intuitions I've drawn on here are implicit in Parker (1994, 1998a) and González (2003), albeit in a very embryonic form. That acknowledgment aside, the analysis that I advocate is radically different from the alternatives that have been offered in earlier work on Huariapano, as will become clear.

2.4.1 Stress placement

2.4.1.1 Primary stress

Unlike ᴅꜰᴀʜ, I assume that the foot bearing primary stress in Huariapano is always bisyllabic. Default penultimate stress, then, is the result of bisyllabic trochaic footing (more or less as in the ᴅꜰᴀʜ).

(32) Penultimate stress: right-aligned bisyllabic trochee

    a. /...LL/ → [...(ĹL)]

    b. [(β̃i.na)] 'male'

    c. /...HL/ → [...(ĤL)]

    d. [(máj.ti)] 'hat'

Assuming invariant bisyllabic footing at the right edge leads to a different analysis of word-final primary stress. Recall that word-final syllables bear primary stress if heavy. The DFAH views final stress as the expression of a monosyllabic, word-final moraic trochee [...(Ĥ)]. The alternative that I pursue here is that final stress represents a trochaic-iambic *rhythmic reversal*: under pressure from WEIGHT-TO-STRESS, or some other principle favoring stressed heavy syllables, Huariapano constructs a bisyllabic word-final iamb rather than a default trochaic foot.[9]

(33) Final stress: right-aligned bisyllabic iamb[10]

    a. /...LH/ → [...(LĤ)]

    b. [(ja.wíʃ)] 'opossum'

    c. /...HH/ → [...(HĤ)]

    d. [(hon.tˢís)] 'claw; fingernail'

There is some empirical evidence that supports a rhythmic reversal analysis of final stress. First, there are apparently no trisyllabic words in Huariapano bearing final

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[9]Foot-form reversals of this sort have also been proposed for Yidinʸ, Cairene Arabic (McCarthy & Prince 1986/1996:7-8), Choctaw, Southern Paiute, Ulwa, Axininca Campa (Prince & Smolensky 1993/2004:58), Tiriyó Carib (van de Vijver 1998:Ch.2), Hopi (Gouskova 2003:Ch.3), Nanti (Crowhurst & Michael 2005), other Panoan languages (Elias-Ulloa 2006), Takia (de Lacy 2007), and Awajún (McCarthy 2008b). See Lee (2008) and Chapter 3 for more discussion.

[10]The footing in (33c) might seem counterintuitive, given the well-known tendency for iambs to be quantity-sensitive. That said, quantity-sensitivity is not universal for iambic feet: Altshuler (2009) argues for quantity-insensitive iambs in Osage, and Bye & de Lacy (2008) argue that many purported cases of iambic lengthening actually reflect a more general pressure for primary-stressed syllables to be bimoraic. At any rate, see Section 2.4.3 for arguments that only final codas count as moraic in Huariapano, rendering the issue moot.

primary stress and initial secondary stress.[11]

(34) a.   [βï.roj.ʃín] 'soul; spirit'   LL(Ĥ)#
      b. *[β̀ï.roj.ʃín]   *(L̀L)(Ĥ)#

      c.   [pa.βi.kín] 'ear'   LL(Ĥ)#
      d. *[pà.βi.kín]   *(L̀L)(Ĥ)#

      e.   [ha.no.áʂ] 'afterwards, from then on'   LL(Ĥ)#
      f. *[hà.no.áʂ]   *(L̀L)(Ĥ)#

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[11]There are two potential counterexamples to this generalization: [mà.wa.ʂóm] 'dying' (Parker 1998b:13) and [hà.βo.kán] 'they' (Parker 1998b:17). I am suspicious of the claim that these words bear initial secondary stress. Parker (1998b) reports that the 'stressed' [à] in the initial syllable of [hà.βo.kán] is 71ms long. This is on the short side for a vowel in an open syllable in Huariapano: according to Parker (1998b), the mean vowel length in a [CV] syllable is about 93ms. For comparison, the unstressed [a] in [ha.no.áʂ] 'afterwards, from then on' has a duration of 73ms, which is very close to the length of the 'stressed' [à] in [hà.βo.kán]. The relative shortness of these two vowels is notable, given that low vowels tend to be longer than mid and high vowels (e.g. House 1961, Lehiste 1970, Parker 2002 and references therein). I am thus inclined to believe that, phonologically, the initial syllables of [hà.βo.kán], [ha.no.áʂ], etc. are in fact stressless.

To be sure, the phonetics of stress in Huariapano are not well-understood, though Parker (1998b) provides a good phonetic analysis of the limited data available to him. While Parker (1998b) explicitly denies that vowel length is a correlate of stress in Huariapano (thereby undermining the argument made in the previous paragraph), I am not so sure. Given that vowel length is non-phonemic in Huariapano, and duration is one of the most frequent cues to stress cross-linguistically (Cutler 2005), it would be surprising if stress did not interact with vowel length in some way. It is also unclear why otherwise prosodically-identical trisyllabic words should differ as to the presence or absence of secondary stress. It strikes me as plausible, then, that the initial secondary stress transcribed for [mà.wa.ʂóm] and [hà.βo.kán] actually corresponds to some kind of phrase-level or initial-syllable phonetic prominence rather than phonological secondary stress (see e.g. Hyman 1977, Beckman 1998).

In the interest of full disclosure, I should mention that Steve Parker (p.c.) disagrees with my interpretation of these facts: his view is that all trisyllabic words with final stress probably had initial secondary stress as well, despite the variability in his earlier transcriptions. Given that Huariapano is no longer spoken, the remaining data available to us is probably not sufficient to settle this question definitively. Thankfully, this debate does not bear on my arguments for a single-tier treatment of coda [h] epenthesis (see Section 2.4.4.3).

While only a handful of trisyllabic words are attested in Parker (1994, 1998a,b), all of them contain just one stress peak. The lack of initial secondary stress in forms like (34) is surprising under the assumption that final primary stress results from a monosyllabic, moraic trochee: after building a final monosyllabic foot, the remaining unfooted syllables should be parsed into a left-aligned syllabic trochee bearing secondary stress (35a).

(35)   Moraic trochees wrongly predict secondary stress in trisyllabic forms

    a.   Trochee: *[(β̀i.roj)(ʃín)]

    b.   Iamb: [β̈i(roj.ʃín)]

On the other hand, an analysis of final stress in terms of rhythmic reversal (35b) correctly predicts that secondary stress should be impossible in trisyllabic words, provided that degenerate feet are disallowed in Huariapano (as suggested by the bimoraic word minimality condition; Section 2.2.2).

A second argument for this approach to final stress is that weight-driven rhythmic reversals are attested in other closely-related Panoan languages — some of which were mutually intelligible with Huariapano (see e.g. Parker 1994, Loos 1999, Elias-Ulloa 2006). The claim that Huariapano makes use of both trochaic and iambic footing is thus less radical than it might at first seem.

2.4.1.2 Regular secondary stress

I assume that regular secondary stress (odd-numbered syllables) is due to the left-to-right parsing of syllabic (i.e. quantity-insensitive) trochees. This portion of my analysis is thus shared with the DFAH.

(36)   Regular secondary stress: L → R syllabic trochees (as in DFAH)

    a.   [(mà.na)(páj.ri)] 'I will wait' $\overrightarrow{(\text{L̀L})}(\text{ĹL})$

    b.   [(jò.mï)(rà.no)(ʂih.ká̃j̃)] 'they will hunt' $\overrightarrow{(\text{L̀L})(\text{L̀L})}(\text{LH́})$

However, where the DFAH simply stipulates that secondary stress is quantity-insensitive (Parker 1998a, McGarrity 2003), in Section 2.4.3 I show that this fact can be derived from other assumptions.

2.4.1.3 Irregular secondary stress

Unlike the DFAH, I assume that irregular secondary stress (even-numbered syllables) still involves left-to-right parsing — that is, the direction of parsing for secondary stress is fixed across all lexical items. Instead, I propose that irregular secondary stress is the result of non-default, quantity-insensitive *iambic* parsing.

(37)   Irregular secondary stress: L → R syllabic iambs

    a.   [(βis.mà)(noh.kò)no(ṣí.ki)] 'I forgot' $\overrightarrow{\text{(LL̀)(LL̀)}}$L(ĹL)

    b.   [(ɟï.nà)(ko.ṣón)] 'spider' $\overrightarrow{\text{(LL̀)}}$(LH́)

Lexical items in Huariapano thus differ in the *shape* of footing rather than the direction.

These two approaches to modeling lexically-determined secondary stress are not equivalent. In particular, the DFAH predicts that there should be no even-parity words with irregular stress.[12] The reason is simple: with an even number of syllables to parse, left-to-right and right-to-left syllabic trochees produce exactly the same patterns of surface stress assignment.

(38)   Parsing even-parity words under the DFAH: $\overset{\textit{Irregular?}}{\overleftarrow{\text{(L̀L)(L̀L)(L̀L)}}}$ (ĹL)
                                                     $\underset{\textit{Regular?}}{\overrightarrow{}}$

Under the DFAH, regular and irregular stress should be indistinguishable in even-parity words: they both predict odd-syllable stress. In contrast, an iambic analysis of irregular secondary stress predicts that even-parity words could bear even-syllable stress, as in (39). Note that iambic parsing also predicts the possibility of medial trapped syllables as an effect of clash avoidance (where 'trapped' means 'unfootable'; Mester

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[12]Or more precisely, no words with irregular stress and an even number of syllables preceding primary stress.

1994).

(39)   Parsing even-parity words with irregular iambic feet: $\overrightarrow{(L\grave{L})(L\grave{L})}LL(\acute{L}L)$

It should also be pointed out that in order to compare the two hypotheses, we need
to consider words with six or more syllables. Given that stress clashes are completely
disallowed in Huariapano, both left-to-right iambs and right-to-left trochees predict
the same pattern of stress assignment for four- and five-syllable words (at least when
primary stress is on the penult).

(40)   a.   Trochaic parse:
              4σ: $[(\grave{\sigma}_1\sigma_2)(\acute{\sigma}_3\sigma_4)]$
              5σ: $[\sigma_1(\grave{\sigma}_2\sigma_3)(\acute{\sigma}_4\sigma_5)]$

        b.   Iambic parse:
              4σ: —
              5σ: $[(\sigma_1\grave{\sigma}_2)\sigma_3(\acute{\sigma}_4\sigma_5)]$

It is not quite clear whether words like (39) exist in Huariapano. Parker (1998b:13-4)
includes the following examples, which seem to be even-parity words with irregular
stress.

(41)   a.   [βi.t͡ʃä̀.na.na.naŋ.ká.ti] 'I found myself (face to face with the jaguar)'
        b.   [o.nà.ja.ma.káŋ.ki] 'they don't know (how to speak Huariapano)'

        c.   Iambic parse: ✓ (L$\acute{L}$)LL($\acute{L}$L)
        d.   Trochaic parse (DFAH):   * ($\acute{L}$L)($\acute{L}$L)($\acute{L}$L)

These examples — which have a medial lapse — are consistent with an iambic parse
for secondary stress (as in my account), but *not* with a right-to-left trochaic parse (as in
DFAH). These examples thus provide evidence in favor of an iambic analysis of irregular
secondary stress in Huariapano.

    That said, Parker (1998a:9) explicitly claims that words with the pattern of stress
assignment in (41) are systematically absent in Huariapano. However, given the ex-

istence of the examples in (41), and the fact that words with six or more syllables are relatively rare to begin with in Huariapano (Parker 1998a:32), I believe we have reason to doubt the reliability of Parker's generalization. I conclude, then, that the available evidence supports an iambic treatment of irregular secondary stress assignment.

To summarize the discussion so far, I am making the following claims about stress assignment in Huariapano:

(42)   Stress assignment in Huariapano

      a.   Primary stress is assigned to a word-final, bisyllabic foot: $[\dots(\sigma\sigma)]$

      b.   Penultimate primary stress involves default trochaic footing: $[\dots(\acute{\sigma}\text{L})]$

      c.   Weight-driven final primary stress involves non-default iambic footing: $[\dots(\sigma\acute{\text{H}})]$

      d.   Regular secondary stress involves left-to-right, quantity-insensitive *trochees* $[\overrightarrow{(\grave{\sigma}\sigma)(\grave{\sigma}\sigma)\dots}]$

      e.   Irregular secondary stress involves left-to-right, quantity-insensitive *iambs* $[\overrightarrow{(\sigma\grave{\sigma})(\sigma\grave{\sigma})\dots}]$

      f.   Stress clash and degenerate feet are completely disallowed: $^{*}[\grave{\sigma}\acute{\sigma}]$, $^{*}[(\sigma_{\mu})]$

These assumptions will be complicated slightly in what follows, but for the moment they are sufficient to begin the analysis of coda [h] epenthesis.

2.4.2   Coda [h] epenthesis

As discussed in Section 2.3.2, the DFAH assumes that coda epenthesis serves to augment the weight of prosodic heads, where the 'headedness' relevant for epenthesis is determined on the rhythmic tier, completely independent of stress assignment. This assumption makes some sense, given that there are languages with trochaic footing and lengthening of vowels in stressed [CV] syllables (e.g. Lahiri & Dresher 1999, Revithiadou 2004; though cf. Hayes 1995:83-4). On the other hand, footing on the

rhythmic tier in Huariapano does not otherwise care about mora count: foot parsing for epenthesis is quantity-insensitive, a property that it shares, suspiciously, with the assignment of secondary stress. This argues against the claim that coda [h] epenthesis is motivated by a pressure for bimoraic foot heads (as Parker 1998a points out).

Here, I offer a different analysis of the phonological motivation for coda [h] epenthesis in Huariapano. Specifically, I propose that coda [h] epenthesis occurs in order to augment *foot-initial syllables*, whether or not those syllables are also stressed. This assumption derives the fact that both coda [h] epenthesis and secondary stress display quantity-insensitive rhythm, since the two phenomena are determined by the same underlying metrical structure. By assuming that epenthesis targets foot-initial syllables, and further, that feet may be either trochaic or iambic in Huariapano, this single-tier analysis also derives the fact that stress and epenthesis do not always coincide. In Section 2.5 I justify this analysis on typological grounds. For now, I show that it correctly derives coda [h] epenthesis in Huariapano without the need for disjoint footing.

2.4.2.1 Words with final primary stress

On my analysis, primary stress is always assigned to a word-final bisyllabic foot in Huariapano. Words of the same length therefore contain the same foot boundaries, whether primary stress falls on the final syllable or on the penult. Under the assumption that coda [h] epenthesis occurs in foot-initial syllables, words differing only in the position of primary stress should have epenthesis in the same locations, *ceteris paribus*. This prediction is of course borne out.

(43)   a.   [jò.mï.ràh̲.ka.tíh̲.kãj̃] 'they hunted'   (L̀L)(L̀$_h$L) $\boxed{(\text{Ĺ}_h\text{L})}$

       b.   [jò.mï.rà.no.s̲ih̲.kãj̃] 'they will hunt'   (L̀L)(L̀L) $\boxed{(\text{L}_h\text{H́})}$

       c.   [nah̲.ká] 'manioc beer' $\boxed{(\text{L}_h\text{Ĺ})}$

If foot construction is uniform (with variable headedness), then all odd-numbered syllables will also be foot-initial, and thus correctly eligible for coda [h] epenthesis. The essential insight here is that stress and coda [h] epenthesis *sometimes* coincide because they are based on the same foot structure; still, stress itself has no direct relevance

for coda [h] epenthesis, which explains why the two phenomena are only imperfectly correlated.

2.4.2.2 Even-parity words

In even-parity words with regular secondary stress (odd-numbered syllables) and penultimate primary stress, my analysis and the DFAH make identical predictions: stress and coda [h] epenthesis should coincide perfectly. Under either account of Huariapano, regular secondary stress involves trochaic footing. This means that syllables bearing secondary stress will also be foot-initial, and thus eligible for epenthesis.

(44)   Regular secondary stress: L → R syllabic trochees

    a.   [pàh̲.tˢaj.ní h̲.kã͂j] 'they are washing'   (L̀ₕH)(ĹₕL)

    b.   [jò.mï.ràh̲.ka.tí h̲.kã͂j] 'they hunted'   (L̀L)(L̀ₕL)(ĹₕL)

For even-parity words with irregular secondary stress, my account (like the DFAH) predicts that secondary stress and coda [h] epenthesis should diverge. Left-to-right iambic footing would derive even-syllable stress (on foot-final syllables), but odd-syllable epenthesis (on foot-initial syllables). This prediction is correct as well.[13]

(45)   Irregular secondary stress: L → R syllabic iambs

    a.   [βis.mà.noh̲.kò.ja.máj] 'I have forgotten'   (LL̀)(LₕL̀)(LH́)

    b.   [ih̲.kàʂ.t͡ʃaŋ.ká.ti] 'you would shake with fear'   (LₕH̀)H(ĹL)

    c.   [rah̲.kï.ja.màj.βa.ʂí.ki] 'I was afraid of it (the jaguar)'   (LₕL̀)(LH̀)L(ĹL)

2.4.2.3 Odd-parity words

When we turn to odd-parity words, it looks like the DFAH has an edge over the single-tier account of Huariapano defended in this chapter. Unamended, the proposal that

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[13]See Sections 2.4.2.3 and 2.4.6, respectively, on the lack of [h] epenthesis in the stressed penults in (45b) and (45c).

coda [h] epenthesis occurs in foot-initial syllables seems to undergenerate epenthesis in some attested surface forms.

(46) a. [jò.mï.ra<u>h</u>.ká.no] 'let's go hunting'   (ĽL) L$_h$ (ĹL)

     b. [ha.jà.ji<u>h</u>.káŋ.ki] '(they) possessed, had'   (LĽ) L$_h$ (ĤL)

     c. [nï<u>h</u>.tï.no] 'day (locative)'   L$_h$ (ĹL)

The examples in (46) should have unfooted antepenults under the current assumptions regarding foot parsing. Unfooted syllables are of course not foot-initial, so it follows that unfooted syllables should not show coda [h] epenthesis. Nevertheless, the unfooted antepenults in (46) *do* show coda [h] epenthesis, and therefore appear to falsify the analysis advanced here.

To remedy this problem, I propose that the antepenults in (46) *are* in fact footed — but not in the usual way. Specifically, the antepenultimate syllables in (46) are recursively adjoined to the foot to their right, i.e. to the foot bearing primary stress.

(47) Recursively adjoined antepenults in Huariapano

     a. [jò.mï.ra<u>h</u>.ká.no] 'let's go hunting'   (ĽL)(L$_h$(ĹL))

     b. [ha.jà.ji<u>h</u>.káŋ.ki] '(they) possessed, had'   (LĽ)(L$_h$(ĤL))

     c. [nï<u>h</u>.tï.no] 'day (locative)'   (L$_h$(ĹL))

Assuming recursive left-adjunction of trapped syllables solves the undergeneration problem. Antepenultimate syllables in odd-parity words are no longer unfooted — instead, they are initial within the foot that immediately contains them. The antepenults in words like (47) and are thus correctly predicted to be possible epenthesis sites. Since these recursively parsed antepenults are adjuncts rather than prosodic heads, we also expect that they should be unstressed, which is consistent with the empirical facts.[14]

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[14]In the recursive foot structure proposed here, maximal feet seem to be right-headed, while minimal feet may be left-headed: $(\sigma_D (\sigma_H \sigma_D)_H)$. I assume that this apparent 'headedness switch' is only illusory: the lack of stress on the adjoined syllable has to do with its status as an adjunct, rather than its status as

I claim that recursive adjunction is exploited in Huariapano as a last-resort strategy for ensuring exhaustive parsing. Without recursive footing, antepenultimate syllables in odd-parity words would be prosodically 'trapped' (Mester 1994), given the inviolable prohibitions on degenerate feet and stress clash in Huariapano. Recursive adjunction thus serves to foot otherwise unfootable syllables. Importantly, we already have evidence that Huariapano prefers exhaustive parsing of words: namely, the existence of iterative secondary stress, which results from the maximal parsing of syllables into feet.

An additional fact in need of explanation is that penults in odd-parity words — which are also foot-initial, under the current set of assumptions — are not eligible for coda [h] epenthesis.

(48)   No coda [h] epenthesis in penults in odd-parity words

    a.   [pa<u>h</u>.tˢá.kï] 'we washed'   (L$_h$ ($\boxed{\text{Ĺ}}$ L))

    b. *[pa<u>h</u>.tˢá<u>h</u>.kï]   *(L$_h$ ($\boxed{\text{Ĺ}_h}$ L))

    c.   [ra<u>h</u>.kï̀.t͡ʃa.í.ki] 'it's scary'   (L$_h$ L̀)(L ($\boxed{\text{Ĺ}}$ L))

    d. *[ra<u>h</u>.kï̀.t͡ʃa.í<u>h</u>.ki]   *(L$_h$ L̀)(L ($\boxed{\text{Ĺ}_h}$ L))

The lack of penultimate coda [h] epenthesis in words like (48) can be explained if epenthesis only targets syllables at the edges of *maximal* feet (Itô & Mester 1992/2003, 2009, 2010, et seq.). The intuition here is that the application of epenthesis is limited to syllables that are strictly foot-initial. Syllables at the left-edge of a non-maximal foot [$(\sigma(\underline{\sigma}\sigma))$] are also non-initial within the superordinate maximal foot; as such, they do not qualify as 'foot-initial' in the most stringent sense. In this respect, coda [h] epenthesis in Huariapano can be thought of as a segmental cue to the boundaries between adjacent feet, much like the fortition processes found in many Yupik languages (Section 2.5.1).

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the leftmost member of the maximal foot. See also Itô & Mester (2012a).

(49) Maximal foot (Ft$_{MAX}$; see Partee et al. 1990, Itô & Mester 2009):

A foot not dominated by any other foot.

(50) Coda [h] epenthesis only targets initial syllables of Ft$_{MAX}$

a. [pa$\underline{h}$.tˢá.kï]   ($_{MAX}$ $\boxed{L_h}$ ($_{MIN}$ Ĺ L))

b. [ra$\underline{h}$.kï̀.t͡ʃa.í.ki]   ($_{MAX}$ $\boxed{L_h}$ L̀)($_{MAX}$ $\boxed{L}$ ($_{MIN}$ Ĺ L))

In odd-parity words with recursive adjunction of 'trapped' antepenults, penults will not be eligible for epenthesis, but antepenults, which are initial in Ft$_{MAX}$, will. The assumption of recursive footing thus reconciles the distribution of coda [h] epenthesis with a single-tier analysis of Huariapano in which epenthesis is an augmentation process that targets foot-initial syllables.

It is also clear that recursive footing in odd-parity words cannot be discarded in favor of assuming imperfectly aligned iambs. Under the assumption that epenthesis applies in foot-initial syllables, the imperfectly aligned iambic structure $[(\sigma\acute{\sigma})\sigma]$ would correctly predict antepenultimate epenthesis in forms like [pa$\underline{h}$.tˢá.kï], as well as the lack of epenthesis in the penult. However, recursive footing makes additional predictions about trisyllabic words with final stress. Words of this shape $[\sigma\sigma\acute{\sigma}]$ should be footed recursively, $[(\sigma(\sigma\acute{\sigma}))]$. This predicts that penultimate epenthesis should be ruled out. The non-recursive footing $[\sigma(\sigma\acute{\sigma})]$, in contrast, predicts that penultimate epenthesis should be licit. Words like [pa.βi.kín] 'ear', which lack penultimate epenthesis, show that recursive footing is necessary for a single-tier analysis of Huariapano to account for the distribution of epenthesis in odd-parity words. (See Section 2.4.4.3 for related discussion.)

At this point, we might wonder whether the need for recursive footing counts as a liability of the single-tier analysis of Huariapano. In fact, recursive footing has been proposed many times in the existing phonological literature. In early work on metrical stress theory, it was often assumed that syllables left unparsed by a language's footing algorithm were recursively adjoined to adjacent prosodic constituents (so-called 'stray syllable adjunction'; e.g. Prince 1976, Liberman & Prince 1977, Selkirk 1980, Hayes 1981, etc.). My analysis of Huariapano draws on the same basic intuition, in that ex-

haustive parsing is taken to be the driving motivation behind foot-level recursion. This assumption is made plausible by the independent fact that Huariapano has a robust system of secondary stress assignment. In contrast, the epenthesis-specific metrical tier proposed by the DFAH subserves no larger phonological purpose — there is no credible principle that compels the existence of multiple metrical tiers, apart from the need to account for rhythmic epenthesis itself.

Recursive footing has also been employed to account for voiceless stop allophony in English (e.g. Hammond 1997, Jensen 2000, Davis & Cho 2003), patterns of infixation (McCarthy 1982, Yu 2004), and ternary stress (Rice 1992, 2007, Caballero 2008). Compared to disjoint metrical tiers, including recursive footing as part of metrical theory counts as a relatively conservative assumption, and one that is broadly supported by empirical evidence. (See Section 2.6 for more discussion of foot-level recursion, and Martínez-Paricio 2012 for a recent exploration of similar ideas.)

It should also be pointed out that admitting recursive feet into the analysis of Huariapano does not lead to a proliferation of recursive structure. As discussed in more detail in Section 2.4.4, recursion occurs only in order to incorporate trapped syllables into metrical structure. Exhaustive parsing can often be achieved without resorting to recursion — for example, even-parity words can be exhaustively parsed into bisyllabic feet without leaving behind any stray syllables, as in [(pàh̠.tˢaj)(níh̠.kãj̃)] 'they are washing'. In cases where recursion is not needed for exhaustive parsing, it is gratuitous, and therefore banned by economy considerations.

A remaining issue has to do with the direction of adjunction. It is crucial for the analysis of Huariapano that trapped antepenults adjoin to the right rather than to the left. To correctly derive the distribution of epenthesis trapped antepenults must be initial in Ft_{MAX}, which in turn requires left-adjunction (51a) rather than right-adjunction (51b).

(51) a. Left-adjunction: ✓ (L̀L)(L$_h$(ĹL))

      b. Right-adjunction: * ((L̀L)L$_h$)(ĹL)

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The question, then, is how to rule out right-adjunction in favor of uniform left adjunction. There are at least two possibilities we could pursue. First, it may be that unparsed syllables preferentially adjoin to the foot bearing primary word stress. In other words, head feet may be the best 'hosts' for adjoined syllables. This would account for the fact that antepenults always adjoin to the right in Huariapano (51a), since the foot to the immediate right of the antepenult always bears primary stress (i.e. it is the head foot of the word).[15]

A different explanation for the preference for left-adjunction (51a) depends on the notion of edge-alignment in footing. In the left-adjunction structure (51a), two out of three feet are perfectly aligned with the right edge of the word; in the right-adjunction structure (51b), only one foot out of three is perfectly right-aligned. Any constraint preferring right-aligned feet will thus favor left-adjunction (provided that the constraint in question does not distinguish between maximal and non-maximal feet). There are a number of ways to implement this basic idea, but here it suffices to point out that there are several well-motivated strategies for guaranteeing that stray syllables always adjoin to the right in Huariapano.

While recursive footing is an important aspect of my proposal, most cases of epenthesis in odd-parity forms can be readily analyzed without any recursive structure. Outside of the penult and antepenult, the distribution of coda [h] epenthesis can be captured under the same assumptions needed for even-parity forms: namely, that epenthesis targets foot-initial syllables, and secondary stress always involves left-to-right parsing of bisyllabic feet.

(52)   a.   [ih̥.kàṣ.t͡ʃaŋ.ká.ti] 'you would shake with fear'   (L$_h$ H̀)(H (Ĺ L))

        b.   [βis.mà.noh̲.kò.ja.máj.kaj] 'I forget'   (H L̀)(L$_h$ L̀)(L (H́ L))

Since this analysis was designed to limit epenthesis to odd-numbered syllables, regardless of overall syllable count, it comes as no surprise that it succeeds at doing so

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[15]There may be a connection between the idea that stray syllables preferentially adjoin to head feet and the observation that stress lapses are less marked when adjacent to main stress (Lapse-at-Peak; Kager 2001, 2005, etc.). In at least some cases, lapse adjacent to primary stress could be interpreted as recursively parsed [((σ́σ)σ)] or [(σ(σσ́))].

in both even-parity and odd-parity words.

One last word on footing before concluding this section. In example (41) above I provided two even-parity words containing a medial stress lapse, repeated in (53).

(53)   Medial stress lapse

    a.   [β̈i.t͡ʃà.na.naŋ.ká.ti] 'I found myself (face to face with the jaguar)'

    b.   [o.nà.ja.ma.káŋ.ki] 'they don't know (how to speak Huariapano)'

An obvious question is how these words should be footed, given the strong drive toward exhaustive footing in Huariapano. For the sake of explicitness, I assume that the medial syllables participating in such stress lapses are *both* recursively adjoined to the right, as in (54).

(54)   Medial stress lapse with multiply-recursive footing: $[(\sigma(\sigma(\acute{\sigma}\sigma)))]$

    a.   [(β̈i.t͡ʃà)(na(naŋ(ká.ti)))] 'I found myself (face to face with the jaguar)'

    b.   [(o.nà)(ja(ma(káŋ.ki)))] 'they don't know (how to speak Huariapano)'

Provided that epenthesis only targets maximal feet, as I argue, these structures correctly predict the lack of epenthesis in the unstressed antepenult [ma] of (54b). The lack of epenthesis in either the initial syllable or the penult of (54a) is a bit more puzzling; it seems plausible that this word simply patterns with a small set of other lexical items in prohibiting epenthesis absolutely (see Section 2.4.6).

This concludes the heart of my reanalysis of Huariapano. To recap, I have made the following claims regarding coda [h] epenthesis:

(55)   Coda [h] epenthesis in Huariapano

    a.   In odd-parity words, otherwise unfootable antepenults are recursively adjoined to the foot to their right (i.e. the foot bearing primary stress): $[\ldots(\sigma(\sigma\sigma))]$

    b.   Coda [h] epenthesis targets syllables that are initial within a maximal foot, regardless of whether or not they bear stress: $(_{\text{MAX}} \text{L}_h \, \sigma)$ or $(_{\text{MAX}} \text{L}_h \, (\sigma\sigma))$

c. Foot-initial position is a phonologically prominent position. Coda [h] epenthesis is thus an augmentation process that serves to enhance the salience of phonologically prominent foot-initial syllables (see also Section 2.5).

2.4.3 Are epenthetic [h]s moraic?

A central claim of my analysis of Huariapano is that coda [h] epenthesis is motivated by a pressure to augment foot-initial syllables. So far, nothing has been said about *how* [h] epenthesis contributes to the salience of the syllables that it targets. One obvious possibility is that epenthetic [h]s are moraic (as suggested by Parker 1994, 1998a,b). On this view, coda [h] epenthesis in Huariapano is roughly analogous to stressed-syllable vowel lengthing in other languages, in that both processes derive heavy, bimoraic syllables in phonologically prominent positions.

Though seemingly reasonable, this set of assumptions ultimately proves untenable. If coda [h]s are moraic, then epenthesis creates (HĹ) and (HH́) iambs — sequences that are very badly formed from the perspective of grouping harmony (Prince 1991, Prince & Smolensky 1993/2004, Hayes 1995).

(56)   a. [na<u>h</u>.ká] 'manioc beer'   (H$_h$ Ĺ)

        b. [po<u>h</u>.ʂój] 'I open'   (H$_h$ H́)

Indeed, many quantity-sensitive languages actively avoid unstressed, foot-internal heavy syllables (e.g. Hayes 1981, 1995). This is especially true of languages with iambic footing. Since primary stress is quantity-sensitive in Huariapano, any account of that language that assumes [...(Hσ́)#] footing should thus be viewed with skepticism.

Given these difficulties, I would like to suggest that coda [h]s are never moraic in Huariapano. Furthermore, I claim that the non-moraic nature of coda [h]s stems from a more general property of the language: only word-final coda consonants can sponsor their own mora. A number of important consequences follow from this assumption. First, limiting moraic codas to final position means that only [CVC#] ultimas count as heavy in Huariapano (setting aside long vowels, which are restricted to [CV:] mono-

syllables). This is a valuable result, because it *derives* the fact that only primary stress assignment is sensitive to syllable weight. Final [CVC#] syllables are the only syllables in Huariapano that perturb stress assignment. This fact receives a direct explanation under the assumption that only final consonants are moraic, since it follows that only word-final syllables could have distinctions in syllable weight. Since primary stress is rightmost, and is always assigned to a word-final bisyllabic foot containing the ultima, it also follows that only primary stress will display quantity-sensitivity. Assuming positionally-restricted coda weight thus obviates the need for specialized constraints that enforce quantity-sensitivity for primary stress, but not for secondary stress (cf. Parker 1998a, McGarrity 2003).

If only final coda consonants may be moraic, as I propose, then there can be no ill-formed (Hσ́) or (σ́H) feet in Huariapano. If all medial codas are non-moraic, then all non-final syllables must count as light. Final [CVC$_\mu$#] syllables attract stress, so it follows that there are no unstressed heavy syllables at all in Huariapano, and thus no feet of the shape (Hσ́) or (σ́H). Another corollary of these assumptions is that there are no moraic [h]s in Huariapano; this follows from (i) the fact that there are no word-final coda [h]s, and (ii) the assumption that only word-final codas may sponsor a mora.[16] By restricting moraic codas to final position, then, we derive the fact that only primary stress interacts with syllable weight, while also guaranteeing that coda [h] epenthesis does not create prosodically ill-formed feet.

There is in fact additional support for positionally-restricted coda weight in Huariapano. Parker (1998a:33) points out that assuming a moraic basis for coda [h] epenthesis (i.e. 'trochaic strengthening' to ensure bimoraic foot heads on the rhythmic tier) is at odds with the fact that the foot parsing algorithm that determines possible epenthesis sites is itself quantity-insensitive. My account of Huariapano avoids this conceptual dissonance: coda [h] epenthesis depends on foot structure that, in most cases, is quantity-insensitive; since coda [h] epenthesis never introduces a mora, it does not con-

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[16]Parker (1998b) conducts a phonetic study that purports to show that epenthetic coda [h] is moraic in Huariapano. What Parker (1998b) actually establishes, however, is that coda [h]s are prosodically 'the same' as regular medial coda consonants — he does not in fact demonstrate that *any* medial codas are moraic. His phonetic findings (which do strike me as convincing) are thus consistent with my claim that all medial coda consonants are non-moraic in Huariapano.

travene the initial quantity-insensitive metrical parse. Furthermore, Hayes (1995:83-4) claims that there are no trochaic systems in which feet bearing secondary stress (non-head feet, $[(\acute{\sigma}\sigma)]$) manifest stressed vowel lengthening or any other moraic augmentation of the foot head (though cf. Revithiadou 2004, Bye & de Lacy 2008). While Huariapano is not a 'trochaic' system in the simplest sense, it does show a clear preference for trochaic footing, and thus constitutes a *prima facie* counterexample to Hayes' generalization. On the other hand, if coda [h] epenthesis is always non-moraic, then Huariapano fits neatly into the typology of quantitative adjustment as established by Hayes (1995).

There is also ample precedent for position-specific coda moraicity (also known as WEIGHT-BY-POSITION-BY-POSITION, or WxPxP; Rosenthall & van der Hulst 1999). In some languages, closed syllables only count as heavy in word-initial position (Yupik, van de Vijver 1998; Kuuku-Yaʔu, McGarrity 2003). In Capanahua (Loos 1969, González 2003), codas only contribute weight in peninitial syllables (though the facts may be consistent with allowing moraic codas in all non-initial syllables). More relevant for the analysis of Huariapano, Trommer & Grimm (2004) propose that only word-final coda consonants count as moraic in Albanian, while Rosenthall & van der Hulst (1999) make the same claim for Goroa and Uma Juman. Hyman (1977:fn. 30) observes that Bhojpuri and Mapuche (formerly Araucanian) are like Huariapano in that closed syllables attract stress just in final position, consistent with the view that only word-final codas bear moras in those languages as well. Languages in which monosyllabic [(CV́C)] feet are permitted only in word-final position (so-called 'generalized trochee' languages like Wergaia; Kager 1993b, Pruitt 2010) might be open to a reanalysis along the same lines. Similarly, languages that allow final but *not* medial codas might be analyzed as systems in which non-moraic codas undergo deletion, and moraic codas are only licensed in final position (e.g. Tagalog, French 1988; Guajajara, Bendor-Samuel 1963). I conclude, then, that there is both language-internal and typological support for the claim that only word-final codas are moraic in Huariapano.

The finality condition on moraic codas found in Huariapano is probably not an accident. In particular, it may be grounded in the phonetic phenomena of word- and phrase-final lengthening. Domain-final segments in many languages undergo gradi-

ent phonetic lengthening (e.g. Klatt 1976 and much subsequent work; see also Lunden 2006 for additional references). Final lengthening of this sort may have its source in very general properties of gestural planning (Klatt 1976, Edwards, Beckman & Fletcher 1991, Myers & Hansen 2007); along with its high frequency of occurrence (Myers & Hansen 2007), this suggests that final lengthening is a good candidate for a phonetic universal, at least in broad terms. While I have no concrete evidence that domain final consonant lengthening occurred in Huariapano, given the wide incidence of such processes it does seem extremely likely. It is my contention, then, that Huariapano speakers reinterpreted the increased duration of domain-final consonants as a phonetic reflection of a phonological difference — the asymmetrical licensing of moras on consonants in word-final position.

A potential concern for this explanation is that domain-final consonant lengthening is often phonologized in exactly the opposite direction. There are many languages in which coda consonants contribute to syllable weight *except* when appearing in absolute word-final position (e.g. Cairene Arabic and Norwegian; see Lunden 2006 for further examples and references). A common interpretation of such patterns is that moraic codas in these languages are allowed in all positions except word-finally — the mirror-image of my proposed analysis of Huariapano. Phonological systems of this sort plausibly represent a different, but still phonetically-motivated reaction to final lengthening. For example, final lengthening may mask the durational correlates of stress, thereby creating a state of affairs in which it appears that final [CVC] syllables exceptionally reject otherwise quantity-sensitive stress assignment. This perceptual ambiguity could then push learners toward a phonological analysis in which final codas are simply excluded from contributing to syllable weight, i.e. are non-moraic. Alternatively, language learners might interpret the durational variability of final consonants as an indication that they do not bear an independent mora, given the common conception of the mora as an abstract timing unit. Finally, the difference in phonetic salience between lengthened, word-final [CV·#] and [CVC·#] syllables may not reach the perceptual threshold required for [CVC·#] to count as heavy in final position (Lunden 2006).[17]

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[17]Another historical source for non-moraic final codas is vowel deletion. In at least some languages

While there might seem to be a tension between my analysis of Huariapano (which assumes that moraic codas are limited to final position) and the existence of mirror-image weight systems (in which final moraic codas are disallowed), there is nonetheless good reason to suspect that position-dependent weight systems of both sorts derive from the phonetics of final lengthening. There is nothing contradictory in the view that a single phonetic phenomenon might be phonologized in two distinct, diametrically opposed ways. The domain-final lengthening of vowels, for instance, has led to the development of numerous phonological systems in which vowel length contrasts are suppressed in word-final syllables. However, such languages differ in the direction of neutralization: there are languages in which only short vowels are permitted in final syllables (e.g. Choctaw), as well as languages that require long vowels in all final syllables (e.g. Kolami; see Buckley 1998, Lunden 2006, Barnes 2006:Ch.3.7, and Myers & Hansen 2007 for relevant discussion, and Hammond 1997 on related phenomena concerning word-final vowels in English). The fact that domain-final segments are durationally different from their non-final counterparts therefore underdetermines the phonological analysis that learners construct upon observing such lengthening effects (assuming that sub-phonemic durational effects of this sort are phonologized at all). As a result, domain final vowel lengthening has led to phonological systems in which final vowel length contrasts are neutralized in dramatically divergent, and seemingly conflicting ways.[18] The position-dependent weight system that I propose for Huariapano, in which moraic codas are limited to final position, thus rests on sound typological, phonological, and phonetic grounds.[19]

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with non-moraic, word-final consonants, the codas in question were originally non-moraic onsets of [CV] syllables that underwent a diachronic process of apocope, e.g. [CVCV#] > [CVC#] (Lunden 2006 and references there). These newly-derived [CVC#] syllables are then, for historical reasons, treated as light [CV] syllables in the calculation of quantity-sensitive stress placement.

This same diachronic trajectory could, of course, lead to the development of moraic word-final codas instead, provided stress was historically penultimate (see Hyman 1977:fn. 30).

[18]I thank Armin Mester for pointing out the relevance of domain-final vowel lengthening to this discussion.

[19]A potential alternative is to assume that all codas are moraic in Huariapano, but only those moras contained in the head foot (the foot bearing primary stress) are 'visible' for the computation of stress (in the sense of Dresher & van der Hulst 2002). While a reanalysis of Huariapano stress in these terms might ultimately prove tractable, I am not sure that it would amount to anything more than a theo-

This proposal raises an important question regarding the function of epenthesis in Huariapano: if coda [h]s aren't moraic, how do they serve to 'augment' foot-initial syllables, as proposed here? My claim is that coda [h] epenthesis increases the prominence of foot-initial syllables by maximizing the amount of segmental material those syllables contain — in other words, epenthesis increases overall syllable duration (Parker 1998b), but does so in a non-moraic fashion.[20] This is not a novel idea: Beckman (1998), Hall (2000), Bye & de Lacy (2008), and others have proposed that there is an independent pressure to maximize the amount of segmental material contained in prominent syllables, irrespective of moraic weight (cf. the constraint *Head/CV, González 2003, Section 2.4.7). Coda [h] epenthesis in Huariapano, then, is a prosodically-determined but non-moraic strengthening process. In Section 2.5 I provide several other plausible cases of non-moraic coda augmentation in foot-initial syllables, further supporting this view of rhythmic [h] epenthesis in Huariapano.

2.4.4 OT implementation

In this section I formalize my analysis of Huariapano within Optimality Theory (Prince & Smolensky 1993/2004). The goal of this section is simply to make the preceeding theoretical claims as explicit and precise as possible, and to demonstrate that my account of Huariapano is both internally consistent and empirically adequate. Most of the constraints I rely on should be familiar from other work in OT, but constraint definitions are provided throughout for perspicuousness.

2.4.4.1 Primary stress

I assume that primary stress in Huariapano (and the associated footing) results from the interaction of five constraints:

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retical translation of my own proposals. Furthermore, adopting the notion of prosodic visibility would not itself eliminate the need for a foot-based, but non-moraic treatment of coda [h] epenthesis (Section 2.4.4.4), given that coda [h] occurs in many non-head feet where (by hypothesis) moraic structure is not phonologically active. As such, I will not pursue this alternative analysis any further here.

[20]Parker (1998b) confirms that syllables closed by coda [h] have a greater duration than open syllables in Huariapano, though they are not quite as long as [CVC] syllables closed by other coda consonants.

(57)   a.   Anchor-R(ω, Ft) (Anch-R):

         Assign one violation for every prosodic word ω_i such that the right edge of ω_i does not coincide with the right edge of some foot (McCarthy & Prince 1995, 1999, McCarthy 2003b; see also McCarthy & Prince 1993a, Zoll 1998, Pater 2000, Nelson 2003, Hyde 2008)

     b.   Weight-to-stress (wsp):

         Assign one violation for every unstressed bimoraic syllable (Prince & Smolensky 1993/2004)

     c.   NonFinality (NonFin):

         Assign one violation for every word-final syllable that is stressed (Prince & Smolensky 1993/2004; see also Hyman 1977, Hyde 2007)

     d.   Parse(σ):[21]

         Assign one violation for every syllable that is not contained within a foot (Prince & Smolensky 1993/2004, McCarthy & Prince 1993a, et seq.)

     e.   FootBinarity(σ) (FtBin(σ)):

         Assign one violation for every monosyllabic foot (Hewitt 1994, Elias-Ulloa 2006; see also Prince & Smolensky 1993/2004, Mester 1994 and many others)

The combined action of the constraints in (57) ensures that default primary stress will fall on the penult, as in (58).[22,23]

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[21] See Selkirk (1996) and Itô & Mester (2009) for discussion of the related Exhaustivity constraint family.

[22] Tableaux are presented in the 'mixed' format in this dissertation, with both explicit violation marks and comparative annotations included (see Prince 2002 for an introduction to comparative tableaux).

[23] For the moment, I ignore the recursive parse [(ka(nó.ti))], which I take to be the actual output form in tableau (58).

(58)   Default primary stress on the penult

/ kanoti /	Parse(σ)	Anch-R	wsp	NonFin
a. ☞ ka(nó.ti)	*			
b. (ka.nó)ti	*	*! W		
c. (ká.no)ti	*	*! W		
d. ka(no.tí)	*			*! W

[ka.nó.ti] 'bow (weapon)'

Note that the preference for trochaic footing under primary stress is not due to the general foot-form constraint Trochee (e.g. Prince & Smolensky 1993/2004). Instead, default trochaic footing occurs under pressure from NonFinality, which militates against word-final stress. This is an important distinction, since the foot bearing primary stress may be trochaic even when all other feet in the word are iambic (Section 2.4.4.2).

Still, NonFinality is not absolute in Huariapano. Word-final stress does occur when necessary to place stress on a heavy, bimoraic ultima (the only heavy syllables in the language). It follows from this fact that wsp must outrank NonFinality (59).

(59)   Final primary stress triggered by weight sensitivity: wsp ≫ NonFin

/ ṣomoṣ /	FtBin(σ)	Parse(σ)	Anch-R	wsp	NonFin
a. ☞ (ṣo.móṣ)					*
b. (ṣó.moṣ)				*! W	L
c. ṣo(móṣ)	*! W	*! W			*
d. (ṣò)(móṣ)	*!* W				*

[ṣo.móṣ] 'needle'

The ranking wsp ≫ NonFin derives quantity-sensitivity in the rightmost foot, as required by the distribution of primary stress. The undominated constraint Parse(σ) ensures that footing will be exhaustive, thereby ruling out candidate (c) *[so(mós)]. FtBin(σ) prohibits monosyllabic (and monomoraic) feet, and is therefore also responsible for eliminating (c) from contention. Candidate (d) *[(sò)(mós)] satisfies Parse(σ)

by footing all syllables, but violates FtBin(σ) twice (once for each monosyllabic foot), and is ruled out as a result.

It should be pointed out that in almost all cases where FtBin(σ) eliminates a candidate, the form in question would be sub-optimal for independent reasons, e.g. for violating Parse(σ) (59c) or for containing a stress clash (59d). It may be that FtBin(σ) is not actually needed in the analysis of Huariapano stress — see Section 2.4.4.3 for more discussion of this point.

2.4.4.2 Secondary stress

To guarantee that secondary stress will be quantity-insensitive, we must first ensure that only word-final codas count as moraic. This can be accomplished with the following three constraints.

(60)   a.   *C$_\mu$:
             Assign one violation for every consonant associated with a unique mora
             (Sherer 1994; see also Rosenthall & van der Hulst 1999, Gordon 2000)

       b.   Weight-by-position (WxP):
             Assign one violation for every coda consonant that is not associated with
             a unique (i.e. non-nuclear) mora (Hayes 1989; see also Rosenthall & van
             der Hulst 1999, Gordon 2000)

       c.   FinalMora (Fin(μ)):
             Assign one violation for every word-final segment that is not uniquely
             associated with a mora (i.e. final codas are associated with a non-nuclear
             mora) (cf. Rosenthall & van der Hulst 1999)

The constraint *C$_\mu$ prohibits moraic codas (or more precisely, prohibits moras that are affiliated with a coda without also being affiliated with a nuclear vowel). The constraint WxP demands that every coda (or coda cluster) must sponsor its own mora; by ranking *C$_\mu$ above WxP, we render all coda consonants non-moraic. This effect can be subverted by ranking FinalMora above *C$_\mu$, thereby deriving the fact that all and only word-final codas count as moraic in Huariapano.

(61)   Only final coda consonants are moraic: $\text{Fin}(\mu) \gg {}^*C_\mu \gg \text{WxP}$

/ CVCCVC /	$\text{Fin}(\mu)$	${}^*C_\mu$	WxP
a. ☞ CVC.CVC$_\mu$		*	*
b. CVC$_\mu$.CVC$_\mu$		**! W	L
c. CVC.CVC	*! W	L	** W

The joint action of ${}^*C_\mu$, WxP, and ${}^*C_\mu$ determines the distribution of moraic codas in Huariapano, thereby setting the table for an analysis of the quantity-insensitive system of secondary stress.[24]

For the moment I focus on regular secondary stress; see Section 2.4.5 for an analysis of irregular stress in Huariapano. The analysis of regular secondary stress requires the following additional constraints.

(62)   a.   Trochee:

Assign one violation for every right-headed foot (i.e. feet are trochaic) (Prince & Smolensky 1993/2004)

b.   Iamb:

Assign one violation for every left-headed foot (i.e. feet are iambic) (Prince & Smolensky 1993/2004)

c.   AllFootLeft (afl):

For each foot Ft_i, assign one violation for every syllable intervening between Ft_i and the left edge of the prosodic word ω_j that immediately contains Ft_i (Prince & Smolensky 1993/2004; see also Zoll 1997, McCarthy 2003b, Hyde 2008)

d.   EndRuleRight (End-R):

Assign one violation for every foot intervening between a head foot Ft_{HEAD} and the right edge of of the prosodic word ω_j that immediately contains Ft_{HEAD} (i.e. the rightmost stress is the primary stress) (Prince 1983, 1985,

---

[24]I omit moraic subscripts in all subsequent tableaux. From here on it can be safely assumed that all and only word-final coda consonants count as moraic.

Hayes 1995, Prince & Smolensky 1993/2004, McCarthy 2003b, and others)

The constraint AllFootLeft prefers feet that fall as close to the beginning of the word as possible, and thereby determines the left-to-right direction of foot parsing for secondary stress. The ranking Anch-R ≫ afl ensures that the foot bearing primary stress (the rightmost foot) is always perfectly right-aligned, even though right alignment is penalized by afl. The further ranking Trochee ≫ Iamb establishes trochaic footing as the default foot-form for secondary stress assignment. Lastly, EndRuleRight sets the rightmost foot in each word as the foot that bears primary stress, i.e. as the head foot.[25]

(63)   Regular secondary stress is L → R parsing of syllabic trochees:
Anch-R ≫ afl, Trochee ≫ Iamb (not shown)

/ ꞵïnanoṣiki /	End-R	Parse(σ)	Trochee	Anch-R	afl
a. ☞ (ꞵì.na)no(ṣí.ki)		*			***
b. ꞵï(nà.no)(ṣí.ki)		*			****! W
c. (ꞵì.na)(nó.ṣi)ki		*		*! W	** L
d. (ꞵï.nà)no(ṣí.ki)		*	*! W		***
e. ꞵï.na.no(ṣí.ki)		**!* W			***
f. (ꞵï.na)no(ṣì.ki)	*! W	*			***

[ꞵì.na.no.ṣí.ki] 'he is going to seek/look for'

To account for words with regular, trochaic secondary stress and weight-driven, iambic final stress, we must assume the additional ranking wsp ≫ Trochee. This ranking allows words to have non-homogenous footing with respect to rhythmic type when needed to place stress on a final heavy syllable.

_____

[25]Again, I momentarily ignore the recursive parse [(ꞵì.na)(no(ṣí.ki))], which I take to be the actual winner in tableau (63).

(64) Weight-driven iambic primary stress: {wsp, Parse(σ)} ≫ Trochee

/ t͡ʃikïnamaŋ /	FtBin(σ)	Parse(σ)	wsp	Trochee	NonFin
a. ☞ (t͡ʃìh̲.kï)(na.máŋ)				*	*
b. (t͡ʃìh̲.kï)(ná.maŋ)			*! W	L	L
c. (t͡ʃìh̲.kï)na(máŋ)	*! W	*! W		L	*

[t͡ʃìh̲.kï.na.máŋ] 'corner'

Undominated FtBin(σ) then eliminates candidates like (64d) *[(t͡ʃìh̲.kï)na(máŋ)], which foot a final monosyllabic moraic trochee rather than a disyllabic iamb. This is an important assumption: since the third syllable [na] is in principle eligible for epenthesis, this syllable must be parsed as the first member of a foot. There is additional evidence that this is the correct parse. As discussed in Section 2.4.1.1, the lack of initial secondary stress in trisyllabic words like [βï.roj.ʃín] 'soul; spirit' speaks to a bisyllabic parse for final primary stress, as in [βï(roj.ʃín)], rather than a monosyllabic parse, as in *[(βï̀.roj)(ʃín)]. I return to the footing of such examples, and to the role played by FtBin(σ), in the next subsection.

2.4.4.3 Recursive parsing

As proposed in Section 2.4.2.3, prosodically trapped antepenults in odd-parity words are recursively adjoined to the right, to the foot bearing primary stress. This assumption is crucial for unifying the distribution of coda [h] epenthesis with the distribution of stress. The motivation behind recursive footing is a pressure to exhaustively parse syllables into feet — that is, to fully satisfy the constraint Parse(σ). To induce recursive footing of antepenultimate trapped syllables, then, an additional ranking is needed: Parse(σ) ≫ *Recursion(Ft). This ranking ensures that foot-level recursion will occur in order to attain exhaustive parsing in odd-parity words.

(65) *Recursion(Ft) (*Rec):

Assign one violation for every foot Ft$_i$ that dominates a distinct foot Ft$_j$ (Selkirk 1996, Truckenbrodt 1999, Selkirk 2011, and others)

(66)   Foot-level recursion achieves exhaustive parsing: Parse(σ) $\gg$ *Rec

/ kanoti /	FtBin(σ)	Parse(σ)	Trochee	Anch-R	*Rec
a. ☞ (ka(nó.ti))					*
b. ka(nó.ti)		*! W			L
c. ((ka.nó)ti)			*! W	(*)	*
d. ((ká.no)ti)				(*)	*

[ka.nó.ti] 'bow (weapon)'

While the ranking Parse(σ) $\gg$ *Recursion(Ft) induces recursive footing, it does not distinguish between candidate (a), with a recursively adjoined antepenult, and candidates (c) and (d), which have recursively adjoined ultimas. Since candidate (a) must ultimately emerge as the victor, some other constraint must penalize candidates (c) and (d) for having right-adjoined ultimas. One possibility is that there are two distinct constraints penalizing left- and right-adjunction separately. High-ranked *Right-adjunct (or a constraint in the same spirit) would then eliminate candidates (c) and (d) from contention. A second, perhaps more appealing possibility is that Anchor-R(ω, Ft) is only satisfied by right-aligned *minimal* feet, since the minimal foot is the domain of stress assignment. Anchor-R would then prefer the desired winner (a) over candidates (c) and (d). From here on, I will assume that undominated Anchor-R is responsible for favoring left-adjunction of antepenults to right-adjunction of ultimas, as needed for the analysis of Huariapano. (See Section 2.4.2.3 for discussion of adjunction possibilities in longer words.)

To reiterate a point raised in Section 2.4.2.3, allowing for some recursive footing in Huariapano does not lead to an explosion of recursive prosodic structure. The presence of *Recursion(Ft) in the constraint set ensures that gratuitous recursion will be prohibited. Furthermore, if constraints like AllFootLeft do not distinguish between maximal and minimal feet, recursion will be dispreferred because it increases the number of non-left-aligned feet.

(67)

/ t͡ʃiβaŋkaŋki /	*Rᴇᴄ	ᴀꜰʟ
a. ☞ (t͡ʃì.βaŋ)(káŋ.ki)		**
b.　(t͡ʃi(βaŋ(káŋ.ki)))	*!* W	***! W

[t͡ʃì.βaŋ.káŋ.ki] '(they) followed'

The intuition at work here — and one that is very naturally expressed in an OT framework — is that foot-level recursion is a last-resort strategy for achieving exhaustive parsing. When recursion does not lead to any gain in exhaustivity, it is banned as a matter of course by general principles of structural economy.

The role of FᴛBɪɴ(σ) in this analysis comes into sharp relief when we consider the footing of trisyllabic words with final stress. I previously argued (Section 2.4.1.1) that three-syllable words ending in a stressed heavy syllable contain a right-aligned bisyllabic iamb, e.g. [βï(roj.ʃín)] 'soul; spirit'. Given the ranking Pᴀʀsᴇ(σ) ≫ *Rᴇᴄ established in (67), such forms should also manifest recursive footing, e.g. [(βï(roj.ʃín))]. Since words of this shape contain four moras, an obvious competitor to this output is one containing two bimoraic feet and two stress peaks, *[(βï̀.roj)(ʃín)]. Tableau (68) shows that undominated FᴛBɪɴ(σ) is responsible for eliminating this unwanted alternative parse.

(68)　Trisyllabic [LLH] words contain one stress peak: FᴛBɪɴ(σ) ≫ {Tʀᴏᴄʜᴇᴇ, *Rᴇᴄ}

/ βïrojʃin /	FᴛBɪɴ(σ)	Pᴀʀsᴇ(σ)	Tʀᴏᴄʜᴇᴇ	Aɴᴄʜ-R	*Rᴇᴄ
a. ☞ (βï(roj.ʃín))			*		*
b.　βï(roj.ʃín)		*! W	*		L
c.　(βï̀.roj)(ʃín)	*! W		L		L
d.　(βï̀)(roj.ʃín)	*! W		*		L

[βï.roj.ʃín] 'soul; spirit'

While I believe that this analysis is essentially correct, there is some question as to whether words like [βï.roj.ʃín] might actually bear initial secondary stress, as predicted by the footing (68c) [(βï̀.roj)(ʃín)] (see footnote 11). Interestingly, provided that epenthesis occurs in foot-initial syllables (as I contend), both of these parses —

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[(β̈i(roj.ʃín))] and [(β̈ì.roj)ʃín)] — predict exactly the same epenthesis possibilities. Since coda [h] epenthesis never applies word-finally or in [CVC] syllables, these two parses each entail that epenthesis should only target the initial syllable in an [LLH́] word.

(69)   a.   Non-recursive footing:
       [(L̀$_h$ L)(H́)]

       b.   Recursive footing:
       [(L$_h$ (L H́))]

In fact, this congruence holds for all odd-parity words ending in a heavy syllable: the non-recursive structure (70a) has exactly the same left-edge Fτ$_{MAX}$ boundaries as the recursive structure (70b) (setting aside the final heavy syllable, which is ineligible for epenthesis anyway).

(70)   a.   Non-recursive footing:
       [...(σ$_h$ σ) (σ$_h$ σ) (H́)]

       b.   Recursive footing:
       [...(σ$_h$ σ) (σ$_h$ (σ H́))]

The message here is simple: whether or not [LLH́] words bear initial secondary stress, my single-tier account of Huariapano makes the same desirable predictions regarding the position of epenthesis. If words like [β̈i(roj.ʃín)] 'soul; spirit' do bear initial secondary stress (69c), as Steve Parker (p.c.) contends, then FτBin($σ$) no longer plays a crucial role in the analysis of Huariapano foot structure.

It may be the case, then, that recursive footing as in (69a) is only necessary when the syllable bearing primary stress is preceded by an odd number of syllables, since such a string could not otherwise be exhaustively parsed into bisyllabic [(LL)] feet. When the syllable bearing primary stress is preceded by an even number of syllables, the ultimate foot structure depends on whether or not the preference for non-recursive footing (*Rᴇᴄ) trumps the preference for bisyllabic feet (FτBin($σ$)). The foot parsing

structures consistent with my analysis of Huariapano are given schematically in (71).

(71)   a.   Even number of syllables before primary stress

        (i)   [(σ_h σ) (H́)]   or   [(σ_h (σ H́))]

        (ii)   [(σ_h σ) (σ_h σ) (Ĺ$_h$ L)]

        (iii) [(σ_h σ) (σ_h σ) (H́)]   or   [(σ_h σ) (σ_h (σ H́))]

    b.   Odd number of syllables before primary stress

        (i)   [(σ_h H́)]

        (ii)   [(σ_h σ) (σ_h σ) (σ_h (Ĺ L))]

        (iii) [(σ_h σ) (σ_h σ) (σ_h H́)]

2.4.4.4 Coda [h] epenthesis

A core claim of my analysis of Huariapano is that coda [h] epenthesis is driven by a pressure to increase the prominence of foot-initial syllables. Here, the operative notion of prominence is syllable duration, expressed as the number of segments that a given syllable contains. Following Beckman (1998), Smith (2005b), and others, I assume that there is a family of constraints encouraging prominence enhancement in phonologically 'strong' positions. A novel aspect of my proposal is the claim that foot-initial syllables belong to the set of strong phonological positions (see Section 2.5 below for further justification of this view).

For Huariapano coda [h] epenthesis, the relevant prominence-enhancement constraint is Branch-Initial(Ft).[26]

---

[26]An alternative way to compel coda epenthesis in foot-initial syllables would be to exploit an anti-faithfulness constraint (Alderete 2001a,b) like the following:

(i)   ¬Dep-Ft-Initial:
        Insert a segment in every foot-initial syllable.

As in my account, the choice of [h] as the epenthetic segment (and its licensing conditions) would be determined by markedness considerations. I leave it an open question as to which approach is preferable,

(72)   BRANCH-INITIAL(FT) (BI(FT)):

Assign one violation for every maximal foot $Ft_{MAX,i}$ such that the initial syllable in $Ft_{MAX,i}$ has a non-branching rhyme.

The intent of BRANCH-INITIAL(FT) is to penalize foot-initial syllables with rhymes containing a single short vowel:

(73)   Rhyme structure that violates BRANCH-INITIAL(FT):

$$
\begin{array}{c}
R \\
| \\
\mu \\
| \\
V
\end{array}
$$
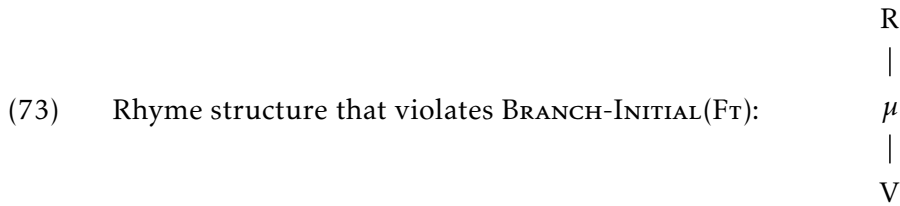
Foot-initial syllables containing a long vowel or diphthong satisfy BRANCH-INITIAL(FT), as do foot-initial syllables closed by a coda consonant — whether or not that coda consonant bears a mora of its own.

(74)   Rhyme structures that satisfy BRANCH-INITIAL(FT):

a.
$$
\begin{array}{c}
R \\
| \\
\mu \\
\diagup\,\diagdown \\
V \quad C
\end{array}
$$

b.
$$
\begin{array}{c}
R \\
\diagup\,\diagdown \\
\mu \quad \mu \\
| \quad\ | \\
V \quad C
\end{array}
$$

c.
$$
\begin{array}{c}
R \\
\diagup\,\diagdown \\
\mu \quad \mu \\
| \quad\ | \\
V \quad V
\end{array}
$$
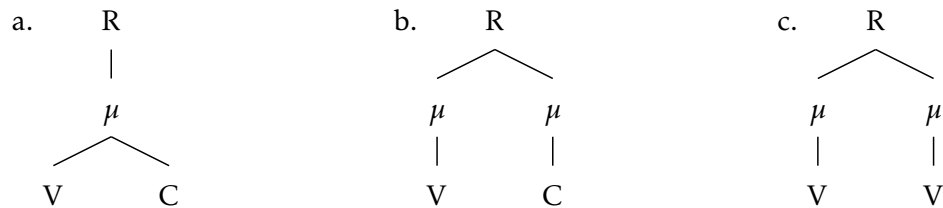
The ranking BRANCH-INITIAL(FT) ≫ DEP(C) is then responsible for inducing coda [h] epenthesis in foot-initial syllables.

(75)   DEP(C):

Assign one violation for every [-VOCALIC] segment in the output that lacks a correspondent in the input (Prince & Smolensky 1993/2004, McCarthy & Prince 1993a)

though I favor BRANCH-INITIAL(FT) because it more directly captures the intuition that coda [h] epenthesis is driven by a desire to 'maximize' strong positions.

(76)

/ pikatikã̃j /	Branch-Initial(Ft)	Dep(C)
a. ☞ (pì̱h.ka)(tí̱h.kã̃j)		**
b. (pì.ka)(tí̱h.kã̃j)	*! W	* L
c. (pì.ka)(tí.kã̃j)	*!* W	L
d. (pì̱h.ka̱h)(tí̱h.kã̃j)		***! W

[pì̱h.ka.tí̱h.kã̃j] 'they ate'

As candidates (76a-c) show, ranking Branch-Initial(Ft) over Dep(C) ensures that coda [h] epenthesis will occur in all foot-initial (i.e. odd-numbered) syllables that satisfy the remaining licensing conditions on epenthesis. Importantly, epenthesis fails to apply in syllables that are not foot-initial (candidate (d)). This is because epenthesis in non-initial syllables is gratuitous, in that it does not improve surface well-formedness, and is therefore blocked by economy considerations. Finally, satisfaction of Branch-Initial(Ft) is achieved by consonant epenthesis rather than vowel lengthening because long vowels are highly restricted in Huariapano, and occur only occur to satisfy minimality requirements in monosyllabic [CV:] words (see also Parker 1998a).

While Branch-Initial(Ft) may strike some readers as *ad hoc*, it is at least plausible that constraints of the form Branch-Initial(π) are active at other levels of the prosodic hierarchy as well. For example, Elordieta (2007) and Selkirk (2011) claim that Lekeitio Basque requires maximal ϕPs to branch into two non-maximal ϕPs when appearing in ιP-initial position (see also Gussenhoven 2004:180,290). Another potential example comes from the Japanese language game *zuu-jago* (Poser 1990, Itô & Mester 1992/2003, Itô et al. 1996). The rules of *zuu-jago* require all output forms to fit a prosodic template consisting of either two feet [Ft+Ft] or a single foot followed by a single light syllable [Ft+σ]. A single light syllable followed by a foot, [σ+Ft], is not a licit output, which might be interpreted as evidence that the initial member of a *zuu-jago* form must be branching.

A so-far unanswered question is why [h], rather than some other segment, is chosen as the epenthetic consonant in Huariapano. I assume (with Parker 1994, 1998a) that [h] is chosen as the epenthetic segment for two reasons: first, [h] has no oral place features, and is thus relatively unmarked (Prince & Smolensky 1993/2004, de

Lacy 2002b, etc.); and second, the occurrence of [h] is licensed by a following voiceless obstruent, i.e. coda [h] insertion is a species of (heterosyllabic) pre-aspiration. (See Parker (1998a) for an OT implemention of this view; I will not formalize it here.) In this respect, [h]-epenthesis is akin to a kind of gemination — an important parallel, given that gemination is sometimes employed in other languages as a strategy for closing syllables in prosodically prominent positions (e.g. Hayes 1995, Bye & de Lacy 2008). In fact, there are some interesting cross-linguistic connections between pre-aspiration and gemination. In Icelandic, pre-aspirated stops are arguably derived from underlying synchronic geminates (Thráinsson 1978). In Los Reyes Metzontla Popoloca, gemination, pre-aspiration, and pre-glottalization all occur in order to close stressed, monomoraic syllables (Veerman-Leichsenring 1991, González 2003). Most notably, in Section 2.5 I show that some languages exploit pre-tonic gemination as an exactly analogous strategy for closing foot-initial syllables (thereby satisfying Branch-Initial(Ft)).

A final outstanding issue concerns the lack of coda [h] epenthesis in word-initial syllables bearing primary stress (Section 2.2.4). Along with Parker (1998a) and de Lacy (2001), I assume that this amounts to a cumulative positional markedness effect: coda [h] is banned from initial syllables bearing primary stress because [h] isn't prominent enough to appear in such an eminently 'strong' position. I will not formalize this intuition here — see Parker (1998a) and de Lacy (2001) for an implementation.[27]

The crucial ranking arguments for this analysis of Huariapano are provided in (77). The most important stress-related rankings are given as a Hasse diagram in Figure 2.1.

(77)   Summary of crucial ranking arguments

    a.   wsp ≫ NonFinality (59)

        Final stress occurs only in order to stress a word-final heavy syllable.

---

[27]Jaye Padgett suggests that coda [h] epenthesis might not apply to word-initial syllables bearing primary stress because such syllables (despite being foot-initial) are already so prominent that coda [h] epenthesis becomes redundant. While I see the appeal of this mode of explanation, it is incompatible with my claim that coda [h] epenthesis is driven by the constraint Branch-Initial(Ft) (72) rather than by some more general notion of perceptual prominence.

b. $\text{Fin}(\mu) \gg {}^{\star}C_{\mu} \gg \text{WxP}$ (61)

Only word-final coda consonants are moraic.

c. $\text{Parse}(\sigma) \gg \text{AllFtL}$ (not shown)

Footing is iterative.

d. $\text{Anchor-R}(\omega, \text{Ft}) \gg \text{AllFtL}$ (63)

Feet are parsed left-to-right (for secondary stress), but there is always a foot in absolute word-final position (for primary stress).

e. $\text{Trochee} \gg \text{Iamb}$ (63)

Regular secondary stress involves trochaic footing.

f. $\text{wsp} \gg \text{Trochee}$ (64)

Iambic footing occurs in order to place stress on a word-final heavy syllable.

g. $\text{Parse}(\sigma) \gg \text{Trochee}$ (64)

Final [... LH] sequences are footed with an iamb [... (L H́)] when necessary to achieve exhaustive parsing.

h. $\text{Parse}(\sigma) \gg {}^{\star}\text{Recursion}(\text{Ft})$ (66)

Recursive footing occurs when necessary to achieve exhaustive parsing.

i. $\text{Branch-Initial}(\text{Ft}) \gg \text{Dep}(\text{C})$ (117)

Coda [h] epenthesis occurs to augment foot-initial syllables.
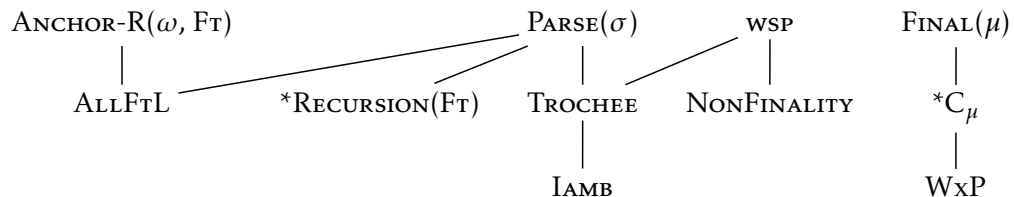
Figure 2.1: Hasse diagram of core ranking arguments for stress-related constraints

2.4.5 Exceptional stress

There are three kinds of exceptional stress in Huariapano (Parker 1994, 1998a:5-10,17-22): exceptional word-final primary stress on a light [CV#] syllable; exceptional antepenultimate primary stress; and exceptional (iambic) secondary stress on even-numbered syllables.[28]

(78)   Exceptional word-final primary stress

    a.   [uʃ.tá] 'garbage'

    b.   [jo.βĩ́] 'witch'

(79)   Exceptional antepenultimate primary stress

    a.   [βĩ́.ma.na] 'face (noun)'

    b.   [ríʃ.ki.ti] 'whip (noun)'

(80)   Exceptional secondary stress on even-numbered syllables

    a.   [βis.mà.noh̠.kò.no.ʂí.ki] 'I forgot'

    b.   [ha.jà.jih̠.káŋ.ki] '(they) possessed, had'

I will treat these exception types in turn.

2.4.5.1 Exceptional word-final primary stress

Only nouns and adjectives may have exceptional primary stress on a final light syllable in Huariapano. In Parker's corpus, there are no verbs with exceptional final stress. Parker (1998a) assumes that words with exceptional final stress contain lexically-specified metrical structure, i.e. an underlying word-final degenerate foot.

(81)   a.   [ʃa.nó] 'species of venomous snake (*Bothrops pictus*)'

    b.   Parker's (1998a) analysis: /ʃa(nó)/ → [ʃa(nó)]

---

[28] For simplicity of exposition I do not address Parker's (1998a) arguments for suffix-specific mora extrametricality in Huariapano. As far as I can tell, his analysis of exceptionally stress-repelling verbal suffixes could be ported over to my account with little or no modification.

Parker further proposes that the underlying, prespecified metrical structure in such words is maintained in surface forms under pressure from faithfulness constraints specific to the class of nouns (e.g. Ident(stress)$_{\text{Noun}}$; see Smith 2011 and her earlier work on the same topic). This analysis explains the fact that there are no verbs with primary stress on a light ultima: under a ranking schema like Faith$_{\text{Noun}}$ ≫ Markedness$_{\text{Footing}}$ ≫ Faith$_{\text{General}}$, any underlying metrical structure on a verb (but not a noun) will neutralize to default footing in surface forms. I largely follow Parker's (1998a) analysis, with one alteration: exceptional forms are underlyingly specified with an *iambic* foot.[29]

(82)   /(ʃa.nó)/ → [(ʃa.nó)] 'species of venomous snake (*Bothrops pictus*)'

A (small) advantage of my analysis is that iambic footing is independently needed in other surface forms, whereas under Parker's (1998a) analysis degenerate feet are *only* found in words with exceptional final stress. Furthermore, my account of coda [h] epenthesis in Huariapano is incompatible with assuming a final degenerate foot, since bisyllabic words with exceptional final stress still manifest coda [h] epenthesis in the initial syllable.

(83)   a.   [(ih̠.sá)] 'bird'
       b.   *[ih̠(sá)]

2.4.5.2 Exceptional antepenultimate primary stress

Antepenultimate primary stress is rare in Huariapano. Only twelve forms of this sort are attested in Parker's corpus, and all of them are nouns or adjectives. There are no attested words in Huariapano with pre-antepenultimate primary stress, though given the small number of exceptional forms to begin with, this gap may be accidental.

A further observation is that at least four words with antepenultimate stress seem to have variants with regular penultimate stress. Parker does not comment on this variation, but the relevant data is provided in Parker (1998b).

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[29]Or alternatively, such words belong to a cophonology in which iambic footing is prefered (Anttila 2002, Inkelas & Orgun 2003, Inkelas & Zoll 2007, among others). This alternative analysis makes the interesting prediction that words with irregular final primary stress should also have irregular (i.e. iambic) secondary stress. There is one example, [hi.màŋ.ko.ʃó] 'species of ant', that supports this prediction.

(84)   Variation in exceptional antepenultimate primary stress

　　a.　[há.ka.t͡ʃu] ~ [ha.ká.t͡ʃu]　'afterwards, later'
　　b.　[sá.na.ma] ~ [sa.ná.ma]　'well, good, beautiful, nice, etc.'
　　c.　[ḯ.βi.ra]　　~ [ï.βí.ra]　　'I (topic)'
　　d.　[há.βï.βi]　~ [ha.βí.βi]　'to him (also)'

Given the variability in (84), it seems possible that at least some cases of antepenultimate stress may result from the displacement of regular penultimate stress, perhaps conditioned by the surrounding phrasal context (cf. the 'rhythm rules' found in English and other languages; see Hayes 1984 and Gussenhoven 2004:141, Chs. 13-14 for overviews and references). Consequently, I am unsure whether antepenultimate stress really exists as a distinct pattern of primary stress assignment. Nevertheless, for the sake of comparision with Parker (1994, 1998a) I will proceed under the assumption that exceptional antepenultimate stress should be accounted for within the word-level phonology of Huariapano.

Parker (1998a) proposes that exceptional antepenultimate primary stress is due to lexically-specified final syllable extrametricality, implemented with a root-specific constraint ranking that prevents parsing of the final syllable.

(85)　　[(βḯ.ma)⟨na⟩] 'face (noun)'

This view of antepenultimate stress can be easily incorporated into my account of regular stress assignment in Huariapano. Adopting Parker's extrametricality analysis requires an additional non-finality constraint, since NonFinality itself (as defined in Section 2.4.4.1) does not necessarily trigger underparsing of the final syllable.[30]

(86)   NonFinality(Ft) (NonFin(Ft)):
　　Assign one violation for every foot Ft_i such that the right edge of Ft_i coincides with the right edge of the prosodic word ω_j that immediately contains Ft_i.

---

[30]See also Flack (2009), Bennett & Henderson (to appear), and Chapter 3 on the parameterization of markedness constraints like NonFinality to different levels of the prosodic hierarchy.

(87) Exceptional antepenultimate stress: lexically-determined ranking of
NonFin(Ft) ≫ Anch-R

/ β̈imana /	NonFin(Ft)	Anch-R	Parse(σ)	NonFin
a. ☞ (β̈í.ma)na		*	*	
b. β̈i(má.na)	*! W	L	*	
c. β̈i(ma.ná)	*! W	L	*	* W

[β̈í.ma.na] 'face (noun)'

The question of course arises as to how antepenultimate stress interacts with coda [h] epenthesis. Unfortunately, there is only one word in Parker (1994, 1998a,b) in which coda [h] epenthesis applies to a word with antepenultimate stress.

(88) [pah̲.táṣ.po.ra] 'narrow'

Epenthesis in (88) follows if [pah̲.táṣ.po.ra] is parsed with a recursive foot and an unfooted final syllable, as predicted by the analysis of Huariapano proposed here.

(89) [($_{MAX}$ pah̲ ($_{MIN}$ táṣ.po)) ra]

Somewhat strangely, there are also several words with antepenultimate stress in which epenthesis fails to apply in otherwise eligible odd-numbered syllables (see also Section 2.4.6).

(90) a.   [i.káṣ.β̈i.ra] 'the same person (topic)'[31]
      b. *[ih̲.káṣ.β̈i.ra]

      c.   [i.káj.no.aṣ] 'being'
      d. *[ih̲.káj.no.aṣ]

---

[31] The meaning of [i.káṣ.β̈i.ra] is somewhat unclear. Steve Parker suggests the morphological decomposition /ik-aṣ-β̈i-ra/ 'to.be-same.subject-?-topicalizer'. His Huariapano consultant translated this word as Spanish *sea* 'be (3s subjunctive)' and *pero* 'but'.

e.   [há.ka.t͡ʃu] 'afterwards, later'

f.   *[há<u>h</u>.ka.t͡ʃu]

g.   [βá.kï̈.βu] 'children'

h.   *[βá<u>h</u>.kï̈.βu]

It may be the case that the failure of epenthesis is actually the norm in words with antepenultimate stress (for whatever reason). Epenthesis in [pa<u>h</u>.táʂ.po.ra] 'narrow' would then be attributed to some countervailing pressure, such as paradigm uniformity under analogy with related words like [pa<u>h</u>.táʂ] 'side'. I will not decide between these two alternatives here.

2.4.5.3   Irregular secondary stress

Irregular secondary stress has largely been treated in the preceding sections. Here, I flesh out a few remaining details, and formalize the basic descriptive analysis.

Parker (1998a) argues that irregular secondary stress (unlike exceptional word-final primary stress) cannot result from underlyingly-specified metrical structure. The evidence comes from derivationally related forms like the following:

(91)   a.   [rá.kï̈] 'fear'   (regular [σ́])

b.   [<u>rah.kï̈</u>.ja.màj.βa.ʂí.ki] 'I was afraid of it (the jaguar)'   (irregular [σ̀],

                                                                        regular [σ́])

Cf.

c.   [<u>mì</u>.raj.βa.ʂí.ki] 'we found'   (regular [σ̀], regular [σ́])

d.   [<u>pàh.t</u>ˢaj.βa.ʂí.ki] 'I washed'   (regular [σ̀], regular [σ́])

All morphologically complex words containing the root /ra.kï̈/ 'fear' have irregular secondary stress on even-numbered syllables (respecting clash avoidance). This is true regardless of which suffixes are attached to the root.

(92) a. [rah.kï̀.ja.màj.βa.ṣí.ki] 'I was afraid of it (the jaguar)'

b. [rah.kï̀.t͡ʃa.í.ki] 'it's scary'
etc.

On the other hand, the simplex isolation form [rá.kï] 'fear' has regular primary stress
on the penult, even though stress falls on the second syllable [kï̀] in all derived forms
containing this root. If the root /ra.kï/ were underlyingly specified with an iambic foot
(to account for irregular secondary stress on its second syllable), we wrongly expect
/(ra.kḯ)/ → *[(ra.kḯ)], with irregular *primary* stress, to be the attested isolation form.[32]

(93) a. [(rá.kï)] 'fear'   (regular [σ́])
b. [(uʃ.tá)] 'garbage'   (irregular [σ́]

Parker concludes (as do I) that irregular secondary stress must be the result of root-
specific constraint ranking for individual roots rather than lexically-specified metrical
structure.[33] It is perhaps not surprising that lexical specification of secondary stress
fails here: Huariapano word formation is heavily suffixing (i.e. agglutinating), so there
is no guarantee that longer words are lexically stored at all, much less stored with sec-
ondary stress specified. Indeed, only words with at least four syllables bear secondary
stress in Huariapano, and words of that length tend to be morphologically complex.

My conclusion is that the default rhythmic type for a subset of roots is iambic
rather than trochaic. Formally, lexical variation in the relative ranking of Trochee
and Iamb accounts for variation in secondary stress.[34] Recall from Section 2.4.2.2 that
assuming lexically-specific variation in foot-form does a better job accounting for sec-

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[32]Since [rá.kï] 'fear' is a noun, any lexically-specified final stress should be preserved in isolation
forms, as in [ʃa.nó] 'sp. of snake'.

[33]See also Inkelas & Zoll (2007) for discussion of the 'scope' of morpheme-specific exceptionality in
morphologically complex words.

[34]While I implement root-determined footing here using multiple cophonologies with constraint re-
ranking (Anttila 2002, Inkelas & Zoll 2005, 2007, etc.), the analysis could easily be translated into a model
of lexical variation that makes use of lexically-specific markedness constraints instead, e.g. Iamb_SPECIFIC
≫ Trochee_GENERAL ≫ Iamb_GENERAL (Pater 2000 and others).

ondary stress than assuming lexically-specific variation in the direction of parsing.[35] Since penultimate primary stress emerges under pressure from NonFinality rather than Trochee, subordinating Trochee under Iamb will lead to foot-form reversals for secondary stress, but *not* for primary stress. (See also Kondo 2001 on lexically-specific iambic vs. trochaic footing in Guahibo.)

(94)   Irregular secondary stress: lexically-specific L → R iambic parsing:
         Iamb ≫ Trochee; NonFin ≫ Iamb

/ miβombirama /	End-R	afl	wsp	NonFin	Iamb	Trochee
a. ☞ (mi.βòm)(bi(rá.ma))		**			*	*
b. (mì.βom)(bi(rá.ma))		**			**! W	L
c. (mi.βòm)(bi(ra.má))		**		*! W	L	** W
d. (mi.βóm)(bi(rà.ma))	*! W	**			*	*

[mi.βòm.bi.rá.ma] 'you (plural)'

Finally, it should be emphasized that non-default, iambic secondary stress is a fundamentally different phenomenon than cases of exceptional primary stress assignment (Sections 2.4.5.1 and 2.4.5.2). Exceptional primary stress is found in a relatively small number of examples, all of which are nouns or adjectives. Exceptional iambic secondary stress is more widespread, and shows no sensitivity to syntactic category. It seems appropriate, then, to use two distinct mechanisms to capture these two classes of exception: underlying metrical structure for exceptional primary stress (protected by special faithfulness to nominal forms), and an iamb-dominant cophonology for words containing a root that triggers non-default secondary stress assignment.

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[35]There is at least one other language for which it has been claimed that the direction of footing for secondary stress is lexically-determined. In Lenakel (Hammond 1986, Hayes 1995:167), secondary stress for nouns involves right-to-left parsing, while secondary stress for verbs and adjectives involves left-to-right parsing (moraic trochees in all cases). See also Pater (2000) on lexical variation in English secondary stress.

2.4.6 Exceptional epenthesis blocking

Parker (1994, 1998a) notes that there are a number of words in Huariapano in which the conditions for epenthesis are met, yet epenthesis fails to apply.

(95)   Exceptional failure of epenthesis

   a.   [t͡ʃu.ʃí.ki] 'he/it dried up'
   b.   *[t͡ʃu<u>h</u>.ʃí.ki]

   c.   [ʃ̈i.nà.ko.ʂón] 'spider'
   d.   *[ʃ̈i.nà.ko<u>h</u>.ʂón]

Parker (1998a) reports that nine morphemes in his corpus manifest exceptional non-epenthesis, compared with 115 morphemes that show epenthesis as expected. These figures yield an aggregate 93% rate of productivity.

   Since Huariapano is no longer spoken, it's difficult to determine whether there are any underlying generalizations to be made about the exceptional non-application of epenthesis in particular morphemes. In the absence of any deep insight into such exceptions, I assume that certain roots and affixes belong to a cophonology in which Dep(C) outranks Branch-Initial(Ft), thereby inhibiting foot-based epenthesis.

(96)   Exceptional non-epenthesis: lexically-specific Dep(C) ≫ Branch-Initial(Ft)

/ t͡ʃuʃiki /	Dep(C)	Branch-Initial(Ft)	
a. ☞ (t͡ʃu(ʃí.ki))		*	
b. (t͡ʃu<u>h</u>(ʃí.ki))	*! W	L	

[t͡ʃu.ʃí.ki] 'he/it dried up'

However, this analysis does make a clear prediction about the scope of epenthesis: the (non-)application of epenthesis should be *uniform* throughout a particular word.[36] Assuming strict domination, the relative ranking of BI(Ft) and Dep(C) has a global effect: BI(Ft) ≫ Dep(C) should compel coda [h] epenthesis at all licit sites, while the

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[36]As far as I can tell, the analyses proposed by Parker (1994, 1998a) and González (2003) make the same prediction.

converse ranking should inhibit foot-initial epenthesis across the board. In many cases, this prediction is borne out, as shown in (97) and (98).

(97)   Uniform non-epenthesis ('_' indicates exceptional epenthesis blocking)

  a. [βï‿.t͡ʃà.na.naŋ.ká‿.ti] 'I found myself (face to face with the jaguar)'

  b. [i‿.pà.kï‿.kã̃́j] 'it (the jaguar) is growling'

  c. [rï̀‿.tï.ká‿ti] 'I killed it'

  d. [pà‿.pa.jò‿.si.βu.nḯn] 'my ancestors'

(98)   Uniform epenthesis

  a. [hùh̲.ka.tíh̲.kã̃́j] 'they arrived'

  b. [jò.mï.ràh̲.ka.tíh̲.kã̃́j] 'they hunted'
  etc.

In many cases where the prediction of uniformity appears to be falsified, epenthesis is blocked in a syllable immediately preceding the suffix [-ṣi.ki].

(99)   a. [pàh̲.tˢaj.βa‿.ṣí.ki] 'I washed'

  b. [rah̲.kï̀.ja.màj.βa‿.ṣí.ki] 'I was afraid of it (the jaguar)'

  c. [βis.mà.noh̲.kò.no‿.ṣí.ki] 'I forgot'

However, the suffix [-ṣi.ki] seems to inhibit epenthesis more generally, as in (100).

(100)   a. [mï̀.raj.βa‿.ṣí.ki] 'we found'

  b. [kù.βjaj.βa‿.ṣí.ki] 'I cooked'

This suggests that the blocking of [h]-epenthesis may be morphologically conditioned, as Parker (1994) speculates. While Parker does not provide morphological decom-

positions for most Huariapano words, there are two reasons to believe that [-ʂi.ki] constitutes an independent affix. First, words ending in [-ʂi.ki] are always in the past tense in Huariapano. Along similar lines, the related Panoan language Capanahua has an apparently cognate temporal auxiliary [ʂiʔk-i], which indicates future indicative mood rather than past tense (González 2003:299-302). It seems very plausible, then, that [-ʂi.ki] is a tense or aspect auxiliary of some sort (Parker 1998a identifies [-ʂi.ki] as a perfective aspect marker).

Interestingly, the Capanahua auxiliary [ʂiʔk-i] shows exceptional blocking of an otherwise regular process of metrically-conditioned coda [ʔ] deletion in that language. González (2003) (citing personal communication from Eugene Loos) takes this fact as evidence that the Capanahua form [ʂiʔk-i] actually initiates a new prosodic word, thereby disrupting the metrical conditioning of coda [ʔ] deletion. It may be the case, then, that coda [h] epenthesis in Huariapano is inhibited before [-ʂi.ki] because this morpheme, like its cognate in Capanahua, begins a new prosodic word ω. Epenthesis (as preaspiration) cannot be licensed across ω-boundaries (Section 2.2.4), so it follows that epenthesis should be blocked before [-ʂi.ki].

On the other hand, the auxiliary [-ʂi.ki] does not interrupt stress assignment in Huariapano — that is, words containing [-ʂi.ki] show the expected distribution of primary and secondary stresses. This fact can be reconciled with the blocking of epenthesis if we assume that [-ʂi.ki] induces a recursive ω structure, as in (101). Given this structure, it is internally consistent to assume that stress is assigned within maximal prosodic words ω_{MAX}, while preaspiration is blocked across all prosodic word boundaries, both minimal and maximal.[37]

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[37]One might reasonably ask whether the structure in (101) leads to a bracketing mismatch. If stress is assigned at the level of the maximal prosodic word ω_{MAX}, it should in principle be possible to construct feet that span the ω-boundaries defined by [-ʂi.ki], i.e. [. . . (σ {$_\omega$ ʂi)(ki }$_\omega$ σ). . .]. Such a structure would violate the principle of PROPER BRACKETING, which I take to be an inviolable condition on relations between levels of the prosodic hierarchy (Chapter 1, though cf. Hyde 2002).

Empirically speaking, I suspect that this problem does not actually arise in Huariapano. As far as I can tell [-ʂi.ki] always appears in final position, presumably because of its historical source as an independent auxiliary. If this generalization is correct, then [-ʂi.ki] will always be coextensive with the right-aligned foot in which primary stress is assigned, and there will be no bracketing mismatches, i.e. [. . . {$_\omega$ (ʂi.ki) }$_\omega$ #].

(101)   Prosodic word structure induced by Huariapano auxiliary [-ṣi.ki]

ω_{MAX}

ω_{MIN} ω_{MIN}

STEM   [-ṣi.ki]
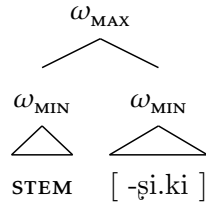
Importantly, this structural explanation for the exceptional behavior of [-ṣi.ki] pro-
vides further evidence that Huariapano distinguishes between maximal and non-maximal
prosodic categories — a crucial component of the foot-based analysis of coda [h] epenthe-
sis developed in Section 2.4.2.3.

This analysis might also explain why coda [h] epenthesis is inhibited within
[-ṣi.ki] itself (i.e. *[-ṣi̲h̲.ki]).

(102)   a.   [jò.mï.rá.no.ṣí‿ki] 'he is going to hunt'
         b.   *[jò.mï.rá.no.ṣíh̲.ki]

In all words containing [-ṣi.ki] that I have found in Parker (1994, 1998a,b), the auxilary
appears in word-final position, with default primary stress falling on its first syllable,
[-ṣí.ki#]. In this configuration, the primary stressed syllable would be initial within
the ω_{MIN} that [-ṣí.ki] itself initiates. Exceptional epenthesis blocking in *[-ṣíh̲.ki]
is then reducible to the independent observation that epenthesis does not occur in ω-
initial syllables bearing primary stress (Section 2.2.4).[38]

Another case of non-uniform epenthesis involves blocking of epenthesis after word-
initial [#t͡ʃu].

(103)   [t͡ʃù‿kaj.βah̲.káŋ.ki] 'they washed'

---

[38]It is suspicious that several other examples of exceptional non-epenthesis in Parker (1994, 1998a,b)
end in a [ʃi.kï] sequence (e.g. [no.ʃí.kï] 'he/it broke', *[noh̲.ʃí.kï]). This may be a mistranscription of
[-ṣi.ki], since both sequences appear word-finally in past tense verbs. Moreover, many other exceptional
forms have either [ṣi] as the penult or [ki] as the ultima (e.g. González 2003:315). Note also that Parker
(1998a) claims that both [-ki] and [-ṣiki] are perfective aspect markers. All this suggests to me that,
once the morphophonology of Huariapano is better-understood, a fairly unified account of epenthesis
blocking should be possible in the terms sketched here.

However, this sequence shows exceptional non-epenthesis in other cases as well.

(104)　　a.　[t͡ʃu‿.káj.ni] 'I am washing'

　　　　b.　[t͡ʃù‿.ʃi.káŋ.ki] 'they dried'

I surmise that the prediction of uniform (non-)epenthesis made by my analysis is essentially correct, though there may be certain morpho-phonological contexts that exceptionally block epenthesis for principled reasons.

2.4.7　Comparison with González (2003)

González (2003) provides the only other single-tier analysis of Huariapano that I am aware of. Her account shares some intuitions with the analysis I defend here: first, that the boundaries of non-head feet are fixed, while the position of secondary stress within those feet may vary; second, that epenthesis is sensitive to the feet that define secondary stress; and third, that epenthesis always occurs in foot-initial syllables (though for different reasons than those I propose). In this section I will refer to González's (2003) proposal as the 'segmental rhythm analysis of Huariapano', or sʀᴀʜ (the rationale for selecting this cover term should be apparent shortly).

While the sʀᴀʜ is an important precursor to my analysis of Huariapano, there are significant differences between the two accounts. A crucial claim of the sʀᴀʜ is that foot heads may be unstressed, and conversely, foot dependents (i.e. footed, non-head syllables) may be stressed (an idea shared with Vaysman 2009; see also Liberman & Prince 1977).

(105)　　Possible bisyllabic trochees in the sʀᴀʜ

　　　　a.　Stressed foot head:　　　　　$(\acute{\sigma}_H\ \sigma_D)$

　　　　b.　Unstressed foot:　　　　　　$(\sigma_H\ \sigma_D)$

　　　　c.　Stressed foot dependent:　　$(\sigma_H\ \acute{\sigma}_D)$

　　　　d.　'Double-stressed' foot (?):　　$(\acute{\sigma}_H\ \acute{\sigma}_D)$

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I agree with the first half of this claim: it is clear that there are languages with foot structure in which not all foot heads are realized with phonetic stress or pitch accent (e.g. Poser 1990, Hayes 1995, Crowhurst 1996, van de Vijver 1998, Kubozono 2008, Buckley 2009, van der Hulst 2009, etc.; see also Chapter 4). However, below I will take issue with the second half of the SRAH's conception of the relation between headedness and stress. Specifically, I propose that the following unidirectional implication holds between stress and headedness:.

(106)   **Stress-headedness homomorphism**:
         All stressed syllables are foot heads, though not all foot heads are stressed.

         a. $\acute{\sigma} \rightarrow \sigma_{\text{H}}$
         b. $\sigma_{\text{H}} \nrightarrow \acute{\sigma}$

In my view, this implicational relation is a definitional property of phonological stress, in that there can be no syllables that are both relationally 'weak' (i.e. foot dependents) and relationally 'strong' (i.e. stress-bearing) at the same time. The implication in (106) is thus axiomatic, and necessarily holds without exception in natural language.

The details of the SRAH are as follows. First, the SRAH is in accord with the disjoint footing analysis of Huariapano (DFAH; Section 2.3) in assuming that all feet in Huariapano are moraic trochees. Second, the SRAH claims that coda [h] epenthesis always targets foot heads, again as in the DFAH. The two accounts differ in that the SRAH does not posit a distinct rhythmic tier for epenthesis — the feet that determine secondary stress are the same as the feet that determine the distribution of coda [h].

When coda [h] epenthesis and stress coincide transparently, the SRAH assumes that both coda [h] epenthesis and stress assignment occur in trochaic foot heads. This much is shared with all extant accounts of Huariapano.

(107)   a.   [βìh̲.tˢa.káŋ.ki] 'they laughed'
         b.   [(βìh̲.tˢa)(káŋ.ki)]

         c.   [βò.no.síh̲.kãj̃] 'they will take'
         d.   [(βò.no)(síh̲.kãj̃)]

The SRAH proposes two different mechanisms to account for discrepancies between epenthesis and stress assignment. The first is covert footing. Under the SRAH, some foot heads in Huariapano do not bear stress — the foot structure in question is thus 'covert', because it has no independent phonetic realization. However, the heads of covert feet can still be targeted by coda [h] epenthesis, since epenthesis is sensitive to headedness rather than stress *per se*.

(108)   Covert footing in Huariapano (Parker 1994, González 2003)

    a.   [kïh̠.pín] 'I open'

    b.   [(kïh̠)(pín)]

The adoption of covert footing comes directly from Parker (1994). Following Parker, the SRAH assumes that coda [h]s are moraic, and that coda [h] epenthesis occurs in (108) to ensure that underlying / kïpïn / can be exhaustively parsed into binary moraic trochees (cf. *[kï(pín)] and *[(kï)(pín)]). The existence of covert footing in (108) is, on this view, a consequence of clash avoidance: better to have a covert foot [(kïh̠)(pín)] than an overt, stressed foot that participates in stress clash *[(kì̠h̠)(pín)].

The second mechanism that the SRAH proposes for handling mismatches between stress and epenthesis is what I will call ANTI-STRUCTURAL STRESS ASSIGNMENT. Anti-structural stress describes a configuration in which stress falls on a foot dependent rather than a foot head, e.g. $[(\sigma_H \; \acute{\sigma}_D)]$. According to the SRAH, anti-structural stress arises in words in which secondary stress assignment is irregular, i.e. falls on even-numbered syllables. The SRAH assumes that irregular secondary stress results from the realization of underlyingly specified stress on even-numbered positions (though cf. Parker 1998a and Section 2.4.5.3 for arguments against this view). These prespecified stresses cannot be preserved by altering foot parsing itself, since in the SRAH the location of foot heads must remain fixed across lexical items to capture the distribution of coda [h]. Instead, the SRAH proposes that foot heads and boundaries remain consistent across words of the same length, but in words with irregular secondary stress on even-numbered syllables, stress is realized on foot dependents rather than foot heads. Coda [h] epenthesis always targets foot heads, so anti-structural stress leads to mismatches

between stress and epenthesis.

(109)   SRAH: anti-structural exceptional secondary stress (σ^h = locus of epenthesis)

    a.   [βis.mà.no<u>h</u>.kò.no.sí.ki] 'I forgot'

    b.   [(βis.mà)(no<u>h</u>.kò)(no.sí)ki] (from /βis.mà.no.kò.no.si.ki/)

    c.   [(σ_H $\grave{\sigma}_D$)(σ_H^h $\grave{\sigma}_D$)(σ_H $\acute{\sigma}_D$)σ]

    Cf.
    d.   [jò.mï.rà<u>h</u>.ka.tí<u>h</u>.kãj̃] 'they hunted'

    e.   [($\grave{\sigma}_H^h$ σ_D)($\grave{\sigma}_H^h$ σ_D)($\acute{\sigma}_H^h$ σ_D)]

This pattern of stress placement is 'anti-structural' in the sense that the foot-internal prominence relation defined by stress is the exact inverse of the prominence relation defined by the headedness of the same foot. It is this portion of the SRAH that I object to most strenuously, as discussed below. While the foot parsing that I propose for examples like (109) is superficially very similar to that proposed by the SRAH, our accounts differ greatly regarding the nature of foot headedness, as well as the phonological motivation for [h] epenthesis.

The larger claim of the SRAH is that languages may opt to 'realize' headedness relations via rhythmic segmental phenomena rather than stress. As González (2003) puts it:

> "In general secondary stress and [h] epenthesis will coincide; the cases where they do not coincide are explained by the preference for rhythmicity to be segmentally realized rather than realized by stress." (González 2003:257)

The notion that foot-based rhythmicity might be realized in segmental rather than prosodic terms lies behind the choice of 'segmental rhythm account of Huariapano' (SRAH) as the designation for González's (2003) proposals.

2.4.7.1 Conceptual objections to the SRAH

There are at least two conceptual problems with the SRAH. The first concerns the assumption that foot dependents — syllables in the weak branch of a foot — may bear stress. The central motivation for analyzing stress placement with metrical structure is the fact that stress is a *relational* property of syllables, and not a feature that can be freely assigned in the absence of some underlying prosodic scaffolding (Liberman 1975, Liberman & Prince 1977, Hayes 1995). This conception of stress accounts for, among other things, the fact that stress has no inherent or invariant phonetic correlates (Hayes 1995): stress is always relational in nature, but languages may differ in how those prosodic relations are phonetically interpreted. In other words, "stress is a feature of structure" (Liberman 1975:310), not a feature of phonological elements in isolation.

Headed metrical structures express the relational nature of stress directly: the head syllable (or mora) of a foot is phonologically prominent only by virtue of being the most prominent syllable (or mora) within that containing foot. This relative phonological prominence may then be cashed out as phonetic stress. It should be pointed out this view of the mapping from prosodic structure to stress is consistent with the existence of covert footing in natural language. It is well-known that languages differ in how phonological representations are mapped to phonetic representations (e.g. Keating 1990, Cohn 1993, Cho & Ladefoged 1999, etc.). This is especially true when it comes to the phonetics of stress: one language may cue stress with duration, intensity, and pitch, while another language may only make use of duration — or perhaps, may not cue stress along any phonetic dimension at all. Covert footing, then, is simply one extreme endpoint of the wide cross-linguistic variability in how prosodic structure is given a phonetic realization. There is thus a logical consistency to covert footing: a given syllable may be phonologically prominent with respect to abstract prosodic structure, while also having no particular phonetic realization of that abstract prominence.

I therefore agree with González (2003) that foot heads may sometimes be unstressed, e.g. $[(\breve{\sigma}_H \, \sigma_D)]$. However, the mirror-image proposition — that foot dependents may sometimes bear stress, $[(\sigma_H \, \acute{\sigma}_D)]$ — is almost a category error. Stress and head-

edness are not features that freely cross-classify. Headedness is relative phonological prominence, defined over prosodic structure: stress is the phonetic interpretation of that phonological prominence. Stress and headedness, then, are expressions of the same underlying phonological relation, realized at two different linguistic levels. Assuming that foot dependents can bear stress thus amounts to the contradictory claim that a single phonological element can be both relatively prominent and relatively non-prominent within the same domain. As Liberman & Prince (1977) put it:

> "[relative prominence] is a local property of the tree structure...the apparent 'node labels' *s* [strong/head] and *w* [weak/dependent] cannot have any existence independent of the definition of such a relation...constituent structure is an essentially syntagmatic notion...[and] rules are not allowed to create the configuration *s*/[-stress] as a matter of general principle" (Liberman & Prince 1977:256,263,319)

My claim, then, is that anti-structural stress assignment is conceptually incoherent: only foot heads may bear stress (see especially Selkirk 1980 and the 'Relative Prominence Projection Rule' of Liberman & Prince 1977). As such, the SRAH should be dispreferred on conceptual grounds alone.[39]

The second conceptual objection is a simple one: the SRAH requires two mechanisms to account for discrepancies between stress and epenthesis in Huariapano, while both my account and the DFAH require only one. Since my account of Huariapano differs from the DFAH in assuming only a single metrical tier, it is also the most parsimonious of the three.

These conceptual problems are in themselves severe enough to constitute a powerful argument against the SRAH. In the next section, I show that the SRAH is also empirically inadequate.

2.4.7.2 Empirical objections

The SRAH both undergenerates and overgenerates the distribution of coda [h] epenthesis in Huariapano. The undergeneration problem concerns the distribution of covert

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[39]Indeed, it is not clear to me that the SRAH differs meaningfully from an approach in which coda [h] epenthesis is foot-based, but stress assignment is purely grid-based and does not refer to foot structure at all (see also Vaysman 2009). In other words, it seems to be a notational variant of the two tier account of Huariapano that posits disjoint footing for stress and epenthesis.

feet that the sʀᴀʜ posits. The sʀᴀʜ asserts that a word like [(kïh̲)(p̈ín)] 'I open' receives coda [h] epenthesis in the initial syllable so that the word may be exhaustively parsed into binary feet. This hinges on the claim that non-final [(kïh̲)] constitutes a well-formed binary trochee. Unfortunately, this assumption is plainly at odds with the fact that non-head feet in Huariapano are *syllabic* trochees, not moraic trochees. A non-final, non-head foot like [(kïh̲)] thus does not qualify as binary. Since degenerate feet are not allowed in Huariapano (Sections 2.2.2 and 2.4.1.1), [(kïh̲)] is not a licit foot, and the sʀᴀʜ has no explanation for why epenthesis occurs in words of this type. The same objection holds for any word with coda [h] epenthesis in the immediately pretonic syllable, e.g. [(jò.mï)(rah̲)(ká.no)] 'let's go hunting', [(jò.mï)(rà.no)(ṣih̲)(ḱã́j̃)] 'they will hunt', etc.

The overgeneration problem concerns penults in trisyllabic words. The footing assumed by the sʀᴀʜ entails that trisyllabic words contain two feet, as in (110). Note that this assumption is already problematic, given that there are no trisyllabic words with two stress peaks, even when stress clash is not an issue (Section 2.4.1.1).

(110)   a.   [maj.tí.βu] 'hats'
        b.   [(maj)(tí.βu)]

        c.   [ka.nó.ti] 'bow (weapon)'
        d.   [(ka)(nó.ti)] or [ka(nó.ti)]

        e.   [nïh̲.tí.no] 'day (locative)'
        f.   [(nïh̲)(tí.no)]

If there are two feet in trisyllabic words, then there are necessarily two foot heads, and thus two potential sites for epenthesis. Specifically, when stress falls on the penult in a trisyllabic word, both the penult and the antepenult should be targets for epenthesis. For antepenults, this prediction is correct, as shown by examples like [nïh̲.tí.no] 'day (locative)'. However, stressed penults are *not* targets for epenthesis in trisyllabic words (111), which falsifies the predictions of the sʀᴀʜ.

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(111)   a.   [pi.ní̠.kã̃j] 'they are eating'

        b. *[pi.ní̠h.kã̃j]

        c. Presumed footing for ꜱʀᴀʜ:
           [(pi)(ní̠.kã̃j)] or [pi(ní̠.kã̃j)]

        d. [pa̠h.tˢá̠.kï] 'we washed'

        e. *[pa̠h.tˢáh̠.kï]

        f. Presumed footing for ꜱʀᴀʜ:
           [(pa̠h)(tˢá̠.kï)]

This finding is unsurprising, since epenthesis never applies in adjacent syllables in Huariapano. The ꜱʀᴀʜ thus falls short on both conceptual and empirical grounds.

I do want to stress that the ꜱʀᴀʜ shares some important insights with my own single-tier analysis of Huariapano: it assumes that the foot boundaries of non-head feet are consistent for both regular and irregular secondary stress assignment; it assumes that coda [h] epenthesis is sensitive to the prosodic structure defined by those non-head feet; and it assumes that epenthesis always occurs in foot-initial syllables (because foot-initial syllables are taken to be foot heads). However, the ꜱʀᴀʜ is hindered by the implicit assumption that coda [h] epenthesis could only be motivated by a desire to augment foot heads. Once this assumption is abandoned, it becomes possible to account for epenthesis without making the conceptually problematic claim that stress can fall on foot dependents. Similarly, the ꜱʀᴀʜ does not make use of foot level recursion, and consequently cannot provide an internally-consistent explanation for the distribution of epenthesis in odd-parity words, or in pre-tonic syllables more generally.

2.4.8 Huariapano as an argument for prosodic constituency

Up to this point I have only considered the relative merits of foot-based accounts of Huariapano stress and epenthesis. As Parker (1998a) rightly points out, a strength of such foot-based approaches is that they straightforwardly explain why coda [h]

epenthesis is rhythmic, and why it has parallels with secondary stress assignment. However, one could plausibly entertain an alternative analysis of the same facts that makes no reference whatsoever to foot-like prosodic constituents. To model alternating stress in such a framework, it would be sufficient to construct a metrical grid with non-adjacent prominences, and no representation of constituency (in the spirit of Prince 1983, Selkirk 1984, Gordon 2002a, van der Hulst 2009, etc.)

(112)   Huariapano stress in a grid-only framework

    a.   [jò.mï.rà.no.ṣí.ki] 'he is going to hunt'

```
        Level 2                                    *
   b.   Level 1        *              *            *
        Level 0        *      *       *      *     *       *
                   j   ò  . m  ï  . r  à  . n  o  . ṣ  í  . k  i
```

But what of epenthesis? In words with regular secondary stress (and penultimate primary stress), stress and epenthesis coincide perfectly. In a constituent-free approach to Huariapano, the basic generalization must then be that coda [h] is epenthesized in eligible stressed syllables.

The challenge for this alternative analysis of Huariapano prosody, of course, is to account for words in which stress and epenthesis do not coincide. Since there are no feet in this framework, it is not possible to refer to foot heads or foot boundaries in the determination of epenthesis sites. Given that this analysis does not have recourse to rich prosodic representations, it seems natural to look for a derivational explanation of stress-epenthesis mismatches instead. An obvious possibility is that such mismatches are the result of derivational opacity: stress assignment first feeds coda [h] epenthesis; then, in some lexical items, the conditions on epenthesis are opaquely masked by subsequent rightward stress shift.

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(113)　Stress-epenthesis mismatches as derivational opacity

　　a.　[ih̲.kà̱ṣ.t͡ʃaŋ.ká.ti] 'you would shake with fear'

　　b.　Step 1: default stress assignment

```
Level 2                              *
Level 1    *                         *
Level 0    *         *         *        *        *
           ì   . k   a   ṣ   . t͡ʃ  a   ŋ   . k   á   . t   i
```

　　c.　Step 2: coda [h] epenthesis in stressed syllables

```
Level 2                                *
Level 1    *                           *
Level 0    *              *         *        *        *
           ì   h̲  . k   a   ṣ   . t͡ʃ  a   ŋ   . k   á   . t   i
```

　　d.　Step 3: lexically-determined stress shift

```
Level 2                                *
Level 1    – – – – ➤ *                 *
Level 0    *              *         *        *        *
           i   h̲  . k   à   ṣ   . t͡ʃ  a   ŋ   . k   á   . t   i
```

On this view, the derivation for [ih̲.kà̱ṣ.t͡ʃaŋ.ká.ti] 'you would shake with fear' begins by assigning stress to the the initial and penultimate syllables (Step 1). Default stress then feeds coda [h] epenthesis in the initial syllable (Step 2; I will return to the question of why the stressed penult [ká] is not similarly subject to epenthesis). In words containing particular exceptional roots, epenthesis is followed by the rightward displacement of secondary stress (Step 3). This process of stress shift then renders the conditions on epenthesis opaque: in the actual output, the initial syllable [ih̲] is unstressed, and thus should not contain a coda [h] at all if epenthesis only targets stressed syllables.

　　There is a certain appeal to analyzing these mismatches in terms of derivational opacity. For one, it accounts for the fact that the distributions of coda [h] epenthesis and secondary stress coincide fairly closely, and seems to capture the divergences

between stress and epenthesis with a single, reasonably simple mechanism (though I will dispute this momentarily). I would also guess that the derivation in (113) roughly corresponds to the actual historical development of stress-epenthesis mismatches in Huariapano (see Shell 1965, González 2003:Ch.5 for discussion of the diachrony of Panoan). Furthermore, other cases of purported mismatch between stress feet and the feet needed for segmental phonotactics can likely be modeled as opaque interactions between independent phonological processes (e.g. Mari, Blumenfeld 2006:129-32, Vaysman 2009; Tiberian Hebrew, Churchyard 1999).

However, this non-constituent analysis of Huariapano rhythmic phonology is more complicated than it initially seems. Consider a word like [jò.mï.ra̱ẖ.ká.no] 'let's go hunting', which contains a medial lapse, and which has an epenthetic coda [h] in one of the unstressed syllables participating in that lapse. It follows from the presence of coda [h] in the antepenult that there must be some derivational stage where the antepenult bears stress. The derivation of stress on the antepenult could proceed in one of two ways: either stress is assigned to the antepenult, then shifted to some other syllable; or the stress initially assigned to the antepenult is simply deleted later in the course of the derivation.

Both of these alternatives are implausible. Most obviously, they both depend on the assumption that Huariapano tolerates stress clash at intermediate derivational stages, e.g. hypothetical [jò.mï.rä̱à̱.ká.no]. If nothing else, this adds a layer of complexity to the analysis, because mismatches between stress and epenthesis arise under root-specific stress shift, or as the result of destressing triggered by clash avoidance. This analysis is also highly abstract: apart from the distribution of coda [h], there is no evidence for stress clash at any derivational stage. Indeed, there is ample evidence that Huariapano actively avoids stress clash — for one, clash avoidance explains the basic fact that secondary stress assignment is alternating. Furthermore, the requisite destressing rule leads to a Duke-of-York derivation (Pullum 1976, McCarthy 2003a) in which the antepenult is first stressed (in violation of clash avoidance), and then destressed (in order to satisfy clash avoidance).

A related problem arises in trisyllabic words. Consider the following contrast:

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(114)   a.   [pa<u>h</u>.tˢá.kï] 'we washed'

         b.   *[pa<u>h</u>.tˢá<u>h</u>.kï]

In trisyllabic words like [pa<u>h</u>.tˢá.kï], the antepenult, but not the penult is eligible for coda [h] epenthesis. This entails that, at the stage when coda [h] applies, the antepenult must be stressed, and the penult must be unstressed, i.e. hypothetical [pá<u>h</u>.tˢa.kï]. This is an extremely dubious assumption: in almost all words of Huariapano, primary stress is limited to the last two syllables of the word. There are thus no grounds for assuming that primary stress is first assigned to the antepenult in (114), then shifted to the penult following the application of coda [h] epenthesis. Without this assumption, however, the constituent-free analysis of Huariapano cannot capture the distribution of coda [h] in trisyllabic words.[40] The same basic point can be made regarding [i<u>h</u>.kàʂ.t͡ʃaŋ.ká.ti] 'you would shake with fear' (113): no plausible derivation accounts for the lack of coda [h] epenthesis in the stressed penult of this word.

Finally, like the DFAH and the SRAH, the constituent-free approach to Huariapano stress assignment has no explanation for the fact that trisyllabic words with final stress contain only a single stress peak.

(115)   a.   [βï.roj.ʃín] 'soul; spirit'

         b.   *[βï̀.roj.ʃín]

The unattested form *[βï̀.roj.ʃín] evinces regular primary stress, regular secondary stress, and does not contain a stress clash. The non-constituent analysis of Huariapano stress then incorrectly predicts that *[βï̀.roj.ʃín] should be grammatical.

The lesson to be drawn from this discussion is that foot structure is a necessary component of any adequate treatment of Huariapano phonology. In particular, the prosodic constituents that I propose cannot be dispensed with by moving to a derivational model of phonological computation. Huariapano thus furnishes a compelling

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[40]As a side note, it does us no good to assume that only secondary stress assignment precedes (and feeds) coda [h] epenthesis, e.g. /patˢakï/ → [pà.tˢa.kï] → [pà<u>h</u>.tˢa.kï] → [pà<u>h</u>.tˢá.kï] → [pa<u>h</u>.tˢá.kï]. Words like [hù<u>h</u>.ka.tí<u>h</u>.kã̃j] 'they arrived' demonstrate that both secondary stress and primary stress must be present when coda [h] epenthesis occurs, at least under the assumption that epenthesis targets stressed syllables.

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argument that stress assignment and other rhythmic phonological phenomena are indeed foot based in natural language.

This conclusion may appear somewhat retrograde — after all, thirty years of research on prosodic structure has already uncovered a substantial body of evidence for the existence of foot structure. However, in recent years this consensus has been challenged, thereby resurrecting the debate over the need for prosodic constituency in models of stress assignment. Gordon (2002a), for instance, argues that the typology of quantity-insensitive stress systems can be satisfactorily captured without any reference to foot structure (though cf. Bane 2011). Theoretical parsimony would thus seem to favor a non-metrical model of quantity-insensitive stress. Similarly, van der Hulst (2009, submitted, *et seq.*) has suggested that the calculation of secondary stress never makes reference to prosodic constituents, and relies entirely on properties of the metrical grid (clash, lapse, etc.)

Huariapano shows us that both of these approaches are on the wrong track. The distribution of coda [h] epenthesis demonstrates that secondary stress assignment *is* foot-based, despite being quantity-insensitive in character. While foot structure may not be critical for capturing stress assignment in Huariapano, it is necessary to capture coda [h] epenthesis. The argument from theoretical parsimony is thus irrelevant: a holistic account of Huariapano phonology is only possible in a framework that countenances metrical feet, even if the stress system in isolation could be modeled without them (though cf. (115)).

2.4.9 A derivational alternative to foot-initial prominence?

While the preceding discussion conclusively establishes that prosodic constituency is needed to model coda [h] epenthesis in Huariapano, it does not foreclose the possibility of a derivational account of the same facts in a framework that makes use of foot structure. By treating mismatches between stress and epenthesis as a residue of derivational ordering, models of this sort have the potential to deal with Huariapano under more traditional assumptions about the motivation behind epenthesis — namely, the view that coda [h] epenthesis occurs to augment foot heads. In this section I entertain, then ultimately reject such a derivational account of the rhythmic phonology of

Huariapano.

The analysis of Huariapano proposed in this chapter accounts for mismatches between stress and epenthesis by assuming that each process has a different locus within the foot: stress targets foot heads, but epenthesis targets foot-initial syllables. This amounts to a representational solution to the problem. That there even *is* a problem is suggested by the fact that coda [h] epenthesis and stress assignment are clearly sensitive to the same underlying structure — quantity-insensitive, bisyllabic feet — but do not coincide on the surface. In this respect, the interaction of stress and [h] epenthesis resembles a case of derivational opacity, as suggested above in Section 2.4.8. But being couched in a non-derivational framework (classic OT), my analysis of Huariapano has no recourse to opaque orderings between epenthesis and stress shift. The only remaining tact is to approach the interaction of stress and [h] epenthesis as a puzzle of surface representation. However, doing so requires the assumption that epenthesis targets foot-initial position, a claim that some readers may be hesitant to accept (though see Section 2.5 for further defense of this view).

We should ask, then, whether a foot-based, derivational treatment of Huariapano phonology is tenable. Here, I will consider whether Stratal OT (Kiparsky 2000 and others) can successfully model coda [h] epenthesis without relying on the assumption that epenthesis targets foot-initial syllables. The choice of Stratal OT as the derivational foil for my proposals is one of convenience, since it allows for fairly straightforward comparison between the two analytic alternatives. My intention, however, is to address the more general question of how a derivational framework allowing for foot structure could accommodate the Huariapano facts.

As in the non-metrical account sketched in Section 2.4.8, within a Stratal OT analysis it seems natural to assume that coda [h] epenthesis generally targets stressed syllables, as in (117). I assume that the constraint responsible for epenthesis in this counter-analysis is Branch-Head(Ft) (116).

(116)   Branch-Head(Ft) (BH(Ft)):

Assign one violation for every foot Ft$_i$ such that the head syllable of Ft$_i$ has a non-branching rhyme.

(117)

/ pikatikãj̃ /	Branch-Head(Ft)	Dep(C)
a. ☞ (pìh̲.ka)(tíh̲.kãj̃)		**
b. (pì.ka)(tíh̲.kãj̃)	*! W	* L
c. (pì.ka)(tí.kãj̃)	*!* W	L
d. (pìh̲.kah̲)(tíh̲.kãj̃)		***! W

[pìh̲.ka.tíh̲.kãj̃] 'they ate'

In the basic case, secondary stress assignment will involve left-to-right footing of syllabic trochees. I assume that coda [h] epenthesis and regular secondary stress assignment occur at the same stratum, as in (118).

(118)   First stratum: L → R syllabic trochees and coda [h] epenthesis in foot heads

/ βismanokojamaj /	AFL	WSP	NonFin	Trochee	Iamb
a. ☞ (βìs.ma)(nòh̲.ko)(ja.máj)	**		*	*	**
b. (βìs.ma)(nòh̲.ko)(já.maj)	**	*! W	L	L	*** W

[βis.mà.noh̲.kò.ja.máj] 'I have forgotten'

For words with irregular secondary stress (such as [βis.mà.noh̲.kò.ja.máj]), the relative ranking of Trochee and Iamb must be inverted at a subsequent stratum, deriving secondary stress on even-numbered syllables (119).[41] Since this change in foot headedness follows coda [h] epenthesis, the resulting output contains a mismatch between stress and [h] epenthesis. (I assume that Dep(C) and Max(C) are ranked high at this later stratum, to account for the preservation of previously inserted [h]s and the non-insertion of additional [h]s in newly-minted foot heads. Constraints preserving underlying stress or headedness must also be ranked low.)

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[41] Note that the relative re-ranking of Trochee and Iamb at this stage must be a property of specific words rather than the grammar as a whole. This may be problematic for a stratal framework: if bracket erasure co-occurs with affixation (e.g. Bermúdez-Otero to appear), phonological computation should be unable to detect whether a given word contains a root that triggers exceptional stress at the stratum where stress shift occurs (see also Section 2.4.5.3).

(119)   Second stratum: iambic foot-form reversal in non-head feet

/ (βìs.ma)(nòh.ko)(ja.máj) /	AFL	WSP	NonFin	Iamb	Trochee
a. ☞ (βis.mà)(noh.kò)(ja.máj)	**		*		***
b. (βìs.ma)(nòh.ko)(ja.máj)	**		*	*!* W	* L

[βis.mà.noh.kò.ja.máj] 'I have forgotten'

While mechanically successful for simple cases, this stratal account of Huariapano en-counters at least two empirical problems, both of which it shares with the non-metrical approach to Huariapano discussed in Section 2.4.8:

1. **Pretonic epenthesis in antepenults**.

   The stratal account sketched here has no satisfactory explanation for the presence of coda [h] in words like [pah.tˢá.kï] 'we washed'. If [h] epenthesis targets foot heads, there must be a derivational stage where [pah.tˢá.kï] is footed [(páh.tˢa)kï]. Since antepenultimate primary stress is rare, if not unattested in Huariapano (Sec-tion 2.4.5.2), this is a deeply problematic assumption.

2. **Failure of epenthesis in stressed penults**.

   The stratal account of Huariapano does not provide a principled account for the failure of epenthesis in stressed penults in words like [rah.kì.t͡ʃa.í.ki] 'it is scary'. The footing of this particular word should, under reasonable assumptions, be [(rah.kì)t͡ʃa(í.ki)] or the recursively parsed [(rah.kì)(t͡ʃa(í.ki))]. In either case, the penult is wrongly predicted to be eligible for epenthesis in such forms.

   One could imagine ways to remedy this shortcoming — perhaps epenthesis only targets the heads of non-recursive feet — but such remedies appear to be ground-less. To be sure, I myself propose that epenthesis only targets the initial syllable in a maximal foot (Section 2.4.2.3), but this proposal is conceptually linked to the demarcative function of epenthesis, which serves as a segmental signal marking the boundaries between adjacent feet.

These two objections suggest that derivational models of phonology cannot account for the distribution of coda [h], at least under the assumption that epenthesis targets foot heads. A derivational treatment of Huariapano might, of course, be feasible if built

on my claim that the driving motivation behind coda [h] epenthesis is a pressure to augment foot-initial syllables. However, since this claim can be fully implemented in a non-derivational framework (as I have done in this chapter), I fail to see any reason to adopt a derivational analysis of the Huariapano facts (though there may well be good reasons that simply haven't occurred to me yet). The overarching point remains that, even in a derivational framework, there is no need to assume the existence of multiple metrical tiers in Huariapano.

2.4.10 Interim conclusion

This completes the discussion of Huariapano. To review, I claim that an empirically adequate account of Huariapano phonology brings us to the following conclusions:

(120) a. All rhythmic word-level phonological processes in Huariapano are based on binary foot structure. This includes both stress and [h] epenthesis.

b. Huariapano phonology makes use of only a single metrical tier (the UNI-FORMITY OF FOOTING HYPOTHESIS)

c. The rhythmic type of feet in Huariapano (iambic or trochaic) varies depending on phonological and/or lexical factors. A single word in Huariapano may contain both trochaic and iambic feet.

d. Coda [h] epenthesis is motivated by a pressure to augment foot-initial syllables, because foot-initial elements are in a phonologically 'strong' position.

e. Coda [h]s are non-moraic, so foot-initial augmentation is non-moraic as well. This follows from the fact that only word-final coda consonants may sponsor moras in Huariapano.

f. Huariapano makes use of a limited amount of recursive footing. Foot-level recursion occurs only as a last resort to ensure exhaustive parsing of syllables into feet.

I have also argued, albeit implicitly, for a parallel model of phonological computation — that is, for classic Optimality Theory. In particular, conclusions (120c) and (120f) fit very naturally into an OT framework: they exemplify the 'do-something-only-when-*X*' logic inherent to a computational system that relies on ranked and violable constraints (e.g. Prince & Smolensky 1993/2004:§3, McCarthy 2002:Chs. 1.3, 3.2). This logic is hard or impossible to express in strict parametric approaches to metrical typology. The parametric 'switch' determining foot type, for example, should hold uniformly across a given language, regardless of the phonological environment that each foot appears in (Hayes 1995:55, 315; see also Hayes 1981, Halle & Vergnaud 1987, Halle & Idsardi 1995, van der Hulst 2009, submitted). Huariapano shows us that designating entire languages as 'trochaic' or 'iambic' is too simplistic (see also Chapter 3). Huariapano is a 'trochaic language' only in the sense that trochaic footing is preferred; this preference can be subordinated to other, more pressing phonological desiderata (e.g. quantity-sensitivity). A more nuanced parametric theory could probably capture the same facts, but in doing so it would edge ever closer to the model of constraint interaction embodied by OT (see also McCarthy & Prince 1986/1996:7-8).

In the following sections, I take a wider view of the theoretical positions listed in (120). I begin by presenting additional evidence for the claim that foot-initial position is a phonologically strong position (Section 2.5). This is followed by a general discussion of foot-level recursion, and how it fits into a broader conception of recursive prosodic categories (Section 2.6). Section 2.7 considers a potential exception to the uniformity of footing hypothesis: namely, the possibility that tonal and segmental tiers may have distinct, incommensurate types of metrical organization within a single language. Section 2.8 concludes.

2.5   Evidence for foot-initial prominence

The foot-based analysis of Huariapano that I endorse hinges on the claim that foot-initial position is phonologically prominent, independent of whether the foot-initial syllable bears stress. While this might seem to be an *ad hoc* stipulation, it is in fact supported by cross-linguistic phonological and phonetic evidence. The following sections are dedicated to adumbrating that evidence, thereby supporting the proposed

foot-based, single-tier analysis of Huariapano.

2.5.1 Yupik (Eskimo-Aleut; Alaska)

Yupik languages are well-known for having fortition processes that demarcate foot edges. In particular, various varieties of Yupik (e.g. Norton Sound, Alutiiq, and Koniag) have iambic footing with fortition of foot-initial consonants (Leer 1985a,b,c, Jacobson 1985, Hayes 1995, van de Vijver 1998, González 2003, Vaysman 2009, etc.). This fortition may involve subphonemic consonant lengthening (with concomitant devoicing), or in the case of Norton Sound Yupik, alternations in consonantal manner.

(121)   Foot-initial fortition in Norton Sound Yupik (Jacobson 1985, van de Vijver 1998:43-4, 132)

  a.   Foot-initial approximants become voiced fricatives:

    /w j l/ → [v z ɮ] / (Ft __ …)

  b.   [(ma.ˈjuɣ)(ˈvik)] 'place to go up'[42]

  c.   [(ˈat)(xaɣ.ˈwik)] 'place to go down'

  d.   [(ma.ˈjuɣ)(ˈzux.tuq)] 'he wants to go up'

  e.   [(ˈat)(xaɣ.ˈjux)(tuq)] 'he wants to go down'

  f.   [(ku.ˈvən)(qix.ˌtan)ka] 'I spilled them again'

  g.   [(ˈkuː)(ˈvə.ˌɬə)(quq)] 'it will spill'

Both approximants and voiced fricatives are present in underlying representations in Norton Sound Yupik, e.g. /qajani/ → [qa.ˈjaː.ni] 'his own kayak' and /kuɣluni/ → [ˈkuɣ.lu.ni] 'it spilling' (Jacobson 1985).[43] As (121) illustrates, allophonic fortition

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[42]Word-final syllables do not receive stress in Norton Sound Yupik, even when the distribution of foot-sensitive fortition indicates that they are parsed as the strong branch of an iambic foot. See Hayes (1995), van de Vijver (1998), and references therein for discussion. Jacobson (1985) reports that there is no phonetic difference between primary and secondary stress in Norton Sound.

[43]I assume that Jacobson's (1985) transcription [ˈkuɣ.lu.ni] 'it spilling', which contains an approximant [l] rather than the predicted fricative [ɮ], is simply a broad transcription that does not represent the effects of fortition.

neutralizes underlying /w j l/ and /v z ʐ/ to [v z ʐ]. Whether or not fortition applies to a given consonant depends on prosodic properties of the preceding syllable: onset approximants are realized as voiced fricatives just in case they are post-tonic. Since Norton Sound Yupik has iambic footing, post-tonic syllables will also be foot-initial.[44] Importantly, these alternations occur whether or not the targeted onsets belong to a stressed syllable: onset approximants appear in stressed and unstressed syllables alike (121b,c), as do voiced fricative onsets (121f,g).

Since fortition targets foot-initial onsets, which are always in post-tonic syllables, it is possible to state the conditions on fortition in terms of stress alone. Doing so, however, is not particularly explanatory. Post-tonic position is generally a locus for weakening rather than strengthening, setting aside weight-driven effects like post-tonic gemination (e.g. Lavoie 2001, González 2003, Gurevich 2004). Since the allophonic processes in (121) are clearly a species of consonant fortition, we should expect them to target segments in positions of phonological strength (e.g. Smith 2005b). Indeed, Lavoie (2001:43) cites two languages (Guyabero and Sawai) in which an analogous process of [w] → [β] fortition occurs in a phonologically prominent position (onset of a stressed vowel and first member of an initial [#CC] cluster, respectively). The foot-based account of Norton Sound fortition thus assimilates the fricativization of approximants to the more general phenomenon of consonant strengthening in prominent environments. A stress-based treatment of the same facts fails to recognize the obvious connection between Norton Sound fricativization and the typology of phonological processes manipulating consonant strength. It would also represent the only pattern of consonant allophony I am aware of in which the degree of consonant constriction is conditioned by the presence of stress on a preceding *syllable* rather than a preceding *segment* (cf. lenition processes, like English flapping, that target intervocalic consonants depending on the stress profile of the immediately flanking vowels; Lavoie

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[44]I have found no examples of underlying word-initial approximants in Norton Sound Yupik. Given the stress system of this variety of Yupik, word-initial approximants should also be foot-initial, and thus undergo fortition. However, the question of word-initial fortition may be a non-starter for other reasons: the Yupik languages are almost exclusively suffixing, so underlying word-initial approximants should always be realized as surface fricatives, making it impossible to discern whether or not fortition has applied.

2001, González 2003, Gurevich 2004).

It seems clear, then, that foot-initial fortition exists in the Yupik languages. What makes these patterns of fortition particularly interesting is that they are *non-quantitative*; that is, they do not alter phonological syllable weight. In that respect, Yupik-type fortition is akin to coda [h] insertion in Huariapano, in that both processes augment foot-initial syllables in a non-moraic fashion. (I am assuming that Yupik-type fortition is 'strengthening' in the sense that it reduces the sonority of onsets in phonologically prominent positions; see e.g. Smith 2005b.)

2.5.2   Russian (Slavic; Russia and elsewhere)

In most Central and Southern dialects of Russian, unstressed [ă] is permitted only in immediately pre-tonic syllables (Halle & Vergnaud 1987, Suzuki 1998, Crosswhite 2000, 2001, Padgett & Tabain 2005, Iosad to appear, and references therein). This asymmetric pattern of vowel reduction is plausibly foot-based: assuming that footing is iambic in these varieties of Russian, we can conclude that the reduction of unstressed [ă] (to [ə]) is inhibited in foot-initial syllables, [(σ σ́)].

(122)   Pre-tonic vowel reduction in some Central Russian dialects (Crosswhite 2000)

    a.   [ˈs<u>a</u>t] 'garden (nom. sg.)'

    b.   [s<u>ə</u>.da.ˈvot] 'gardener (nom. sg.)'

    c.   [s<u>ə</u>(da.ˈvot)]

    d.   [ˈd<u>a</u>tʲ] 'to give'

    e.   [d<u>a</u>.ˈvatʲ] 'to give (iterative)'

    f.   [(d<u>a</u>.ˈvatʲ)]

It is of course relevant here that [a] is a highly sonorous vowel, and as such, tends to be licensed in phonologically strong positions (e.g. de Lacy 2002b, 2004, 2007). If foot-initial position counts as phonologically prominent, as I propose, then the retention of underlying /a/ in pretonic syllables amounts to the preservation of sonorous vowels in a position of phonological strength — a typologically familiar pattern. Indeed, in some Russian dialects that have this system of reduction, the mid vowels /e o/ lower

to [a] when pretonic, thereby becoming *more* sonorous even at the cost of contrast neutralization.

(123) Pre-tonic vowel lowering in some Central Russian dialects (Crosswhite 2000)

 a. /rʲe̲ka/ → [rʲa̲.ˈka] 'river (nom. sg.)'

Cf.

 b. [ˈrʲe̲t͡ʃ.ka] 'little river (nom. sg.)'

 c. /nʲo̲su/ → [nʲa̲.ˈsu] 'I carry'

Cf.

 d. [ˈnʲo̲s] 'he carried'

Interestingly, these patterns of vowel reduction go against the clear typological preference for *low*-sonority vowels in unstressed, footed syllables (i.e. in stress-adjacent syllables; see e.g. Kager 1989:312-17, Kenstowicz 1994, 1997, Kager 1997, de Lacy 2002b, 2004, 2007, Gouskova 2003, Blumenfeld 2006, McCarthy 2008b, Itô & Mester 2011a). This apparent discrepancy disappears once we recognize that, in iambic systems, the push towards foot-initial prominence may trump the preference for low-sonority vowels in foot dependents (see also Section 2.5.10).

There is further evidence for an iambic syllable grouping in certain varieties of Russian. In so-called 'dissimilative' dialects, the vowel inventory found in pre-tonic syllables interacts with the quality of the following stressed vowel. Specifically, pretonic [ă] is disallowed in some dialects when the tonic vowel is non-high.

(124) 'Dissimilative' vowel reduction in some Southwest Russian dialects (Nesset 2002)

 a. /pʲa̲tʲak/ → [pʲi̲.ˈtak] 'five-kopeck coin'
 b. *[pʲa̲.ˈtak]

Cf.

 c. [ˈpʲa̲tʲ] 'five (nom. sg.)'
 d. [pʲa̲.ˈtʲi] 'five (gen. sg.)'

e. /lʲesa/ → [lʲi.ˈsa] 'forest (gen. sg.)'

f. *[lʲa.ˈsa]

Cf.

g. [ˈlʲes] 'forest (nom. sg.)'

h. [lʲa.ˈsu] 'forest (loc. sg.)'

These vowel reduction patterns would appear to be instances of foot-internal vowel dissimilation (e.g. Suzuki 1998). Even if one rejects the notion that these interactions involve true featural 'dissimilation' (as Crosswhite 2000, 2001 does), they nonetheless provide further evidence for a rhythmic, iambic grouping of pre-tonic and tonic vowels. (See also Bennett & Henderson to appear and Chapter 3 for discussion of another phenomenon implicating the relative sonority of two vowels in the same foot.)

Finally, there is some indication that pretonic syllables also bear phonetic prominence in Russian. To wit:

> "... the unstressed vowel in the immediately pretonic syllable in many Russian dialects is durationally distinct from other unstressed vowels of the same quality. Furthermore, although unstressed vowels in Russian are frequently devoiced or deleted in fast speech, the vowel of the immediately pretonic syllable is not..." (Crosswhite 2000:116; see also Padgett & Tabain 2005)

I conclude that there is convergent evidence for iambic footing in Russian, and furthermore, that the exceptional behavior of pre-tonic vowels can be attributed to the fact that foot-initial syllables are phonologically and phonetically prominent.

2.5.3 Tataltepec Chatino (Zapotecan; Southern Mexico)

In Tataltepec Chatino (henceforth TC) pre-tonic syllables support a wider range of tonal contrasts than other unstressed syllables (Pride & Pride 1964, Pride 1984a,b). Since pre-tonic syllables in TC are arguably parsed as the first member of an iambic foot, the distribution of tone suggests that foot-initial syllables are phonlogical privileged in this language as well.

As in other varieties of Chatino, stress in TC is uniformly word-final. This suggests that footing is iambic. Stressed, final vowels [... ˈσ#] can host seven distinct contrastive

tones (two level tones and five contour tones). Pre-tonic unstressed vowels — that is, penults [... $\underline{\sigma}$'σ#] — can support four phonemic tones (two level tones and two contour tones). Tone is otherwise non-contrastive in TC. In pre-penultimate syllables, only high and low level tones are permitted, and their distribution is entirely predictable from the tone of the penult. Antepenultimate tone is determined by OCP-driven tonal dissimilation: antepenults bear high tone when the penult is low or rising, and bear low tone when the penult is high or falling. Similarly, when the antepenult bears high tone the pre-antepenult bears low tone (and vice-versa).

To summarize:

(125)   Distribution of tone in Tataltepec Chatino

   a.   Stressed ultimas [... '$\underline{\sigma}$#]:
        7 contrastive tones (2 level, 5 contour)

   b.   Unstressed penults [... $\underline{\sigma}$'σ#]:
        4 contrastive tones (2 level, 2 contour)

   c.   Unstressed (pre-)antepenults [$\underline{...\,\sigma\sigma}\sigma$'$\sigma$#]:
        No contrastive tones (2 predictable, allophonic level tones)

Under the natural assumption that footing is iambic in TC, then the last two syllables of the word will be parsed into a shared foot, [... (σ'σ)#]. It follows from this that unstressed, pre-tonic penults will always be foot-initial. The fact that penults host more phonemic tones than other unstressed syllables can then be chalked up to the typological observation that strong positions often support a larger range of phonological contrasts (e.g. Trubetzkoy 1939, Beckman 1998, Smith 2005b) — provided that foot-initial position counts as phonologically strong.[45]

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[45]I am unaware of any trochaic systems in which unstressed, post-tonic footed syllables license an expanded inventory of tones. If such systems exist, it would undercut my claim that penults in TC are phonologically privileged because they are foot-initial, and not simply because they are parsed into a foot.

2.5.4 Canela (Jê; Central/NE Brazil)

In Canela, intervocalic onset consonants undergo lengthening in stressed syllables, provided the pre-tonic vowel is short (Popjes & Popjes 1971, 1986). Vowel length is contrastive, though it doesn't carry a high functional load.

(126) Contrastive vowel length in Canela

    a.   [mã] (benefactive)

    b.   [mãː] 'rhea' (species of bird)

    c.   [ka.t͡swa] 'night'

    d.   [kaː.t͡swa] 'salt'

(127) Stressed onset lengthening: /CVCV/ → [CVC.ˈCV]

    a.   /kuhe/ → [kuh.ˈhe] 'abcess'

    b.   /kɐpi/ → [kɐp.ˈpi] 'try'

    c.   /kumɣ̃ kuhehnõ ŋõ/ → [kum.ˈmɣ̃ kuh.ˈheʔ.ˈnõ gõ] 'give him another bow'

(128) No lengthening after long vowels : /CVːCV/ → [CVː.ˈCV]

    a.   /kuːhe/ → [kuː.ˈhe] 'bow'

    b.   /kɐːpõ/ → [kɐː.ˈpõ] 'sweep'

    c.   /haːklun/ → [haː.ˈkɹun] 'he danced'

Stress is uniformly word-final in Canela (at least in nouns and verbs), which points toward iambic footing, e.g. [(kuh.ˈhe)] 'abcess'. It appears, then, that the lengthening of onset consonants in stressed syllables is a gemination process that provides a closing coda for light, pre-tonic [CV] syllables — in other words, gemination ensures that foot-initial syllables will be bimoraic. This explanation also accounts for the fact that stressed onset lengthening fails when the vowel in the preceding unstressed syllable is long: in words ending in a [(CVː.ˈCV)] foot, the foot-initial syllable is already bimoraic; since gemination not prosodically motivated in such forms, it does not apply.

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Another explanation for the blocking of gemination in such forms is the fact that closed syllables containing long vowels, [CVːC], are independently unattested in Canela. However the conditions on gemination are accounted for, it is clear that the gemination of stressed onsets is sensitive to structural properties of the pre-tonic syllable. This speaks against an analysis of the language that treats gemination as a fact about stressed syllables rather than a fact about entire feet. What's more, gemination doesn't affect the structure of the stressed syllable itself: it is [ˈCV(X)] whether or not gemination takes place (albeit with a multiply-linked onset when gemination applies). If gemination is structurally motivated in Canela, it must be sensitive to foot structure rather than just syllable structure alone (cf. Giavazzi 2010).

Implicit in the preceding analysis is the assumption that gemination has a moraic basis in Canela. This is not a necessary commitment: it is possible that geminates in Canela are actually non-moraic consonants linked to two syllable nodes, and occupying two timing slots (see e.g. Tranel 1991, Hume, Muller & van Engelenhoven 1998, Muller 2001, Davis 2003, and references therein; see also Section 2.5.9). Under this conception of gemination, Canela resembles Huariapano in that foot-initial syllables are augmented with non-moraic codas in service to Branch-Initial(Ft). Since Branch-Initial(Ft) is satisfied by foot-initial [CVː] syllables, this alternative analysis of onset gemination in Canela also accounts for the inhibiting effect of vowel length in pre-tonic syllables.

At any rate, the crucial observation here is that gemination in Canela is dependent on properties of unstressed, pre-tonic, foot-initial syllables rather than stressed syllables *per se*. As such, Canela provides a strikingly clear case of foot-initial coda augmentation, as proposed for Huariapano in Section 2.4. This is true whether onset gemination is an instance of prosodically-determined quantitative adjustment, manipulating mora count, or a purely segmental phenomonon with no moraic consequences.

2.5.5   Karo (Ramarama Tupí; SW Brazil)

Like Canela, Karo has a stress-sensitive gemination process that provides a closing coda for open [CV] syllables in foot-initial position. Specifically, the voiceless stops /p t c k/ undergo lengthening in the onset of stressed syllables (Gabas 1999, Blumen-

feld 2006)

(129)   Onset lengthening in Karo (Gabas 1999:13)

    a.   [mo.ˈpːik˺] 'guan (species of bird)'

    b.   [i.ˈtːɨ] 'deer'

    c.   [i.ˈcːɨ] 'water'

    d.   [ko.ˈkːi] 'hawk'

    e.   [wa.ˈkːɔ̃.ỹa] 'species of rodent'

This process of stressed onset lengthening is subject to two important restrictions. First, lengthening does not apply to word-initial stressed onsets.

(130)   No word-initial onset lengthening (Gabas 1999:18,22)

    a.   [ˈpɨj] 'lazy'

    b.   [ˈtɨᵈn] 'to burn'

    c.   [ˈcu] 'big'

    d.   [ˈkɨj] 'truth'

Second, stressed onset lengthening does not apply when the *pre*-tonic syllable is closed [CVC] (glottal stop [ʔ] is the only word-medial coda consonant in Karo; Gabas 1999:24).

(131)   No onset lengthening after [CVC] syllables (Gabas 1999:23-6)

    a.   [aʔ.ˈpɛ.ja] 'do it'

    b.   [naʔ.ˈtup˺] 'end'

    c.   [jaʔ.ˈcĩ] 'bad odor'

    d.   [iʔ.ˈke] (negative particle)

Onset lengthening is thus limited to intervocalic position, provided the following vowel is stressed:

(132)   Stressed onset lengthening in Karo:
    /p t c k/ → [pː tː cː kː] / V __ V́

As in Canela, it appears that footing is iambic in Karo. *Ceterus paribus*, stress tends to fall on the ultima, and less frequently on the penult.[46] The preference for final stress can be easily accomodated by assuming iambic footing with default right-alignment.

I interpret the Karo facts as follows. Parallel with Canela, the lengthening of stressed onsets is a gemination process that serves to close pre-tonic [CV] syllables. Words with lengthening (e.g. [i.ˈtːɨ] 'deer') would then be better transcribed with a pre-tonic coda followed by a linked, homorganic onset in the stressed syllable (e.g. [it.ˈtɨ]). Assuming that footing is indeed iambic in Karo, as suggested by the preference for final stress, this amounts to another case of coda augmentation in foot-initial position (e.g. [(it.ˈtɨ)]).[47]

The gemination of stressed onsets fails when the pre-tonic syllable is already closed [CVC] (131). This follows from the assumption that gemination is driven by a desire to close foot-initial syllables: when the pre-tonic syllable is already [CVC], there is simply no motivation for lengthening to apply. (There are no long vowels in Karo, so we cannot test whether pre-tonic vowel length also interacts with gemination, as in Canela.)

There are two reasons why the onsets of word-initial stressed syllables do not lengthen (130). First, it may be the case that Karo, like most languages, does not allow onset geminates (a possibility that also bears on the lack of gemination in [CVC.ˈC̲V] words, (131)). Second, onset lengthening in a stressed, word-initial syllable like [(ˈcu)] 'big', *[(ˈcːu)] fails to remedy the fact that the foot-initial syllable is open [CV]. As such, gemination in word-initial onsets might be banned for being gratuitous, in the sense that it does not lead to any gain in phonological well-formedness.

To round out the argument, one more fact needs to be accounted for: the failure of onset gemination in post-tonic syllables when stress is initial. Gemination does not occur in [ˈCV.CVC] words, even though gemination could conceivably close a foot-

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[46]See Gabas (1999) and Blumenfeld (2006) for some contrasting views on the details of stress assignment in Karo.

[47]A different analysis, inspired by the treatment of Huariapano in Parker (1994) and González (2003), would be to assume that gemination derives exhaustive parsing into (potentially covert) moraic trochees, e.g. [(mop)(ˈpik)] 'guan (species of bird)'. However, this account is committed to the problematic claim that some words ending in a light stressed syllable are gratuitously parsed with a degenerate head foot, e.g. [(ic)(ˈcɨ)] 'water', cf. my proposed [(ic.ˈcɨ)]. As such, it is not a serious alternative to my proposal.

initial syllable in such forms, e.g. *[('CVC$_x$.C$_x$VC)]. As it happens, the lack of post-tonic gemination stems from independent properties of the phonology of Karo. In particular, post-tonic intervocalic stops are subject to a process of allophonic voicing, essentially a kind of lenition (Gabas 1999:29,39, Blumenfeld 2006:26-7).[48]

(133)   Non-pre-tonic intervocalic stop voicing in Karo

    a.   /p t k/ → [b/w ɾ g] / V ＿ V̌

    b.   /cop<u>i</u>/ → ['co.<u>bɨ</u>] 'hook'
    c.   /cá<u>t</u> + a/ → ['cá.<u>ɾa</u>] 'wash'
    d.   /wá̃<u>k</u> + a/ → ['wá̃.<u>ga</u>] 'be sick'

Since only voiceless stops undergo gemination in Karo, the allophonic voicing of intervocalic stops bleeds gemination. Hence /pa<u>p</u> + a/ → ['pa.<u>ba</u>] 'die', but *['pa.<u>bba</u>], *['pa.<u>ppa</u>].

It may also be the case that the preference for iambic footing in Karo is so strong that a word like /ke<u>t</u> + a/ → [ke<u>ɾa</u>] 'sleep' is footed with a degenerate iamb, [('ke)<u>ɾa</u>], rather than a binary trochee with gemination, *[('ke<u>t.t</u>a)]. If geminates cannot cross foot boundaries in Karo (so *[('ke<u>t</u>)t<u>a</u>]), this would supply a second explanation for the failure of post-tonic onset stop gemination.

I conclude that in Karo (as in Canela) the gemination of stressed onsets serves to close an otherwise light pre-tonic [CV] syllable. In other words, Karo provides a third instance of coda augmentation in foot-initial position.[49]

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[48]Gabas (1999) claims that allophonic stop voicing targets [p t k] but not [c]. However, I have been unable to find any instances of [c] appearing in the relevant phonological environment. It may be that the lack of allophonically voiced [ɟ] is an accidental gap resulting from sparse data; alternatively, it may be related to the fact that palatal [c] is the only voiceless stop in Karo without a phonemic voiced counterpart, */ɟ/. See also footnote 49.

[49]A complication with this analysis is that, apart from lengthening environments, [c] appears exclusively in onset position in Karo (Gabas 1999:27). Since heterosyllabic geminates like [Vc.cV] are linked to an onset position, my analysis of Karo onset lengthening is still consistent with Gabas' generalization regarding the syllabic affiliation of [c]. See Itô (1989) for related discussion.

2.5.6 Kaapor (Tupí-Guaraní; NE Brazil)

Kaapor has a gemination process that very much resembles onset lengthening in Canela and Karo.[50] In Kaapor, the oral stops /p t k kʷ ʔ/ undergo lengthening when appearing in the onset of a syllable bearing primary stress (Kakumasu 1986, Kakumasu & Kakumasu 1988, González 2003, Bye & de Lacy 2008, Giavazzi 2010).

(134)   Stressed onset lengthening in Kaapor

    a.   /ipo/ → [i.ˈppo] 'finger'

    b.   /katu/ → [ka.ˈttu] 'it is good'

    c.   /pukek/ → [pu.ˈkkek] 'conceal, hide'

    d.   /akʷa/ → [a.ˈkkʷa] 'I know'

    e.   /kaʔa/ → [ka.ˈʔʔa] 'forest'

Primary stress in Kaapor always falls on the ultima, with secondary stresses falling on every other preceding syllable.

(135)   [ˌwa.ɾu.ˈwa] 'glass, mirror'

As in Tataltepec Chatino and Canela, the fact that primary stress is fixed on the ultima strongly suggests that footing is iambic in Kaapor. To account for secondary stress, I assume that degenerate feet are allowed in odd-parity words in order to achieve exhaustive parsing, e.g. [(ˌwa)(ɾu.ˈwa)] (though cf. Hayes 1995:87,99,262).

Unfortunately, the phonological descriptions of Kaapor that I have been able to consult provide only a handful of transcriptions explicitly illustrating stressed onset lengthening. In particular, I have been unable to determine from Kakumasu (1986) and Kakumasu & Kakumasu (1988) whether onset lengthening occurs after coda consonants or word-initially in monosyllables (Kaapor does allow codas, but seems to disallow or at least disprefer monosyllabic content words). This makes it difficult to determine whether onset lengthening derives heterosyllabic geminates [CVC$_x$.ˈC$_x$V], or tautosyllabic onset geminates [CV.ˈC$_x$:V]. Though I cannot settle the matter conclusively,

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[50]Kaapor is also known as Urubu-Kaapor, but since the term 'Urubu' is considered pejorative I omit it here (Kakumasu & Kakumasu 1988).

Kaapor may be akin to Canela and Karo in that stressed onsets are lengthened to provide a closing coda for light pre-tonic syllables in foot-initial position, e.g. [(ip.ˈpo)] 'finger'.[51]

2.5.7   Tokyo Japanese (probably Altaic; Japan and elsewhere)

Tokyo Japanese provides evidence that foot-initial position is prominent in phonetic as well as phonological terms. Tokyo Japanese (henceforth just 'Japanese') is a prototypical pitch accent language: there is no stress, but the presence, absence, and position of lexical *HL tone is contrastive (e.g. McCawley 1968, Hirayama 2009 and many others). Despite the absence of stress in Japanese, there is a plethora of evidence for phonological foot structure — specifically, moraic trochees (e.g. Poser 1990, Mester 1990, Haraguchi 1999, Itô & Mester 1992/2003, Itô et al. 1996, Kubozono 2008, etc.).

Japanese also contrasts plain and palatalized consonants, e.g. [boː] 'stick' and [bʲoː] 'second'. In conservative varieties of Japanese, there is no contrast between plain /t/ and palatalized /tʲ/ before [i]: they neutralize to palatalized [tʲ], e.g. [i.no.tʲi] 'life'. As in many languages, palatalized [tʲ] is affricated in Japanese, and might be better represented as the complex coronal segment [t͡ɕ].

Shaw (2007) reports that [t͡ɕi] sequences have a greater degree of stop affrication in foot-initial position than in foot-final position. Schematically (where [t͡ɕˑ] marks phonetically lengthened affrication):

$$(136) \quad \left/ \begin{array}{c} \text{ti} \\ \text{tʲi} \end{array} \right/ \rightarrow \left[\begin{array}{c} \text{t͡ɕi} \,/\, (_{\text{Ft}}\, \sigma \, \_\_\,) \\ \text{t͡ɕˑi} \,/\, (_{\text{Ft}}\, \_\_\, \sigma) \end{array} \right]$$

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[51] Kakumasu (1986) reports a small number of words in which a stressed syllable containing a lengthened onset is preceded by a syllable bearing secondary stress, e.g. *nupā ta* [nu.ˌpã.ˈtta] 'he will hit'. Such forms are problematic for the foot-based account of gemination in Kaapor, since they seem to entail that a foot boundary can intercede between the tonic and pre-tonic syllables, e.g. [(nu.ˌpã)(ˈtta)]. However, the description of stress in Kakumasu (1986) and Kakumasu & Kakumasu (1988) is scanty at best, and what little information is given suggests that Kaapor normally avoids stress clashes of this sort. In connection with this point, it is likely relevant that all of the problematic examples derive from isolation forms in which the syllable bearing secondary stress carries primary stress instead, e.g. *nupā* [nu.ˈppã]. Without a more complete description of stress in Kaapor, and secondary stress especially, it's hard to know what to make of these facts.

Japanese does not have stress, so phonetic phenomena of this sort cannot be analyzed as being conditioned by stress rather than foot structure. Since not all words of Japanese bear lexical pitch accent, foot-initial position is also separable from the accented syllable. Japanese thus instantiates a clear case of foot-initial phonetic prominence (see also Tajima & Port 2004 on foot-based effects in the production of spoken Japanese).

2.5.8 Initial prominence in other prosodic domains

There is mounting evidence that the initial elements in many prosodic domains are phonologically and/or phonetically prominent. In the interest of brevity I will not review specific evidence for this view here, but (137) provides a short list of some relevant references (see also Itô & Mester 2009, 2010, Flack 2009, Vogel 2009).

(137) π-initial prominence in different prosodic domains

    a.   Phonological evidence

        (i)   Word-initial position:
             Trubetzkoy (1939), Beckman (1998), Smith (2005b)

        (ii) ϕP-initial position:
             Elordieta (2007), Selkirk (2011), Bennett et al. (in prep)

    b.   Phonetic evidence

        (i) ϕP- and ιP-initial position:
             Fougeron & Keating (1997), Hsu & Jun (1998), Keating, Cho, Fougeron & Hsu (2004), et seq.

        (ii) ϕP-, ιP-, and Utterance-initial position:
             Onaka, Palethorpe, Watson & Harrington (2002), Kawahara & Shinya (2008)

A novel contribution of the work presented here is that it demonstrates that foot-initial position counts as phonologically prominent (and perhaps phonetically prominent) in

much the same way.

The question arises as to why the prominence of foot-initial elements has not been previously recognized as a general phenomenon. One obvious reason is that stress and footing are often confounded. Foot-initial prominence may be masked by the effects of stress, because stress itself often conditions prominence-based phonological patterns. This overlap can result in systematic ambiguity as to the source of prominence-triggered effects, especially in trochaic languages (see e.g. González 2003). The foot is also a much smaller domain than other prosodic levels, so there is a smaller window (both phonologically and temporally) for the effects of foot-initial prominence to be manifested. The relative compactness of the foot no doubt contributes to the relatively low visibility of foot-initial strengthening effects. Still, there are some circumstances — iambic languages, languages without stress accent, etc. — in which foot-initial prominence effects come into sharper relief.

Based on the emerging typology of domain-initial prominence effects, and the conclusions regarding foot structure presented here, I would like to make the following conjecture.

(138)   The initial position in any prosodic domain π counts as linguistically prominent for phonology and/or phonetics.

At the moment, it is not clear to me whether the hypothesis stated in (138) might have an extra-phonological, or even extra-linguistic source. For example, it may be grounded in rather general facts about motor planning, auditory perception, language processing, and so on (e.g. Beckman 1998, Smith 2005b). Indeed, Hale & Reiss (2008) take the strong stance that many, if not all such phenomena are extra-grammatical in character. In their view, domain-initial prominence effects in synchronic phonology should be attributed to the influence of perceptual and psycholinguistic factors on the historical development of sound systems (e.g. Ohala 1981, Blevins 2004), and have no place in formal grammars.

However, I am skeptical of extra-grammatical explanations for the foot-initial prominence effects discussed here. Unlike word-initial position, which plays a crucial role in lexical access, foot-initial position has no special place in language processing.

Unlike ω, ϕP, and ιP, the foot does not in general correspond to a syntactic or morphological constituent with special psycholinguistic or communicative relevance (apart from e.g. foot-based word minimality effects and other forms of prosodic morphology; see also Section 2.6). And unlike stress, foot structure itself has no direct phonetic realization, and thus no particular psychoacoustic salience.

It is of course true that the foot-initial phenomena discussed here have *some* historical source — after all, every synchronic phonological pattern derives diachronically from some phonological or phonetic precursor (e.g. Hyman 1976). The question is whether foot-initial prominence effects arise organically, as the result of extra-grammatical conditions on language transmission, or emerge due to the active influence of synchronic grammars that formally distinguish π-initial elements from phonological objects appearing in other positions.

Given the phonetically 'hidden' character of foot structure, non-grammatical explanations for the existence of foot-initial phenomena strike me as dubious, though admittedly not out of the question. It seems more likely to me that foot-initial phenomena arise in synchronic phonologies because phonological grammars are formally capable of expressing patterns that privilege domain-initial positions. That is, INITIAL(π) is a well-formed expression of phonological grammars, but e.g. THIRD(π) and MEDIAL(π) are not. Similarly, STRONG(INITIAL(π)) is a well-formed phonological expression, but WEAK(INITIAL(π)) is not. In other words, foot-initial prominence effects exist because language learners have access to grammars that allow them to state phonetic or phonological generalizations in those terms, whatever their historical source might have been (see also Giavazzi 2010 and Chapter 4).

If this is on the right track, then the foot-initial prominence effects described here are a vindication of the view that domain-initial privilege plays a part in synchronic phonology (see also Barnes 2006, Becker, Nevins & Levine to appear). Foot-initial phonological patterns exist because they fall into a larger schema of INITIAL(π) effects that can be expressed by formal phonological grammars. While foot-initial prominence may not itself be grounded in phonetics or psycholinguistics, the broader formal category of INITIAL(π) clearly is. In other words, foot-initial prominence is an analogical extension (or perhaps, an exaptation) of phonetically-grounded initial prominence

effects in other domains (see Blevins 2004 and Padgett & Myers (2011) for related discussion of final devoicing). This conclusion in turn supports the claim that substantive knowledge — that is, knowledge about phonetics — plays a role in synchronic phonological computation (e.g. Archangeli & Pulleyblank 1994, Flemming 1995, Beckman 1998, Hayes & Steriade 2004, Smith 2005b, Wilson 2006, etc.).

2.5.9 Foot-initial augmentation and the weight-to-stress principle

As touched on in Section 2.4.3, in some cases foot-initial prominence effects appear to be at odds with the weight-to-stress principle (wsp): in particular, coda augmentation in foot-initial syllables seems to derive unstressed, footed heavy syllables, $[(\sigma_{\mu\mu}\ \acute{\sigma})]$. This might appear problematic, since many languages actively avoid unstressed heavy syllables, especially in the weak branch of the foot (e.g. Hayes 1981, Prince 1991, Kager 1999, Norris 2010, McCarthy et al. to appear, Chapter 3). A potential objection, then, is that the coda augmentation processes discussed here can't be motivated by well-formedness conditions on foot-initial syllables, since they lead to an increase in prosodic markedness with respect to wsp and other related principles.

I do not think that there is anything inherently problematic about the tension between foot-initial coda augmention and wsp. Not all languages show the same phonological sensitivities, and within a given language certain phonological desiderata are often subordinated to other, more pressing requirements. These facts are of course central to the empirical success of Optimality Theory, which directly models conflicts between opposing phonological tendencies as the interaction of ranked and violable constraints. It is thus perfectly consistent to claim that foot-initial coda augmentation increases the relative well-formedness of feet in some languages, but not in others, depending on how highly-valued wsp is in each case.

This analysis of foot-based coda augmentation also makes a clear typological prediction: no coda augmentation process should ever target the weak branch of a *trochaic* foot, since foot dependents in trochaic languages are foot-final rather than foot-initial (see also Section 2.5.10). To the best of my knowledge, this prediction is borne out. The existence of such augmentation processes would also be problematic for most extant theories of foot structure, given that the avoidance of $[(\acute{\sigma}\ \sigma_{\mu\mu})]$ trochees plays a major

role in standard foot parsing algorithms. Even those languages that tolerate $[(\acute{\sigma}\ \sigma_{\mu\mu})]$ trochees do not seem to seek them out.[52]

Indeed, a virtue of the analysis proposed here that is it provides a coherent account of several iambic languages that appear to augment foot dependents with utter disregard for the well-formedness of surface feet. Something like Branch-Initial(Ft) is needed to explain why languages like Huariapano Canela, etc. do derive what seem to be quantitatively ill-formed $[(\sigma_{\mu\mu}\ \acute{\sigma})]$ iambs. Without an independent pressure for prominent foot-initial syllables, such patterns would remain troublesome and mysterious exceptions to the larger typology of foot structure and quantitative adjustment.

I suspect it is also relevant that the foot-initial prominence effects I have identified tend to occur in languages with limited or no quantity-sensitivity in stress assignment. The languages discussed in this chapter either have fixed stress (Tataltepec Chatino, Canela), lexical stress (Russian, Karo), or quantity-insensitive stress (Huariapano, Karo, Kaapor). The main exception to this generalization is Yupik, which has quantity-sensitive stress placement in all varieties I am familiar with (Leer 1985a,b,c, Jacobson 1985, Hayes 1995). On the other hand, the foot-initial fortition patterns found in Yupik are non-quantitative in character, and probably do not alter moraic structure (including consonant lengthening, which is subphonemic). Tokyo Japanese falls into the same class: footing is quantity-sensitive, but foot-initial fortition is both subphonemic and non-quantitative. It seems possible, then, that augmentation processes deriving bimoraic foot-initial syllables may be limited to languages in which footing itself is not sensitive to syllable weight. Another possibility is that, in some languages, foot-initial coda augmentation is simply non-moraic in nature. I believe that this is the correct analysis of coda [h] epenthesis in Huariapano (Section 2.4.3),

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[52]A brief digression on Revithiadou (2004): Revithiadou proposes that iambic lengthening — a common process whereby vowels are lengthened in foot heads in iambic languages (Hayes 1995) — results from the interaction of stressed-syllable vowel lengthening and foot-final vowel lengthening. As Revithiadou (2004) recognizes, assuming foot-final vowel lengthening predicts the existence of trochaic languages that prefer $[(\acute{\sigma}\ \sigma_{\mu\mu})]$ feet. Revithiadou claims that the non-existence of such languages can be attributed to the absolute ill-formedness of $[(\acute{\sigma}\ \sigma_{\mu\mu})]$ trochees. This position is untenable, as there are languages with syllabic trochees and quantity oppositions that allow $[(\acute{\sigma}\ \sigma_{\mu\mu})]$ feet (Hayes 1995:102). I conclude, then, that there is no evidence for foot-final lengthening in synchronic phonology. See Kager (1993a), Hayes (1995), and Hyde (2007) for some alternative approaches to iambic lengthening.

and it is even consistent with languages like Canela (Section 2.5.4), in which coda augmentation potentially involves non-moraic geminate consonants.

I conclude that the conflict between WSP and foot-initial prominence is not a liability of my account. Instead, the interaction of these two conflicting principles leads to a better understanding of actual, attested typologies of quantitative adjustment and foot form.

2.5.10   Foot-initial strengthening vs. weak branch weakening

A related worry is that foot-initial strengthening in iambic languages seems inconsistent with the tendency for phonological weakening in foot dependents found in many languages. In particular, languages often have patterns of vowel reduction or deletion that preferentially target unstressed, footed syllables, i.e. foot dependents (e.g. Kager 1989:312-17, Pandey 1990, Hayes 1995:84, Kager 1997, Gouskova 2003, Blumenfeld 2006, McCarthy 2008b, Norris 2010, Kimper 2011b, Chapters 3 and 4). Foot-based reduction patterns of this sort are found in iambic and trochaic systems alike.

To reiterate a point raised in the previous section, the mere fact that two phonological principles are in conflict does not demonstrate that one of the principles should be discarded. Foot-initial strengthening and the reduction of foot dependents are simply orthogonal pressures on prosodic organization, which happen to be in conflict in iambic systems. There is nothing contradictory in this statement. Furthermore, weak branch weakening does not by itself explain the existence of languages like Tataltepec Chatino and Russian, in which foot dependents are clearly *protected* from weakening processes that target foot-external unstressed syllables.

The theory advocated here again predicts a clear asymmetry between iambic and trochaic languages: there should be no trochaic languages with weak branch strengthening. As far as I know, this prediction is once more supported by the typology of non-quantitative, foot-based reduction processes.[53] The existence of weak branch weakening in both iambic and trochaic languages follows directly from the fact that the

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[53]The prediction that weak-branch strengthening should be asymmetric (i.e. limited to iambic systems) distinguishes my account of e.g. Russian from approaches like Alderete (1995) and Crosswhite (2000, 2001), which analyze pre-tonic strengthening by assuming that all footed syllables have special licensing properties, regardless of where they appear in the foot.

structural notion 'weak branch' is defined in non-linear relational terms, and is completely independent of the right- or left-headedness of a given foot.

2.6 On recursive footing

In Section 2.4.2.3 I proposed that Huariapano exploits recursive footing in order to achieve exhaustive parsing of syllables. To support this claim, I referred to earlier research in which it was also assumed that syllables can be recursively adjoined to feet (though cf. McCarthy & Prince 1993a:6, who explicitly deny that recursive footing is possible). In this section I compare foot-level recursion with recursion at other levels of the prosodic hierarchy.

2.6.1 Recursion at other levels of the prosodic hierarchy

Recursive prosodic structure has been proposed at other levels of the prosodic hierarchy, including the prosodic word ω (McCarthy & Prince 1993a,b, Selkirk 1996, Itô & Mester 2009, 2010, etc.), the phonological phrase ϕP (Selkirk 2011, Itô & Mester 2012a,b), and the intonational phrase ιP (Selkirk 2011). (See also Gussenhoven 2004, Ladd 2008, and many other references cited in the works just mentioned.) Within prosodic hierarchy theory, the consensus appears to be that recursion is a general property of prosodic structure at the word level and above (for prosodic recursion in a 'label-free' theory, see Wagner 2010).

I would like to defend the somewhat stronger position that recursion is available at *all* levels of the prosodic hierarchy. On this view, recursive footing is just one instantiation of a generic structure-building operation (139) that may in principle apply to any prosodic category. There is a sense in which this is the null hypothesis, since it does not require any further stratification of the prosodic hierarchy into 'recursible' and 'non-recursible' layers.

(139)   Prosodic recursion:

$$\pi_n \rightarrow \pi_n + \left\{ \begin{array}{c} \pi_n \\ \pi_{n-1} \end{array} \right\}$$

The task is then to account for differences between foot-level recursion and recursion at higher prosodic categories. One such difference is frequency: in particular, ω- and ϕP-level recursion are fairly common both typologically and within individual languages, while foot-level recursion does not appear to be as widespread.

To account for this difference, I would like to suggest that there is an *implicit* stratification of the prosodic hierarchy into levels at which recursion is a more (or less) useful operation. This stratification arises epiphenomenally, as a result of the mapping relations between prosodic categories and morpho-syntactic constituents. Itô & Mester (2012b) make a useful conceptual distinction between INTERFACE CATEGORIES and RHYTHMIC CATEGORIES. The interface categories are ω, ϕP, ιP, and υ (the utterance, if it exists as a distinct level). Interface categories are *extrinsically defined*, in the sense that constituent structure at these levels is partially determined by the underlying morphosyntactic structure of the same utterance.

(140)   Mappings from morphosyntax to prosodic interface categories (XP a lexical projection; see e.g. Selkirk 1996, 2011, Elfner 2012)

   a. $\omega \leftrightarrow x^0$
         Phonological word $\leftrightarrow$ Lexical (or syntactic) word

   b. ϕP $\leftrightarrow$ XP
         Phonological phrase $\leftrightarrow$ Syntactic phrase

   c. ιP $\leftrightarrow$ CP
         Intonational phrase $\leftrightarrow$ Syntactic clause

In other words, the role of the interface categories is to provide a rough, but audible image of the syntactic constituency of an utterance. This partial isomorphism between syntax and prosody has obvious functional advantages for on-line syntactic parsing, language acquisition, etc. (e.g. Bloom 1993, Frazier, Carlson & Clifton 2006). Recursion of the interface categories is common precisely because prosodic structure at these levels closely mirrors syntactic structure, and recursive embedding is a defining feature of the syntax of natural languages. In other words, recursion is *externally motivated* at the prosodic word and above. Importantly, recursion of the interface cate-

gories is possible, but not profligate: it occurs only when needed to enforce parallelism between prosodic structure and a corresponding recursive syntax.

In opposition to the interface categories, we have the rhythmic categories: the foot Ft, the syllable σ, and perhaps the mora μ. There are no mapping principles that demand isomorphism between rhythmic categories and constituents of morphosyntax.[54] The rhythmic categories are thus *intrinsically defined*, in the sense that their organization primarily depends on properties of phonological structure (sonority, binarity, syllable count, etc.), and makes little or no reference to morphosyntactic information.

What about recursion of the rhythmic categories? Recursion is phonologically 'marked', in that natural languages appear to prohibit unmotivated recursive structure in prosodic representations (see Sections 2.4.2.3 and 2.4.4.3, Truckenbrodt 1999, Itô & Mester 2012b, etc.). It follows that there must be some evaluation metric that penalizes the gratuitous recursion of prosodic categories (e.g. a family of *Recursion(π) constraints, Selkirk 1996, 2011). While recursive prosodic structure is dispreferred, it is nonetheless allowed when it serves some overarching purpose, like a desire for partial isomorphism between syntax and prosody.

The question, then, is whether recursion of the rhythmic categories has any external motivation. Since there is no pressure for the rhythmic categories to line-up with morphosyntactic objects, any external motivation for recursion of these levels must be phonological in nature. At the level of the foot, exhaustive parsing clearly fits the bill: as argued for Huariapano in Section 2.4, recursive footing occurs as a last-resort strategy to ensure that all syllables will be parsed into feet, thereby satisfying the Exhaustivity clause of the Strict Layer Hypothesis (Selkirk 1996). In this respect, there is a clear parallelism between foot-level recursion — which occurs to parse syllables into feet — and recursion of ω, which ensures that functional morphemes like clitics will be parsed into a containing prosodic word.[55]

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[54]There are of course cases in which certain abstract morphemes (e.g. reduplicants) are required to map to feet or syllables, e.g. McCarthy & Prince (1986/1996, 1993b, 1994), etc. The existence of prosodic morphology is beside the point: the issue at hand is whether there are mapping principles that hold in the other direction, demanding isomorphism between e.g. feet and morphological words.

[55]An important difference between ω-level and foot-level recursion is that the underparsed elements in ω-level recursion are clitics, determiners, and other functional items — in other words, they are lexemes of some sort. As such, they are capable of idiosyncratically selecting for a particular host (e.g.

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(141)   a. ω-level recursion   b. Fᴛ-level recursion

```
        ω_MAX                            Fᴛ_MAX
        /  \                             /    \
      ω_MIN  \                        Fᴛ_MIN   \
        |     \                        /\       \
    [[Lᴇx]  Cʟɪᴛɪᴄ]              (( σ σ )     σ)
```
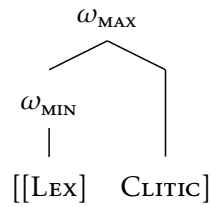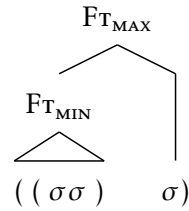
One could imagine other motivations for a recursive foot parse: as one example, under certain conditions recursive parsing might lead to better satisfaction of constraints requiring footing to be oriented toward a particular word-edge (e.g. Martínez-Paricio 2012).

It is harder to see how syllable-level recursion could be similarly motivated (though cf. Smith 1999).[56] On analogy with recursive foot parsing, we should ask whether un-derparsing of segments into syllables could ever lead to recursive syllabification (142).

(142) σ-level recursion?

```
        σ_MAX
        /  \
      σ_MIN  \
       /\     \
     CVC.     C
```
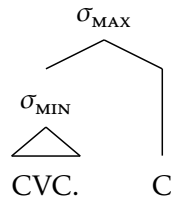
Underparsed segments are generally consonants (though cf. Downing 1998), and arise when an underlying consonant cannot be parsed into a syllable without violat-ing language-specific conditions on syllable margins (i.e. a prohibition against codas

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Inkelas 1990), which may give rise to lexically-motivated recursive structure or underparsing at the ω level.

[56]The view taken in Smith (1999) is that all consonant clusters involve recursive syllabification. Re-lated work in Government Phonology assumes (very roughly) that all syllables are maximally CV, so consonant clusters and codas necessarily involve a phonetically null vowel nucleus — an idea which can be reinterpreted in terms of recursive syllable structure (e.g. van der Hulst 2010).

It is not clear to me what actually compels recursion in these frameworks, apart from the fact that something like recursion is needed to account for the existence of codas and consonant clusters in a theoretical system that refuses to countenance anything larger than a CV (or CVC) syllable. At any rate, I do not find the evidence for this view sufficiently compelling to merit in-depth discussion here.

or consonant clusters). In such cases, underparsing is either tolerated (resulting in so-called syllable appendices) or resolved by vowel epenthesis, consonant deletion, metathesis, etc. (Itô 1989). For the sake of argumentation, let's assume the existence of a hypothetical language ℓ in which underparsed consonants are resolved by syllable recursion rather than a phonological operation like deletion, as in (143).

(143)   Language ℓ: underparsed consonants are recursively adjoined to full syllables

    a.   /CVCCV/ $\rightarrow$ [CVC.CV]

    b.   /CVCC/ $\rightarrow$ [$_\sigma$ [$_\sigma$ CVC] C]

However, the recursive syllable structure (143b) raises an implicit learning problem. All else being equal, the recursive parse (143b) would be phonetically identical to the underparsing structure [CVC⟨C⟩], and perhaps the fully parsed structure [CVCC] as well (see also Shaw, Gafos, Hoole & Zeroual 2009). Even if recursively parsed consonants were subject to some distinguishing phonological process (say, place neutralization), the conditioning environment for this process would still be fully ambiguous: no empirical evidence would tell the language learner that the process in question targeted recursively adjoined consonants rather than the second member of a coda cluster, or an underparsed consonant. While we might imagine phonological diagnostics that could distinguish between disyllabic [CV.CV] and recursively parsed [$_\sigma$ [$_\sigma$ CV] CV] (e.g. vowel reduction in adjoined syllables), the phonological motivation for parsing a surface [CVCV] string as recursive [$_\sigma$ [$_\sigma$ CV] CV] seems obscure at best.

Given that recursion is phonologically 'costly' — and as such, avoided when gratuitous — it seems extremely unlikely that a language learner encountering this state of affairs would ever have reason to posit recursive syllable structure. It follows, then, that the apparent non-existence of syllable recursion doesn't need to be encoded in phonological theory, because language learners would never be confronted with empirical evidence forcing them to posit recursive syllables. If it turns out that recursive syllables do in fact exist, that would only strengthen the claim that recursion is a general property of all prosodic categories.

Finally, we arrive at the question of mora recursion. Given that the mora is the

lowest (and most questionable) member of the prosodic hierachy, it seems reasonable to assume that recursive moras are unattested because they are simply unmotivated. One could imagine situations in which moraic recursion might serve a purpose — for example, a superheavy [CVC$_\mu$C$_\mu$] syllable could be rendered bimoraic by parsing the two consonantal moras into a recursive [$_\mu$ μ μ] structure (though admittedly, it is not clear to me whether this structure would could as one, two, or perhaps even three moras for the purposes of computing syllable weight). However, there are a number of equally satisfactory repairs that do not require moraic recursion: for instance, parsing the second coda of a [CVCC] syllable as a non-moraic consonant would derive a well-formed bimoraic constituent, as would subsuming both codas under a single branching mora [$_\mu$ CC]. Whether or not moraic recursion could be motivated on other grounds of course depends on our conception of the principles that govern moraic structure. At the least, I believe there is reason for skepticism. Furthermore, some authors have argued that the mora should be understood as a property of syllables rather than an autonomous object within the prosodic hierarchy (see e.g. Trubetzkoy 1939, Itô & Mester 1992/2003, Lunden 2006). If this conception of the mora turns out to be correct, then the question of recursion simply does not arise for moras.

I conclude, then, that the distribution of recursion across the prosodic hierarchy follows from (i) the assumption that recursion is a formal operation available for any prosodic category, and (ii) the observation that recursion does not occur unless it has some external motivation.

2.7 Projection, tiers, and metrical organization: mismatches in tonal languages

The analysis of Huariapano proposed here is partly intended as a defense of the UNIFORMITY OF FOOTING HYPOTHESIS, repeated in (144).

(144) **Uniformity of footing hypothesis (UFH):**
Within a single language, there are no mismatches between the metrical feet needed for stress assignment and the feet needed to explain foot-sensitive segmental processes.

In Section 2.4 I alluded to the possibility that there may be a principled exception to the ʊꜰʜ: namely, languages in which the tonal and segmental tiers seem to require distinct principles of metrical organization. In this section, I consider whether Bamana (Leben 2002, Weidman & Rose 2006, Green et al. 2009, Green 2010), a Mende language spoken in Mali, might exemplify a language of exactly this sort.

2.7.1 Metrical organization in Bamana

Bamana (also known as Bambara and Bamanankan) is a prototypical tone language: it makes use of a fairly rich inventory of contrastive tonal melodies, and there is no evidence of phonetic stress. There are two pieces of evidence for foot structure in Bamana. The first concerns the surface distribution of tone (Leben 2002, Weidman & Rose 2006, Green 2010). For the sake of argumentation I will focus on the proposals advanced by Weidman & Rose (2006), though this should not be construed as an endorsement of any particular analysis of Bamana.

The variety of Bamana analyzed by Weidman & Rose (2006) has the following tonal melodies on nouns of four or less syllables (setting aside some additional melodies that arise under special morphosyntactic conditions, or as the result of free variation).

(145)   Basic surface melodies for Bamana nouns (Weidman & Rose 2006)

  a. One σ: L, H
  b. Two σ: LL, HH
  c. Three σ: LLL, HHH; LHH, HLL; LHL
  d. Four σ: LLLL, HHHH; LLHH, HHLL; LLHL

Weidman & Rose (2006) propose an analysis of these tonal contours in terms of foot structure. Specifically, they propose that nouns in Bamana are exhaustively parsed into trochaic feet. For trisyllabic words, a degenerate, monosyllabic foot is built at the left edge of the word — in other words, the direction of parsing is right-to-left.

(146) Foot structure proposed by Weidman & Rose (2006) ($\underline{\sigma}$ = foot head)

    a.   [($\underline{\sigma}$)]

    b.   [(<u>bà</u>)] 'goat'

    c.   [($\underline{\sigma}$ σ)]

    d.   [(<u>bà</u>.là)] 'porcupine'

    e.   [($\underline{\sigma}$)($\underline{\sigma}$ σ)]

    f.   [(<u>bàn</u>)(<u>fú</u>.lá.)] 'hat'

    g.   [($\underline{\sigma}$ σ)($\underline{\sigma}$ σ)]

    h.   [(<u>kú</u>.lú)(<u>kù</u>.tù)] 'ball'

Weidman & Rose (2006) assume five distinct underlying tonal melodies for Bamana, /L/, /H/, /LH/, /HL/, and /LHL/. They also make the further assumption that underlying tones preferentially link to the heads of the trochaic feet, and then spread within each foot as needed to ensure that each syllable bears a surface tone.[57] Tones may never spread across a foot boundary.

(147)   a.   /bala, L/   → [(<u>bá</u>.lá)]   'balafon'

        b.   /mangoro, HL/   → [(<u>mán</u>)(gò.rò)]   'mango'

        c.   /garijɛgɛ, LH/   → [(<u>gà</u>.rì)(<u>jɛ́</u>.gɛ́)]   'chance'

This analysis captures a number of important properties of the tonal system of Bamana. First, it explains why tonal plateaus in trisyllables are on the last two syllables of the word, rather than the first two (though see Weidman & Rose 2006 for some important details on this point). Further, it accounts for the fact that quadrisyllabic nouns may contain tonal plateaus on the first two syllables or the last two syllables, but never on the two medial syllables, e.g. there are no words of the form /$\sigma\sigma\sigma\sigma$, LHL/ → *[(<u>ò</u> ó)(<u>ó</u> ò)]. Along with the additional assumption that Bamana prefers to realize

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[57]It is not clear to me how Weidman & Rose (2006) would account for the absence of bisyllables with [LH], [HL], or [LHL] tonal melodies in Bamana. Trisyllabic words like /sakɛnɛ, LHL/ → [(sà)(kɛ́.nɛ̀)] 'lizard' demonstrate that a foot may contain more than one independent tone, especially if the tone on the foot dependent is low.

high tone on foot heads (de Lacy 2002a), this analysis also explains why quadrisyllabic words with underlying /LHL/ melodies surface as [(L̲L̲)(H̲L)] rather than *[(L̲H)(L̲L̲)].

The second source of evidence for foot structure in Bamana comes from some segmental processes that appear to be foot-bounded in nature. Green et al. (2009), Green (2010) describe two deletion processes in Colloquial Bamana, an innovative variety of Bamana spoken by younger individuals in Bamako, Mali.[58] Colloquial Bamana (CB) has a process of intervocalic velar stop deletion that elides /k ɡ/ when appearing between two identical vowels.

(148)   Intervocalic velar deletion in CB (Green et al. 2009, Green 2010)

   a.   /cogo, H/   → [cóó]   'manner'
   b.   /duku, L/   → [dùú]   'village'
   etc.

Importantly, intervocalic velar deletion does not apply to velar consonants appearing outside of the first two syllables of the word. This generalization can be easily restated in terms of foot structure: provided that words in Bamana begin with a disyllabic foot, deletion may not target velars external to that initial foot.

(149)   Blocking of intervocalic velar deletion[59]

   a.   /mɛlɛkɛ, L/   → [(mɛ̀.lɛ̀)kɛ́]   'angel'
   b.   *[(mɛ̀.lɛ̀ɛ́)], *[(mɛ̀.lɛ́ɛ́)]

   c.   /baraka, H/   → [(bá.rá)ká]   'blessing'
   d.   *[(bá.ráá)]

Alternatively, one could assume that intervocalic velar deletion is suppressed when it would derive an initial [CV.CVV] sequence, given that such a sequence would have to be parsed as an ill-formed trochee [(C̲V̲.CVV)] or an iamb [(CV.C̲V̲V̲)]. Either way,

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[58]The variety of Bamana analyzed by Weidman & Rose (2006) is also spoken in Bamako, but is apparently a more conservative lect.

[59]The words [(mɛ̀.lɛ̀)kɛ́] 'angel' and [(bá.rá)ká] 'blessing' are subject to the syncope process alluded to later in this section, and actually surface as [mɛ̀l.kɛ́] ∼ [mlɛ̀.kɛ́] and [bár.ká] ∼ [brá.ká].

the domain of application for velar consonant deletion would seem to implicate a left-aligned bisyllabic foot. Additional evidence for foot structure of this sort comes from a widespread pattern of vowel syncope targeting the first two syllables of the word (Green et al. 2009, Green 2010).

We are now in a position to consider whether Bamana constitutes a counterexample to the UFH. The crucial data comes from trisyllabic words. Weidman & Rose (2006) argue on the basis of tonal distributions that a trisyllabic word like [dú.ké.né] 'court-yard' must be footed [(dú)(ké.né)], with an initial monosyllabic foot. This is in direct conflict with the footing that Green et al. (2009) and Green (2010) propose to account for the domain of application of velar consonant deletion, which requires an initial disyllabic foot [(dú.ké)né]. It seems, then, that the phonology of Bamana makes use of two distinct systems of metrical organization, one operating on the tonal tier, and one on the segmental tier. If this is correct, then Bamana would appear to falsify the strong version of the UFH (in which 'stress' is taken in the more general sense of 'foot head', as relevant for suprasegmental phenomena).

However, there are several reasons to suspect that this conclusion is premature. The tonal system of Bamana is a subject of some controversy (see Green 2010 for an overview), and it is not clear that Weidman & Rose's (2006) analysis of Bamana, which describes a more normative variety of the language, actually extends to the tonal system of Colloquial Bamana. Indeed, Green (2010:Ch.7) provides a unified analysis of CB that captures the distribution of surface tone and the domain of foot-sensitive phonotactics within a single system of metrical organization. It seems likely, then, that Bamana is in fact consistent with the strong version of the UFH.

Nevertheless, I'd like to entertain the possibility that Bamana, or some other tonal language, really does require two distinct systems of metrical organization. Imagine a language в', which requires one system of foot parsing for tone, and another for segmental phonotactics. Were such a language to exist, I do not believe that it would be in conflict with the spirit of the UFH. The intuition behind the UFH is that stress feet and 'phonotactic feet' must be identical because they are constructed over the same phonological objects — namely, a string of segments, hierarchically organized into syllables. The structural principles governing tone, on the other hand, are quite

different. As such, there is no necessary congruence between tonal constituents and the constituents that determine segmental phonotactics.

Tone and stress are fundamentally distinct linguistic phenomena. For one, tone shares a number of properties with phonological features like rounding, nasalization, etc.: in particular, tone may undergo local spreading, and often participates in processes of assimilation and dissimilation. Stress, in contrast, does not (e.g. Hayes 1995:Ch.3). Furthermore, the notion of 'locality' relevant for tonal phenomena is not equivalent to segmental adjacency: successive tone-bearing units (e.g. vowels) may manifest tonal interactions whether or not additional segments (e.g. consonants) intervene.

These observations are of course some of the core evidence for an autosegmental treatment of tone (Goldsmith 1976, 1990, etc.). In autosegmental phonology, tone *projects* onto an independent tier, which may have an organizing logic of its own.

(150)   Projection and tonal tiers

<center>

ADJACENT

TONAL TIER: T   T
                   | |
SEGMENTAL TIER: CV   CV

NON-ADJACENT

</center>
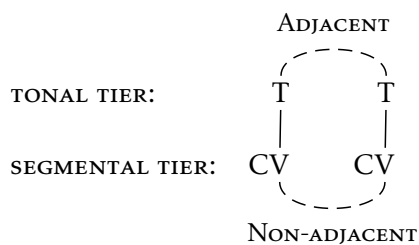
As touched on in Section 2.4, it is the notion of projection that distinguishes a hypothetical language like в′ from the case of Huariapano. The disjoint metrical systems required for в′ operate over different phonological objects: tones are grouped into feet on the tonal tier, and segments are grouped into feet of a different sort on the segmental tier. In principle, then, there is no incompatibility between having two distinct metrical systems within a single language, provided that the systems in question operate over distinct phonological objects, represented on distinct tiers. The problem with Huariapano is that the apparent mismatch between stress feet and 'epenthesis feet' actually concerns two phenomena defined over the same phonological plane (namely, the segmental tier).[60]

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[60]I am assuming that segments, along with the constituents of the prosodic hierarchy superimposed on

A clear prediction of this view is that we might encounter languages in which other projecting elements — in particular, segmental features — have a metrical organization that is incompatible with the foot structure required for stress placement. Such languages may perhaps exist. In the Central dialect of Crimean Tatar, for instance, the feature [ROUND] is limited to the the first two vowels of the word, which also constitutes the domain of rounding harmony (Kavitskaya 2010). However, stress is almost exclusively word-final in Crimean Tatar. This means that the foot-like domain in which round vowels are licensed may not correspond to the metrical constituent associated with stress.

(151)   Multiple metrical systems in Crimean Tatar?

   a.   [tuz.lu.ˈɣɯm] 'my salt shaker'

   b.   Stress foot: [tuz(lu.ˈɣɯm)]

   c.   [ROUND] 'foot':   [{tuz.lu}ˈɣɯm]

Kavitskaya (2011) suggests that stress assignment in Crimean Tatar may be post-lexical (as is arguably true for final stress in French, Turkish, and other languages). This opens the possibility that 'stress' in this language is a phrase-level phenomenon, and does not actually depend on word-level foot structure. If this view is correct, it would undermine the notion that Central Crimean Tatar is a language with multiple systems of metrical organization. In either case, I would maintain that the UFH is consistent with the potential existence of languages that have both metrically organized featural domains and a distinct, incompatible system of metrical stress.

That said, I am skeptical that the phonological constituents organizing autosegmental features like tone, [ROUND], etc. are really 'metrical' constituents of the same type as those determining stress assignment. Stress is an abstract, relational property holding between syllables, with no fixed cross-linguistic phonetic realization. Conceptually speaking, then, it makes sense to represent stress with relationally-defined

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those segments, are all co-present on a single tier. That is, there is no independently projecting 'syllable tier' or 'foot tier' (cf. Halle & Vergnaud 1980). Even if there are independent foot and syllable tiers, as long as those tiers are unique (e.g. because they project from a unique string of segments), I believe the same basic objection holds.

metrical structures (see also Chapter 1). The same cannot be said for tone, or for distinctive features like [ROUND]. While there is a sense in which tone is also 'relational' (high tone has to be higher than something, after all), the distinction between e.g. lexical low tone and lexical high tone has no analogue in terms of stress. In other words, [bá] and [bà] is clearly a potential minimal pair with respect to tone, but no language has a corresponding minimal pair [ˈba] vs. [bǎ], in which a lexical contrast between content words is cued by the presence or absence of stress. Similarly, the distinction between primary and non-primary stress (i.e. head and non-head feet) does not seem to have an analogue in tonal or featural constituents (where featural constituents might be posited for languages with bounded vowel harmony, like Central Crimean Tatar).

There are also important formal differences between stress feet and other foot-like phonological constituents. Some theories of tonal and featural constituent structure (e.g. Optimal Domains Theory; Cole & Kisseberth 1994, Cassimjee & Kisseberth 2007, etc.) countenance unbounded 'tonal feet' or 'harmony feet' spanning three or more syllables (see also Flemming 1994, McCarthy 2004). While unbounded feet of this sort have also been entertained within metrical stress theory, at least since Prince (1985) it has been recognized that theories of stress allowing only maximally bisyllabic feet are both empirically adequate and theoretically parsimonious (see also Kager 1989, Hayes 1995, Rice 2007, Chapter 3, and references therein). A related issue has to do with iterativity. There are many languages in which footing is iterative: words contain a contiguous string of binary feet, which induces a pattern of alternating stress. As far as I know, languages with iterative, binary domains for featural or tonal processes are rare, if not unattested (though see Cassimjee & Kisseberth 2007 on tone assignment in Emakhuwa). Such a language would look something like Central Crimean Tatar, except e.g. rounding harmony would only hold between successive pairs of vowels.

(152)   Iterative binary rounding harmony (hypothetical)

   a.   / CyCiCiCy / → [{ Cy.C<u>y</u> } { Ci.C<u>i</u> }]
   b.   / CiCyCyCi / → [{ Ci.C<u>i</u> } { Cy.C<u>y</u> }]

There thus appear to be important structural differences between stress feet and the 'feet' that may be active on featural and tonal tiers. There are of course similarities as

well: both kinds of 'feet' may be bounded and headed, where the 'head' of a feature or tonal domain might be taken to be e.g. the trigger for a harmony or spreading process (i.e. the sponsor; see e.g. Cole & Kisseberth 1994, Cassimjee & Kisseberth 2007). Both kinds of 'feet' may also show edge-orientation, as well-illustrated by Central Crimean Tatar (151). Nevertheless, I believe that the discrepancies between stress feet and other suprasegmental or featural constituents are sufficient to doubt that they represent the same kind of phonological object. In other words, featural and tonal constituents are non-metrical — they are not, properly speaking, feet at all. This relates to the point, raised earlier, that stress feet define a relational structure, while featural and tonal domains are not relational in the same sense. Similarly, while featural and tonal constituents define domains for spreading, stress feet do not, given that stress does not spread (though stress feet might define domains for other spreading processes).

This discussion raises the interesting question of whether phonological theory really needs to admit distinct prosodic constituents for autosegmental processes. Many spreading processes are unbounded, in the sense that their domain is the entire prosodic word, or spreading proceeds toward a particular word edge (see e.g. Krämer 2003, Rose & Walker 2011 for recent overviews of vowel harmony processes). Since the prosodic word is independently needed as a prosodic category, these languages do not obviously motivate additional tier-specific constituency. The question, then, is whether there are any languages in which (i) some autosegmental process or generalization has a domain δ smaller than the prosodic word, but bigger than the syllable, (ii) δ is incompatible with the metrical feet needed to account for stress assignment, and (iii) the bounded nature of the process in question cannot be attributed to some secondary cause (see e.g. Kaplan 2008 on sources of non-iterativity in phonology). As noted above, Central Crimean Tatar might be such a language, if not for the fact that stress assignment is potentially reanalyzable as a non-metrical, phrase-level phenomenon. There may of course be other contenders, though I am not well-enough versed in the typology of action-at-a-distance patterns to say so with any confidence.

It should be pointed out as well that autosegmental tiers clearly interact with stress feet in a meaningful way. For example, de Lacy (2002a, 2007) argues that the distribution of tone in many languages can be understood as resulting from constraints

that enforce correspondence between particular tones and foot heads or foot dependents. The term 'foot' is meant here in its truest sense, as the domain of stress assignment, so de Lacy's analysis does not require any additional sub-word prosodic constituents apart from the metrical foot itself (see also Pearce's 2006 discussion of vowel harmony, stress, and tone in Kera). The most restrictive assumption would then seem to be that *all* bounded autosegmental processes have the binary metrical foot as their conditioning domain, at least when the bounding of such processes cannot be attributed to some independent factor (see again Kaplan 2008), and the domain of application is not the syllable or word. It is also relevant here that the domain of autosegmental spreading is often morphologically conditioned, and may be limited to roots, blocked by particular affixes, and so on (see Krämer 2003, Rose & Walker 2011, and references therein). Such morphological conditioning may be partially responsible for cases in which bounded spreading domains do not appear to coincide with the metrical foot.

Apart from serving as bounding domains for spreading, tier-specific prosodic constituents have also been motivated by a desire to account for transparency effects in otherwise local patterns of feature assimilation. In Optimal Domains theory, for example, individual features like [ROUND] define phonological constituents (marked by '{ }') that may extend over stretches of contiguous segments, e.g. the two-syllable [ROUND] span in Turkish [{pu.lun}] 'stamp' (Cole & Kisseberth 1994). These consituents are called F-domains; harmony occurs under pressure for all segments in a given F-domain to express the feature F; and the local nature of spreading follows from the fact that F-domains necessarily span contiguous segments. While there is pressure for the segments in an F-domain to express the feature [F], this is not obligatory. Transparent segments — segments that do not participate in harmony but which allow feature spreading to proceed 'through' them — are then simply segments in an F-domain that do not express the particular feature that defines that domain. For example, in Kinande the low vowel [a] is transparent for [ATR] spreading. The vowel [a] is thus contained in an [ATR]-domain, but does not express the feature [ATR], e.g. schematic /CʊCaCu/ → [{Cu.Ca.Cu}].

While domain-based approaches to harmony very naturally account for trans-

parency in spreading, there are alternative models of harmony on the market that also cope well with transparent segments without relying on featural constituents. As one example, the AGREEMENT-BY-CORRESPONDENCE (ABC) framework (Rose & Walker 2004) provides an elegant account of transparency in consonant harmony, and makes no use whatsoever of featural domains. The ABC approach to has recently been extended to vowel harmony systems by Rhodes (2010), significantly weakening the apparent advantages of domain-based models of harmony.

I conclude from all of this that the evidence for featural constituents is actually rather slim, since (i) there are few (if any) cases of bounded spreading that require autonomous featural domains, and (ii) the existence of transparent segments in local spreading systems does not necessitate a constituent-based theory of harmony. Since the typology of harmony systems is somewhat outside my expertise, in the interest of responsible agnosticism I will leave it an open question as to whether tier-specific prosodic constituents are actually required in phonological theory. Nevertheless, the preceeding discussion should make it clear that I am skeptical. More to the point, even if tier-specific prosodic domains are in fact needed, they would appear to be different in kind from truly 'metrical' constituents, given that they lack many of the characteristic properties of stress feet (binarity, iterativity, relational prominence, etc.). Apart from the debate over tier-specific prosodic domains, it bears repeating that *process*-specific prosodic constituents, like the 'epenthesis feet' proposed for Huariapano, are at best superfluous, and and at worst conceptually incoherent.

2.8   Conclusion

In this chapter I presented evidence from a variety of languages that foot-initial position counts as phonologically prominent in synchronic grammars. This observation opens the door for a reanalysis of the relation between stress and coda [h] epenthesis in Huariapano. Once it is recognized that coda [h] epenthesis occurs in foot-initial syllables, regardless of stress, the rhythmic distribution of coda [h] can be captured without assuming that possible epenthesis sites are determined by a distinct, epenthesis-specific metrical tier.

The single-tier analysis of Huariapano provides the cornerstone for the larger con-

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ception of foot structure defended in this chapter. According to the UNIFORMITY OF FOOTING HYPOTHESIS (UFH), the phonological component of a given language may make use of at most one system of metrical organization. While a diverse set of phonological processes can be sensitive to the foot structure defined by stress (or to a single system of covert footing), no further metrical structure can be defined over the very same syllables. A corollary of the UFH is that there can be no process-specific metrical tiers – that is, there can be no systems of metrical structure, distinct from stress feet, that exist solely to condition some phonological phenomenon such as epenthesis, vowel reduction, etc.

What, then, of those phonological systems that do seem to necessitate process-specific metrical tiers? The analysis of Huariapano developed here demonstrates that the apparent need for such tiers sometimes stems from an overly rigid view of foot structure. My single-tier account of coda [h] epenthesis in Huariapano depends on the assumption that a single language might make use of both iambs and trochees, even within a single word. While this assumption is somewhat unorthodox, variable footing fits very naturally within the model of constraint interaction embodied by Optimality Theory. Similarly, in order to capture the phonology of Huariapano within a single-tier framework we must be willing to countenance the existence of recursive feet, at least as a last-resort device for ensuring exhaustive parsing. By accepting that a single language might employ a diversity of foot structures, we create an expanded analytical space in which it becomes possible to model seemingly independent rhythmic phenomena within a unified system of metrical organization.

Finally, I also argued that the relation between stress and headedness is unidirectional: all stressed syllables are foot heads, but not all foot heads bear stress. This premise entails that all languages with stress (and perhaps all languages *simpliciter*) have phonological foot structure. The remainder of the dissertation is dedicated to exploring this claim in greater detail.

Chapter 3

'Unbounded' stress, bounded phonotactics: binary feet in non-rhythmic languages

> *It don't mean a thing if it ain't got that swing.*
>
> James "Bubber" Miley

3.1 Introduction

In Chapter 2 I argued that any single language may make use of at most one system of word-level metrical organization. In this chapter I approach the typology of footing from the other direction, and make a case for the claim that all languages employ *at least* one system of binary foot structure. This is a fairly strong position to take, since it amounts to the assertion that the metrical foot is a prosodic universal.

The basis for this claim comes from two languages, Irish and Uspanteko, in which stress appears to be based on word-edges rather than feet. Despite the 'unbounded' nature of stress in these languages, convergent evidence points toward the existence of binary metrical footing of a rather quotidian sort in other aspects of phonology and morphology. These observations suggest that foot structure plays a central organizational role even in those phonological systems in which stress itself is not crucially foot-based. The next logical question is *how* binary foot structure arises in languages, like Irish and Uspanteko, in which stress provides at best ambiguous evidence for footing. I explore this question in greater detail in Chapter 4. In the present chapter, it suffices to demonstrate that foot structure is more widespread than suggested by the typology of stress systems alone.

3.2 Uspanteko

Uspanteko is an endangered Mayan language spoken in the western highlands of Guatemala, around the municipality of Uspantán.[1] There are likely no more than 2000 remaining speakers of Uspanteko (Richards 2003). Unfortunately, language attrition is high in Uspanteko communities: most Uspanteko speakers also speak K'ichee' and Spanish, and many children in the Uspantán area speak K'ichee' rather than Uspanteko as their first language.

Word-level stress in Uspanteko is quantity-insensitive, non-iterative, and plausibly assigned on the basis of word-edges alone. In other words, stress in Uspanteko content words is not obviously foot-based. Nevertheless, there is convergent evidence for the existence of grammatically active, binary foot structure in the phonology of the language. This section is dedicated to explicating the evidence behind this conclusion.

The Uspanteko data discussed here comes from Can Pixabaj (2006) and from original fieldwork conducted in Guatemala in 2010-2011 (a joint project with Robert Henderson). See Bennett & Henderson (to appear) for a more comprehensive discussion of word-level prosody in Uspanteko.

3.2.1 Stress and tone in Uspanteko

In this section I present an analysis of the core aspects of Uspanteko prosody, as developed by Bennett & Henderson (to appear). I will not defend the particulars of the analysis here; see Bennett & Henderson (to appear) for extensive justification. The purpose of this discussion is simply to set the stage for subsequent arguments that word-level prosody in Uspanteko is dependent on a system of binary foot structure.

As is typical in K'ichean-branch Mayan languages, stress in Uspanteko is normally word-final. In native words lacking lexical tone, stress is final without exception (I return to lexical tone in a moment). Syllable weight has no direct effect on stress placement: final stress occurs on light [. . . (C)V(C)#] and heavy [. . . (C)VV(C)#] alike.[2] There

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[1] The self-designation for Uspanteko is *Tz'unun Kaab'*, or 'sweet hummingbird'. Since the name 'Uspanteko' is in wider use, even among Uspanteko speakers, I adopt it here.

[2] All examples are given in standard Mayan orthography, which is essentially phonemic and corresponds fairly closely to IPA norms (see Bennett & Henderson to appear for relevant correspondences).

is no evidence of secondary stress in Uspanteko.

(1) Final stress in Uspanteko (<u>σ</u> = stressed syllable)

    a.   me<u>wa</u> 'fast'

    b.   lajo<u>ri</u> 'today'

    c.   chi<u>kach</u> 'basket'

    d.   xib'al<u>b'al</u> 'half-brother'

    e.   chen<u>kleen</u> 'lame'

    f.   xinlowi<u>saaj</u> 'I sheparded it.'   (Can Pixabaj 2006:21,22,33,70-71,280)

       etc.

Uspanteko is unique among the Mayan languages of Guatemala in having innovated a system of lexical tone. Lexical tone is contrastive in Uspanteko, as (2) shows.

(2) Contrastive lexical tone in Uspanteko ([V́] = high-toned vowel)

    a.   ín-kar
        ERG.1s-fish
        'my fish'

    b.   in-kar
        ABS.1s-fish
        'I am a fish'   (Can Pixabaj 2006:64)

    c.   in-téleb'
        ERG.1s-shoulder
        'my shoulder'

    d.   in-teleb'
        ABS.1s-shoulder
        'I am a shoulder'

    e.   siip 'tick'

    f.   síip 'gift'

Since the identity of particular segments is not at issue here, the use of standard Mayan orthography should be unproblematic. Of note is the fact that standard Mayan ['] is IPA [ʔ].

Bennett & Henderson (to appear) argue that lexical tone in Uspanteko is best under-
stood as a privative H tone pitch accent that associates to the penultimate vocalic mora
of the word — that is, to the rightmost, non-final tone-bearing unit. This accounts for
the fact that tone always surfaces on the ultima when the final vowel is long (3a), but
on the penult instead when the final vowel is short (3b). Long vowels are restricted to
final syllables in Uspanteko, so (3) is an exhaustive listing of possible tonal configura-
tions in this language.

(3)   Tone placement in Uspanteko: privative H on penultimate vocalic mora

   a.   [... ǿ$_{VV}$ #]
   b.   [... ǿ$_V$σ$_V$ #]

   c.   *[... σ$_{VV}$ ... #]

The remaining descriptive facts needed for the present argument concern the relation
between tone and stress. Tone and stress always coincide in Uspanteko. When tone
is on the ultima, stress is final as well, consistent with the general preference for final
stress. When tone is on the penult, however, stress shifts to the penult to coincide with
tone.

(4)   Tone-driven stress shift in Uspanteko

   a.   <u>sii</u>p 'tick'
   b.   in.<u>síi</u>p 'my tick'

   c.   in.<u>kar</u> 'I am a fish'
   d.   <u>ín</u>.kar 'my fish'

   e.   in.te.<u>leb'</u> 'I am a shoulder'
   f.   in.<u>té</u>.leb' 'my shoulder'

   g.   xi.<u>né</u>.lik 'I left'   (Can Pixabaj 2006:605)
        etc.

There are no words with tone or stress on a pre-penultimate syllable. In other words,

both stress and tone are restricted to two-syllable window at the right-edge of the word.

Bennett & Henderson (to appear) provide a formal analysis of word-level prosody in Uspanteko couched within parallel OT (Prince & Smolensky 1993/2004). In their account, default final stress results from the interaction of two constraints: Iᴀᴍʙ, which prefers right-headed footing, and AʟʟFᴛR, which requires all feet to align with the right edge of a prosodic word. These constraints derive default stress on the ultima; they also correctly ensure that stress (and by extension, tone) will be limited to a word-final two-syllable window, as defined by an immutably right-aligned foot.

(5)   Constraints for default stress assignment in Uspanteko (Prince & Smolensky 1993/2004, McCarthy & Prince 1993a; see also Bennett & Henderson to appear and references therein)

a.   Iᴀᴍʙ:
Assign one violation for every left-headed foot.

b.   AʟʟFᴛR:
Assign one violation for every foot that is not right-aligned with a containing prosodic word.

(6)   Default final stress in Uspanteko

	/ tiqab'ana' /	AʟʟFᴛR	Iᴀᴍʙ
→ a.	ti.qa(b'a.<u>na'</u>)		
b.	ti.qa(<u>b'a</u>.na')		*! W
c.	ti(qa.<u>b'a</u>)na'	*! W	
d.	(ti.<u>qa</u>)b'a.na'	*! W	

tiqab'ana' 'we're doing it' (Can Pixabaj 2006:136)

The two-syllable window for stress and tone could conceivably be explained without recourse to foot structure, e.g. by relying on constraints governing edge-tropic accent and the distribution of lapses (e.g. Kager 2001, 2005). However, there are also segmental phenomena in Uspanteko that implicate the presence of binary foot structure.

I will return to these phenomena momentarily, in Section 3.2.2. In the light of these additional facts, the two-syllable accentual window of Uspanteko can be taken as our first piece of evidence for grammatically active binary foot structure in the language.

Since tone placement is entirely predictable in Uspanteko, Bennett & Henderson (to appear) assume that the lexical H tone is underlyingly floating rather than associated (an assumption they share with McCarthy, Mullin & Smith 2010, who put forward a general account of tone association in Harmonic Serialism).

(7) a. / anim, H / 'woman' → [á.nim]
     b. / in-kar, H / 'my fish' → [ín.kar]
     c. / ajchaak + -ib', H / 'workers' → [aj.chá.kib']   (Can Pixabaj 2006:58,62)

Bennett & Henderson (to appear) attribute the non-finality condition on tone to the workings of a constraint, NonFin(T, tbu), that bans tone from appearing on the last TBU of a word (i.e. the last vocalic mora, μ_v).[3] The constraint *Unstressed-H (de Lacy 2002a, Gordon 2003), which prohibits unstressed lexical H tones, explains why pitch accent always appears on a stressed syllable. This constraint also indirectly accounts for the rightward orientation of tone, given that stress is independently drawn toward word-final position, and tone and stress must coincide. Lastly, *Unstressed-H drives stress retraction in words with a final short vowel and tone on the penult (see (10) below).

The constraint ranking {AllFtR, *Unstressed-H, NonFin(T, tbu), Max(t)} ≫ Iamb then accounts for final stress and tone in words with a long vowel in the ultima (9), as well as penultimate stress and tone in words with a short vowel in the ultima (10). It bears mentioning that Bennett & Henderson (to appear) thus treat penultimate tone/stress as a case of exceptional trochaic footing in an otherwise iambic language (see also Chapter 2 on Huariapano and Section 3.8 on Munster Irish).

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[3]For other examples of the avoidance of domain-final high tone, see: Cassimjee & Kisseberth (2007) and Hyman (2007) on Bantu languages; Pulleyblank (1986) on Margi (Chadic); Kawahara & Shinya (2008) on Japanese; Demers, Escalante & Jelinek (1999:43) on Yaqui; Silverman & Pierrehumbert (1990) on English (at the phonetic level); various examples in Yip (2002:29,66,90-1); and the general discussion in Hyman (1977).

(8) Constraints needed for tone-stress interactions in Uspanteko
(Prince & Smolensky 1993/2004, McCarthy & Prince 1993a, de Lacy 2002a; see also Bennett & Henderson to appear and references therein)

    a.   *Unstressed-H (*H̆):[4]

       Assign one violation for every H tone appearing on an unstressed syllable.

    b.   NonFin(T, tbu) (NF(T)):

       Assign one violation for every tone on a final TBU in the output.

    c.   Max(t):

       Assign one violation for every input tone T_i that does not have a correspondent in the output.

(9) Final stress and tone in $[\ldots \acute{\sigma}_{VV} \#]$ words

/ in-siip, H /	AllFtR	*Unstressed-H	NF(T)	Max(t)	Iamb
→ a. (in.síip)					
b. (ín.siip)					*! W
c. (in.siip)				*! W	
d. (in.siíp)			*! W		
e. (ín.siip)		*! W			* W
f. (ín)siip	*! W				

in-síip 'my tick' (Can Pixabaj 2006:69)

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[4]*Unstressed-H should be understood as a constraint requiring lexical high tone to associate to foot heads, rather than a constraint requiring high tone to co-occur with phonetic stress (e.g. Itô & Mester 2011b, 2012a). I retain the name *Unstressed-H for the sake of consistency with de Lacy (2002a). Note the conceptual affinity between this constraint and the well-known tendency for phrase-level intonational melodies to affiliate with stressed syllables (e.g. Bollinger 1958, Pierrehumbert & Beckman 1988, Hayes 1995, Gussenhoven 2004, etc.).

(10)   Penultimate stress and tone in $[\ldots \acute{\sigma}_v \sigma_v \#]$ words

	/ in-kar, H /	ALLFTR	*UNSTRESSED-H	NF(T)	MAX(T)	IAMB
→ a.	(ín.kar)					*
b.	(in.<u>kar</u>)				*! W	L
c.	(in.<u>kár</u>)			*! W		L
d.	(ín.kar)		*! W			L
e.	(ín)kar	*! W				L

ín-kar 'my fish' (Can Pixabaj 2006:64)

Finally, monosyllabic words containing a short vowel never bear tone. Bennett & Henderson (to appear) capture this fact by assuming that NonFin(T, tbu) outranks Max(t).[5]

(11)   No tone on monosyllabic words with short vowels

	/ CVC, H /	ALLFTR	*UNSTRESSED-H	NF(T)	MAX(T)	IAMB
→ a.	<u>CVC</u>				*	
b.	<u>CV́C</u>			*! W	L	

3.2.2 Footing in Uspanteko

The best evidence for foot structure in Uspanteko comes from two segmental phenomena: stress-conditioned syncope, and interactions between tone and vowel sonority in bisyllabic roots. I now discuss these patterns in turn.

3.2.2.1 Syncope

Uspanteko has a regular process of stress-sensitive syncope. In words with final stress, the pre-tonic vowel may syncopate.

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[5]Instead of assuming full tonal deletion for monosyllabic words containing a short vowel (i), one could instead assume that the underlying tone persists to the surface as an unlinked floating tone. As far as I know, there is no evidence for surface floating tones in Uspanteko (cf. the downstep patterns triggered by floating tones in many African languages, e.g. Welmers 1959 and many others), so tonal deletion appears to be the appropriately conservative assumption.

(12)   Pret-tonic syncope (⟨V⟩ = syncopated vowel)

    a.   si<u>miin</u> ∼ s⟨i⟩<u>miin</u>   'ginger'
    b.   chu<u>kuy</u> ∼ ch⟨u⟩<u>kuy</u>   'pine fruit'
    c.   ku<u>wa'y</u> ∼ k⟨u⟩<u>wa'y</u>   'horse'
    d.   ra<u>qan</u> ∼ r⟨a⟩<u>qan</u>   'his leg'   (Can Pixabaj 2006:37)

Before discussing this phenomenon further, a few words of clarification are in order.
Labeling the vowel allophony exemplified in (12) as 'syncope' may be an oversimpli-
fication. For one, syncopation is variable: in elicitation, speakers produce the same
word both with and without vowel deletion (in a fixed sentential context). It is also
gradient: non-syncopated weak vowels are reduced to various degrees, and syncope
seems to be an endpoint for this gradient reduction. Furthermore, this pattern of syn-
cope derives consonant clusters that are otherwise illicit in Uspanteko (a property it
shares with schwa deletion in French; e.g. Anderson 1982, Dell 1995). All this might
indicate that 'syncope' is really an extreme sub-case of vowel reduction rather than
true vowel deletion (i.e. it may be syllable-preserving 'pseudosyncope'; Kager 1997,
McCarthy 1999, 2008b). These caveats aside, I will continue to use the term 'syncope'
to refer to these patterns of vowel reduction.

    Despite the aforementioned complications, the *locus* of syncope in Uspanteko pro-
vides further evidence for the foot structure proposed in the previous section. Syncope
is not simply the context-free deletion of unstressed vowels: in words with final stress,
syncope only targets the immediately pre-tonic syllable.

(13)   a.   inacha<u>pe'</u> ∼ inach⟨a⟩<u>pe'</u> 'Grab me!'
           b.   *in⟨a⟩cha<u>pe'</u>
           c.   *⟨i⟩nacha<u>pe'</u>

Syncope is also sensitive to segmental structure. For one, syncope only targets low
sonority vowels: [u i] and [ə] may syncopate, but the mid-vowels [e o] cannot (where
[ə] = unstressed orthographic *a*).

(14) No syncope of pre-tonic mid vowels

    a. keqiix 'dark-colored mushroom'

    b. *k⟨e⟩qiix

    c. xinkojon 'I accepted it'

    d. *xink⟨o⟩jon

Syncope is also blocked between identical consonants, where its application would derive a (false) geminate. This restriction on vowel deletion is attested in other languages, and goes under the rubric of ANTIGEMINATION (McCarthy 1986).

(15) Antigemination in Uspanteko syncope

    a. jujun 'some'

    b. *j⟨u⟩jun

Cross-linguistically, many cases of stress-sensitive syncope are conditioned by foot-structure. A common pattern is that unstressed vowels delete when parsed into the weak branch of a foot (e.g. Kager 1997, Gouskova 2003, Blumenfeld 2006, McCarthy 2008b, Norris 2010, Kimper 2011b). In the words we've seen so far, pre-tonic syncope (12) is consistent with a foot-based analysis (16).

(16)   a. (si.miin) ∼ (s⟨i⟩.miin)
      b. i.na(cha.pe') ∼ i.na(ch⟨a⟩.pe')

The foot-based analysis of pre-tonic syncope makes some clear predictions regarding words with penultimate tone and stress. If syncope of unstressed vowels is foot-based in Uspanteko, and penultimate accent is the result of tone-driven trochaic footing (Section 3.2.1), then we should expect *post*-tonic syncope in words with penultimate accent. Importantly, this prediction distinguishes the structure-dependent analysis of syncope from a purely linear alternative making no reference to footing at all (i.e. 'delete the vowel of the immediately pretonic syllable').

(17) a. Syncope in iambic forms: (CV.<u>CV</u>) ~ (C⟨V⟩.<u>CV</u>)

      b. Predicted syncope in trochaic forms: (<u>CV́</u>.CV) ~ (<u>CV́</u>.C⟨V⟩)

This prediction is borne out: words with penultimate tone and stress undergo post-tonic vowel deletion (18). Syncope is thus *structure-dependent* in Uspanteko.

(18) a. <u>ín</u>chaj ~ <u>ín</u>ch⟨a⟩j 'my pinetree'
      b. <u>ín</u>pix ~ <u>ín</u>p⟨i⟩x 'my tomato'
      c. <u>wá</u>lib' ~ <u>wá</u>l⟨i⟩b' 'my sister-in-law'

      d. xincha<u>kú</u>nik ~ xincha<u>kú</u>n⟨i⟩k 'I worked'
      e. *xinch⟨a⟩<u>kú</u>nik

To round out the argument, it needs to be shown that pre-tonic and post-tonic syncope represent a unitary phenomenon. That much is easy. Post-tonic syncope is subject to the same conditions that govern pre-tonic syncope. First, only foot-internal (i.e. post-tonic) syllables are targeted in words with penultimate accent (18). Second, mid vowels may not be targeted for either pre-tonic syncope (14) or for post-tonic syncope (19).

(19) No syncope of post-tonic mid vowels

      a. <u>wíx</u>keq 'my fingernail'
      b. *<u>wíx</u>k⟨e⟩q

      c. <u>é</u>tzel 'evil'
      d. *<u>é</u>tz⟨e⟩l

Third, like pre-tonic syncope (15), post-tonic syncope is prohibited when its application would derive a false geminate (20).

(20) a. <u>á</u>jij 'sugarcane'
      b. *<u>á</u>j⟨i⟩j

      c. <u>á</u>xix 'garlic'
      d. *<u>á</u>x⟨i⟩x

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It seems safe to conclude that syncope in Uspanteko is indeed foot-based, and sensitive to exactly the foot structure predicted by the analysis of stress shift presented in Section 3.2.1.[6]

3.2.2.2 Relative vowel sonority

Additional evidence for binary foot structure in Uspanteko comes from interactions between tone and vowel sonority. In particular, there are some unusual static generalizations regarding the distribution of tone in bisyllabic roots in the language. Tone appears in most $[\sigma_V \sigma_V]$ roots in which the first vowel is of equal or greater sonority than the second vowel, as in (22) and (23). I assume the vowel sonority scale in (21) (Jespersen 1904, Dell & Elmedlaoui 1985, Clements 1990, Prince & Smolensky 1993/2004, etc.).

(21)   Relative sonority scale for vowels: Low > Mɪᴅ > Hɪɢʜ/ə

(22) V_1 more sonorous than V_2: penultimate tone and stress

    a.   <u>á</u>nim 'woman'

    b.   <u>sá</u>q'əj 'summer'

    c.   <u>á</u>wus 'fava bean'

(23) V_1 as sonorous as V_2: penultimate tone and stress

    a.   <u>rú</u>xib' 'his/her/its aroma'

    b.   <u>í</u>sim 'stamp'

    c.   <u>tú</u>nəq' 'Adam's apple'

    d.   <u>ó</u>jor 'a long time ago'   (Can Pixabaj 2006:58)

These effects are limited to $[\sigma_V \sigma_V]$ roots, and are not observed in $[\sigma_V \sigma_{VV}]$ roots like [tu.<u>kuur</u>] 'owl'. The term 'bisyllabic root' should thus be understood in this context as refering exclusively to roots containing two short vowels.

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[6]If 'syncope' in Uspanteko turns out to be true vowel deletion, then post-tonic syncope raises an opacity problem, in that the output of syncope contains tone on a final TBU, in contravention of NᴏɴFɪɴ(T, ᴛʙᴜ). See Kager (1997) and Bennett & Henderson (to appear) for discussion.

In bisyllabic roots in which V_1 is *less* sonorous than V_2, we find default final stress and no tone.

(24) V_1 less sonorous than V_2: default final stress, no tone

   a.   ix<u>k'</u>eq 'nails'
   b.   i<u>k</u>eq' 'twine sling'
   c.   chu<u>ke</u>j 'cramp'
   d.   u<u>ke</u> 'guachipilín (species of plant)'

The analysis of these facts begins by assuming that there is some pressure for bisyllabic roots to bear tone. For simplicity, I remain agnostic here as to what this pressure might be.[7] Given this assumption, the generalization regarding tone in bisyllabic roots can be restated in terms of foot structure: tone may be inserted only when the resulting foot structure has properly 'balanced' internal sonority relations, in a sense to be made more precise shortly.

The logic of this generalization is as follows. Tone insertion in $[\sigma_v \sigma_v]$ roots will always trigger stress shift, due to the pervasive influence of NonFinality(T, tbu). The resulting output will have a trochaic foot with V_1 as its head, and V_2 as its dependent: $(\acute{\sigma}_v \sigma_v)$. This structural difference between V_1 and V_2 provides the fulcrum for understanding why vowel sonority should interact with the presence or absence of tone. There is a substantial amount of evidence indicating that foot heads are phonologically 'strong' positions, apart from the fact that they generally bear stress. Of particular relevance is the well-documented pressure for strong positions to be associated with prominent segmental material (e.g. Trubetzkoy 1939, Beckman 1998, de Lacy 2001, 2002b, González 2003, Smith 2005a, etc.; see also Chapter 2). Conversely, there are good empirical indications that structural *dependents* are weak, and are antithetical to relatively prominent phonological material (e.g. McCarthy 2008b).

Sonority is of course a kind of phonological prominence, and one with clear phonetic grounding (e.g. Parker 2002 and work cited there). We should thus expect

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[7]See Bennett & Henderson (to appear) and Itô & Mester (2011b) for an explanation of why these effects are limited to bisyllabic roots. Not surprisingly, Bennett & Henderson (to appear) argue that the limitation to bisyllabic roots is itself grounded in facts about foot structure.

sonority to interact with the structural distinction between prosodic heads and dependents. Indeed, Kenstowicz (1994), Gouskova (2003), Zec (2003) and de Lacy (2004, 2007) (among others) have argued that feet may impose different sonority requirements on their strong and weak branches, with a clear preference for high-sonority heads and low-sonority non-heads. More generally, Teeple (2009) also argues at length that prominence constraints within a phonological domain (like the foot) should refer to both prominent and non-prominent positions simultaneously.

With this background in mind, we can now reconsider the role of sonority in conditioning tone insertion in bisyllabic roots in Uspanteko. If V_2 is more sonorous than V_1 in a bisyllabic $[\sigma_v \sigma_v]$ root, then trochaic footing would result in a configuration in which the head of the foot is less sonorous than the weak branch of the foot. This is disallowed: * $[V]_{\text{HEAD}} <_{son} [V]_{\text{WEAK}}$. The basic claim, then, is that tone insertion in bisyllabic roots is blocked when the resulting foot-internal sonority profile would be at odds with the foot-internal prominence relations defined by metrical structure itself (i.e. the distinction between foot heads and dependents).

It should be emphasized that the *absolute* sonority of the foot head is not at issue here. Any vowel may appear in a stressed, tonal penult in a bisyllabic root, as in (25).

(25) a. <u>á</u>nim 'woman'
     b. <u>ó</u>jor 'a long time ago'
     c. <u>é</u>tzel 'evil'
     d. <u>rú</u>xib' 'his/her/its aroma'
     e. <u>í</u>sim 'stamp'   (Can Pixabaj 2006:58)

What matters for Uspanteko is the *relative* sonority of the two vowels in a footed $[(\sigma_v \sigma_v)]$ root. To reiterate, the essential generalization is that the weak branch of the foot may not be more prominent (~ sonorous) than the head of the same foot. In other words, relative vowel sonority and relative structural prominence may not work at cross-purposes within a single foot. When tone insertion would derive such a configuration, it is blocked.

(26)   a.   (i.keq̱') 'twine sling'

   b.   *(í̱.keq')

   c.   [i]$_{\text{HEAD}}$ <$_{son}$ [e]$_{\text{WEAK}}$

The take-home message from this discussion is simple: the need for a *relational* statement regarding vowel sonority strongly implicates the presence of a binary metrical constituent spanning both syllables in a bisyllabic root, $[(\sigma_v \sigma_v)]$. This metrical constituency — which is independently motivated by the accentual window of Uspanteko, and by the location of syncope — supplies a principled explanation for why tone insertion on penults might depend on the relative sonority of the vowels in the penult and ultima (see Chapter 2 for related discussion of the role of footing in vowel reduction in Russian; and Section 3.8 on similar facts in Munster Irish).

A non-metrical analysis of these facts, making no reference to foot structure, must simply stipulate that the licensing of tone in bisyllabic roots depends on the relative sonority of vowels in the penult and ultima. This is clearly a non-explanatory tack to take: it treats the conditions on relative vowel sonority as essentially arbitrary, and it provides no account of why the appearance of tone on penults depends non-locally on properties of the *ultima*. In contrast, a metrical approach that accepts the existence of foot structure in Uspanteko is able to reduce an apparent non-local effect to a local, domain-internal relation, thereby capturing the interaction between tone and vowel sonority in a principled way. I conclude from this that the distribution of vowels in Uspanteko is partially foot-based, and that Uspanteko phonology shows wide-ranging sensitivities to binary foot structure.

3.2.3   Conclusion

On the basis of default stress assignment alone, there are no grounds for assuming that foot structure is active in the phonology of Uspanteko. Default stress falls on the word-final syllable, which puts Uspanteko in the class of languages that have sometimes been analyzed using 'unbounded' feet that span the entire prosodic word (see Prince 1985 for discussion and references). Empirically speaking, the use of unbounded feet is

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indistinguishable from an analysis that makes no use of foot structure, in which stress is simply a non-relational prominence assigned to word-final syllables. While both of these approaches can account for the placement of default stress in this language (albeit somewhat trivially), they are clearly deficient when it comes to integrating stress assignment with other aspects of Uspanteko phonology. The two-syllable accentual window of Uspanteko, which bounds tone-driven stress shift, strongly implicates the presence of a right-aligned binary foot. This conclusion is further supported by patterns of stress-sensitive, structure-dependent syncope, and by interactions between tone, stress, and vowel sonority in bisyllabic roots. There is thus plentiful evidence that Uspanteko assigns word-level prominence on the basis of binary metrical structure, exactly as in languages with alternating rhythmic stress.

In Section 3.4 I provide similar arguments in favor of analyzing edge-based stress in Irish using left-aligned binary foot structure. In the next section (3.3) I argue in favor of using a parallel model of constraint-based evaluation (classical OT), rather than Harmonic Serialism (a derivational variant of OT), to analyze tone-stress interactions in Uspanteko. Readers who are primarily interested in empirical arguments for binary foot structure in 'unbounded' stress systems should feel free to skip ahead to Section 3.4.

3.3   Digression: Uspanteko as an argument for parallel evaluation

In this section I argue that Harmonic Serialism (Prince & Smolensky 1993/2004, Black 1993, McCarthy 2007, etc.; henceforth HS) is unable to provide an adequate account of tone-stress interactions in the Mayan language Uspanteko.[8] The crux of the problem is that tone and stress in Uspanteko exert conflicting demands on the location of phonological prominence; while these demands may be successfully negotiated in parallel OT, in HS the derivation of such interactions necessarily violates the principle of HARMONIC ASCENT. Since harmonic ascent is a central aspect of the grammatical archi-

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[8]I thank Wendell Kimper for feedback on an earlier version of this section. The usual disclaimers apply.

tecture of HS, I conclude that Uspanteko poses a serious undergeneration problem for that framework.

The argument depends on a demonstration that HS is sometimes unable to generate derivations with ill-formed but necesssary intermediate representations. In order to derive the attested surface forms of Uspanteko, an HS derivation of tone-stress interactions must produce intermediate outputs in which tone and stress do not coincide, but one or the other resides on the penult. It cannot. This shortcoming is a consequence of the fact that derivations in HS stall when they encounter local minima (an instance of the 'you can't get there from here' phenomenon; see McCarthy 2006, 2007, 2008a). Schematically, a derivation [A → B → C] will fail whenever the intermediate mapping [A → B] is less harmonic than some other mapping [A → X], even if the derivation [A → B → C] would ultimately yield a more optimal surface form than [A → X → ...] (see Section 3.3.1).

3.3.1   Uspanteko in Harmonic Serialism

I assume familiarity with the mechanics of Harmonic Serialism; for in-depth discussion of this framework, see Prince & Smolensky (1993/2004), Black (1993), and McCarthy (2006, 2007, 2008a,b). Briefly: Harmonic Serialism differs from classical OT in that surface forms are computed by successive passes through the constraint set. The ranking of constraints is fixed for all passes through the system; the output of each pass becomes the input to the next pass; and each [INPUT → OUTPUT] mapping may only make one 'basic change' to the input form in question. The derivation finishes (or CONVERGES) when the optimal candidate produced by some pass through the constraint set is identical to the input to that pass. Other work in HS includes Pruitt (2010), McCarthy et al. (2010), Kimper (2011b), McCarthy & Pruitt (2012), Jesney (to appear), Elfner (to appear), Staubs (to appear), McCarthy et al. (to appear). Some criticisms of HS can be found in Hyde (2009, 2012), Walker (2010) and Kurisu (2012). For more details, see the following discussion and citations therein.

Having seen that tone-stress interactions in Uspanteko can be successfully derived in parallel OT, we now attempt an account of the same facts within Harmonic Serialism. Following McCarthy (2008b), I begin by assuming that the first pass through EVAL

necessarily involves the creation of stress and foot structure. In other words, I assume that HEADEDNESS (Selkirk 1984, 1996, Itô & Mester 1992/2003, 2009) is a condition on GEN.[9] Given this assumption, a conundrum arises: until underlying lexical tone is associated, there is no motivation for placing stress on the penult rather than the ultima (its default position); but unless stress is first assigned to the penult, there is no way to ensure that tone will ultimately appear on the penult either. Tone-stress interactions in Uspanteko thus present an ordering paradox for HS. In Section 3.3.1.1 I show that HS has trouble modeling Uspanteko even if tone association is permitted to take place prior to metrical parsing and stress assignment.

The HS analysis of Uspanteko requires the following additional constraints, taken from Myers (1997), Zoll (1997), Yip (2002), McCarthy (2008b) and McCarthy et al. (2010).

(27)   Additional constraints needed for the HS analysis of Uspanteko

    a.   *FLOAT (*FLT):
          Assign one violation for every unassociated tone.

    b.   DEP(ASSOCIATION) (DEP(A)):[10]
          Assign one violation for every association line in the output that does not have a correspondent in the input.

    c.   IDENT(STRESS) (ID(STR)):
          Assign one violation for every unstressed syllable in the input that is stressed in the output.

The HS derivation in (28)-(29) correctly places tone on the ultima in words with a final long vowel — that is, in words lacking tone-driven deviations from default stress. As

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[9]It is an open question in the HS literature whether (and how) prosodic structure may be altered once established (e.g. McCarthy 2008b, Pruitt 2010, Kimper 2011b, Kiparsky 2011). This issue is largely orthogonal to the points made here, but for the sake of argumentation I assume no *a priori* prohibitions on how prosodic structure may be manipulated over a derivation: rebracketing, stress shift, etc. are all taken to be available operations for GEN.

[10]DEP(ASSOCIATION) also appears under the name *ASSOCIATE in some publications.

shown in (28), the first constraint pass involves the creation of an iambic foot. Since the underlying H tone remains unassociated at this point, the winning candidate violates *FLOAT (Myers 1997).[11]

(28) [... ó$_{vv}$ #] words, first step: iambic footing

/ in-siip, H / 1st iteration	ID(STR)	*Ĥ	IAMB	NF(T)	MAX(T)	*FLOAT	DEP(A)
→ a. (in.<u>sii</u>p), H	*					*	
b. (<u>in</u>.siip), H	*		*! W			*	

Tonal association happens at the second step of the derivation, under pressure from *FLOAT. The ranking MAX(T) ≫ DEP(ASSOCIATION) ensures that candidate (29c) correctly beats out (29e), which vacuously satisfies *FLOAT by deleting the underlying H tone. As long as *FLOAT also dominates DEP(A) (so that floating tones are not doomed to remain forever floating, (29d)), associating H tone to the stressed, penultimate mora will be optimal. All else being equal, the derivation will correctly converge on (29c) at the next step.

(29) [... ó$_{vv}$ #] words, second step: associate floating tone

/ (in.siip), H / 2nd iteration	ID(STR)	*Ĥ	IAMB	NF(T)	MAX(T)	*FLT	DEP(A)
→ c. (in.s<u>íi</u>p)							*
d. (in.<u>sii</u>p), H						*! W	L
e. (in.<u>sii</u>p)					*! W		L
f. (in.s<u>íí</u>p)				*! W			*
g. (<u>ín</u>.siip)		*! W					*
h. (<u>in</u>.siip), H	*! W		*! W			*! W	L

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[11] For simplicity's sake I assume that candidates with unassociated tones vacuously satisfy *UNSTRESSED-H (*Ĥ). Nothing much depends on this assumption.

The difficulty for HS arises when we consider tone-stress interactions in words with a final short vowel. As in (28), the derivation for such words begins with footing and stress assignment. At this stage there are no tonal associations, so there is no motivation to build anything other than a default iambic foot.

(30)   [... ó𝓋σ𝓋 #] words, first step: iambic footing

/ x-in-el-ik, H / **1st iteration**	ID(STR)	*H̆	IAMB	NF(T)	MAX(T)	*FLT	DEP(A)
→ a. xi(ne.<u>lik</u>), H	*					*	
b. xi(<u>ne</u>.lik), H	*		*! W			*	

xinélik 'I left.' (Can Pixabaj 2006:605)

Tonal association becomes a possibility at the second pass through the constraint set. Consider now the set of candidates in (31). Every candidate except (31h) can win under some ranking of Con ((31h) is harmonically bounded by (31c), at least within this subset of constraints).

(31)   [... ó𝓋σ𝓋 #] words, possible second steps

/ xi(ne.<u>lik</u>), H / **2nd iteration**	ID(STR)	*H̆	IAMB	NF(T)	MAX(T)	*FLT	DEP(A)
? → c. xi(ne.<u>lik</u>), H						*	
? → d. xi(ne.<u>lik</u>)					*		
? → e. xi(ne.<u>lík</u>)				*			*
? → f. xi(né.<u>lik</u>)		*					*
? → g. xí(ne.<u>lik</u>)		*					*
h. xi(<u>ne</u>.lik), H	*		*			*	

Candidates (31c) and (31d) cannot be the correct outputs at this iteration. Since candidate (31c) is identical to the input, selection of (31c) as optimal would wrongly cause the derivation to converge before the association of underlying H tone. Similarly, selection of (31d) as optimal wrongly predicts outright tonal deletion in words with a final

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short vowel. Clearly, the only relevant candidates at this stage are candidates (31e,f,g), which all involve tonal association of some sort.

(32) Possible outputs of second pass through Con:
/ x-in-el-ik, H /   →   xi(ne.<u>lik</u>), H   →   . . .

    a. xi(ne.<u>lík</u>) (H on stressed ultima)

    b. xi(né.<u>lik</u>) (H on penult)

    c. xí(ne.<u>lik</u>) (H on antepenult)

The question, then, is whether any of the three tonal candidates (31e,f,g) will successfully map to the attested form [xi(<u>né</u>.lik)] in the course of the derivation. To a large extent, this depends on whether stress shift is possible in HS. This is because all of the intermediate forms (31e,f,g) have iambic stress, while the desired final output has trochaic stress. Given the GRADUALNESS requirement on HS derivations (e.g. McCarthy 2007, 2008a), it seems reasonable to assume that stress shift in HS is a two-stage process consisting of destressing (and perhaps concomitant defooting) followed by the reassignment of stress on a different syllable. But as pointed out by Elfner (to appear), destressing will not in general be harmonically improving in HS, because it violates faithfulness to stress while also sacrificing whatever markedness gain was achieved by assigning stress in the first place. Tableaux (33) and (34) demonstrate this problem using (31e) and (31f) as hypothetical inputs to the next iteration of EVAL.

(33) [. . . σ́ᵥσᵥ #] words, possible third step: destressing 1

/ xi(ne.<u>lík</u>) / **3rd iteration**	Id(str)	*H̆	Iamb	NF(T)	Max(t)	*Flt	Dep(A)
→ i. xi(ne.<u>lík</u>)				*			
j. xi.ne.lík	*! W	*! W		*			

(34)   [... ǿ_vσ_v #] words, possible third step: destressing 2

/ xi(né.<u>lik</u>) / 3rd iteration	Iᴅ(ꜱᴛʀ)	*Ȟ	Iᴀᴍʙ	NF(T)	Mᴀx(ᴛ)	*Fʟᴛ	Dᴇᴘ(A)
→ i. xi(né.<u>lik</u>)		*					
j. xi.né.lik	*! W	*					

If this is the correct view of stress shift in HS, then the preceding HS derivation simply fails to produce the attested pattern of tone-stress interactions in [... ǿ_vσ_v #] words in Uspanteko.

A more charitable view of stress shift in HS might assume that foot-internal stress shift (as in Uspanteko) is in fact a one-step process. Since stress is a relational, syntagmatic notion, foot-internal stress shift might amount to a single relabeling operation, as in (35).

(35)   Foot-internal stress shift as one-step relabeling
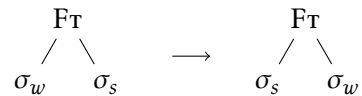
As it turns out, assuming one-step stress shift still fails to derive the correct output form. Consider first candidate (31e) in which stress and tone coincide on the final syllable, [xi(ne.<u>lík</u>)]. Assume that this candidate wins at the second iteration of Eᴠᴀʟ, and serves as the input to the third constraint pass. At the third iteration, either stress shift or tone shift can occur, but not both. It is clear from (36) that stress shift is not a viable option: since tone remains on the final syllable, stress shift (36j) is unmotivated and, consequently, harmonically bounded within this constraint set.

(36)   [... ǿ_vσ_v #] words, possible third step: one-step stress shift

/ xi(ne.<u>lík</u>) / 3rd iteration	Iᴅ(ꜱᴛʀ)	*Ȟ	Iᴀᴍʙ	NF(T)	Mᴀx(ᴛ)	*Fʟᴛ	Dᴇᴘ(A)
→ i. xi(ne.<u>lík</u>)					*		
j. xi(<u>ne</u>.lík)	*! W	*! W	*! W		*		

We might instead assume that tone shift, rather than stress shift, occurs at this point. As suggested by McCarthy (2006, 2009), McCarthy et al. (2010) and McCarthy (to appear), tone shift in HS should consist of several stages: the addition of an association line between tone and a new (adjacent) host, followed by deletion of the original tonal association line.

(37)   Tone shift in HS
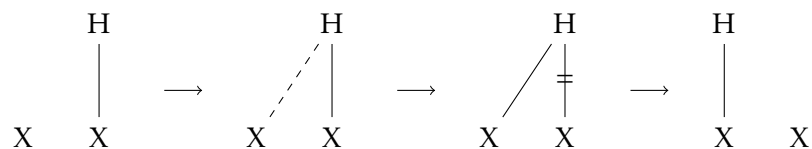
Sequential tone shift of this sort is a natural assumption given the GRADUALNESS requirement of HS (I will return to the possibility of one-step tone shift). However, if tone shift is necessarily gradual, then HS incorrectly predicts that tone shift should be blocked at this stage. Adding an association line between H and the penult incurs an extra violation of the markedness constraint *UNSTRESSED-H while also failing to improve performance on NONFIN(T, TBU). Even if spreading does not create a new violation of *UNSTRESSED-H — perhaps because H is associated to *some* stressed syllable — the violation of DEP(ASSOCIATE) is still gratuitous from the perspective of markedness, and therefore fatal. Tableau (38) demonstrates that tone shift is in fact harmonically bounded by the fully faithful candidate.[12]

(38)   [... ´σ_v σ_v #] words, possible third step: tone spreading

/ xi(ne.lík) / 3rd iteration	ID(STR)	*Ĥ	IAMB	NF(T)	MAX(T)	*FLT	DEP(A)
→ i. xi(ne.lík)				*			
j. xi(né.lík)		(*! W)		*			*! W

The intermediate candidate [xi(ne.lík)] (31e), which has final tone and stress, thus cannot be the output of the second stage of the derivation. That leaves us with two

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[12]Removing the association line between tone and the ultima would also prove fruitless here, since that would amount to a regression to the output of the first pass through the constraint set (see (30)).

remaining alternatives, [xi(né.<u>lik</u>)] (31f) and [xí(ne.<u>lik</u>)] (31g). Taking the first of those two candidates to be the output of the second iteration seems to yield the desired result: assuming that one-step, foot-internal stress shift is licit, and that *Unstressed-H outranks Ident(stress) and Iamb, [xi(né.<u>lik</u>)] will correctly map to [xi(<u>né</u>.<u>lik</u>)].

(39)   [. . . σ́ᵥσᵥ #] words, possible third step: stress shift

/ xi(né.<u>lik</u>) / 3rd iteration	*Ĥ	Id(str)	Iamb	NF(T)	Max(t)	*Flt	Dep(A)
→ i. xi(<u>né</u>.lik)		*	*				
j. xi(né.<u>lik</u>)	*! W	L	L				

The problem here is that there is no way to guarantee that [xi(né.<u>lik</u>)] will actually emerge as the output of the second pass through Eval. Specifically, if tone is placed on an unstressed syllable in violation of *Unstressed-H, nothing compels tone to appear on the penult rather than any other arbitrary unstressed syllable. As shown in (31), the candidates [xi(né.<u>lik</u>)] and [xí(ne.<u>lik</u>)] have identical violation profiles over the relevant constraints. If [xí(ne.<u>lik</u>)] is instead selected as the output of the second iteration, the derivation again fails to produce the desired result. Just as before, stress shift and tone shift fail to provide any improvement on markedness, so such candidates are harmonically bounded by the fully faithful candidate (40i) within this constraint set.

(40)   [. . . CV́.CV#] words, possible third steps

/ xí(ne.<u>lik</u>) / 3rd iteration	*Ĥ	Id(str)	Iamb	NF(T)	Max(t)	*Flt	Dep(A)
→ i. xí(ne.<u>lik</u>)	*						
j. xí(né.<u>lik</u>)	*						*! W
k. xí(<u>ne</u>.lik)	*	*! W	*! W				

It is of course likely that [xí(ne.<u>lik</u>)] and [xi(né.<u>lik</u>)] are in fact distinguished by other markedness constraints, thus breaking the apparent tie seen in (31). Could there be a markedness constraint that prefers [xi(né.<u>lik</u>)] to [xí(ne.<u>lik</u>)], resolving the tie in fa-

vor of the only promising intermediate candidate? It seems doubtful. If anything, markedness should prefer [xí(ne.<u>lik</u>)] to [xi(né.<u>lik</u>)] because [xí(ne.<u>lik</u>)] bears tone on the leftmost TBU, in line with the well-known tendency for tones to associate left-to-right (the ᴜɴɪᴠᴇʀsᴀʟ ᴀssᴏᴄɪᴀᴛɪᴏɴ ᴄᴏɴᴠᴇɴᴛɪᴏɴ of Goldsmith 1976, 1990, cashed out in McCarthy et al. 2010 as the markedness constraint Lɪɴᴋ-Iɴɪᴛɪᴀʟ).

The intermediate candidate [xí(ne.<u>lik</u>)] also fares poorly with respect to markedness constraints governing the relation between tone and foot structure. A growing body of evidence suggests that unstressed syllables are phonologically 'weaker' when parsed into the weak branch of a foot than when simply left unfooted (e.g. Kager 1989, Gouskova 2003, McCarthy 2008b, etc.). Of particular interest here is de Lacy's (2002a) claim that H tone is least marked when associated with a foot head, and most marked when associated with a foot dependent. From this perspective as well, then, [xí(ne.<u>lik</u>)] is more harmonic than the desired winner [xi(né.<u>lik</u>)].

One could imagine a hypothetical constraint that prefers [xi(né.<u>lik</u>)] because tone is 'closer' to stress than in [xí(ne.<u>lik</u>)] — say, *Uɴғᴏᴏᴛᴇᴅ(ᴛ), or a gradiently-evaluated Aʟɪɢɴ(T, $\acute{\sigma}$) constraint. The question is not whether such constraints are logically possible — they clearly are — but rather whether they are *credible*. I know of no crosslinguistic evidence for constraints like *Uɴғᴏᴏᴛᴇᴅ(ᴛ) or Aʟɪɢɴ(T, $\acute{\sigma}$), apart from the general affinity for tone to associate to prosodic heads (a preference already captured here via the constraint *Uɴsᴛʀᴇssᴇᴅ-H).[13] More to the point, there is no evidence for the activity of such constraints in surface forms in Uspanteko: lexical tone always coincides with the stressed syllable exactly. While the analyst is free to assume that constraints like Aʟɪɢɴ(T, $\acute{\sigma}$) are at work in Uspanteko, doing so is clearly an *ad hoc* and highly abstract solution to a formal problem that only arises within the framework of HS. As Hyman (2011) puts it, "the goal is not to come up with a proposal [consistent with theoretical preconceptions], rather to come up with an analysis in which one can have confidence". An HS account of Uspanteko that invokes such *ad hoc* constraints fails to satisfy that more ambitious theoretical goal.

As a final alternative, consider a gradiently-evaluated alignment constraint like

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[13]While there may be pressure for tone to spread within a foot (Yip 2002:Ch.4, Pearce 2006), such a pressure is distinct from the claim that tone seeks out foot-internal position over and above seeking out prosodic heads.

Align-R(t). This constraint, which draws tone toward word-final position, would indeed favor [xi(né.<u>lik</u>)] over [xí(ne.<u>lik</u>)].

(41)   [...ó$_v$σ$_v$ #] words, possible second steps

/ xi(ne.<u>lik</u>), H / **3rd iteration**	Align-R
→ e. xi(né.<u>lik</u>)	*
f. xí(ne.<u>lik</u>)	**! W

The problem with Align-R(t) is that it predicts a highly aberrant pattern of tone association, even in HS. Under the rankings Align-R(t), *Float ≫ {*Contour, Align-L(t), Dep(Associate), Link-Initial} and Dep(Associate) ≫ {Specify, Link-Initial}, we predict a language in which all underlying tones associate with the final syllable, creating final contour tones preceded by an unbounded sequence of non-tonal syllables (43).

(42)   Some additional tonal constraints (Myers 1997, Yip 2002, McCarthy et al. 2010)

a.   Align-L/R(t):
      For every tone T_α associated to a TBU_α, assign one violation for every TBU intervening between TBU_α and the left/right edge of the word.

b.   *Contour (*Con):
      Assign one violation for every TBU associated to more than one tone.

c.   Link-Initial (Link-Init):
      Assign one violation if the initial TBU is not associated to the initial tone.

d.   Specify (not shown):
      Assign one violation for every TBU not associated with some tone.

(43)   ALIGN-R(T) in Harmonic Serialism

/ bababa, TTT / **1st iteration**	ALIGN-R	*FLT	*CON	ALIGN-L	DEP(A)	LINK-INIT
a. T T T / | / ba ba ba		**		**	*	*
b. T T T / ba ba ba		***! W		L	L	*
c. T T T / | / ba ba ba	*! W	**		* L	*	*
d. T T T / | / ba ba ba	*!* W	**		L	*	L
2nd iteration	ALIGN-R	*FLT	*CON	ALIGN-L	DEP(A)	LINK-INIT
e. T T T / \\\| / ba ba ba		*	*	** **	*	*
f. T T T / | / ba ba ba		**! W	L	** L	L	*
g. T T T / | | / ba ba ba	*! W	*		** * L	*	*
h. T T T / | | / ba ba ba	*!* W	*		** L	*	L
3rd iteration	ALIGN-R	*FLT	*CON	ALIGN-L	DEP(A)	LINK-INIT
→ i. T T T / \\\\\| / ba ba ba			*	** ** **	*	*
j. T T T / \\\| / ba ba ba		*! W	*	** ** L	L	*
k. T T T / | \\\| / ba ba ba	*!* W		*	** ** L	*	L

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With Align-R and *Float undominated, all underlying tones will link to the final TBU in sequence. The additional rankings Dep(Associate) ≫ {Link-Initial, Specify} ensure that candidates like (44), which spread tone leftward, are not possible contenders at any stage — in other words, association lines are inserted to eliminate floating tones, but for no other reason. The derivation thus converges after the third step, with (43i) as the ultimate output.

(44)   Dep(Associate) ≫ {Link-Initial, Specify}: no leftward tone spreading

$$\begin{array}{ccc} \text{T} & \text{T} & \text{T} \\ & \diagdown\!\diagdown & | \\ \text{ba} & \text{ba} & \text{ba} \end{array}$$

No language has the pattern of tone association in (43); indeed, the absence of such languages was part of the original motivation for Goldsmith's (1976) universal association convention (see also Hyman & Schuh 1974, Goldsmith 1990, Hyman 2007, among others). While it is very common for contour tones to be restricted to final syllables (e.g. Zoll 1997 and references there), any tone-bearing units preceding a contour tone are always *specified* for tone themselves. It is this property that distinguishes (44) from the those tone systems that are actually attested. I conclude, then, that Align-R(t) is not a viable constraint within HS.[14] Consequently, Align-R(t) cannot distinguish [xi(né.lik)] and [xí(ne.lik)] in tableau (31). I conclude from this that there is no principled way to guarantee that [xi(né.lik)] will triumph over [xí(ne.lik)] in the course of the derivation, and thus no principled HS account of Uspanteko in which stress assignment precedes tone association.

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[14]McCarthy (2006, 2009, to appear) also argues against gradient alignment constraints for autosegmental feature spreading. See Bennett & Henderson (to appear) for reasons to reject Align-R(T) within a parallel OT analysis of Uspanteko (basically, it misses the generalization that the rightward orientation of tone is reducible to the rightward orientation of stress).

There are languages in which underlying tones preferentially associate to initial and final syllables and then spread inward (so-called 'edge-in' association; Yip 1988, Hyman & Ngunga 1994). While such languages might call for a categorical alignment constraint like Anchor-R(t) (McCarthy 2003b), they do not motivate gradient tonal alignment.

3.3.1.1 Ordering tone association before stress assignment does not help

The failure of HS to account for tone-stress interactions in Uspanteko is essentially due to the fact that the derivation begins by constructing an iambic foot. Once final iambic stress is established, the GRADUALNESS condition on derivations in HS, along with the principle of HARMONIC ASCENT, prevents tone-triggered realignment of stress to the penult.

What if tone were assigned first, contrary to McCarthy's (2008b) suggestion that stress assignment (as footing) always occurs at the first pass through the constraint set?[15] As alluded to in Section 3.3.1, in the absence of stress there is no principle or mechanism that forces lexical tone to associate to the penult. However, tone must first be placed on the penult to set the stage for penultimate stress; since association of tone to the penultimate vowel cannot be assured, the derivation again fails to converge on the attested output.

For an underlying form like / x-in-el-ik, H /, there are three possible outcomes of initial tonal association:

(45)   Tone assigned first: possible outcomes

	/ x-in-el-ik, H / **1st iteration**	Iᴅ(sᴛʀ)	*Ĥ	Iᴀᴍʙ	NF(T)	Mᴀx(ᴛ)	*Fʟᴛ	Dᴇᴘ(A)
a.	xi.ne.lík		*		*!			*
? → b.	xi.né.lik		*					*
? → c.	xí.ne.lik		*					*
? → d.	xi.ne.lik						*	

Candidate (45a) necessarily loses because it incurs a gratuitous violation of NᴏɴFɪɴ(T, ᴛʙᴜ); in the absence of constraints like Aʟɪɢɴ-R(ᴛ), (45a) is harmonically bounded by (45b,c). Even if (45a) were selected as optimal, it would next map to [xi(ne.lík)], which was shown to be an untenable intermediate candidate in the last section (see (36), (38)).

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[15]See Pruitt (2010), Kimper (2011b), McCarthy & Pruitt (2012), Jesney (to appear), Elfner (to appear), McCarthy et al. (to appear) for various views on whether or not footing is intrinsically ordered before other operations in HS.

Selection of [xi.né.lik] as the winner seems more promising: given penultimate tone, trochaic stress could be correctly assigned at the next stage.

(46)   Promising second stage

/ xi.né.lik / **2nd iteration**	ID(STR)	*Ȟ	IAMB	NF(T)	MAX(T)	*FLT	DEP(A)
→ e. xi(<u>né</u>.lik)	*		*				
f. xi(né.<u>lik</u>)	*	*! W	L				

But this success is illusory. As argued earlier, there are no reasonable tonal constraints that would prefer [xi.né.lik] over its competitor [xí.ne.lik]; and if [xí.ne.lik] is selected instead at the first constraint pass, the derivation once again fails.

(47)   Failing second stage

/ xí.ne.lik / **2nd iteration**	ID(STR)	*Ȟ	IAMB	NF(T)	MAX(T)	*FLT	DEP(A)
? → e. xí(ne.<u>lik</u>)	*	*					
f. xí(<u>ne</u>.lik)	*	*	*!				
g. xí.né.lik		*(*!)					*!
? → h. xí.ne.lik		*					

Candidate (47f), with trochaic footing, is harmonically bounded by the iambic candidate (47e) (within this constraint set). Similarly, the tone-spreading candidate (47g) is harmonically bounded by the fully faithful candidate (47h). If (47h) is selected as optimal at this stage, the derivation will wrongly converge ((47h) is the fully faithful candidate). That leaves (47f) [xí(ne.<u>lik</u>)] as the only remaining contender. Since it has already been established that [xí(ne.<u>lik</u>)] is not a viable intermediate form (see tableau (40)), the derivation once again fails.

The essential problem for an HS treatment of Uspanteko is that tone placement and stress placement are *co-determined*: tone is attracted to stress, but simultaneously triggers deviations from default stress assignment (see also McCarthy 2002:143-6 on

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other 'chicken-egg effects'). Interactions of this sort can be straightforwardly captured in parallel OT but not in HS, because the latter framework falters on the ill-formedness of the requisite intermediate derivational stages.

3.3.1.2   Tone and stress cannot be assigned in a single step

If stress assignment and tone association were allowed to happen simultaneously in HS, then the HS derivation of tone-stress interactions in Uspanteko would simply reduce to the successful parallel OT analysis (10). But there is much reason to doubt the validity of such an approach. Given the GRADUALNESS requirement on HS derivations, simultaneous application of stress assignment and tone association amounts to the claim that one of those two operations does not count as a 'basic change' from input to output. If 'basic change' is defined in terms of faithfulness violations (McCarthy 2007, Elfner to appear, etc.), this claim is clearly false.[16] As McCarthy (2008b) notes, the existence of contrastive lexical stress would seem to entail that (de)stressing is subject to faithfulness pressures (though cf. McCarthy & Pruitt 2012). Some authors have proposed constraints on transderivational (OUTPUT-OUTPUT) faithfulness (Benua 2000) or anti-faithfulness (Alderete 2001a,b) to stress placement, which again suggests that stress can be regulated by faithfulness constraints.

There is at least some indication that tone association is also regulated by faithfulness constraints. As with stress, contrastively specified underlying tones should be protected by faithfulness constraints (as in Japanese, McCawley 1968, Kubozono 2008; Somali, Hyman 1981; etc., though cf. again McCarthy et al. 2010). There is also evidence for paradigmatic, transderivational (anti-)faithfulness constraints governing tonal associations (Alderete 2001a,b, Bennett & Henderson to appear).

Moreover, there is a simple argument from richness of the base that tonal associations can be blocked by faithfulness: something needs to prevent a non-tonal language like English from realizing (hypothetical) underlying tonal melodies as a surface contrast in lexical tone. Presumably, a FAITHFULNESS ≫ MARKEDNESS ranking like

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[16]To be sure, not all researchers in HS take the position that the definition of 'basic change' is contingent on the inventory of faithfulness constraints. Since this is nonetheless a prevalent view in the HS literature, it merits discussion here.

Dep(Associate) ≫ {*Float, Initial-Link, Specify, …} is required to accomplish that task.

(48)   No lexical tone in English: Dep(Associate) required

	/ kæt, H /	Dep(A)	Specify	*Float	Initial-Link	Max(t)
→ a.	kæt		*			*
b.	kǽt	*! W	L			L
c.	kæt, H		*	*! W	*! W	L

A corresponding argument could be mustered that faithfulness constraints on stress are also needed to prevent stress assignment in prototypical pitch accent and tonal languages.[17]

It's also worth noting that researchers in HS have independently proposed that both stress assignment and tone association count as single basic changes. McCarthy (2008b), Pruitt (2010) and McCarthy & Pruitt (2012) claim that only one stress/foot can be assigned per constraint pass in HS; this architectural assumption (called 'iterative foot optimization') is supposed to provide advantages over a fully parallel mode of stress assignment (though cf. Hyde 2009). McCarthy et al. (2010) assume that insertion of a tonal association line counts as a basic change, and McCarthy (2006, 2009, to appear) and Kimper (2011a) make the same claim regarding autosegmental feature associations (see also Shaw 2009 on moraic associations in OT with candidate chains). It is therefore in line with general theorizing in HS to assume that both stress assignment and tone association constitute basic changes. Furthermore, sacrificing those assumptions to capture Uspanteko weakens some of the putative advantages that HS enjoys over parallel OT. For example, if tonal association does not count as a single basic change, then both HS and parallel OT predict (wrongly, I presume) that vowel epenthesis should be a possible strategy for avoiding contour tones.

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[17]As far as I can tell, the arguments from richness of the base are valid even under the diacritic approaches to contrastive tone and stress espoused by McCarthy et al. (2010) and McCarthy & Pruitt (2012).

(49)   Epenthesis to avoid contour tones (unattested): {*Con, Specify} ≫ Dep(V)

/ baban, HLH /	*Con	Specify	Dep(V)
→ a. bá.bà.ní			*
b. bá.bàn, H		*! W	L
c. bá.bǎn	*! W		L

From a conceptual standpoint, every time an operation is allowed to apply 'for free' in HS, computations involving that operation will closely resemble the corresponding parallel OT evaluation, since parallel OT does not generally restrict the operations that may apply in a given [INPUT → OUTPUT] mapping (FREEDOM OF ANALYSIS, Prince & Smolensky 1993/2004). Assuming that stress and tone assignment come 'for free' in HS thus blurs the architectural distinction between the two theories, and may resurrect the 'pathological' globality that HS was in part intended to address (McCarthy 2007, Embick 2010, Pruitt 2010, etc.). As HS becomes more liberal with the inventory of permissible one-step operations, it will grow less restrictive with respect to the predicted typology of phonological interactions, thereby reducing the apparent empirical advantages that HS holds over parallel OT. Put simply, addressing the undergeneration problem that Uspanteko poses for HS recapitulates some of the overgeneration problems that motivate HS in the first place.

3.3.2   Conclusion

In this section I have argued that interactions between stress and lexical pitch accent in Uspanteko are best modeled within parallel OT (setting aside alternative rule-based analyses). A derivational treatment of the same facts within Harmonic Serialism leads to a serious loss of descriptive coverage, as HS is unable to account for a core pattern of tone-driven stress shift. While this undergeneration problem might be alleviated by positing certain *ad hoc* constraints on tonal alignment, the need for non-explanatory constraints specific to HS counts as a strike against the HS framework.

3.4 Irish

Modern Irish (henceforth just 'Irish') is a Celtic language, belonging to the Goidelic branch, spoken on a daily basis by over 70,000 people in the Republic of Ireland (Walsh 2010). In this section I demonstrate that Irish (like Uspanteko) has a robust system of phonological foot structure, despite the fact that stress assignment does not at first appear to be foot-based. The core evidence comes from two domains: prosodically-conditioned plural allomorph selection, and a pattern of prosodically-determined vowel epenthesis. I begin with the plural system of Irish.[18]

3.5 Irish plurals

In Irish, plural nouns are formed with a wide array of suffixal morphology. As a brief illustration, observe that plurality can be expressed by final consonant palatalization (50a), by suffixation of [ə] (50b), and by the simultaneous occurrence of both processes (50c).[19,20]

(50) a. Final C palatalization
          bád [bɑːd] → *báid* [bɑːdʲ]   'boat(s)'

      b. [ə] suffixation, with syncope
          focal [fokəl] → *focla* [foklə]   'word(s)'

      c. Final C palatalization and [ə] suffixation, with syncope
          solas [soləs] → *soilse* [sailʲʃə]   'light(s)'

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[18]Thanks are due to audiences at UC Santa Cruz, WCCFL 28, and CLC 7 for comments on earlier stages of this work. I am also indebted to Junko Itô for advising this project, and to Emily Elfner, Jim McCloskey, Armin Mester, Jaye Padgett, Mary Paster, Sharon Rose, and Judith Aissen for further feedback.

[19]Unless otherwise noted, all examples are taken from Ó Siadhail (1991, 1995), Doherty (1991), and Carnie (2008). In Irish orthography, acute accents mark underlying vowel length rather than stress placement.

[20]Here and throughout, I set aside the genitive plural, which is generally indistinct from the nominative plural form of the noun. I also ignore certain phonemic distinctions, such as the tense/lax contrast in sonorant consonants, except when relevant for the issues at hand (tense sonorants are digraphs in Irish orthography, e.g. *nn*).

Beyond the appearance of a suffix, plural forms are sometimes also marked by changes in root-internal vowels. For example, we find syncope in (50b), and both syncope and ablaut in (50c).[21] For the most part this paper is concerned only with the plural suffixes, though syncope will be briefly discussed in Section 3.8.

The three types of plural formation shown above constitute only a small subset of the patterns found in Irish. With respect to plural inflection, Ó Siadhail (1995) divides Irish nouns into six different major classes, with twenty-six smaller subclasses. Unfortunately, as noted in Ó Siadhail (1991:159), it is "very difficult to predict how the plural of any given noun is formed" (see also Stenson 1978:519).[22] In general, nouns that follow the same pattern for plural formation cannot also be grouped together on the basis of semantic, phonological, or further morphological similarity. To illustrate, consider the following nouns:

Noun	Singular	Plural	Genitive Sg.	Gloss
clog	klog	klog-ənə	klig^j	'clock'
deoch	d^{j}ox	d^{j}ox-ənə	d^{j}iː	'drink'
troid	tred^j	tred^j-ənə	trod-ə	'fight'
cloch	klox	klox-ə	klox^j-ə	'stone'

Table 3.1: Some Irish nominal paradigms

As Table 3.1 suggests, the choice of plural allomorph cannot be determined by the segmental content of the root noun. Though both *deoch* and *cloch* end in an [ox] rhyme, the two nouns take different plural suffixes, *deoch* pluralizing with [-ənə] and *cloch* with [-ə]. Similarly, *cloch* and *clog* are segmentally identical up to their final consonants (both velar obstruents), yet *clog* patterns with *deoch* in taking the plural suffix [-ənə].

The incoherence of these plural inflectional classes is also evident when we consider the system of genitive inflection. *Clog*, *troid*, and *deoch* all take the plural suffix

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[21]'Ablaut' of short vowels is an epiphenomenon of the fact that the backness of short vowels in Irish is determined by the backness (i.e. palatalization or velarization) of adjacent consonants, which may vary with morphological context (Hickey 1985b, Ní Chiosáin & Padgett 2001).

[22]The plural forms of derived nouns are somewhat more predictable. See Ó Siadhail (1991:140) for examples.

[-ənə], but have distinct patterns of inflection in the genitive singular (respectively: final palatalization; [-ə] suffixation with depalatalization; and suppletion). There is some affinity between the genitive forms of *troid* and *cloch* — both genitives are formed by a change in final consonant palatalization, along with suffixation of [ə] — but the two nouns take different plural suffixes. Since no obvious semantic properties characterize the plural inflectional class containing *clog*, *troid*, and *deoch*, its membership is apparently an arbitrary fact about the lexicon. (See Carnie 2008 for further discussion of the arbitrariness of nominal paradigms in Irish.)

3.5.1   A subregularity: *-(e)anna* and *-(e)acha*

At first glance, Irish plural morphology appears to be quite erratic. When we turn to the plural suffixes themselves, however, we find certain regularities. In particular, the distribution of two plural suffixes, *-(e)anna* and *-(e)acha*, is at least partially predictable. For those nouns that appear with either *-(e)anna* or *-(e)acha*, the plural suffix *-(e)anna* [-ənə] typically attaches to monosyllabic root nouns:

(51)   a.   *bus*   [ˈbus]   →   *busanna*   [ˈbus - ənə]   'bus(es)'

        b.   *dream*   [ˈdʲrʲɑːm]   →   *dreamanna*   [ˈdʲrʲɑːm - ənə]   'crowd(s)'

        c.   *sráid*   [ˈsrɑːdʲ]   →   *sráideanna*   [ˈsrɑːdʲ - ənə]   'street(s)'

        d.   *fón*   [ˈfoːn]   →   *fónanna*   [ˈfoːn - ənə]   'telephone(s)'

Importantly, the distribution of *-(e)anna* - [-ənə] is not strictly limited to monosyllabic root nouns: it also attaches to polysyllabic root nouns with final stress (52) (though such forms are not numerous in Irish).[23]

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[23]Ó Siadhail (1991:160) characterizes this pattern differently, claiming that [-ənə] attaches to "monosyllables and…polysyllables…with a double stress," i.e. with two equal stress peaks. However, *meaisín* (52a) is the only monomorphemic word I am aware of that bears putative "double stress" of this sort (and cf. Hickey 1985b).

At any rate, examples like (52b) suggest that final stress rather than 'double' stress conditions the appearance of [-ənə]. Furthermore, if Ó Siadhail's (1991) generalization is correct, a morphologically complex compound like *droch-inín* [ˈdrox - ˈinʲiːnʲ] 'bad daughter' should pluralize as **droch-iníneanna* *[ˈdrox - ˈinʲiːnʲ - ənə], even though the bare form *inín* 'daughter' pluralizes as *iníneacha* [ˈinʲiːnʲ - əxə].

(52) Polysyllabic noun with irregular final stress

    a. *meaisín* [ˈmʲæːˈʃiːnʲ] → *meaisíneanna* [ˈmʲæːˈʃiːnʲ - ənə] 'machine(s)'

    b.   [dəˈgʲrʲiː] →   [dəˈgʲrʲiː - ənə] 'degree(s)'

                                        (Hickey 1985b)

In contrast, the plural suffix *-(e)acha* - [-əxə] normally attaches to polysyllabic root nouns (without final stress):

(53) a. *suíleáil* [ˈsiːlʲɑːlʲ] → *suíleálacha* [ˈsiːlʲɑːl - əxə] 'ceiling(s)'

    b. *aifreann* [ˈæːfʲrʲən] → *aifreannacha* [ˈæːfʲrʲən - əxə] 'Mass(es)'

    c. *inín* [ˈi.nʲiːnʲ] → *iníneacha* [ˈi.nʲiːnʲ- əxə]   'daughter(s)'

    d. *atitim* [ˈæ.tʲə.tʲəmʲ] → *atitimeacha* [ˈæ.tʲə.tʲəmʲ - əxə] 'relapse(s)'

These two suffixes, then, are essentially in complementary distribution: *-(e)anna* [-ənə] attaches to nouns bearing final stress, while *-(e)acha* [-əxə] attaches elsewhere. Since the distribution of these two suffixes is determined by root noun stress, this subcase of Irish plural marking instantiates ᴘʀᴏsᴏᴅɪᴄᴀʟʟʏ ᴄᴏɴᴅɪᴛɪᴏɴᴇᴅ sᴜᴘᴘʟᴇᴛɪᴠᴇ ᴀʟʟᴏᴍᴏʀᴘʜʏ, or ᴘᴄsᴀ (Mester 1994, Paster 2006).

    There are some exceptions to the basic distribution of *-(e)anna* and *-(e)acha*. Specifically, certain monosyllabic nouns take the suffix [-əxə] rather than [-ənə]:

(54) a. *áit* [ˈɑːtʲ] → *áiteacha* [ˈɑːtʲ - əxə]   'place(s)'

    b. *tír* [ˈtʲiːrʲ] → *tíreacha* [ˈtʲiːrʲ - əxə]   'land(s)'

    c. *éan* [ˈeːn] → *éanacha* [ˈeːn - əxə]   'bird(s)'

Perhaps unsurprisingly, exceptional forms like (54) are subject to regional variation, and many dialects use regular plural forms like *áiteanna* instead of irregular forms like *áiteacha*:

(55) a. [ˈɑːtʲ] 'place'

    b. *áiteacha*   [ˈɑːtʲ - əxə] (Connacht)

    c. *áiteanna*   [ˈɑːtʲ - ənə] (Dunquin, County Kerry)

There is a curious asymmetry in these lexical exceptions: examples of irregular suffixation of [-əxə] to monosyllables are fairly common, but forms in which [-ənə] exceptionally attaches to polysyllables with non-final stress are apparently nonexistent.[24] So, for both regular and exceptional plural forms, [-ənə] has a more narrowly circumscribed distribution than [-əxə].

We can thus restate the basic descriptive generalization: barring a set of dialectally unstable lexical exceptions, *-(e)anna* [-ənə] appears adjacent to (primary) stressed syllables, and *-(e)acha* [-əxə] appears elsewhere.

Plural suffix	Attaches to	Lexical exceptions?
-(e)anna [-ənə]	Stressed syllables	No
-(e)acha [-əxə]	Unstressed syllables (i.e. elsewhere)	Yes: some monosyllabic stems

Table 3.2: Distributions of *-(e)anna* [-ənə] and *-(e)acha* [-əxə]

Lastly, though not all loanwords display this pattern of plural marking, some recent and semi-recent borrowings suggest that these suffixes are still productive (see also Hickey 1985b):[25]

(56)   a. *bál* → *bálanna* 'ball(s)'
        b. *blag* → *blaganna* 'blog(s)'

        c. *peaicits* → *peaicitseacha* 'package(s)'
        d. *acrainm* → *acrainmneacha* 'acronym(s)'

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[24]I know of only two potential counterexamples, *comharsa* 'neighbor' and *ailibí* 'alibi'. *Comharsa* might be analyzed as multimorphemic (see *comh-* 'joint', *comhar* 'cooperation', *áras* 'abode', etc.), with *-sa* as a sort of monosyllabic bound root, akin to English Latinate roots like *-mit* (e.g. *admit*, *remit*, etc.; see e.g. Taft & Forster 1975, Hammond 1999, Harley 2007). Though *ailibí* is less amenable to such an analysis, it is clearly a loanword, which might help explain its exceptional status.

[25]Examples of *blag/blaggana* are widespread on the internet. The forms *acrainm/acrainmneacha* were found at "1,000 Téarma Ríomhaireachta" (`http://www.dcu.ie/fiontar/btfbeag/BTFbeag-20.html`).

3.5.2 *-(e)anna* and *-(e)acha* as contextual allomorphs

There are a number of reasons to believe that [-ənə] and [-əxə] are in fact allomorphs of the same underlying plural morpheme. For one, the two suffixes are in (near-)complementary distribution, as just discussed in Section 3.5.1. This distributional pattern makes sense under the assumption that [-ənə] and [-əxə] are simply contextually restricted surface forms of a single underlying plural suffix.

Further evidence that [-ənə] and [-əxə] are contextual allomorphs of a single affix comes from a pattern of double plural marking (Ó Siadhail 1991:140-1,160-1 and Stenson 1978:527-535). The plural suffix *(a)í* /-iː/ attaches to root nouns (57a,b) and derived nouns (57c,d); but it can also appear outside of the plural suffixes *-(e)anna* and *-(e)acha* (58), creating a doubly-marked plural noun.[26] It is probably not an accident that *-(a)í* is the plural suffix found most commonly on derived nouns, as well the suffix implicated in multiple plural marking (Ó Siadhail 1991:140).

(57)   Regular affixation of *-(a)í* /-iː/

    a. *féasóig* [ˈfʲiːsoːgʲ] → *féasógí* [ˈfʲiːsoːgʲ- iː] 'beard(s)'

    b. *gúna* [ˈguːnə] → *gúnaí* [ˈguːn - iː] 'dresse(s)'

    c. *bádóir* [ˈbaːd - orʲ] → *bádóirí* [ˈbaːd - orʲ- iː] 'boatman/men'

    d. *Gaeltacht* [ˈgeːlt - əxt] → *Gaeltachtaí* [ˈgeːlt - əxt - iː] 'Irish-speaking area(s)'

(58)   Double plural marking with *-(a)í* /-iː/

    a. *am* [ˈaːm] → *amannaí* [ˈaːm - ən - iː] 'time(s)'

    b. *reilig* [ˈrilʲəkʲ] → *reiligeachaí* [ˈrilʲəkʲ - əx - iː] 'graveyard(s)'

      etc.

Double plural marking of this sort is apparently variable for some speakers, and one finds single plural forms like *craobhanna* [kriːv - ənə] 'branches' alongside doubly-marked plurals like *craobhannaí* [kriːv - ənə - iː] (Stenson 1978:527-8).

The most relevant fact here is that *-(e)anna* and *-(e)acha* are the only two plural

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[26]These patterns of multiple plural exponence are predominantly found in Northern dialects. Deletion of [ə] before long [iː] as in (57b) and (58) is a general phonological process in Irish (Ó Siadhail 1995:217-8).

suffixes that participate in double plural marking with *-(a)í* /-iː/. For example, outer affixation of *-(a)í* /-iː/ is completely impossible for nouns with final palatalization (59) or more marginal, suppletive-type plural marking (60) as the innermost plural inflection.

(59)   No double plural marking on nouns with palatalization as the inner plural marker

      a.   *bád*   [ˈbɑːd]   →   *báid*   [ˈbɑːd - ʲ]   'boat(s)'

      b.   *bádaí*   [ˈbɑːd - iː]

      c.   *báidí*   *[ˈbɑːd - ʲ -iː]

(60)   No double plural marking on nouns with marginal, root-specific plural marking

      a.   *lacha* [ˈlɑxə]   →   *lachain*   [ˈlɑxə - nʲ]   'duck(s)'

      b.   *lachainí* *[ˈlɑxə - nʲ - iː]

      c.   *plump* [ˈplump] →   *plumpaíl*   [ˈplump - iːlʲ]   'bang(s)'

      d.   *plumpaílí* *[ˈplump - iːlʲ - iː]

If *-(e)anna* and *-(e)acha* are underlying a single 'morph' ᴍ$_x$, we can easily explain why only these two suffixes participate in double plural marking with *-(a)í* [- iː]: the suffix *-(a)í* can only co-occur with ᴍ$_x$; and the surface form of ᴍ$_x$ is determined on independent phonological grounds. Double plural marking thus provides an additional argument for treating *-(e)anna* and *-(e)acha* as surface allomorphs of a single underlying plural suffix (or more abstractly, a 'morph').

Despite the segmental resemblance between [-ənə] and [-əxə] the contextual allomorphy described here must be treated as a case of suppletion. No phonological process exists in Modern Irish — or existed at any historical stage of the language, as far as I know — converting [x] to [n], or vice-versa. Moreover, such a process would be extremely implausible from a phonetic perspective, as it would simultaneously alter the place, manner, and voicing of the targeted segment. Thus, alternations between [-ənə] and [-əxə] must be suppletive.

I am thus proposing something like Figure 3.1 as the basic structure of plural al-lomorphy in Irish. A given noun may idiosyncratically appear with a particular suffix, as determined by some selectional relation between the two morphemes. When the suffix in question is $\textsc{m}_x$, its actual phonological form is conditioned by phonological properties of the noun it attaches to. While this is a fairly rich morphological struc-ture, the data clearly supports an analysis of plural allomorphy in which *-(e)anna* and *-(e)acha* are recognized as a distinguished pair of affixes, set apart from the other plural morphemes in the system.
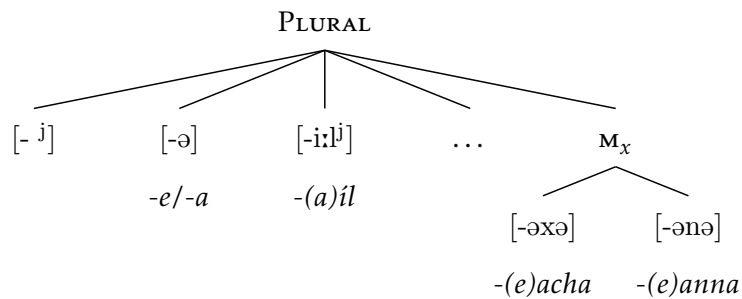
Figure 3.1: Partial selectional structure of Irish plural morphology

Finally, of the two allomorphs, [-əxə] can be considered the 'elsewhere' or 'default' vari-ant. As discussed in Section 3.5.1, the distribution of [-ənə] is sharply restricted: it only attaches to stressed syllables; and there are no lexical exceptions in which [-ənə] at-taches to an unstressed syllable. In contrast, [-əxə] attaches to unstressed syllables, but also exceptionally attaches to a number of (stressed) monosyllabic root nouns. Since [-ənə] has more stringent conditions on its distribution than [-əxə] does, I assume that its appearance is triggered by a specific environment, namely post-tonic position.

In the discussion that follows, I argue that this instance of Irish plural allomor-phy is best analyzed as a case of output optimization, as suggested for various pat-terns of allomorphy by Mester (1994), Tranel (1996), Kager (1996), Mascaró (1996), González (2005), Mascaró (2007), and many others. In particular, I propose that the choice of plural suffix is sensitive to prosodic pressures, namely conditions on foot well-formedness, that are otherwise dormant in the phonology of Irish. Cross-dialectal evidence suggesting that /ax/ sequences have an exceptional status in Irish is also brought to bear on the question of allomorph selection.

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3.5.3 The Irish stress system

Since the distribution of [-ənə] and [-əxə] is conditioned by root noun stress, a brief discussion of the stress system of Irish is in order. Further, the analysis of plural allomorphy presented in Section 3.5.5 depends, in part, on the claim that footing is non-iterative for most dialects of Irish. This claim is justified in Section 3.5.3.1; an OT formalization of the basic stress system of Irish is given in Section 3.5.3.2.

3.5.3.1 Stress placement and non-iterativity

For most dialects of Modern Irish, primary stress placement is straightforward: excluding a few lexical exceptions, primary stress falls on the first syllable of the word.[27] In these dialects, primary stress placement is not conditioned by the presence of heavy syllables:

(61)   [ˈLH]

     a.   *feiceáil*   [ˈfʲe.kʲɑːlʲ]   'seeing'
     b.   *[fʲə.ˈkʲɑːlʲ]

(62)   [ˈLHL]

     a.   *bunábhar*   [ˈbu.nɑː.wər]   'raw material'
     b.   *[bə.ˈnɑː.wər]

(63)   [ˈLLH]

     a.   *cogarnaíl*   [ˈko.gər.niːlʲ]   'whispering'
     b.   *[kə.gər.ˈniːlʲ]

Following Doherty (1991), I take the Irish stress system to be quantity-insensitive and trochaic. Further, I assume that (in most dialects) head feet are aligned with the left edge of the word, deriving initial primary stress (e.g. [(ˈko.gər)niːlʲ]). In Sections 3.5.5

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[27]Nouns with exceptional non-initial stress are largely borrowings. Sadly, most such nouns do not pluralize with either [-ənə] or [-əxə]; e.g. *tobac* - [tə.ˈbɑːk] → *tobací* [tə.ˈbɑː.k - iː] 'tobacco(s)'. See also Hickey (1985b).

and 3.6 I justify the assumption that stress assignment is indeed foot-based in Irish.

There is no evidence of secondary stress in most varieties of Irish. One exception is Munster Irish, a full analysis of which lies outside the scope of this paper (but see Doherty 1991, Green 1996, 1997, Iosad 2009 for more thorough discussion). In all dialects, certain prefixed forms do contain multiple stress peaks, but both prefix and stem are equally stressed, suggesting the presence of two distinct prosodic words (i.e. a compound structure):

Word	Transcription	Structural parse	Gloss
droch-bhád	[ˈdrox.ˈwɑːd]	$[_\omega$ (ˈdrox) $][_\omega$ (ˈwɑːd)]	'bad boat'
fíor-bhean	[ˈfiːər.ˈvʲæːn]	$[_\omega$ (ˈfiːər) $][_\omega$ (ˈvʲæːn)]	'true woman'
an-mhor	[ˈaːn.ˈwoːr]	$[_\omega$ (ˈaːn) $][_\omega$ (ˈwoːr)]	'very big'

Table 3.3: Compounding prefixes in Irish

The lack of secondary stress suggests that footing is non-iterative in most dialects of Irish — that is, content words contain only a single foot. Since I know of no positive evidence for iterative foot structure in the language (apart from secondary stress in Munster Irish), I will simply assume non-exhaustive footing without further comment (though see footnote 58 in Section 3.6). From my perspective, the burden of proof is on those who dispute this view.[28]

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[28]More evidence for non-iterativity comes from the poetics of Early Modern Irish, as spoken in the early 17th century. Meyer (1909:vi) exhorts students of Irish metrics to "read Irish poetry entirely by ordinary word stress, discarding…fanciful theories as to any interchange between stressed and unstressed syllables, or as to any secondary stress enabling certain syllables to carry a rhythmical accent".

Armin Mester points out that Old Irish had a process of rhythmic syncope, which might be indicative of iterative footing at that stage of the language. According to Thurneysen (1946:§§106-10), words with three or more syllables showed syncope of the second syllable, while words with five or more syllables had syncope of the fourth syllable as well (for whatever reason, vowels in word-final syllables were impervious to this syncope process). If rhythmic syncope targeted vowels in the weak branches of trochaic feet in Old Irish (e.g. McCarthy 2008b), these observations are consistent with the view that Old Irish had iterative footing, e.g. $[(\acute{\sigma}\underline{\sigma})(\sigma\underline{\sigma})\sigma]$.

The relevance of these facts for the modern language is not clear to me; at any rate, by the Middle Irish period syncope was no longer a fully rhythmic process, both failing to apply in some even-numbered

Given the meager metrical structure needed for stress placement in Irish, a question arises as to whether Irish words contain any foot structure at all. There are both empirical and theoretical reasons to believe that Irish words do contain some foot structure. First, Ní Chiosáin (1999, 2000) describes a process of [ə] epenthesis in Irish that appears, very roughly, to be foot-bounded: epenthesis only occurs within the first two syllables of the word. The restricted domain of epenthesis thus provides further support for the claim that Irish words contain a single left-aligned foot. This pattern of epenthesis will be discussed further in Section 3.6.

3.5.3.2 Modeling Irish stress: OT analysis

Formally, the basic stress system of Irish can be captured with four constraints: ALL-FOOTLEFT (afl), TROCHEE, WEIGHT-TO-STRESS (wsp), and PARSE(σ) (see Chapter 2 for constraint definitions). In taking these four constraints as the prime determinants of the Irish stress system, the analysis presented here, though developed independently, closely follows that of Green (1996, 1997). As in Selkirk (1996), Itô & Mester (1992/2003, 2009) and other work, I assume that HEADEDNESS, the constraint requiring every prosodic domain of level i to be headed by a prosodic constituent of level i-1, is inviolable. In effect, this assumption simply forces words to contain at least one foot (see Chapter 1 for discussion, and Chapter 4 for experimental work on this topic).

To capture the assumption that all content words begin with a foot, I take afl to be undominated (64c). Since primary stress is always initial in polysyllabic words, even when the second syllable is heavy, TROCHEE must dominate wsp (64b). These two rankings ensure that stress placement will always be edge-based and quantity-insensitive. Finally, the additional ranking afl ≫ PARSE(σ) (64d) derives non-iterative footing.[29]

syllables and overapplying in some odd-numbered syllables. Moreover, words of more than four syllables were not very common in Old Irish, and most (if not all) such forms were morphologically complex, which may have played a role in conditioning the relevant vowel alternations.

[29]The ability to enforce non-iterativity distinguishes afl from a constraint like ANCHOR-L(ω, FT) (McCarthy 2003b), which would also demand left-aligned footing. The restriction to one foot per word could be derived by employing a constraint of the *STRUC family, like *FT or *FT$_{\text{NON-HEAD}}$, in tandem with ANCHOR-L(ω, FT). For simplicity of exposition I make use of afl here; for arguments against *STRUC constraints, see Gouskova (2003, 2004).

(64)   Word-initial primary stress in Irish: Trochee ≫ wsp, afl ≫ {wsp, Parse(σ)}

/ kumoːrtəʃiː /	AFL	TROCHEE	WSP	PARSE(σ)
a. ☞ (ˈku.moːr)tə.ʃiː			**	**
b. (ku.ˈmoːr)tə.ʃiː		*! W	* L	**
c. kə(ˈmoːr.tə)ʃiː	*! W		* L	**
d. (ˈku.moːr)(ˌtʌ.ʃiː)	*! W		**	L

comórtaisí 'competitions'

Note that the winning candidate in (64), [(ˈku.moːr)tə.ʃiː], contains an uneven (ˈL H) trochee, with a heavy syllable in a weak position in the foot. In many quantity-sensitive languages, feet of this shape are actively avoided (Hammond 1986, Hayes 1995, etc.). The fact that such quantitatively ill-formed feet do in fact surface in Irish results from the relatively low ranking of wsp with respect to other metrical constraints. However, in Section 3.5.5 I will argue that (ˈσ H) feet are in fact avoided in Irish plural allomorphy, despite the general acceptability of (ˈσ H) feet in Irish.

Since the Irish stress system is quantity-insensitive, it's not immediately evident whether coda consonants count as moraic. As a result of the ranking AFL ≫ wsp, the presence of moraic coda consonants would have no visible consequences for primary stress placement. Further, monomoraic words are never augmented by consonant epenthesis, so there is no evidence from minimality restrictions to suggest that coda consonants bear morae. Indeed, monomorphemic Irish words freely violate FtBin, the constraint requiring that feet be binary under syllabic or moraic analysis.[30]

(65)   Subminimal content words in Irish

/ tro /	DEP(V)	DEP(C)	FtBin
a. ☞ (ˈtro)			*
b. (ˈtroh$_\mu$)		*! W	L
c. (ˈtroi)	*! W		L

troigh 'foot'

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[30]While subminimal content words are not particularly frequent in Irish, their rarity can be attributed to the fact that Old Irish *did* place a bimoraic minimality condition on content words (Green 1997:64).

Consequently, there seems to be no conclusive evidence either for or against treating coda consonants as moraic in Irish. However, evidence from dialectal variation suggests that coda consonants are indeed non-moraic in Irish. In the quantity-sensitive system of Munster Irish, to which I return in Section 3.5.4.1, "only those syllables containing a long vowel or diphthong count as heavy for the purposes of stress assignment" (Doherty 1991:19). Assuming that the behavior of coda consonants in Munster Irish is typical of the language as a whole, one more ranking argument can be provided. To prevent coda consonants from surfacing as moraic, the constraint $*C_\mu$, which militates against moraic consonants, must dominate Weight-by-position (WxP), the constraint requiring coda consonants to be moraic (see again Chapter 2 for constraint definitions).

(66)   Moraic codas generally prohibited: $*C_\mu \gg$ WxP

/ rud /	$*C_\mu$	WxP
a. ☞ ('rud)		*
b. ('rud$_\mu$)	*! W	L

rud 'thing'

Nevertheless, in Sections 3.5.4 and 3.5.5 I argue that under very specific circumstances coda consonants can be moraic in Irish, and that the presence of moraic codas influences the choice of plural allomorph.

Finally, it should be noted that Parse(σ), even when ranked below other relevant markedness constraints, is still active in eliminating some candidates containing monosyllabic feet. Since building foot structure is a 'cost-free' operation in terms of faithfulness violations (see McCarthy 2008b, Pruitt 2010), disyllabic feet will be constructed whenever possible.[31]

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[31] A similar effect could be derived with a version of FtBin specifically requiring feet to be binary at the syllabic level. See Elias-Ulloa (2006) and Chapter 2.

(67) Word-initial primary stress in Irish: Trochee ≫ wsp, afl ≫ {wsp, Parse(σ)}

/ koːkərʲəxt /	afl	Trochee	wsp	Parse(σ)
a. ☞ (ˈkoː.kə)rʲəxt				*
b. (ˈkoː)kə.rʲəxt				**! W

cócaireacht 'cooking'

Note that, on the basis of stress placement alone, the two candidates in (67) are empirically indistinguishable. This ambiguity, and the role played by Parse(σ) in Irish plural allomorphy, will be discussed further in Section 3.5.5.

In summary, the basic Irish stress system can be captured under the following constraint rankings:

(68)   a.   {afl, trochee} ≫ wsp

       b.   afl ≫ Parse(σ)

       c.   {Dep(V), Dep(C)} ≫ FtBin

       d. $^*C_\mu$ ≫ WxP

3.5.4 The exceptional status of /ax/

The voiceless velar fricative [x], found in the plural suffix *-(e)acha* [-əxə] participates in some unusual metrical phenomena in both quantity-sensitive and quantity-insensitive dialects of Irish. In the following section, I account for this behavior by arguing that [x] is in fact moraic in certain circumstances. This assumption will become relevant in Section 3.5.5, where it is proposed that the moraic status of [x] in the plural suffix [-əxə] drives Irish plural allomorphy.

Readers who are primarily interested in arguments for foot structure in Irish, or in the pattern of plural allomorphy described in Section 3.5.1, should feel free to skip ahead to Section 3.5.5. The analysis presented in that section makes two crucial assumptions: first, that the plural suffix *-(e)acha* is underlyingly /-axə/; and second, that surface [axV] sequences are parsed [ax$_\mu$.V], with a moraic intervocalic coda [x]. Readers who feel their eyebrows raising at those claims are invited to consider the evidence set out in the rest of this section.

3.5.4.1 Munster Irish stress

Further insight into the moraic status of coda consonants can be gleaned by examining the stress patterns of Munster Irish (ᴍɪ), a dialect group located in the southern portion of the Republic of Ireland. Like Irish more generally, ᴍɪ has default word-initial primary stress. However, ᴍɪ differs from most dialects in that the stress system is quantity-sensitive. The basic descriptive generalization is that primary stress falls on the leftmost heavy syllable, otherwise on the initial syllable.[32]

Example	Most dialects	Munster Irish	Weight profile
cailíní 'girls'	[ˈka.lʲiː.nʲiː]	[ka.ˈlʲiː.nʲiː]	LˈHH
marcaraer 'mackerel'	[ˈmar.kə.reːr]	[mar.kə.ˈreːr]	LLˈH
anagal 'corrupt matter'	[ˈa.nə.gəl]	[ˈa.nə.gəl]	LLL

Table 3.4: Quantity-sensitivity in Munster Irish (Ó Siadhail 1991, Doherty 1991:20-1)

As mentioned in Section 3.5.3.2, coda consonants do not generally contribute to syllable weight in ᴍɪ. There is, however, one exception: in the absence of heavy syllables, primary stress falls on a non-initial [(C)ax] syllable, if that syllable is in second position.

(69)   a.   /bakax/   → [bə.ˈkax]   *bacach*   'lame'
       b.   /mʲiʃnʲax/   → [mʲəʃ.ˈnʲax]   *misneach*   'courage'
       c.   /sasənax/   → [ˈsa.sə.nəx]   *Sasanach*   'English person'

(Doherty 1991:28)

Thus, the ᴍɪ stress system makes use of a ternary weight distinction among syllable rhymes: { [V͡V], [Vː] } > [ax] > [V] (Doherty 1991, Green 1996, and references therein).[33]

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[32]As discussed in Doherty (1991), Green (1996, 1997) and Iosad (2009), the empirical facts about stress in ᴍɪ are more complicated than this simple description suggests. For example, words with initial [HHL] sequences deviate from this pattern, with stress falling on the second rather than leftmost heavy syllable, [HˈHL]. I omit several such nuances for clarity's sake, since they do not bear on the discussion presented here.

[33]I will not attempt to account for the ternary weight system of Munster Irish, or for the fact that [ax]

Crucially, only the combination of [a] and [x] draws stress rightward; other [aC] and [Vx] rhymes do not attract stress.[34]

(70)   a.   /doras/   → [ˈdo.rəs] *doras*   'door'
        b.   *[do.ˈras], *[də.ˈras]   (Ó Cuív 1944)

        c.   /ʃan-lux/   → [ˈʃan.ləx] *sean-luch* 'old mouse'
        d.   *[ʃan.ˈlux], *[ʃən.ˈlux]

Since other syllables with [a] nuclei or [x] codas do not attract stress, the special prominence of [ax] sequences must be due to the joint influence of [a] and [x] in combination within a single [ax] rhyme.

3.5.4.2 Vowel reduction in Ulster Irish

The exceptional prominence of [ax] sequences is not limited to the quantity-sensitive stress system of Munster Irish. In fact, the special status of [ax] rhymes is also evident in some quantity-insensitive dialects. As noted in Ó Siadhail (1991:33), in the Ulster dialects of Irish (spoken in the north) unstressed [ax] rhymes do not undergo reduction to [əx], despite the fact that unstressed short vowels otherwise reduce to [ə].[35,36]

rhymes apparently only attract stress in peninitial syllables. See Green (1996, 1997), Iosad (2009), and references therein for discussion.

[34]Since unstressed short vowels also reduce to [ə] in MI, I am inferring possible underlying vowel qualities in (70) from the orthographic form of each word. Example (70c) is constructed from the descriptions in Ó Cuív (1944) and Ó Siadhail (1991), as I have been unable to find any transcribed examples of unstressed, underlying /ux ix ex ox/ rhymes.

[35]The lack of reduction in /ax/ syllables is a conservative feature of Ulster Irish (O'Rahilly 1932). In connection with this fact, syncope in Old Irish (footnote 28) was inhibited when an otherwise eligible vowel appeared as part of an [axt] sequence (Thurneysen 1946:§106).

[36]One might wonder if the lack of reduction in [ax] rhymes in Ulster Irish provides evidence for covert, non-head feet. If [ax] rhymes were footed [(ax)] (under pressure from WSP, or whatever principle draws stress to [ax] rhymes in Munster Irish), they might be exempt from reduction by virtue of being foot heads. Non-initial long vowels [Vː], being bimoraic, would be heads of covert feet as well, [(Vː)].

However, Ulster Irish also has a process of long vowel shortening, which has exactly the same distribution as short vowel reduction: all non-initial (i.e. unstressed) long vowels are shortened. If covert footing of long vowels [(Vː)] is assumed — a conclusion that follows from the view that [ax] rhymes are covertly footed [(ax)] — then the environment for shortening must be stated in terms of stress rather than foot

(71) Unstressed [ax] not reduced in Ulster Irish

    a. *portach*   [ˈpɔr.tax] 'bog'
    b.   *[ˈpɔr.təx]

    c. *currach*   [ˈko.rax] 'coracle'
    d.   *[ˈko.rəx]

    e. *Gaelach*   [ˈɡeː.lax] 'Irish'
    f.   *[ˈɡeː.ləx]

Cf.

    g. *turas* [ˈto.rəs] 'journey'
    h. *orsain* [ˈor.sənʲ] 'jamb'

There is thus both quantitative and non-quantitative evidence that [ax] rhymes are more phonologically prominent than corresponding [aC] or [Vx] rhymes in Irish. What remains to be explained is *why* [ax] rhymes show this unusual constellation of properties. In the next section, I argue that [ax] rhymes are phonologically prominent in Irish because [x] in an [ax] string always bears an independent mora.

3.5.4.3 Syllabification

Besides the stress-attracting properties of [ax] rhymes, and their resistance to reduction, Doherty (1991) claims that [ax] strings also behave exceptionally with regard to syllabification. Specifically, when an [ax] string is followed by a vowel, [axV], intervocalic [x] is syllabified as a coda rather than an onset.[37]

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structure. To explain the lack of reduction of [ax] rhymes, on the other hand, reduction must be stated terms of foot structure and not stress. This analysis misses the clear parallelism between shortening and reduction, which, descriptively speaking, apply in the same environments (unstressed, non-initial syllables). I conclude that the resistance of [ax] rhymes to vowel reduction should not be taken as evidence for iterative footing in Ulster Irish. Instead, these facts indicate that reduction targets unstressed vowels belonging to monomoraic syllables.

[37]There is some dispute over the empirical facts of syllabification in Irish. For example, Green (1996) claims that [ax] strings draw stress to [a] even when [a] and [x] are heterosyllabic [a.xV]. In contrast, Green (1997) suggests an ambisyllabic parse for [x] in [axV] sequences. Ní Chiosáin, Welby & Espesser (2012)

(72)   Intervocalic coda syllabification of [x] in Munster Irish (Doherty 1991:28)

   a. *slisneacha*   [sliʃ.ˈnʲax̠.ə]   'chips'
   b. *spealacha*   [spə.ˈlax̠.ə]   'scythes'

Doherty's (1991) claim is not as radical as it seems (at least in the context of Irish), as there is ample precedent within the descriptive literature on Irish for assuming 'backwards' syllabification of intervocalic consonants as codas under certain circumstances (see Green 1997, Dalton & Ní Chasaide 2005, 2007, Ní Chiosáin & Welby 2009, Ní Chiosáin et al. 2012, and references therein on Irish; see also Clements 1986, Ladefoged, Ladefoged, Turk, Hind & Skilton 1998 for Scottish Gaelic).

One reason to suspect that intervocalic [x] in an [axV] string might be parsed as a coda is the fact that [ax] sequences attract stress in Munster Irish even when followed by a vowel, as in (72). Under the generally accepted view that stress is a property of syllables (Liberman & Prince 1977, Hayes 1995, etc.), it would be deeply surprising to find that hypothetical onset [x] in an [a.xV] string was responsible for attracting stress to a preceding heterosyllabic [a]. Given that onset consonants do not usually contribute to syllable weight — much less to the weight of the *preceding* syllable — such a pattern would be all the more striking.

As hypothesized in Doherty (1991:28n), these observations point toward the conclusion that [x], under some narrowly-circumscribed conditions, counts as a moraic consonant in Irish. (I will return shortly to the question of why [x] might bear a mora specifically when preceded by [a].) Since, under general principles of syllabification, moraic consonants cannot appear in onset position (cf. Topintzi 2008), assuming that [x] is moraic in [axV] strings provides a unified account of its peculiar stress-attracting and syllabification properties (recall that both long vowels and [ax] rhymes attract stress in Munster Irish). The additional fact that unstressed [ax] rhymes resist vowel reduction in Ulster Irish (71) can then be captured under the assumption that reduction in those dialects only targets unstressed short vowels in *monomoraic* syllables. If [ax] rhymes are bimoraic [$a_\mu x_\mu$], it follows that they should be exempt from reduction. I conclude that there is extensive evidence that intervocalic [x] in an [axV] string

provide an overview of the various claims that have been made about the syllabification of intervocalic consonants in Irish.

is parsed as a moraic coda consonant. All subsequent transcriptions will reflect this assumption.

There may be readers who find the notion of backwards syllabification distasteful, if not outright objectionable. I would like to stress that there is good empirical evidence for the existence of intervocalic coda syllabification, both within Irish and in other languages (Celtic or otherwise). As mentioned a moment ago, phonetic studies of Irish (both impressionistic and instrumental) are in rough agreement that intervocalic coda syllabification exists in Irish. Specifically, intervocalic consonants are parsed as codas when following a stressed short vowel (see Kahn 1976, Green 1997 and other work on the related notion of ambisyllabicity).

(73)   Post-tonic coda syllabification of intervocalic consonants in Irish
        / #CV̆CV / → [#ˈCV̆C.V]

Recent experimental work by Ní Chiosáin & Welby (2009) and Ní Chiosáin et al. (2012) has also found that native speaker judgments of syllable divisions in Irish words reflect an ambisyllabic parse (if not full coda syllabification) for intervocalic consonants following a stressed short vowel (though see Steriade 1999 for criticism of methodologies that rely on native speaker intuitions of syllable boundaries).

There is also reason to suspect that onset [x] is disprefered within the larger phonological system of Irish. If so, then there might be an independent phonological pressure to syllabify [VxV] strings with a coda parse for [x]. The first argument in favor of this claim comes from the statistical rarity of clear cases of word-internal onset [x] — specifically, the near-absence of words in which [x] immediately follows a coda consonant, [VC.xV].

The maximal syllable in Irish is [CCCVCC] (Ó Siadhail 1991). Unambigous word-internal codas — that is, consonants appearing as the first member of an intervocalic [VCCV] consonant cluster that is not a possible complex onset — may be either sonorant consonants (74a) or voiceless fricatives (74b) (Gussmann 2002).[38] Word-final coda

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[38]Some loanwords do contain medial coda stops, e.g. *caiptín* [kaːpʲ.tʲiːnʲ] 'captain', which is sometimes nativized as [kaːf̱ʲ.tʲiːnʲ], with a fricative coda rather than a stop. In at least some dialects word-internal coda stops are in fact allowed (e.g. Donegal Irish *bosca* [bok.sə] 'box' and *tuigseannach* [tikʲ.ʃə.nah] 'understanding', Ó Siadhail 1991:101), which casts some doubt on the security of Guss-

consonants are less restricted in Irish, but don't bear on the present argument.

(74)   a.   Word-internal sonorant codas

    (i)   *sláinte*   [ˈslɑːnʲ.tʲə]   'health'

    (ii)   *garda*   [ˈɡɑːr.də]   'policeman'

    b.   Word-internal voiceless fricative codas

    (i)   *sneachta*   [ˈʃnʲax.tə]   'snow'

    (ii)   *bosca*   [ˈbos.kə]   'box'

    (iii)   *scríobhta*   [ʃkʲrʲiːf.tə]   'written'

To identify word-internal onset [x], then, it suffices to find internal consonant clusters consisting of [x] preceded by a sonorant consonant or another voiceless fricative. Unfortunately, I know of no work explicitly discussing possible word-medial consonant clusters in Irish. It was therefore necessary to conduct a small-scale corpus study of the relative frequency of medial consonant clusters in the language. The corpus I relied on for this task (kindly shared with me by Jim McCloskey) consists of roughly 93,000 word tokens, in orthographic transcription, collected from various written sources.[39] A Python script (`http://www.python.org/`) was used to search the corpus for consonant clusters containing [x] or [xʲ] as the second member. Such clusters are represented orthographically as *ch* [x] preceded by a single grapheme like *c* [k$^{(j)}$] or by a digraph like *bh* [v$^{(j)}$].

    This search returned a number of results, not all of which are germane to the question of whether [x] can serve as a word-medial onset. For example, the search uncovered some words with non-standard spellings (e.g. *coitchianta* for standard *coitianta* 'daily', where *tch* corresponds to phonetic [tʲ]), as well as some clusters that appear at the boundary between two members of a compound (e.g. *neamh-choitianta* 'unusual', where *mh-ch* is phonetically singleton [x] at any rate). Only one credible case of a medial obstruent-[x$^{(j)}$] cluster was uncovered; however, the word in question is *Ghlaschú* 'Glasgow', a proper name and potentially a loanword as well (though the name

mann's (2002) generalization.

probably originates in Old Irish). This raises the possibility that *Ghlaschú* is not fully nativized — moreover, at least some speakers pronounce the orthographic sequence *sch* in this word as [səx], with an epenthetic vowel (Jim McCloskey, p.c.).

As for medial sonorant-[x$^{(j)}$] clusters, the picture is a bit more complex. A number of words were found in which an orthographic sonorant-*ch* cluster appears after a stressed, initial short vowel. Importantly, these orthograpic sequences are not actually pronounced as consonant clusters, as an independent process of epenthesis breaks up sonorant-fricative clusters in this position (Section 3.6).

(75)   a.   *Do<u>nnch</u>a*   [ˈdu<u>nəx</u>ə]   'Donncha (man's name)'

        b.   *tio<u>nch</u>a*   [ˈt^{j}i<u>nəx</u>ə]   'influence'

        c.   *do<u>rch</u>a*   [ˈdo<u>rəx</u>ə]   'dark'

After taking these secondary issues into account, only one credible instance of a sonorant-[x$^{(j)}$] cluster was located in this corpus: *monarcha* [munərxə] 'factory' and its derivatives (*n* = 3, or about .003% of tokens in the corpus).

By way of comparision, an analogous search for medial onset [s$^{(j)}$] returned roughly 825 results (around .89% of tokens in the corpus; the overall total is approximate, as the results were imperfectly sorted by hand to control for archaic spellings, compounds, English words, and other confounding factors). Many of these results are function words like *anseo* [ən^j.ˈʃo] 'here' (historically two words, cf. *an* 'the' and *seo* 'this'), or contain the contrastive emphatic suffix *-sa* (e.g. *agamsa* [ˈaː.gəm.sə] 'at **me**'), but the list includes a large number of content words as well (e.g. *saoirse* [siːr^j.ʃə] 'freedom'). Even in a small corpus, then, instances of medial onset [s$^{(j)}$] are orders of magnitude more common than medial onset [x$^{(j)}$] (by a factor of 275:1). Furthermore, instances of medial onset [x] are limited to a single lexical item (*monarcha* 'factory') and its morphological derivatives. I conclude from these findings that Irish plausibly shows a statistical dispreference for word-medial onset [x], setting aside the ambiguous case of intervocalic [VxV].

Apart from medial consonant clusters, there is only one other environment where [x] might receive an indisputable onset parse: word-initial position. As it happens, not a single lexical item in Irish begins with underlying /x/ (Ó Siadhail 1991:82 and

many others). While word-initial [x] does occur in the language, it is always the result of initial consonant mutation (see e.g. Green 2006 for related discussion of consonant mutation in the Celtic languages).

(76)   Initial [x] derived by consonant mutation: *c* /k/ → *ch* [x]

     a.   *croí*   [k̠riː]   'heart'
     b.   *mo chroí*   [mə x̠riː]   'my heart'

     c.   *caoin*   [k̠iːnʲ]   'to cry'
     d.   *chaoin*   [x̠iːnʲ]   'cry (past tense)'

More succinctly, word-initial [x] only occurs in morphologically derived environments. I take this fact as a further piece of evidence that onset /x/ is phonologically dispreferred in Irish, though not banned outright (see also Flack 2009 on segment-specific onset restrictions of this sort).[40]

The absence of underlying word-initial /x/ in Irish has clear ramifications for the syllabic affiliation of word-internal, intervocalic /x/. Many researchers have suggested that speakers infer the set of possible word-internal onsets in their language by observing which consonants and clusters may appear in word-initial position (e.g. Pulgram 1970, Kahn 1976, Treiman & Danis 1988, Steriade 1999 and references therein). If this is correct, the absence of lexical items beginning with underlying /x/ could provide an additional bias encouraging speakers of Irish to parse intervocalic [x] as a coda [Vx.V].

Irish is also not the only language in which one might want to assume backwards syllabification of specific consonants in intervocalic environments. English provides another well-known case. No English words begin with the velar nasal [ŋ], and there are no intervocalic [VC.ŋV] clusters in the language that would force an onset parse for [ŋ]. These facts have led many researchers to assume that [ŋ] is not an allowable onset in English. For words like *dinghy* and *hangar*, which contain an intervocalic [ŋ], it is thus reasonable to assume backwards syllabification of the velar nasal: [ˈdɪŋ.i] and [ˈhæŋ.ɝ].

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[40]Irish may not be alone in this regard: Elfner (2005) points out that /x/ is restricted to coda position in Blackfoot, though there are no instances of intervocalic /x/.

Similar facts obtain in Japanese. The segmental inventory of Japanese includes a 'placeless' moraic nasal [N], which is normally restricted to coda position (as determined by the same distributional tests). However, as discussed in Itô & Mester (2003:9-10) and Labrune (2012), there are a handful of words in which the 'placeless' nasal [N] occurs in intervocalic position.

(77) a.   [seNeN] '1000 yen'   (from /seN + eN/)

     b.   [ãNi] 'easy-going'

     Cf.

     c.   [ani] 'older brother'

A plausible analysis of these facts is that Japanese [N], like Irish [x] and English [ŋ], is parsed as a coda even when appearing intervocalically.[41] It would seem, then, that backwards syllabification of positionally-restricted consonants is well-motivated on cross-linguistic grounds. Returning to the main point of this section, it is thus reasonable to assume that [x] in an [axV] string (and perhaps [VxV] more generally) is parsed as a coda [ax.V].

How, then, to formally capture the moraic nature of intervocalic [x]? We cannot simply assume that [x] is always (or preferably) moraic, since not all [Vx] strings manifest the cluster of properties associated with [ax] rhymes.[42] The correct generalization seems to be that the moraic quality of coda [x] is limited to those forms with an underlying /ax/ sequence. For example, Green (1996) and Ó Siadhail (1991) cite the following words, which show that [x] is only stress-attracting when preceded by underlying /a/ (see also (70c)):

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[41] Intervocalic [N] always appears before a morpheme boundary in Japanese (Junko Itô, p.c.). I assume that backwards syllabification of [N] in such contexts is driven by considerations of paradigm uniformity or morphological cyclicity.

[42] It follows from this that if intervocalic [x] is parsed as a coda when the preceding vowel is *not* underlying /a/, it cannot be motivated by moraic structure. At any rate, both myself and Doherty (1991) are making the more restricted claim that intervocalic /x/ is syllabified as a coda only when preceded by /a/.

(78)   Underlying /ax/ attracts stress in MI

    a.   /atʲ + ax/ → [ə.ˈtʲax], *[ˈa.tʲəx]   *aisteach* 'strange'

    b.   /kelʲax/ → [kə.ˈlʲax], *[ˈke.lʲəx]   *coileach* 'rooster'

(79)   Other underlying /Vx/ does not attract stress in MI

    a.   /atʲ + əxt/ → [ˈa.tʲəxt], *[ə.ˈtʲaxt]   *aisteacht* 'strangeness'

    b.   /boxt + əxt/ → [ˈbox.təxt], *[bəx.ˈtaxt]   *bochtacht* 'poverty'

    c.   /kas + əx/ → [ˈka.səx], *[kə.ˈsax]   *casadh* 'one turned'

Underlyingly, the unstressed vowels in second position in (79) could be either /ə/ or some other short vowel, since vowel reduction would give surface [ə] regardless (see Sections 3.5.3.2 and 3.5.4.2). What matters is that these underlying vowels are *not* /a/, and therefore do not attract stress (see also Ó Cuív 1944:66).

To restate the problem, it appears that only /a/ licenses a mora on a following velar fricative [x]. There is good reason to believe that this is a non-accidental fact. In particular, I would like to suggest that Irish [x] is phonologically a *glide-like counterpart* of [a] within the consonantal domain. If this is correct, then [ax] sequences are in fact quasi-diphthongal — a structural analysis that explains why [ax] strings pattern with true diphthongs with respect to stress attraction in Munster Irish and vowel reduction in Ulster Irish.

I have in mind here a parallel between the behavior of [ax] rhymes and the distribution of post-vocalic [ɹ] in various varieties of English. In dialects of English with 'intrusive *r*', the approximant [ɹ] is inserted in hiatus environments whenever the first vowel is one of [ɑ ɔ ə] (e.g. McCarthy 1993 and references therein).

(80)   Intrusive *r* (Gick 1999)

    a.   *ma is*   /mɑː # ɪz/ → [mɑːɹɪz]

    b.   *law is*   /lɔː # ɪz/ → [lɔːɹɪz]

    c.   *coda is*   /kodə # ɪz/ → [kodəɹɪz]

Several authors have pointed out that intrusive [ɹ] seems to be a homorganic, glide counterpart of the non-high back vowels [ɑ ɔ ə] — precisely those vowels that license

its appearance (see e.g. Kahn 1976, Gick 1999, Baković 1999, Itô & Mester 2009).[43] This observation has led many of those same authors to propose that intrusive [ɹ] is not epenthetic in the strictest sense, but rather represents a diphthongization (or breaking) of a vowel in hiatus into a non-hiatal vowel-glide-vowel [VGV] sequence. The choice of [ɹ] as the intrusive segment then follows from the fact that [ɹ] is roughly homorganic with [ɑ ɔ ə], the vowels that provide its source.

The proposed analogy should be clear: the glide counterpart of [a] in English is [ɹ]; in Irish, it is [x].[44] An important piece of evidence in favor of this view has to do with the featural composition of [a] and [x]. While [a] and [x] are clearly featurally distinct, they do share some place features, most notably [ᴅᴏʀsᴀʟ] and [+ʙᴀᴄᴋ]. It has also been claimed that some dialects of Irish realize velarized /x/ as the *uvular* fricative [χ] (e.g. Ring, Breatnach 1947:40-1; Iorras Aithneach, Ó Curnáin 2007:171,408-14; and others). Recent ultrasound imaging by Bennett, McGuire, Ní Chiosáin & Padgett (2012) confirms that /x/ in Conemara Irish is realized with a relatively low constriction, intermediate between a true velar articulation and a more uvular target. It is therefore plausible that Irish /x/ shares the feature [-ʜɪɢʜ] with /a/ as well. There is a very real sense, then, in which [x] and [a] are phonologically homorganic.

For concreteness, I offer the following proposal. Onset /x/ is generally dispreferred in Irish, as evidenced by the fact that word-initial [x] is limited to morphologically derived environments, and by the observation that post-coda onset [x] is statistically underrepresented in the language. In general, the markedness of onset [x] is not sufficient to trigger coda syllabification of intervocalic [x]. However, in an [axV] string, coda syllabification of [x] is permitted because [x] is, phonologically speaking, a glide-like counterpart of [a]. Nuclear [a] therefore licenses (or 'sponsors') a mora on a following, (near-)homorganic [x]; this mora triggers backwards syllabification of [x], thereby satisfying the independent pressure to avoid onset [x].

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[43]As discussed in the works cited in this section, it is also relevant that [ɑ ɔ ə] are the only licit word-final vowels in English that do not already end in a glide, e.g. [o͡w], [i͡j], etc.

[44]Unlike English approximant [ɹ], the Irish [r] is a trill or tap, and [rʲ] something like a weak trill or fricative. Irish [r⁽ʲ⁾] thus lacks the vocalic character of English [ɹ] (though this may be changing under contact with English). While [ɣ] would seem to be a better consonantal counterpart to [a] than [x], [ɣ] has a highly restricted distribution in Irish, and only appears when word-initial /g/ undergoes morphological consonant mutation.

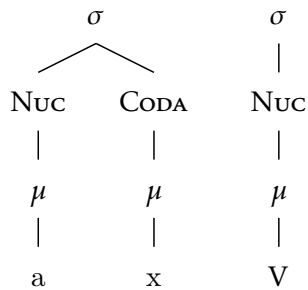(81)   Intervocalic [x]: either an onset or a diphthongal 'offglide'

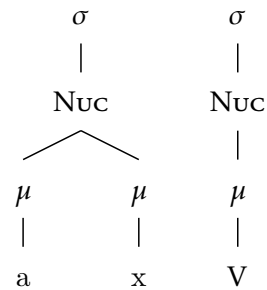   a.   /VxV/ → /V.xV/

   b.   /axV/ → [a͡x$_\mu$.V]

A remaining question concerns the relationship between the homorganicity of [a] and [x] and the licensing of a mora on [x]. It may be the case that intervocalic coda [x] is not a true coda, but rather the second member of a branching nucleus.

(82)   Possible rhyme structures for [ax.V] strings

   a. Coda parse for [x]   b. Nuclear parse for [x]

One reason to favor a nuclear parse (82b) for [x] in an [ax.V] string is that there is independent reason to suspect that branching nuclei (long vowels and diphthongs) count as bimoraic in Irish, while [VC] rhymes do not (see Section 3.5.3.2). The question, then, is why the featural affinity between [a] and [x] licenses a nuclear parse for [x] (Irish does allow non-homorganic diphthongs, e.g. *guagadán* ['ɡu͡ə.ɡa.daːn] 'unsteady thing', Doherty 1991).

   At present, I do not have a satisfying resolution for this problem. One possibility is that [a] and a following [x] literally share a single set of dorsal features (in an autosegmental sense), and that the presence of this shared feature structure encourages a parse in which [a] and [x] occupy the same syllabic subconstituent. However, this cannot be a general principle of syllabification, since many languages (including Irish) allow features to be shared across syllable boundaries (e.g. palatalization agreement in heterosyllabic consonant clusters, Ó Siadhail 1991:83). For the moment, I must leave the relationship between homorganicity and moraic licensing in Irish as a topic for

future research.

One last word is in order regarding the exceptional prominence of [ax] rhymes. I have argued that the phonological prominence of /ax/ sequences can be attributed to the fact that such strings are quasi-diphthongal. This analysis might lead us to expect that other quasi-diphthongal [VC] sequences, such as [uv] and [ij], should behave similarly with respect to stress assignment, vowel reduction, etc. They do not. This contrast in prominence may be related to the high sonority of /a/ relative to other vowels. In phonetic terms, the low vowel /a/ has higher intrinsic duration and overall intensity than non-low vowels (e.g. House 1961, Lehiste 1970, Gordon 1999, Parker 2002). In some languages (e.g. Gujarati), the high sonority of /a/ manifests itself phonologically as 'quality-driven stress': stress is drawn to syllables headed by /a/ (Kenstowicz 1997, de Lacy 2002b, etc.). The obvious connection between these two facts is that high-sonority vowels like [a] are more likely to be interpreted as bearing phonological stress; diachronically, this leads to the development of quality-driven stress systems.

I suspect that something very similar is occurring with /ax/ sequences in Irish. Specifically, the phonetic salience of [ax] sequences might encourage a phonological analysis in which such strings are parsed as a bimoraic rhyme constituent.[45] Furthermore, it is possible (though I am only speculating) that the [a] in an [ax] string may be phonetically half-long [aˑ] when compared to [a] not followed by [x].[46] In other words, [x] may lend some additional phonetic length to a preceding [a], thereby providing

[45]In fact, Ó Sé (2000:46-7) suggests that certain other [aC] strings may also be stress-attracting in the Irish of Corca Dhuibhne (Dingle), e.g. *iomard* [ə.ˈmaɾd] 'reproach, affliction', *réasac* [rʲeː.ˈsak] 'undertow', etc. It is not clear to me whether these examples constitute real cases of phonological stress attraction or simply exceptional, lexicalized stress. For one, some of the examples Ó Sé (2000) provides are loanwords, and some of the [aC] strings in question differ from [ax] rhymes in that they appear to draw stress away from an adjacent long vowel (cf. *réasac*).

[46]This additional half-length might help explain why [ax] counts as more prominent than a simple short vowel, but less prominent than long vowels and true diphthongs, within the stress system of Munster Irish. An interesting connection with this possibility is that Old Irish may have made use of a three-way length distinction in vowels (Thurneysen 1946:31).

Also relevant is the fact that the loss of coda /x/ in some Northern Irish dialects has led to compensatory lengthening of preceding vowels (Ó Dochartaigh 1987). This is consistent with the view that post-vocalic [x] contributes to an increase in the duration of the preceding vowel. See de Chene & Anderson (1979) and Kavitskaya (2002) for discussion of similar diachronic changes in Old English and Turkish.

some phonetic grounds for a bimoraic analysis of [ax] strings.

In this section I have argued that there are robust empirical grounds for assuming 'backwards' syllabification of [x] in an [ax] string, such that [ax] sequences are parsed as a bimoraic rhyme [a$_\mu$x$_\mu$]. The importance of this argument lies in the fact that the plural suffix /-axə/ contains an underlying /ax/ sequence of exactly this sort, as shown in the next section. This observation provides the key to understanding the pattern of Irish plural allomorphy described in Section 3.5.1.

3.5.4.4   *-(e)acha* is underlyingly /-axə/

In Southern and Western dialects of Irish, the plural suffix *-(e)acha* often surfaces as [-əxə], with two reduced vowels.

(83)   Plurals in [-əxə]

    a. *tintreacha*   [t^{j}iːn^{j}t^{j}r^j - əxə]   'fires'

    b. *nóiméadacha*   [nuːm^{j}eːd - əxə]   'moments'

There is nonetheless good evidence that the underlying form of this suffix contains an /ax/ string. As discussed in the preceding sections, two phonological hallmarks of an underlying /ax/ sequence are (i) the lack of unstressed vowel reduction in Ulster Irish, and (ii) stress attraction in Munster Irish. Beginning with the former, we find that the plural suffix *-(e)acha* does indeed remain unreduced in Ulster Irish, surfacing as [-axə] (84) (Ó Siadhail 1991:33; see also O'Rahilly 1932, Ó Dochartaigh 1987).

(84)   No reduction of *-(e)acha* in Ulster Irish

    a. *éanacha*   [ˈe.nax.ə]   'chickens'

    b. *pingineacha*   [ˈp^{j}i.n^{j}ax.ə]   'pennies'   (Doherty 1991:28, Green 1997:78)

Similarly, the first vowel of *-(e)acha* attracts stress in Munster Irish (85); when stressed, this vowel retains its underlying /a/ quality.

(85)   *-(e)acha* attracts stress in Munster Irish

   a.   [sli.ˈʃnʲax.ə] 'chips'

   b.   [spə.ˈlax.ə] 'scythes'

I conclude that there is compelling evidence for assuming that /-axə/ is the underly-
ing form of the plural suffix *-(e)acha*. This suffix thus has the potential to surface with
an exceptionally bimoraic [ax] rhyme, though it frequently appears in its reduced form
[-əxə]. This distinguishes *-(e)acha* /-axə/ from the related contextual allomorph *-(e)anna*
/-ənə/, which contains only reduced, monomoraic underlying vowels. In the follow-
ing section I argue that the stress-sensitive distribution of *-(e)acha* /-axə/ and *-(e)anna*
/-ənə/ follows from the fact that *-(e)anna* /-ənə/ contains an underlying /ax/ string. In
Section 3.5.5.5 I return to some problems posed by the reduction of /-axə/ to [-əxə] in
unstressed positions.

3.5.5   An OT analysis of Irish plural allomorphy

The guiding intuition of this analysis is that /-axə/, which contains the potentially
bimoraic sequence /ax/, cannot attach to a stressed syllable. The reason is simple:
suffixation of /-axə/ to a stressed syllable would create an ill-formed ($'\sigma$ H) trochee,
[$(\text{'}\sigma\text{.ax}_\mu)\text{ə}$].[47] The suffix /-ənə/, found adjacent to stressed syllables, appears only
when needed to avoid such ill-formed feet. This instance of Irish plural allomorphy is
thus output optimizing: the suffix /-ənə/ is chosen exactly when it helps to maximize
the metrical well-formedness of the resulting word.

   Hence, the central premise of the analysis is that this subpattern of Irish plural
allomorphy is non-arbitrary. Nevertheless, certain stipulations about the lexicon are
still necessary. I follow Mascaró (1996, 2007) in assuming that related allomorphs form
a partially-ordered set in the lexicon, with forms at the top of the scale serving as the
preferred realizations of the morpheme in question. In OT, these preference relations

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[47]The intuition behind this analysis could be restated in non-moraic terms, without recourse to back-
wards syllabification of [x]. Assuming that [ax] strings contain a half-long [aˑ] (Section 3.5.4.3), affixation
of /-axə/ to a stressed syllable would derive a foot of the form [$(\text{'}\sigma\text{.aˑ})\text{xə}$]. Provided that half-long vowels
are judged to be too prominent to appear in the weak branch of the foot, the analysis presented here could
be translated unchanged into a duration- or prominence-based equivalent. See also Green (1996).

are enforced by the constraint PRIORITY, which assigns violation marks to output forms in which a morpheme is realized as one of its dispreferred allomorphs.

(86)   PRIORITY (Mascaró 2007):
       Respect lexical priority (ordering) of allomorphs. Given an input containing allomorphs $\{M_1, M_2, \ldots, M_n\}$, and a candidate M_i', where M_i' is in correspondence with M_i, PRIORITY assigns as many violation marks as the depth of ordering between M_i and the highest dominating morph(s).

For Irish plural morphology, we can take /-axə/ to be the preferred allomorph, positing the lexical ordering { -axə > -ənə } between the two plural suffixes. Essentially, this ordering encodes the observation that /-axə/ serves as the 'elsewhere' variant in this case of contextual allomorphy (Section 3.5.2).[48] For expositional purposes, all transcriptions given in this section are representative of Ulster Irish, which does not reduce unstressed [ax] rhymes to [əx]. I return to the question of vowel reduction in Section 3.5.5.5.

(87)   *-(e)acha* as default allomorph

/ taːməl / + {-axə > -ənə}	PRIORITY
a. ☞ (ˈtaː.mə)lax$_\mu$.ə	
b. (ˈtaː.mə)lə.nə	*! W

tamallacha 'distances'

A decisive ranking for this analysis is the ranking between PRIORITY and WSP. Looking at polysyllabic root nouns, we can demonstrate that PRIORITY must dominate WSP:

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[48]Another possibility is that *-(e)anna* is relatively more marked (and thus dispreferred) because it contains a tense sonorant [N] (i.e. [-əNə]). On this view, the distribution of /-axə/ and /-əNə/ would be determined entirely by the relative ranking of markedness constraints. The transcriptions given here ignore tenseness for sonorants, which is indicated in Irish orthography using digraphs (e.g. *nn* in *-(e)anna*).

(88) PRIORITY ≫ WSP

/ uːdər / + {-axə > -ənə}	PRIORITY	WSP
a. ☞ (ˈuː.də)rax$_\mu$.ə		*
b. (ˈuː.də)rə.nə	*! W	L

údaracha - 'authors'

The plural suffix /-axə/ surfaces with a moraic [x$_\mu$], thereby creating a non-initial heavy syllable and giving rise to a WSP violation. This WSP violation could be avoided by selecting the allomorph /-ənə/, as [n] is non-moraic. Since the optimal form appears with the allomorph /-axə/, we can conclude that WSP violations are tolerated in order to avoid the dispreferred allomorph /-ənə/. In other words, PRIORITY outranks WSP.

3.5.5.1 Monosyllabic nouns and WSP$_{FT}$

When we turn to monosyllabic nouns, we immediately encounter a ranking paradox. The ranking PRIORITY ≫ WSP entails that the WSP violations incurred by /-axə/ will always be preferable to realizing the plural suffix as /-ənə/, regardless of the number of syllables in the root noun. Since /-ənə/ does attach to monosyllabic root nouns, the ranking PRIORITY ≫ WSP predicts that certain losing candidates will emerge as optimal:

(89) Monosyllabic root nouns: a ranking paradox

/ klog / + {-axə > -ənə}	PRIORITY	WSP
a. ☺ (ˈklo.gə)nə	*	
b. ☞ (ˈklo.gax$_\mu$)ə		*!

cloganna 'clocks'

The dilemma can be restated more generally: as long as PRIORITY is undominated, nothing compels the appearance of the dispreferred allomorph /-ənə/, in any context. For /-ənə/ to surface, some further phonological considerations, penalizing the selection of /-axə/, must intervene. Specifically, violations of PRIORITY must be driven by some higher-ranked markedness constraint.

One solution would be to posit a variant of WSP that is relativized to foot-internal positions. Any constraint that evaluates foot-internal unstressed heavy syllables as being more ill-formed than unfooted heavy syllables will prefer a candidate like [(ˈklo.gə)nə] (with the non-default allomorph *-(e)anna*) over a default form like [(ˈklo.gax$_\mu$)ə]. Call this constraint WSP$_{\text{Fт}}$:[49]

(90)   WSP$_{\text{Fт}}$:

Assign one violation mark for every heavy syllable in the output that is both unstressed and foot-internal.

WSP$_{\text{Fт}}$ is essentially an OT analog of the 'quantity-sensitivity' parameter of Hayes (1981) and much subsequent work (see Kager 1999, Norris 2010, McCarthy et al. to appear for other uses of WSP$_{\text{Fт}}$). The intuition underlying WSP$_{\text{Fт}}$ is that (ˈσ H) trochees are more ill-formed than (ˈσ L) trochees because (ˈσ H) trochees contain a prominent, heavy syllable in the weak branch of a foot — an extremely non-prominent position (e.g. Gouskova 2003, de Lacy 2004, McCarthy 2008b; see also Section 3.2.2). Similarly, WSP$_{\text{Fт}}$ would also predict (H ˈσ) iambs to be more ill-formed than (L ˈσ) iambs. This is a desirable result: the uneven iamb (L ˈH) is often taken to be the least-marked iambic foot (e.g. Kager 1999:151); and many metrical analyses assume that iambs with unstressed heavy syllables, (H ˈH) and (H ˈL), are not possible feet (e.g. Prince 1991).

Though WSP$_{\text{Fт}}$ may seem ad hoc, there is precedent for metrical markedness constraints that make special reference to foot-internal elements (see Section 3.2 and Chapter 4). McCarthy (2008b), building on work in Gouskova (2003) and de Lacy (2004, 2007), argues that unstressed full vowels within a foot are more highly-marked than unstressed full vowels that remain unfooted. This contrast is formalized with a pair of constraints, *V-Place$_{weak}$ and *V-Place$_{weak-in-foot}$. Like those two constraints, WSP and WSP$_{\text{Fт}}$ stand in a stringency relation: the violation marks assigned by WSP$_{\text{Fт}}$ constitute a proper subset of the violation marks assigned by WSP. With the introduction of WSP$_{\text{Fт}}$, the ranking paradox presented above can be resolved:

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[49]Several readers have suggested that WSP$_{\text{Fт}}$ merely recapitulates the Grouping Harmony constraint of Prince (1991). This is not the case: Grouping Harmony judges (ˈL L) and (ˈH H) trochees to be equally well-formed, while WSP$_{\text{Fт}}$ penalizes the latter.

(91) WSP$_{\text{FT}}$ ≫ PRIORITY ≫ WSP

/ klog / + {-axə > -ənə}	WSP$_{\text{FT}}$	PRIORITY	WSP
a. ☞ ('klo.gə)nə		*	
b. ('klo.gax$_{\mu}$)ə	*! W	L	* W

As long as WSP$_{\text{FT}}$ dominates PRIORITY, the attested candidate will emerge as optimal. Expectedly, we find that WSP$_{\text{FT}}$ transitively dominates WSP. If the ranking were otherwise, the effects of WSP$_{\text{FT}}$ would be obscured by its more general counterpart WSP. Since unstressed [əx$_{\mu}$], but not unstressed [ən], can incur WSP$_{\text{FT}}$ violations, we can already see how the special prominence of /ax/ proves crucial for deriving the correct plural allomorphy pattern. The intuition that [ax] syllables are prohibited from the weak branch of a foot is shared by the analysis of Munster Irish stress developed in Doherty (1991). However, in Doherty (1991) the prohibition against ('σ.ax) feet is simply stipulated; here, it emerges from independently justified constraints on the well-formedness of feet.

Since WSP$_{\text{FT}}$ is freely violated in monomorphemic words of Irish, it must be the case that WSP$_{\text{FT}}$ is dominated by the same metrical markedness constraints that dominate WSP:[50]

(92) {ALLFTLEFT, TROCHEE} ≫ {WSP$_{\text{FT}}$, WSP}

/ gubɑːʃt^{j}ə /	ALLFTLEFT	TROCHEE	WSP$_{\text{FT}}$	WSP
a. ☞ ('gu.bɑː)ʃt^{j}ə			*	*
b. gu('bɑː)ʃt^{j}ə	*! W		L	L
c. (gu.'bɑː)ʃt^{j}ə		*! W	L	L

gabáiste 'cabbage'

An interesting consequence of non-iterative footing in Irish is that there is often no empirical difference between disyllabic and monosyllabic feet. Stress always falls on an initial syllable, regardless of the shape of the initial foot itself. Since footing is non-iterative, nothing about the further metrical structure of Irish words depends on the

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[50]I assume throughout that high-ranked FtBin rules-out candidates containing degenerate monomoraic feet, such as [('gu)bɑː.ʃt^{j}ə].

size of the initial foot. Thus, forms like [ˈkuːm.poːr.tʲəx] are ambiguous as to their footing.

(93)   Ambiguous extent of footing in Irish

/ kuːmpoːrtʲəx /	$\mathcal{H}(\textsc{con})_{\textsc{Irish}}$
a. ?☞ (ˈkuːm)poːr.tʲəx	x
b. ?☞ (ˈkuːm.poːr)tʲəx	y

compoirteach 'comfortable'

In principle, monosyllabic feet could be built to avoid violations of $\textsc{wsp}_{\textsc{Ft}}$ — that is, monosyllabic feet might be preferred to having a heavy syllable in the weak branch of a foot. However, the candidates needed for the crucial comparison are empirically indistinguishable, at least in terms of stress placement:

(94) $\textsc{Parse}(\sigma)$ and $\textsc{wsp}_{\textsc{Ft}}$: no ranking

/ siːlʲaːlʲ /	$\textsc{Parse}(\sigma)$	$\textsc{wsp}_{\textsc{Ft}}$	$\textsc{wsp}$
a. ?☞ (ˈsiː.lʲaːlʲ)		*	*
b. ?☞ (ˈsiː)lʲaːlʲ	*		*

suíleáil 'ceiling'

Though this structural ambiguity suggests that $\textsc{Parse}(\sigma)$ and $\textsc{wsp}_{\textsc{Ft}}$ are not directly rankable, evidence in favor of ranking $\textsc{wsp}_{\textsc{Ft}}$ over $\textsc{Parse}(\sigma)$ is discussed in Section 3.6. At any rate, the effects of $\textsc{wsp}_{\textsc{Ft}}$ can be seen clearly in Irish plural allomorphy. The pressure that $\textsc{Parse}(\sigma)$ exerts on plural allomorph selection is discussed in the next section.

3.5.5.2 $\textsc{Parse}(\sigma)$ and syllabic binarity

The ranking $\textsc{wsp}_{\textsc{Ft}} \gg \textsc{priority} \gg \textsc{wsp}$ accounts for much of the data at hand. However, one vital piece of data remains intransigent under the current analysis: root nouns consisting of a heavy monosyllable are incorrectly predicted to surface with /-axə/:

(95) Heavy monosyllabic root nouns: wrong candidate emerges as optimal

/ dʲrʲɑːm / + {-axə > -ənə}	wsp$_{Ft}$	priority	wsp	FtBin
a. ☺ (ˈdʲrʲɑː.mə)nə		*!		
b. (ˈdʲrʲɑː.max$_\mu$)ə	*!		*	
c. ☞ (ˈdʲrʲɑː)max$_\mu$.ə			*	

dreamanna - 'crowds'

In (95), [(ˈdʲrʲɑː.max$_\mu$)ə] is eliminated by wsp$_{Ft}$; but [(ˈdʲrʲɑː)max$_\mu$.ə], which leaves the offending x$_\mu$ unfooted, wrongly emerges as the most harmonic candidate. Since priority favors candidates bearing the suffix /-axə/, all such candidates must be eliminated by some higher-ranked constraint in order to allow the allomorph /-ənə/ to surface.

The problem lies with the disjunctive formulation of FtBin, which requires feet to be binary under syllabic or moraic analysis. As such, FtBin draws no distinction between a candidate with a disyllabic foot like [(ˈdʲrʲɑː.max$_\mu$)ə], and a candidate with a monosyllabic, bimoraic foot like [(ˈdʲrʲɑː)max$_\mu$.ə]. Without some pressure to build disyllabic feet, nothing ensures that x$_\mu$ will be footed; and if x$_\mu$ remains unfooted, wsp$_{Ft}$ cannot prevent priority from selecting the plural allomorph /-axə/.

Parse(σ), however, *does* favor disyllabic feet. The ranking AllFtL ≫ Parse(σ) restricts Irish words to a single foot; but all else being equal, low-ranked Parse(σ) still exerts pressure to make that single foot disyllabic (see Section 3.5.3.2). So in order to eliminate candidates which sidestep wsp$_{Ft}$ by leaving x$_\mu$ unfooted, Parse(σ) must outrank priority:

(96) parse(σ) ≫ priority

/ dʲrʲɑːm / + {-axə > -ənə}	Parse(σ)	wsp$_{Ft}$	priority	wsp
a. ☞ (ˈdʲrʲɑː.mə)nə	*		*	
b. (ˈdʲrʲɑː.max$_\mu$)ə	*	*! W	L	* W
c. (ˈdʲrʲɑː)max$_\mu$.ə	**! W		L	* W

As (96) shows, high-ranked Parse(σ) compels disyllabic feet to be built whenever possible. The formerly problematic candidate [('dʲrʲɑː)max$_\mu$.ə] is thus eliminated by Parse(σ), as it fails to parse the second syllable, max$_\mu$, into a foot. Note, too, that the losing candidates in (96) are empirically indistinguishable. The crucial observation is that the losing candidates either violate wsp$_{\text{Ft}}$, or violate Parse(σ) to a greater extent than the optimal candidate.

With Parse(σ) dominating priority, we derive the desired distribution of suffixes: /-axə/ will be the preferred allomorph except when [x$_\mu$] could be parsed into a left-aligned, disyllabic foot, violating wsp$_{\text{Ft}}$. Effectively, this ranking prevents /-axə/ from attaching to monosyllables, as the empirical facts demand.

3.5.5.3 Root nouns with exceptional stress

Recall from Section 3.5.1 that /-ənə/ also attaches to polysyllabic nouns with exceptional final stress, such as [də.'gʲrʲiː] → [də.'gʲrʲiː - ənə] 'degree(s)'. I assume that exceptional stress in most varieties of Irish simply corresponds to a non-initial trochaic foot (though see Section 3.8 on Munster Irish).[51]

(97)   Exceptional non-initial stress

/ tər.'naːp /	Trochee	Id(str)	AFL	wsp$_{\text{Ft}}$	Parse(σ)	wsp
a. ☞ tər('naːp)			*		*	
b. (tər.'naːp)	*! W		L		L	
c. ('tər.naːp)		*! W	L	* W	L	* W
d. ('tər)naːp		*! W	L		*	* W

turnapa 'turnip'

[51]Green (1996) suggests that words like *turnapa* [tər('naːp)] have an underlying /ə/ in the initial syllable, which accounts for the lack of initial stress in such forms (given that [ə] is never stressed in Irish, Section 3.5.3.1).

I assume that nouns with 'double stress' like *meaisín* ['mʲæː.'ʃiːnʲ] are either inaccurately transcribed (cf. Hickey 1985b), or have been reanalyzed as a kind of pseudo-compound consisting of two distinct prosodic words (cf. Table 3.3).

The fact that such nouns pluralize with /-ənə/ rather than /-axə/ then follows directly: since post-tonic syllables are parsed as the weak member of a trochee whenever possible, /-axə/ will be dispreferred in post-tonic position whether or not the stressed syllable is word-initial.

(98) Polysllabic nouns with irregular final stress pluralize with /-ənə/

/ də.ˈgriː / + {-axə > -ənə}	Troch	AFL	wsp_Ft	Parse(σ)	priority	wsp
a. ☞ də.(ˈgʲrʲiː.ə)nə		*		**	*	
b. də(ˈgʲrʲiː.ax_μ)ə		*	*! W	**	L	* W
c. (də.ˈgʲrʲiː)ax_μ.ə	*! W	L		**	L	* W

3.5.5.4 Accounting for lexical exceptions

Some monosyllabic noun roots do irregularly take the plural suffix /-axə/ (99).

(99) a. *áit* [ˈɑːtʲ] → *áiteacha* [ˈɑːtʲ - əxə] 'place(s)'
    b. *éan* [ˈeːn] → *éanacha* [ˈeːn - əxə] 'bird(s)'
    c. *tír* [ˈtʲiːrʲ] → *tíreacha* [ˈtʲiːrʲ - əxə] 'land(s)'

In Section 3.5.1 it was also pointed out that there are no polysyllabic root nouns, with non-final stress, that take the suffix /-ənə/. On the current analysis, this falls out straightforwardly from the ordering of allomorphs enforced by priority:

(100)

/ CVCV / + {-axə > -ənə}	Parse(σ)	wsp_Ft	priority	wsp
a. ☞ (ˈCV.CV)ax_μ.ə	**			*
b. (ˈCV.CV)ə.nə	**		*! W	L

In effect, priority serves to restrict /-ənə/ to post-tonic position. Note that re-ranking wsp over priority would give a system in which /-axə/ never appears (because of wsp), rather than a system in which /-ənə/ exceptionally attaches only to some polysyllabic root nouns. The use of priority thus derives a principled connection between the

restricted surface distribution of *-(e)anna* and the lack of lexical exceptions to that distribution.

What about the monosyllabic nouns that irregularly appear with /-axə/? There are at least two ways to account for such exceptional forms. One approach is to assume that different lexical items may be associated with different cophonologies in Irish, expressed as lexically-specific rankings of PRIORITY and WSP$_{Ft}$. Lexically exceptional monosyllabic nouns would then belong to a cophonology in which PRIORITY dominates WSP$_{Ft}$.

(101)　　Lexically exceptional /-axə/ suffixation: PRIORITY ≫ WSP$_{Ft}$

/ eːn / + {-axə > -ənə}	PARSE(σ)	PRIORITY	WSP$_{Ft}$	WSP
a. ☞ (ˈeː.nax$_\mu$)ə	*		*	*
b.　(ˈeː.nə)nə	*	*! W	L	L

éanacha 'birds'

For input forms subject to the ranking PRIORITY ≫ WSP$_{Ft}$, the optimal candidate is correctly predicted to surface with the suffix /-axə/. On such an approach, PRIORITY still ensures that no polysyllabic root noun (with non-final stress) will surface with the suffix /-ənə/:

(102)　　No lexical exceptions involving /-ənə/ (independent of cophonology)

/ CVCV / + {-axə > -ənə}	PARSE(σ)	PRIORITY	WSP$_{Ft}$	WSP
a. ☞ (ˈCV.CV)ax$_\mu$.ə	**			*
b.　(ˈCV.CV)ə.nə	**	*! W		L

éanacha 'birds'

More or less equivalently, we could assume that a version of PRIORITY indexed to particular nouns or a lexical stratum, called PRIORITY$_L$, dominates WSP$_{Ft}$ (e.g. Pater 2000 and subsequent work in that vein).

(103)   Lexically exceptional /-axə/ suffixation: PRIORITY_L ≫ WSP_FT

/ eːn_L / + {-axə > -ənə}	PARSE(σ)	PRIORITY_L	WSP_FT	PRIORITY	WSP
a. ☞ (ˈeː.nax_μ)ə_L	*		*		*
b. (ˈeː.nə)nə_L	*	*! W	L	* W	L

éanacha 'birds'

I will not adjudicate between these approaches here, though see Inkelas & Zoll (2007) for discussion of some differences between the two types of analysis. The general point to be made here is that an account of plural allomorphy in terms of PRIORITY derives all and only the attested lexical exceptions to the basic distributions of *-(e)anna* and *-(e)acha*.

3.5.5.5   Opacity and dialect variation

In Section 3.5.4 I argued that post-vocalic [x] counts as moraic just in case the preceding vowel is [a]. Together with the assumption that post-tonic [ax] is parsed as the dependent member of a prosodically marked (ˈσ H) foot, this claim was leveraged to account for stress-sensitive allomorphic variation between the plural suffixes *-(e)anna* /-ənə/ and *-(e)acha* /-axə/. In Ulster Irish, where unstressed /ax/ is generally realized as surface [ax], the prosodic motivations driving allomorph selection are perfectly transparent. However, other varieties of Irish introduce an important complicating factor. In most dialects spoken in Conemara and Munster, underlying /-axə/ surfaces as [-əxə] rather than [-axə] when unstressed. This instance of vowel reduction is just one example of a more general process, found in all dialects, that converts unstressed short vowels to placeless [ə] (or [ɪ], depending on consonantal context). In some surface forms containing *-(e)acha*, then, there is no [ax] sequence, and thus no motivation for assigning a mora to the intervocalic [x] in *-(e)acha* [-əxə].

This pattern of vowel reduction presents a problem for the analysis of plural allomorphy propounded here. If a reduced form like [-ə.xə] is prefered to its unreduced counterpart [-ax_μ.ə] for reasons of vowel licensing, then nothing prevents reduced [-ə.xə] (which lacks a moraic [x_μ]) from attaching to monosyllabic nouns: / CVC + {-axə > -ənə} / → [(ˈCV.Cəx)ə]. (For convenience I assume that the constraint driving

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the reduction of unstressed short vowels is McCarthy's 2008b *V-Place$_{weak}$, though nothing much depends on this decision.)

(104)   Vowel reduction wrongly preempts allomorph selection

/ klog / + {-axə > -ənə}	*V-Place$_{weak}$	Parse(σ)	wsp$_{FT}$	priority	wsp
a. ☞ (ˈklo.gə̲)xə		*			
b. (ˈklo.ga̲x$_\mu$)ə	*! W	*	* W		* W
c. ☹ (ˈklo.gə)nə		*		* W	

It seems that surface vowel reduction should incorrectly circumvent the selection of the non-default allomorph /-ənə/. The result of this interaction is an apparent case of derivational opacity in the morpho-phonological domain. This observation is consistent with the finding of Paster (2006:143) that, cross-linguistically, prosodically conditioned suppletive allomorphy is "sensitive to input elements, not surface elements". For example, the Turkish 3rd person possessive suffix is realized as /-i/ following a consonant. However, a regular process deleting intervocalic /k/ renders the selection of /-i/ opaque (105) (Paster 2006:99).

(105)   Turkish 3rd person possessive allomorphy: /-i/ ~ /-si/

   a.   [fire] 'attrition' → [fire - si] 'its attrition' (*[fire - i])
   b.   [bedel] 'price' → [bedel - i] 'its price' (*[bedel - si])

   c.   [ekmek] 'bread' → [ekme - i] 'its bread' (*[ekmek - i], *[ekme - si])

Both Turkish possessive allomorphy and Irish plural allomorphy are phonologically conditioned, and seem sensitive to the avoidance of marked structures (hiatus/codas and unstressed, footed heavy syllables, respectively). However, neither process is 'output optimizing' in the strictest sense, since the motivation behind allomorph selection is masked by the application of subsequent phonological processes (velar deletion in Turkish, and vowel reduction in Irish). The problem is especially acute for the Western dialects of Irish, since (unlike Munster and Ulster Irish) there is apparently no empirical evidence in Conemara Irish that the plural suffix *-(e)acha* is underlyingly /-axə/

rather than simply /-əxə/ (I will return to the problem of dialect variation shortly).

There are a number of more-or-less satsifactory ways to address this opacity problem. First, one could assume that all underlying /ax/ sequences contain a pre-specified moraic /x_μ/. Vowel reduction, then, would have no bearing on the fact that *-(e)acha* /-ax_μə/ is avoided in post-tonic position: since [ax_μ] and [$əx_\mu$] are equally bimoraic, [('σ.ax_μ)] and [('σ.$əx_\mu$)] are equally ill-formed feet. The problem with this approach is that it is difficult to motivate on principled grounds. It is far from clear what principle of grammar could guarantee that all and only those velar fricatives following /a/ are specified as moraic in underlying representations. This is especially true within the confines of Optimality Theory, given that OT is formally incapable of stating language-specific constraints on underlying representations (RICHNESS OF THE BASE, Prince & Smolensky 1993/2004). One could imagine a diachronic explanation for why moraic /x_μ/ might be limited to post-/a/ position: as touched on in Section 3.5.4, the surface phonetics of [ax] strings *vis-a-vis* other [Vx] sequences could motivate the learner to postulate an underlying [ax_μ] structure. Even this solution is not without its problems, as it predicts (probably incorrectly) that novel [ax] sequences (e.g. in loanwords) should be treated as light [a.x] rather than heavy [ax_μ]. Nevertheless, assuming the underlying representation /-ax_μə/ for *-(e)acha* would clearly alleviate the opacity problem at hand.

A second, perhaps more palatable solution is to locate vowel reduction in the post-lexical component of Irish phonology. On this view of the phonological architecture of Irish, vowel reduction is *intrinsically ordered* after allomorph selection, given that word formation necessarily occurs in the earlier lexical component of the grammar. These assumptions lead to quasi-serial derivations like (106), in which post-lexical vowel reduction obscures the conditions governing plural allomorph selection in the lexical stratum.

(106)   The serial/stratal interaction of allomorph selection and vowel reduction

		Lexical phonology (Allomorph selection)	Post-lexical phonology (V reduction)	[sr]
	/ur/			
a.	/σσ + Pl/	⟶	ˈσσ-ax$_\mu$.ə	⟶

The last two columns for (a): ˈσσ-ax$_\mu$.ə   ⟶   [ˈσσ-əx$_\mu$.ə]

Analogous interactions between lexical and post-lexical phonology obtain in English. Kaisse & Shaw (1985) argue that allophonic flapping of intervocalic coronal stops in English is a post-lexical process. Evidence for this view comes from the fact that flapping applies across word-boundaries, e.g. *sit in the park* [sɪɾ # ɪn # ðə # pɑɹk]. Post-lexical flapping renders other lexical processes opaque. For example, in all varieties of American English that I am aware of, vowel length (or height) is sensitive to the voicing of following stops. This leads to opaque interactions like (107), in which post-lexical flapping masks the underlying voicing distinctions that condition surface vowel allophony.

(107)   Post-lexical opacity in American English stop allophony

	/ur/	Lexical phonology (V allophony)	Post-lexical phonology (flapping)	[sr]
a.	*writer* /ɹaɪ̯tɝ/	⟶ ɹaɪ̯tɝ	⟶	[ɹaɪ̯ɾɝ]
b.	*rider* /ɹaɪ̯dɝ/	⟶ ɹaɪ̯·dɝ	⟶	[ɹaɪ̯·ɾɝ]

There is some empirical evidence that supports a post-lexical treatment of vowel reduction in Irish. In Munster Irish, nouns like *cipín* [kʲəˈpʲiːnʲ] 'stick', which have an [L H] weight profile, normally bear stress on the second syllable. Since the initial short vowel is unstressed, it reduces to placeless [ə] ~ [ɪ] (see also Section 3.8.2). In sentential contexts, however, stress placement is sensitive to clash avoidance — the Irish equivalent of the Germanic 'rhythm rule' (e.g. Hayes 1984). Specifically, when nouns with an [L ˈH] profile are followed by a post-nominal modifier with initial stress, stress

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retracts one syllable, e.g. *cipín dearg* [ˈkʲi.pʲiːnʲ # ˈdʲa.rəg] 'small red stick' (Ó Siadhail 1991:31-2; see also Ó Cuív 1944:67, Ó Sé 2000:52-4, Ó Buachalla 2003:2, etc.).

(108)   a.   *putóig* [pə.ˈtoːgʲ] 'pudding, sausage'

        b.   *muice* [ˈmi.kʲə] 'pig (genitive singular)'

        c.   *an putóig muice* [ə # ˈfu.toːgʲ # ˈvi.kʲə] 'the pork sausage'

                                                                 (Breatnach 1947:112)

(109)   a.   *corcán* [kər.ˈkɑːn] 'pot'

        b.   *mór* [muːər] 'big'

        c.   *an corcán mór* [əŋ # ˈkor.kɑːn # ˈmuːər] 'the big pot'   (Ó Sé 2000:53,92)

(110)   a.   *portach* [pər.ˈtax] 'bog'

        b.   *móna* [ˈmuː.nə] 'peat (genitive singular)'

        c.   *i bportach móna* [ə # ˈbor.tax # ˈmuː.nə] 'in a peat bog'

                                                               (Ó Sé 2000:27,53)

The crucial observation about this pattern of stress shift concerns the quality of the newly stressed vowel. Vowel reduction eliminates all place features from unstressed short vowels; as such, it destroys the otherwise unpredictable information about contrastive vowel quality that is present in underlying representations like *corcán* /k̠orkɑːn/. Post-lexical stress shift, on the other hand, allows the underlying quality of such short vowels to surface unchanged, e.g. *corcán mór* /k̠orkɑːn # muːər/ → [ˈk̠or.kɑːn # ˈmuːər].

If vowel reduction were a lexical process, it would have to precede phrase-level stress shift, which necessarily applies at the post-lexical stratum. This cannot be the case: lexical vowel reduction would neutralize all underlying vowel qualities to [ə]/[ɪ], making it impossible for the underlying quality of unstressed short vowels to be recovered under post-lexical stress shift.

(111)   Vowel reduction does not precede post-lexical stress shift

$$/\text{k\underline{o}rkɑːn \# muːər}/ \quad \xrightarrow[\text{V reduction}]{} \quad \text{k\underline{ə}r.'kɑːn} \dots \quad \xrightarrow[\text{stress shift}]{} \quad \left\{ \begin{array}{c} *[\text{ k\underline{ə}r.'kɑːn} \dots] \\ *[\text{ 'k\underline{ə}r.kɑːn} \dots] \\ *[\text{ 'k\underline{u}r.kɑːn} \dots] \\ *[\text{ 'k\underline{i}r.kɑːn} \dots] \\ \text{etc.} \end{array} \right\}$$

If vowel reduction must follow post-lexical stress shift, that ordering restriction obviously entails that vowel reduction must be post-lexical as well. If this conclusion is correct, then plural allomorph selection is both phonologically transparent and output-optimizing at the lexical level, even if post-lexical vowel reduction leads to surface opacity down the road.

A third approach to the opaque interaction of allomorph selection and vowel reduction is provided by the theory of Optimal Interleaving (Wolf 2008). Optimal Interleaving (OI) is a derivational variant of OT, inspired by OT with candidate chains (OT-CC; McCarthy 2007), which aims to model serial interactions between morphology and phonology in an optimization-based framework. Morpheme insertion and phonological processes are freely ordered in OI (though specific pairwise-orderings may be enforced between particular phonological processes and the insertion of particular morphs). For our purposes, the most important property of OI is the assumption of GRADUALNESS: only one morphological or phonological operation may apply at any given stage of a derivation. As a consequence of GRADUALNESS, the insertion of morpheme M_x must necessarily occur *before* any phonological process may target M_x (see Wolf 2008:Ch.3). There is thus an intrinsic, serial ordering between phonologically-conditioned allomorph selection and any phonological processes that might render such allomorphy opaque. In the case of Irish plural allomorphy, it follows that the choice of plural suffix must occur before vowel reduction, which obscures the phonological motivation for selecting /-ɑxə/ or /-ənə/ as the exponent of plurality. Like the stratal account of Irish plural allomorphy sketched above, OI straightforwardly expresses the insight that plural allomorph selection is optimizing at an early derivational stage, despite the fact that subsequent vowel reduction may lead to surface opacity.

There are thus several empirically and theoretically plausible strategies for coping with opaque interactions between plural allomorph selection and vowel reduction in Irish. To reiterate, the opacity problem does not occur in Ulster Irish, since underlying /-axə/ is always faithfully realized as unreduced [-axə] in surface forms. In Munster Irish, the interaction between plural allomorphy and vowel reduction is indeed opaque, but stress assignment (and the realization of /-axə/ under stress as [-áxə]) confirm that the plural suffix -(e)acha contains an underlying /ax/ string. Things are not so clear-cut for Conemara Irish, the third of the major dialect groups. To the best of my knowledge, in these varieties of Irish the plural suffix -(e)acha always surfaces as reduced [-əxə]. Consequently, apart from plural allmorph selection itself, there may be no empirical reason to assume that the plural suffix -(e)acha has the underlying representation /-axə/ for in Conemara Irish.

It should be obvious that this conclusion precludes the possibility that allomorphic alternations between /-axə/ and /-ənə/ are actually optimizing in this dialect. If -(e)acha is underlyingly /-əxə/ (with a non-moraic [x]), then the stress-conditioned distribution of -(e)acha and -(e)anna must be phonologically arbitrary. I am perfectly willing to accept this fact. Many regularities in Irish plural affixation are phonologically and morphologically arbitrary (see Section 3.5). Furthermore, it does not follow from this conclusion that alternations between /-axə/ and /-ənə/ are phonologically arbitrary in *all* dialects. Indeed, the reduction of unstressed /ax/ to [əx] is an innovative feature of Conemara and Munster Irish; in the Western dialect group, where all trace of underlying /a/ has disappeared from the plural suffix -(e)acha, the non-optimizing character of this case of plural allomorphy is an innovative feature as well.[52]

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[52]Paster (2006) and Embick (2010) argue that the existence of non-optimizing phonologically-conditioned allomorphy constitutes an argument against modeling *any* patterns of allomorphy as being optimizing in character. I disagree. To my mind, it is an empirical question whether any single pattern of allomorphy should be modeled as output-optimizing, and not one that can be settled by theoretical parsimony alone. Furthermore, it is incumbent on these alternative theories to account for the fact that some patterns of allomorphy do appear to be optimizing in nature. This task has often been approached by attributing the appearance of synchronic optimization to properties of historical change — a strategy that I happen to believe does not work for the pattern of Irish plural allomorphy under consideration here. Since the focus of the present discussion is on evidence for foot structure in Irish, I will not engage these issues further here.

To summarize:

(112)   Dialect variation in conditions on /-axə/ ~ /-ənə/ allomorphy

    a.   Northern dialects (Ulster Irish):

      (i)   No reduction of unstressed /ax/

      (ii) Plural allomorphy is always transparently motivated

    b.   Southern dialects (Munster Irish):

      (i)   Reduction of unstressed /ax/ to [əx] (possibly post-lexical)

      (ii) Motivations for plural allomorphy are rendered opaque by vowel reduction

    c.   Western dialects (Conemara Irish):

      (i)   No evidence that plural suffix *-(e)acha* is underlyingly /-axə/ rather than /-əxə/

      (ii) Plural allomorphy may not be optimizing in character

The upshot of the preceding discussion is that once dialect variation and opacity are controlled for, this pattern of plural allomorphy constitutes a solid argument for the presence of foot structure in Irish phonology. From a practical standpoint, this section also illustrates the point that the detection of foot structure in languages with edge-based stress requires moving beyond the stress system itself, into more detailed, holistic properties of the phonology and morphology of the language.

3.5.5.6   Consequences

In the preceding sections, I have argued that a subpattern of Irish plural allomorphy, involving the suffixes *-(e)anna* and *-(e)acha*, can be analyzed as emerging from the interaction of fairly uncontroversial constraints on metrical structure. Taken together, the constraints wsp$_{\text{Ft}}$ and Parse(σ) serve to penalize [$'\sigma$ H] sequences. Irish plural allomorphy avoids such ill-formed structures by creating [$'\sigma$ L] sequences whenever possible.

However, Irish does tolerate [$'$L H] and [$'$H H] sequences in monomorphemic

words:

(113)   a.   *ciseán*   [ˈkʲiʃ.ɑːn]   'basket'   [$_\omega$ ˈ(L H)]

        b.   *comrádí*   [ˈkum.rɑː.diː]   'friend'   [$_\omega$ ˈ(L H) H]

        c.   *rúnaí*   [ˈruː.niː]   'secretary'   [$_\omega$ ˈ(H) H]

As discussed above, the foot structure of such examples is ambiguous. The footing [(ˈσ H)] violates wsp$_{F\text{T}}$, while the footing [(ˈσ) H] violates Parse(σ). Of course, given the impoverished foot structure of Irish words, the two footings are empirically indistinguishable: either way, stress will fall on the initial syllable.

Parse(σ) and wsp$_{F\text{T}}$ are thus dormant in the language at large: the pressures that they exert are too weak to affect the shape of most words.[53] However, the effects of Parse(σ) and wsp$_{F\text{T}}$ become visible in plural allomorphy. The plural suffix /-axə/ is avoided precisely when it would lead to a [ˈσ H] sequence. In such cases, the plural suffix /-ənə/ surfaces instead, creating a (ˈσ L) foot, and thereby satisfying both Parse(σ) and wsp$_{F\text{T}}$. This case of Irish plural allomorphy is therefore output-optimizing, in that allomorph selection aims at minimizing the overall markedness of output forms (at least at the lexical level). This conclusion holds regardless of the relative ranking of Parse(σ) and wsp$_{F\text{T}}$ — a welcome result, since those two constraints cannot be directly ranked on the basis of evidence from stress placement.

Irish plural allomorphy thus constitutes an interesting case of the emergence of the unmarked in the metrical domain Mascaró (1996, 2007). As just noted, the effects of Parse(σ) and wsp$_{F\text{T}}$, which are normally obscured by other constraints on metrical structure, become evident in plural allomorph selection. A crucial piece of this analysis is the fact that *-(e)anna* and *-(e)acha* are allomorphs of a single underlying morpheme: when the phonology of Irish has a choice between two allomorphs, it selects the allomorph that leads to an optimal prosodic structure. In contrast, other plural suffixes, which have only a single surface form, often give rise to ill-formed

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[53]wsp$_{F\text{T}}$ (or at least wsp) may in fact affect the dialect-specific shape of some monomorphemic words. The word *inín* [ˈi.nʲiːnʲ] 'daughter', which has an [ˈL H] syllabic profile, is realized as *níon* [ˈnʲiːn], with an [ˈH] profile, in Donegal. In Connacht, a more widespread process of initial short vowel deletion similarly converts initial [L H...] sequences into [H...] sequences, e.g. *arán* - [ˈa.rɑːn] → [rɑːn] 'bread' (Ó Siadhail 1991:33,165).

['σ H] sequences:

(114) a. *múr* ['muːr] → *múraíl* ['muːr - iːlʲ] 'shower(s)' ['H H]

      b. *rud* ['rud] → *rudaí* ['rud - iː] 'thing(s)' ['L H]

Nevertheless, wsp$_{\text{Ft}}$ and Parse(σ) may bear on the realization of other plural suffixes. In the dialect spoken in Donegal, monosyllabic nouns often appear with the plural suffix *-a/e* /ə/, while polysyllabic nouns often appear with *-(a)í* /iː/ (Ó Siadhail 1991:141). This closely resembles the distribution of /-ənə/ and /-axə/: the long vowel suffix *-(a)í* /iː/ is avoided in exactly those cases in which it would create a dispreferred ['σ H] sequence.

The analysis developed here thus succeeds in integrating a corner of Irish plural morphology into the broader morphophonology of the language. Such an approach has two desirable consequences. First, it makes clear that the alternation /-ənə/ ∼ /-axə/ is non-arbitrary: it emerges from the independent prominence of /ax/ sequences, and the regular metrical structure of Irish. Secondly, this analysis goes some distance toward explaining why this particular alternation is conditioned by stress, rather than by some other factor, such as the segmental content of the root noun. Further, this analysis implicitly predicts that other possible allomorphy patterns — say, hypothetical /-ənə/ ∼ /-əfə/ — should not be conditioned by stress, unless heavy [ax] or [VV] syllables are involved. As far as I know, this prediction is borne out for Irish.

Irish plural allomorphy thus demonstrates that syllable weight can have visible morphophonological effects even in languages with quantity-insensitive stress placement. In other words, a quantity-insensitive stress system doesn't entail a quantity-insensitive language.[54] Along these same lines, in the following section I claim that a purely phonological process of epenthesis in Irish is sensitive to syllable quantity, and specifically to the influence of wsp$_{\text{Ft}}$.

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[54]The fact that quantity-insensitive stress placement need not entail a quantity-insensitive *language* has, of course, been noted in previous literature (e.g. Kager 1992, 1993b).

3.6 More on wsp$_{F_T}$: sonority-driven epenthesis

While wsp$_{F_T}$ plays a decisive role in Irish plural allomorphy, its effects are not limited to the morphological domain. Indeed, despite the fact that wsp$_{F_T}$ is inactive for determining stress placement in Irish, it remains crucially active in a phonological process of epenthesis. Taking up the account of epenthesis developed in Ní Chiosáin (1999, 2000), I show that wsp$_{F_T}$ eliminates problematic candidates that are otherwise wrongly predicted to surface as optimal under Ní Chiosáin's analysis. In all dialects of Irish, consonant clusters [C$_1$ C$_2$] are split by [ə] epenthesis, provided that C$_1$ is a sonorant, and C$_2$ is a non-homorganic sonorant, fricative, or voiced stop (i.e. anything but a voiceless stop, Ní Chiosáin 1999, 2000). This pattern of epenthesis is thus sonority-driven: it enforces a minimal sonority distance between a sonorant consonant and a following consonant, with only [sonorant + voiceless stop] clusters permitted. The relevant forms are monomorphemic, and do not belong to any particular syntactic category. Though these epenthetic forms do not exhibit any synchronic alternations, Ní Chiosáin (1999, 2000) provides arguments for treating sonority-driven epenthesis as a synchronically live pattern. Note too that the [C$_1$əC$_2$] sequences in question are represented as clusters in the orthography, as indicated in (115) below.

As discussed by Ní Chiosáin (1999, 2000), sonority-driven epenthesis only occurs in clusters that follow an initial stressed vowel:

Input	Output	Example	Cluster	Orthographically
L	LL	ˈgo.<u>rəm</u>	-rm#	*go<u>rm</u>* 'blue'
LL	LLL	ˈda.<u>lə.b</u>ə	-lb-	*da<u>lb</u>a* 'bold'
LH	LLH	ˈa.<u>n^{j}ə.v^j</u>iː	-n^{j}v^j-	*ain<u>mh</u>í* 'animal'
LHL	LLHL	ˈʃa.<u>rə.vo</u>ːn.tə	-rv-	*sear<u>bh</u>ónta* 'servant'

Table 3.5: Epenthesizing forms (Ní Chiosáin 1999, 2000)

Epenthesis never occurs following an unstressed vowel, e.g. *scolgarnach* [ˈskol.gə<u>r.n</u>əx], *[ˈskol.gə.<u>rə.n</u>əx] 'cackle'.

Ní Chiosáin notes another prosodic restriction on epenthesis, namely that "epenthe-

sis does not occur in words containing a non-final bimoraic foot at the left edge"
(2000:8). This restriction amounts to the observation that epenthesis does not occur
in words beginning with an [LLσ] or [Hσ] syllable sequence.

Input	Output	Example	Cluster	Orthographically
LLL	LLL	ˈskol.gər.nəx	-lg-	*scolgarnach* 'cackle'
LLH	LLH	ˈpur.gə.doːr	-rg-	*purgadóir* 'purgatory'
LLHL	LLHL	ˈkarʲ.mʲi.lʲiː.tʲəx	-rm-	*cairmilíteach* 'Carmelite'
HL	HL	ˈlʲeːr.gəs	-rg-	*léargas* 'insight'

Table 3.6: Non-epenthesizing forms (Ní Chiosáin 1999, 2000)

In part, this description is intended to capture the generalization in Ó Siadhail (1991)
and Ní Chiosáin (1999, 2000) that sonority-driven epenthesis never occurs following a
long vowel. However, this generalization may be spurious, as a small number of forms
do show [ə] epenthesis of the relevant type in clusters following a stressed initial long
vowel:[55]

(115)   Sonority-driven epenthesis following a long vowel

    a. *mairg*   [ˈmaː.rʲəgʲ]   'regret'   [HL]

    b. *Gearmáin*   [ˈgʲæː.rə.mɑːnʲ] 'Germany'   [HLH]

                                                           (Ó Siadhail 1995:102)

In contrast with non-epenthesizing /HL/ forms like [ˈlʲeːr.gəs], Ó Siadhail (1995) gives
several examples of /HL/ forms that do show epenthesis:

(116)   Epenthesizing /HL/ → [HLL] forms

    a. *dearmad* [ˈdʲæː.rʲə.məd] 'mistake'   [HLL]

    b. *margadh* [ˈmaː.rə.gə] 'market'   [HLL]

                                                 (Ó Siadhail 1995:128,163)

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[55]Ó Siadhail (1995:66) gives the derived noun *Gearmáinis* [ˈgʲæː.rə.mɑː.nʲəʃ] 'German language'.
Since Ní Chiosáin (1999, 2000) claims that epenthetic vowels are retained in derived forms, I infer here
that the stem *Gearmáin* [ˈgʲæː.rə.mɑːnʲ] 'Germany' also contains an epenthetic [ə].

The status of these examples is unclear, as Ó Siadhail (1991) and Ní Chiosáin (1999, 2000) cite the same forms with short vowels, ['dʲa.rə.məd] and ['ma.rə.gə]. This may be a dialect distinction: the forms in Ó Siadhail (1995) are representative of the Cois Fharraige dialect, which shows lengthening of vowels before historically tense sonorants (Ó Siadhail 1991:49). Given the uncertainty surrounding these examples, I leave them aside in this discussion.[56]

To restate the basic generalization, epenthesis occurs in [L], [Lσ], and [H] words, but not in [Hσ] and [LLσ] words. The core intuition of Ní Chiosáin's analysis is that epenthesis is blocked in [Hσ] and [LLσ] forms because it fails to improve the overall metrical structure of the word. Epenthesis is licensed whenever the input form would otherwise be prosodified with a non-binary foot [('L)], or with a word-final foot [('H)] or [('Lσ)]. The application of epenthesis in such words leads to better metrical well-formedness by deriving either a binary or non-final foot (satisfying FtBin and NonFinality(Ft) respectively).

(117)   Epenthesis applies when it improves FOOT BINARITY

   a.   Degenerate foot without epenthesis: ('gorm)   ('L)

   b.   Binary foot after epenthesis: ('go.rə̲m)   ('L L̲)

(118)   Epenthesis applies when it improves FOOT NON-FINALITY

   a.   Word-final foot without epenthesis: ('dal.bə)   ('L L)#

   b.   Non-final foot after epenthesis: ('da.lə̲)bə   ('L L̲)L#

These two prosodic conditions can already be satisfied without epenthesis in [Hσ] and [LLσ] words. Furthermore, epenthesis in in [Hσ] and [LLσ] words would increase the number of unparsed syllables, leading to a more degraded prosodic structure.

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[56]The analysis in Ní Chiosáin (1999, 2000) actually does predict that epenthesis should occur after the long vowel in monosyllabic forms like *mairg* /maːrʲgʲ/ → ['maː.rʲəgʲ]. The non-epenthetic form [('maːrʲgʲ)] violates NonFinality(Ft) and *RG, and thus loses to the epenthetic candidate [('maː)rʲəgʲ], which violates lower-ranked Parse(σ) and DEP.

(119)   Epenthesis blocked in /LLL…/ words

    a.   /skolgərnəx/ → (ˈskol.gər)nəx 'cackle'   (ˈL L)L#

    b.   *(ˈsko.lə̱)gər.nəx   (ˈL Ḻ)L L#

As a result, epenthesis is not licensed in such forms, and offending [sonorant + C_2] clusters are simply left unrepaired. (Note that epenthesis also applies in [LHL] words, a fact I will return to shortly.) While the actual mechanics of Ní Chiosáin's analysis are more complicated than this brief description suggests, the fact that epenthesis is sensitive to stress, vowel length, and syllable count is nonetheless a good indication that foot structure is somehow relevant.

    Ní Chiosáin (1999, 2000) gives an optimality theoretic account of sonority-driven epenthesis, which is slightly expanded in Green (1997) (the chronological discrepancy is due to the fact that Ní Chiosáin's analysis circulated in manuscript and handout form prior to Green's work). The constraint ranking that Ní Chiosáin arrives at is repeated in (120).[57]

(120)   ALLFOOTLEFT ≫ NONFINALITY(FT) ≫ PARSE(σ) ≫ *RG ≫ DEP

NONFINALITY(FT) penalizes outputs that contain word-final feet (see Chapter 2), while *RG is violated by candidates that contain illicit [sonorant + C_2] clusters.

    Consider how epenthetic forms arise under Ní Chiosáin's analysis:

(121)   Epenthetic form: /dalbə/ → [ˈda.lə.bə]   /LL/ → [LLL]

/ dalba /	ALLFTL	NONFIN(FT)	PARSE(σ)	*RG	DEP
a. ☞ (ˈda.lə)bə			*		*
b. (ˈdal.bə)		*! W	L	* W	L
c. (ˈdal)bə			*	*! W	L

dalba 'bold'

---

[57]Contrary to the ranking in (119), Ní Chiosáin (1999, 2000) actually argues that NONFINALITY(FT) and PARSE(σ) must be crucially unranked with respect to each other. For concreteness, and because this assumption has no bearing on the data discussed here, I assume that NONFINALITY(FT) dominates PARSE(σ).

    The ranking NONFINALITY(FT) ≫ PARSE(σ) also obviates the need for ranking ALLFTL over NONFINALITY(FT). For ease of comparison I leave the ranking ALLFTL ≫ NONFINALITY(FT) intact.

The winning candidate [(ˈda.lə)bə] breaks up an illicit /lb/ cluster via epenthesis, sat-isfying *ʀɢ at the cost of violating Pᴀʀꜱᴇ(σ) and low-ranked ᴅᴇᴘ. On the other hand, the faithful candidate [(ˈdal.bə)] is suboptimal because it violates high-ranked Nᴏɴꜰɪɴᴀʟ-ɪᴛʏ(Fᴛ). The faithful candidate cannot be saved by simply rearranging foot boundaries: [(ˈdal)bə] satisfies Nᴏɴꜰɪɴᴀʟɪᴛʏ(Fᴛ), and violates Pᴀʀꜱᴇ(σ) to the same degree as the optimal candidate, but fails to resolve the illicit /lb/ cluster, and thus incurs a fatal violation of *ʀɢ.

As illustrated in (122), epenthesis is blocked in those longer forms that begin with an [LLσ] or [Hσ] sequence. In such cases, illicit consonant clusters are tolerated. Take, for example, the non-epenthesizing /LLL/ form /skolgərnəx/:

(122)   Non-epenthetic form: /skolgərnəx/ → [ˈskol.gər.nəx]   /LLL/ → [LLL]

/ skolgərnəx /	Aʟʟꜰᴛʟ	Nᴏɴꜰɪɴ(Fᴛ)	Pᴀʀꜱᴇ(σ)	*ʀɢ	ᴅᴇᴘ
a. ☞ (ˈskol.gər)nəx			*	*	
b. (ˈsko.lə)gər.nəx			**! W	L	* W
c. (ˈsko.lə)(ˌgər.nəx)	*! W	*! W	L	L	* W

scolgarnach 'cackle'

Both the faithful candidate [(ˈskol.gər)nəx] and the alternative epenthetic candidate [(ˈsko.lə)gər.nəx] satisfy Nᴏɴꜰɪɴᴀʟɪᴛʏ(Fᴛ); however, the epenthetic candidate [(ˈsko.lə)gər.nəx] incurs an additional violation of Pᴀʀꜱᴇ(σ), and is thus eliminated. So for longer forms, epenthesis worsens prosodic structure, and is therefore disallowed. Irish words contain only a single foot (see Section 3.5.3.1), so epenthetic candidates like [(ˈsko.lə)(ˌgər.nəx)], which satisfy Pᴀʀꜱᴇ(σ) by building multiple feet, must be eliminated. Expectedly, such candidates are ruled-out by high-ranking Aʟʟꜰᴛʟ (and Nᴏɴꜰɪɴᴀʟɪᴛʏ(Fᴛ)).[58]

However, this analysis wrongly predicts that epenthesis should also be blocked for /LHL/ inputs:

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[58]The fact that sonority-driven epenthesis is blocked in such forms, and for reasons of metrical struc-ture, is thus another argument in favor of assuming that footing is non-iterative in Irish (see Section 3.5.3.1 and Ní Chiosáin 1999, 2000).

(123)   /LHL/ inputs: epenthesis wrongly blocked, /LHL/ → [LLHL], *[LHL]

/ ʃarvoːntə /	AʟʟFᴛʟ	NᴏɴFɪɴ(Fᴛ)	Pᴀʀsᴇ(σ)	*ʀɢ	ᴅᴇᴘ
a. ☹ (ˈʃa.rə)voːn.tə			**!		*
b. ☞ (ˈʃar.voːn)tə			*	*	
c. (ˈʃa.rə)(ˌvoːn)tə	*!		*		*

searbhónta 'servant'

Under this ranking, the attested output [(ˈʃa.rə)voːn.tə] loses to the non-epenthetic candidate *[(ˈʃar.voːn)tə]. Since both candidates satisfy NᴏɴFɪɴᴀʟɪᴛʏ(Fᴛ), the decision falls to Pᴀʀsᴇ(σ), which favors the non-epenthetic candidate. In short, epenthesis is blocked with /LHL/ inputs for the same reason it is blocked with /LLL/ inputs: whenever epenthesis leads to more marked prosodic structure (e.g. more unfooted syllables, without any gain in non-finality), it is prohibited.

The solution to this dilemma lies with wsᴘ$_{Fᴛ}$. The problematic candidate *[(ˈʃar.voːn)tə] contains an (ˈL H) foot — precisely the kind of foot structure banned by wsᴘ$_{Fᴛ}$. By simply ranking wsᴘ$_{Fᴛ}$ over Pᴀʀsᴇ(σ), the correct candidate is predicted to emerge as optimal:

(124)   wsᴘ$_{Fᴛ}$ ≫ Pᴀʀsᴇ(σ)

/ ʃarvoːntə /	AʟʟFᴛʟ	NᴏɴFɪɴ(Fᴛ)	wsᴘ$_{Fᴛ}$	Pᴀʀsᴇ(σ)	*ʀɢ	ᴅᴇᴘ
a. ☞ (ˈʃa.rə)voːn.tə				**		*
b. (ˈʃar.voːn)tə			*! W	* L	* L	
c. (ˈʃa.rə)(ˌvoːn)tə	*! W			* L		*

Sonority-driven epenthesis thus provides further evidence that wsᴘ$_{Fᴛ}$ is active in Irish, despite the fact that its influence on stress assignment is completely obscured by high-ranking metrical structure constraints like AʟʟFᴛʟ and Tʀᴏᴄʜᴇᴇ (see Section 3.5.3.2). Consequently, sonority-driven epenthesis presents another argument for including wsᴘ$_{Fᴛ}$ in the constraint set ᴄᴏɴ.

The ranking wsᴘ$_{Fᴛ}$ ≫ Pᴀʀsᴇ(σ) is also fully consistent with the analysis of plural allomorphy developed in Section 3.5.5. wsᴘ$_{Fᴛ}$ is only crucially active for monosyllabic

root nouns, where the ranking wsp$_{\text{Ft}}$ ≫ priority compels the appearance of the dis-preferred plural suffix /-ənə/. For both light and heavy monosyllabic root nouns, the ranking wsp$_{\text{Ft}}$ ≫ Parse(σ) correctly predicts the choice of plural allomorph:

(125)   [L] root noun: /-ənə/ correctly predicted

/ klog / + {-axə > -ənə}	AFL	NF(Ft)	wsp$_{\text{Ft}}$	Parse(σ)	priority	wsp
a. ☞ ('klo.gə)nə				*	*	
b. ('klo.gax$_\mu$)ə			*! W	*	L	* W

cloganna 'clocks'

(126)   [H] root noun: /-ənə/ correctly predicted

/ srɑːdʲ/ + {-axə > -ənə}	AFL	NF(Ft)	wsp$_{\text{Ft}}$	Parse(σ)	priority	wsp
a. ☞ ('srɑː.dʲə)nə				*	*	
b. ('srɑː.dʲax$_\mu$)ə			*! W	*	L	* W
c. ('srɑː)dʲax$_\mu$.ə			**! W		L	* W

sraideanna 'streets'

Sonority-driven epenthesis thus supplies an indirect source of insight into foot structure in Irish. Recall from Section 3.5.5 that the foot structure of monomorphemic words with initial ['σ H...] sequences is ambiguous: footed [('σ H)...], they violate wsp$_{\text{Ft}}$; but footed [('σ) H...], they violate Parse(σ):

(127)   *brionglóidí*   ['bʲrʲiːŋ.loː.dʲiː]   'dreaming'

   a.   [('bʲrʲiːŋ.loː)dʲiː]   [('H H) H]   Violates: wsp$_{\text{Ft}}$
   b.   [('bʲrʲiːŋ)loː.dʲiː]   [('H) H H]   Violates: Parse(σ)

However, the ranking wsp$_{\text{Ft}}$ ≫ Parse(σ) entails that ('σ H) feet will be avoided at the cost of building monosyllabic feet. We can therefore conclude that ['σ H...] words are footed [('σ) H...] rather than [('σ H)...], despite the fact that for the purposes of stress placement, the two alternatives are empirically indistinguishable.[59]

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[59]This discussion primarily pertains to ['H H] sequences. I assume that the footing [('L) H] is prohib-

(128)   ['σ H...] footed [('σ) H...]

/ kuːloːdər /	AʟʟFᴛL	NᴏɴFɪɴ(Fᴛ)	ᴡsᴘ$_{Fᴛ}$	Pᴀʀsᴇ(σ)	ᴡsᴘ
a. ☞ ('kuː)loː.dər				**	*
b. ('kuː.loː)dər			*! W	* L	*

comhlódar 'company'

In this brief discussion of Ní Chiosáin's analysis, I have argued that sonority-driven epenthesis demonstrates that ᴡsᴘ$_{Fᴛ}$ is active in the phonology of Irish, as well as in the morphology. The utility of ᴡsᴘ$_{Fᴛ}$ in both these domains thus constitutes an argument for including it in ᴄᴏɴ, and further solidifies the claim that binary foot structure plays a major role in the phonology of the Irish language. An interesting consequence of grafting ᴡsᴘ$_{Fᴛ}$ onto Ní Chiosáin's analysis is that the foot structure of ['σ H...] words, which was previously ambiguous, is predicted to be [('σ) H...] under the current ranking.

At a more conceptual level, the fact that ᴡsᴘ$_{Fᴛ}$ is independently needed for sonority-driven epenthesis bolsters the claim that Irish plural allomorphy makes direct contact with the phonology of Irish, and is output optimizing in character.

3.7 Conclusion

In the preceding sections I argued that a subset of Irish plural formation, involving alternations between the suffixes *-(e)anna* and *-(e)acha*, should be analyzed as a case of output optimizing allomorphy. Crucial to this analysis was the assumption that surface [ax] strings contain a moraic [x$_μ$]. The exceptionally moraic status of [x$_μ$] allows the suffix *-(e)acha* to be targeted by metrical markedness constraints like Pᴀʀsᴇ(σ) and ᴡsᴘ$_{Fᴛ}$, which drive the weight-sensitive distribution of plural allomorphs. Irish plural allomorphy thus constitutes an interesting case of ᴛʜᴇ ᴇᴍᴇʀɢᴇɴᴄᴇ ᴏғ ᴛʜᴇ ᴜɴᴍᴀʀᴋᴇᴅ (McCarthy & Prince 1994): though most dialects of Irish are quantity-insensitive, and all dialects tolerate sub-minimal feet, crucially dominated prosodic constraints like Pᴀʀsᴇ(σ) and ᴡsᴘ$_{Fᴛ}$ are still instrumental in determining the choice of plural allo-

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ited by high-ranked FᴛBɪɴ, and thus that ['L H] sequences are footed [('L H)].

morph.

In summary, there is both morphological and phonological evidence for the foot in Irish, despite the fact that Irish has word-initial, non-rhythmic stress that does not depend on footing in any obvious way.

3.8 Some remainders

3.8.1 Syncope

As discussed in Section 3.5.5.5, Irish plural allomorph selection is sometimes opaque: for example, the underlying /ax/ must count as heavy or prominent for allomorph selection even when it ultimately surfaces as reduced [əx]. A similar sort of opacity is evident when we consider nouns that undergo syncope in the plural. In Irish, syncope causes some disyllabic noun roots to become monosyllabic when pluralized:

(129)   a.   *máistir*   [ˈmɑːʃtʲə rʲ]   →   *máistirí*   [ˈmɑː.ʃtʲrʲ - iː]   'master(s)'
        b.   *caraid*   [ˈkaːrədʲ]   →   *cairde*   [ˈkɑːrʲdʲ - ə]   'friend(s)'

For those nouns that take /-axə/ in the plural, the effect of syncope is to create a surface form in which /-axə/ appears to attach to a monosyllabic root noun:

(130)   a.   *leitir*   [ˈlʲetʲərʲ]   →   *leitreacha*   [ˈlʲetʲrʲ - əxə]   'letter(s)'
        b.   *obair*   [ˈobərʲ]   →   *oibreacha*   [ˈobʲrʲ - əxə]   'work(s)'

Thus, along with vowel reduction and prefixation, syncope seems to constitute another case of opaque conditioning of plural allomorphy.

However, there is reason to believe that these [ə] ~ [∅] alternations are actually instances of epenthesis, rather than syncope (see also Hickey 1984, 1985a). In all cases of apparent syncope — with any plural suffix — the root noun contains a final consonant cluster that would be an ill-formed coda in Irish (Ó Siadhail 1991:20, Ó Siadhail 1995:218), and the alternating vowel is always reduced [ə] ~ [ɪ]. When a vowel-initial suffix is added, the second consonant in these clusters can be syllabified as an onset. In the unaffixed singular form, resyllabification is not possible, so [ə] epenthesis is used to break up the offending cluster. In fact, as discussed in Ní Chiosáin (1999, 2000) and

Section 3.6 above, illicit consonant clusters are often resolved by [ə] epenthesis in Irish. Note, too, that accounts assuming syncope rather than epenthesis must stipulate that syncope fails to apply in certain forms:

(131) a. *maidin* [ˈmaːdʲənʲ] → *maidineacha* [ˈmaːdʲənʲ - əxə] 'morning(s)'

      b. *fainic* [ˈfaːnʲəkʲ] → *fainiceacha* [ˈfaːnʲəkʲ - əxə] 'warning(s)'

If these [ə] ∼ [∅] alternations are instances of epenthesis, then the lack of alternations for forms like *maidin* and *fainic* is simply due to the fact that they contain an underlying, non-epenthetic [ə]. Thus, singular nouns like *obair* [ˈo.bərʲ] are underlyingly monosyllabic, and contain underlying final consonant clusters that are prohibited in surface forms, e.g. /obrʲ/.[60],[61]

    If this view of [ə] ∼ [∅] alternations is correct, then forms like (130) no longer constitute a case of opaque allomorph selection. Instead, nouns like *leitir* /lʲetʲrʲ/ and *obair* /obrʲ/ must be counted among those monosyllabic root nouns that are lexically specified to take the plural suffix /-axə/.

3.8.2 Munster plurals

The central hypothesis of Section 3.5.5 is that the allomorph /-ənə/ appears adjacent to stressed syllables in order to prevent the formation of [ˈσ H] sequences. Munster Irish, unlike other dialects of Irish, has widespread non-initial stress in singular nouns. This analysis then predicts that, in Munster Irish, some polysyllabic nouns with final stress should take the plural suffix /-ənə/, even if they appear with the plural suffix /-axə/ in other dialects.

    There is widespread dialect variation in the formation of plurals — recall, for example, that the noun *áit* 'place' is variably realized as *áiteacha* [ɑːtʲ - əxə] or *áiteanna* [ɑːtʲ - ənə] in different varieties of Irish. At present, more data collection is needed to

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[60]Interestingly, underlying /brʲ/ in *obair* /obrʲ/ is at odds with the surface generalization that adjacent consonants agree in palatalization in Irish. See Harris (1977) for similar observations about epenthesis and surface-illicit underlying representations in Spanish.

[61]Smith (1999) discusses parallel data for the Leurbost dialect of Scottish Gaelic, and with similar argumentation concludes that such [ə] ∼ [∅] alternations represent the application of syncope rather than epenthesis. I do not fully understand the logic behind this conclusion.

verify or falsify this prediction. However, even if this prediction is falsified, it would not be fatal for the analysis of plural allomorphy defended in Section 3.5.5. If Trochee is ranked relatively low, below AllFtL, non-initial stress will involve iambic rather than trochaic footing (132), (133) (see also Chapter 2 and Section 3.2.1 above). It follows from this assumption that /-axə/ will only be prohibited from attaching to stressed monosyllables, since that is the only configuration in which post-tonic [ax] would be parsed as the dependent member of a foot.

(132)   Possible ranking for Munster Irish stress and plural allomorphy

Initial stress: *sráid* [ˈsrɑːdʲ] → *sráideanna* [ˈsrɑː.dʲə.nə]

/ srɑːdʲ/ + {-axə > -ənə}	wsp_Ft	Parse(σ)	Priority	wsp	AFL	Troch
a. ☞ (ˈsrɑː.dʲə)nə		*	*			
b. (ˈsrɑː.dʲaxμ)ə	*! W	*	L	* W		
c. (ˈsrɑː)dʲaxμ.ə		**! W	L			

(133)   Possible ranking for Munster Irish stress and plural allomorphy

Non-initial stress: *inín* [i.ˈnʲiːnʲ] → *iníneacha* [i.ˈnʲiː.nʲəxμ.ə]

/ inʲiːnʲ/ + {-axə > -ənə}	wsp_Ft	Parse(σ)	Priority	wsp	AFL	Troch
a. ☞ (i.ˈnʲiː)nʲəxμ.ə		**		*		*
b. i(ˈnʲiː.nʲəxμ)ə	*! W	**		*	* W	L
c. i(ˈnʲiː)nʲəxμ.ə		***! W		*	* W	L
d. (i.ˈnʲiː)nʲə.nə		**	*! W	L		*
e. i(ˈnʲiː.nʲə)nə		**	*! W		* W	L

As argued in Green (1997), any analysis of Munster Irish will require the ranking wsp ≫ AllFtL, which is reflected in the tableaux in (133).

There is suggestive evidence that at least some cases of non-initial stress in Munster Irish involve iambic footing. In words with second-syllable stress, the pre-tonic syllable sometimes resists vowel reduction, even when containing an unstressed short vowel. More specifically, if the stressed second syllable is a long high vowel [iː uː],

then pretonic short vowels retain their underlying quality (O'Rahilly 1932:86, Ó Cuív 1944:104-5, Breatnach 1947:124, Ó Sé 2000:38-9, Iosad 2009).

(134)   Exceptional non-reduction in Munster Irish

    a. *bailighim* [ba̠.ˈlʲiːmʲ] 'I gather'

    b. *cocaí* [ko̠.ˈkiː] 'small piles of hay (haycocks)'

    c. *oileamhaint* [e̠.ˈlʲuːnʲtʲ] 'act of rearing'

Cf.

    d. *beagán* [bʲə̠.ˈgːɑn] 'small amount'

    e. *casóg* [kə̠.ˈsoːg] 'coat'

    f. *cromán* [krə̠.ˈmɑːn] 'hip bone'

    g. *sgioból* [skʲə.ˈboːl] 'barn'

(Ó Cuív 1944:19-23,65-7,105)

This pattern of vowel reduction is reminiscent of pre-tonic vowel allophony in various Russian dialects, discussed in Chapter 2. In both cases the quality of the pretonic vowel co-varies with the quality of the stressed vowel. I take this co-variation to be a possible indication that Munster Irish (like some varieties of Russian) places conditions on the relative sonority of vowels within the same foot, e.g. *cocaí* [(ko.ˈkiː)], *beagán* [(bʲə.ˈgɑːn)], etc. (see also the preceding discussion of Uspanteko). Pre-tonic vowel reduction thus supplies some further evidence for an iambic foot parse in Munster Irish words bearing second-syllable stress.[62]

Much more needs to be said about the role of prosodic structure in the determination of stress in Munster Irish. My only intent in this section is to sketch some ways of thinking about the interaction of stress shift, footing, and plural allomorph selection in those dialects.

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[62]The quality of initial short vowels is also retained in Munster Irish when the third syllable bears primary stress, e.g. *spealadóir* [spʲa̠.lə.ˈdoːrʲ] 'reaper', *feirmeóir* [fʲe̠.rʲə.ˈmuːrʲ] 'farmer' (Breatnach 1947:83,125). This is arguably a different phenomenon from the retention of initial vowel quality under second-syllable stress: reduction (or lack thereof) does not interact with the quality of the stressed vowel; and some authors have suggested that these unreduced initial syllables actually bear secondary stress (e.g. Ó Cuív 1944:67, Doherty 1991, Ó Sé 2000, Iosad 2009, and references therein).
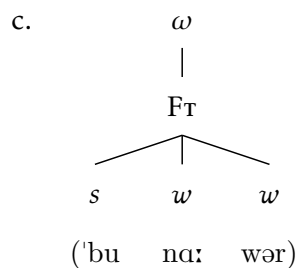
3.9 General discussion

In this chapter I have presented arguments that binary, edge-aligned foot structure plays a major role in the phonological systems of Irish and Uspanteko. In both of these languages stress appears to be assigned solely on the basis of word-edges: default stress is word-final in Uspanteko, and word-initial in Irish. There is thus no immediately apparent evidence that binary foot structure is relevant for the phonology of these two languages. For this reason, languages like Irish and Uspanteko have sometimes been described as 'unbounded' stress systems, because the patterns of edge-based stress found in such languages can be modeled by assuming metrical feet that are coextensive with the entire prosodic word (135), (136).

(135)   Unbounded left-headed feet in Irish

    a.   *bunábhar*   [ˈbu.nɑː.wər]   'raw material'

    b.   [(ˈbu.nɑː.wər)]

    c.

$$
\begin{array}{c}
\omega \\
| \\
F_T \\
\end{array}
$$

       s   *w*   *w*

     (ˈbu   nɑː   wər)

(136)   Unbounded right-headed feet in Uspanteko

    a.   lajo<u>ri</u> 'today'

    b.   [(la.jo.ˈri)]

    c.

$$
\begin{array}{c}
\omega \\
| \\
F_T \\
\end{array}
$$

      w   *w*   *s*

     (la   jo   ˈri)
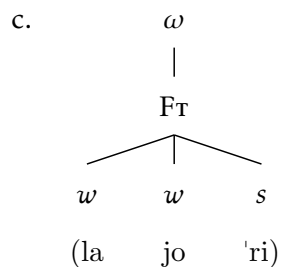
It should be obvious that the structures in (136) and (135) are empirically indistinguishable from an alternative analysis in which Irish and Uspanteko lack foot structure altogether, and stress placement is simply a non-structural prominence assigned to initial or final syllables (i.e. is entirely grid-based).

The results presented in this chapter suggest that both of these approaches to edge-based stress are deeply flawed. By investigating the non-accentual, but prosodically-conditioned aspects of Irish and Uspanteko, we unearth a range of evidence for the view that stress in these languages derives from edge-aligned, but *binary* foot structure. For Uspanteko, assuming that stress is based on binary footing provides a simple account of the two-syllable window limiting tone-driven stress shift; this same foot (which varies between an iamb and a trochee) also determines the distribution of stress-sensitive syncope, and conditions the interaction of tone and vowel sonority in bisyllabic $[\sigma_\mathrm{v}\sigma_\mathrm{v}]$ roots. For Irish, a pattern of plural allomorph selection, along with the prosodic conditions on sonority-driven epenthesis, provide evidence that initial stress is assigned within a left-aligned binary trochee. Importantly, the evidence for footing in these languages is convergent, in that prosodically-conditioned phenomena from several different domains all point toward a single, unified system of binary foot structure in each language.

How do these findings bear on the typology of footing in natural language? I find it telling that the types of foot structure found in Irish and Uspanteko are essentially as expected, given the properties that foot structure has in languages with canonical foot-based stress (i.e. languages with rhythmic/alternating secondary stresses). For example, footing in Irish is binary, edge-aligned, quantity-sensitive, and conditioned by non-finality pressures. These properties are all commonly found in languages in which stress assignment alone provides strong evidence for binary foot structure (e.g. Latin and Cairene Arabic). Footing in Uspanteko is of course binary and edge-aligned as well, but also shows structural interactions between footing and vowel sonority that are widely attested in other languages. In other words, the feet that organize the phonological structure of Irish and Uspanteko are remarkable precisely because they are the typical, garden-variety feet we find in languages that have foot-based stress of a more obvious sort.

The data discussed in this chapter is thus both surprising and suggestive. It is surprising in that the typology of foot structure seems to be fairly independent of whether or not stress assignment in a given language is crucially foot based — feet seem to be more or less the same across languages, even when stress placement could in principle be determined with reference to word edges or morphological structure alone. This observation in turn suggests a more far-reaching conclusion: namely, that the binary metrical foot may be a prosodic universal. In the next chapter, I discuss some experimental results that suggest this conclusion is on the right track: the foot plays a general organizational role in natural language phonology, and does not depend on the prior existence of stress, rhythmic or otherwise.

Chapter 4

Foot structure and cognitive bias: an artificial grammar investigation

> *. . . though all our knowledge begins with experience, it by no means follows that all arises out of experience. . . It is, therefore, a question which requires close investigation. . .*
>
> A Critique of Pure Reason
> Immanuel Kant

4.1   Introduction

This chapter defends the hypothesis that speakers are subject to a cognitive bias favoring foot-based generalizations over linguistic data. It begins with the observation that foot structure is attested in a wide range of languages lacking foot-dependent stress. If, as is commonly assumed, foot structure exists to organize prominent syllables or moras within the word, the presence of foot structure in such languages is mysterious. Two artificial grammar experiments test the claim that foot structure in these languages emerges from a cognitive predisposition for foot-based generalizations. These experiments find that both English and Japanese speakers learn a foot-based vowel phonotactic to account for the distribution of vowels in an artificial language, even though a descriptively equivalent stress-based vowel phonotactic would account for the same facts. These findings support the claim that there is a cognitive bias for the

use of the foot as a general organizing principle in phonology.[1]

4.2   Background

A typologically diverse set of languages employ EDGE-ONLY STRESS (EOS) systems: each word contains exactly one stressed syllable, and that syllable is absolutely initial or final within the word. Stress placement in EOS systems can thus be determined on the basis of word edges alone, without any necessary reference to foot structure. Nevertheless, some EOS systems — like many tonal and pitch accent systems — show substantial evidence of foot structure in domains other than stress assignment (see especially the discussion of Irish and Uspanteko in Chapter 3). Under the assumption that foot structure exists in order to organize prominent syllables or moras within the word, EOS systems pose a puzzle: if foot structure is superfluous for accent assignment, why should it be present at all?

One possible explanation for these facts is that humans are subject to a cognitive bias favoring foot-based generalizations over linguistic data. Such a bias would then be a source for foot structure in EOS languages, where footing is redundant for stress placement. This chapter presents a series of artificial grammar experiments investigating whether such a cognitive bias exists. The first experiment finds that native English speakers are in fact predisposed to make foot-based generalizations about vowel phonotactics, even when a stress-based statement of the same phonotactic is equally available. To ensure the generality of this result, the experiment is replicated with native speakers of Japanese. This second experiment finds that Japanese speakers also prefer foot-based phonological generalizations over extensionally equivalent

stress-based generalizations. It is concluded that there is indeed evidence for a cognitive bias favoring the use of the foot as a general tool for capturing phonological patterns encountered during language learning.

The same questions of universality and bias present themselves when we consider the abundant evidence for metrical footing in many tone and pitch accent languages. Since the languages belonging to this category lack phonetic stress, it remains somewhat unclear why the prosodic organization of such languages would show traces of canonical, binary foot structure. While I will discuss languages of this sort at several points in this chapter, I focus on the evidence for footing in EOS languages because I feel that such phenomena have received relatively little attention in the literature on metrical phonology.

The chapter is organized as follows: Section 4.3 outlines the typological distribution of EOS systems, and briefly surveys some of the evidence for foot structure in such languages. Section 4.3.2 sets out the puzzle posed by EOS languages, and Section 4.4 discusses potential sources for a foot-based parsing bias. Section 4.4.1 introduces the artificial grammar paradigm. Sections 4.5-4.7 report on artificial grammar experiments conducted with English and Japanese speaking participants. Section 4.8.2 argues against alternative explanations for the existence of foot-like metrical structure in languages without rhythmic stress. Section 4.8.3 situates the experimental results with respect to current theories of prosodic structure, and Section 4.8.4 concludes.

4.3 The pervasiveness of foot structure

Many languages have edge-tropic stress systems: stress always falls on the word-initial or word-final syllable.[2]

(1)   Edge-tropic stress

    a.   [σ́ . . .]

    b.   [. . . σ́]

---

[2]See e.g. Hyman (1977), Hayes (1995), Gordon (2002a) and Goedemans & van der Hulst (2009).

A subset of edge-tropic stress systems have only primary stress — that is, there is one and only one stress per word, and it falls on a word edge.[3] The lack of secondary stress renders these systems 'non-rhythmic' or 'non-iterative', thereby distinguishing them from edge-tropic systems more generally.

(2)   Non-rhythmic edge-tropic stress

    a. $[\,\acute{\sigma}\sigma\sigma\ldots\,]$

    b. $[\ldots\sigma\sigma\sigma\acute{\sigma}]$

Non-rhythmic edge-tropic systems are EDGE-ONLY STRESS (EOS) systems, in the sense that stress *only* falls on the absolute left or right word edge.

    EOS systems as a class have held little interest for metrical theory, no doubt due to their relative simplicity (see Baković 1998 on some past analyses of EOS systems). Still, EOS systems are quite widespread, as illustrated by the languages listed in (3).[4]

(3)   Some edge-only stress (EOS) systems

  a. <u>Initial stress</u>:

- Irish (Ó Siadhail 1991)
- Senoufo (Mills 1984)
- Southeast Tepehuan (Willett 1982, Kager 1999, Hall 2000)[5]
- Hungarian (Blaho & Szeredi 2011, though cf. Hayes 1995:330)
- Senadi (González 2007)
- Tinrin (Osumi 1995)
- Miskito (Salamanca 1988)

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[3]I focus on stress systems here, though much of the discussion would also be relevant for edge-tropic lexical pitch accent systems. The so-called 'two-pattern' accent of Kagoshima Japanese, for example, might be such a system (see Kubozono 2004, 2008 and Uwano 2007 for descriptive details).

[4]This list could be expanded by considering languages with regular penultimate or peninitial stress, such as Polish (penultimate; Newlin-Łukowicz 2011) or Dakota (peninitial; Shaw 1985, Hayes 1995:267). As observed by Hayes (1995:204), such systems could be analyzed as edge-based stress in conjunction with final-syllable or initial-syllable extrametricality.

[5]Stress will shift to a heavy peninitial syllable in Southeast Tepehuan, provided the initial syllable is light. Stress in Capanahua behaves similarly (González 2007).

b. <u>Final stress</u>:

- Mayan (K'ichean branch)
  - ○ K'ekchi, Kaqchikel (Berinstein 1979), K'ichee' (Pye 1983), Tz'utujil (Dayley 1985), Uspanteko (Can Pixabaj 2006)

- Turkic
  - ○ Turkish (default stress only; Inkelas & Orgun 2003), Crimean Tatar (Kavitskaya 2010), Uzbek (Walker 1995)

- Copala Trique (Silverman 1997)

- Central Carrier (Pike 1986)

- Mwotlap (François 2005)

- Farsi (Ferguson 1957)[6]

- French (Walker 1975, Jun & Fougeron 2002)[7]

A search of the StressTyp database (Goedemans & van der Hulst 2009) finds 18 additional edge-only accent systems (9 with initial accent, 9 with final accent).[8] Combining the results from StressTyp with my own findings yields roughly 15-20 distinct language families containing at least one EOS language as a member. EOS systems are thus found in a non-trivial range of typologically diverse languages. (See Gordon 2002a for a list of further examples.)

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[6]Final stress is essentially a property of uninflected words in Farsi, and stress retraction is strongly conditioned by morphological complexity.

[7]Though French 'stress' may be a phrase-level rather than word-level prominence (e.g. Jun & Fougeron 2002), it nevertheless associates with word-final syllables. See also Selkirk (1984) and Gussenhoven (2004) on the association of phrasal tones to stressed syllables.

[8]Latvian (initial stress) was excluded from these results because there is some controversy over whether it has secondary stress (see Buckley 2009:411 for discussion). Poqomchi (final stress) was excluded because it belongs to the set of K'ichean-branch Mayan languages listed in (3).

A searchable version of StressTyp is available at `http://www.unileiden.net/stresstyp/form2b.htm`. The search terms used here were `Rhythm=N` and `Type=I/U` (matched exactly).

4.3.1 EOS systems and foot structure: case studies

As discussed in Section 4.3, EOS systems have two defining properties: (i) stress placement can be described with reference to word edges alone; and (ii) stress placement is non-rhythmic, in the sense that there are no alternating stresses. Condition (i) sets EOS systems apart from non-rhythmic systems that nevertheless require a foot-based algorithm for placing primary stress.[9] Condition (ii) further distinguishes EOS languages from edge-tropic accent systems with secondary stress, like those found in many Australian languages (e.g. Hercus 1994, Hayes 1995:200-204, Dixon 2011).

Conditions (i) and (ii) hint at a simpler way of characterizing the difference between EOS systems and other superficially similar accent systems: while many edge-tropic and non-rhythmic accent systems depend on foot structure for some aspect of stress placement, EOS systems can be accurately described without any reference to foot structure whatsoever. That is, EOS systems provide no evidence for a metrical constituent intervening between the syllable and the word.

The question arises, then, as to whether there is any independent evidence for foot structure in EOS languages in domains other than stress placement. The issue is of more than passing theoretical interest, as it bears directly on the putative universality of the prosodic hierarchy (see e.g. Hayes 1995:119, Green 1997:99, Jun 2005, Goad & Buckley 2006, Kawahara & Shinya 2008, Itô & Mester 2009, Vogel 2009, Selkirk 2011, Schiering et al. 2010, Hyman 2011, Bennett & Henderson to appear, Labrune 2012, and references therein for discussion). If EOS languages lack any detectable trace of foot structure, then it might well be conceded that not all levels of the prosodic hierarchy are obligatorily instantiated in every language.

For at least some EOS languages, the evidence falls firmly on the side of the universalist position: the empirical facts support a foot-based analysis of one or more phonological phenomena. This was demonstrated in Chapter 3, where I presented multiple arguments for the existence of foot structure in Irish and Uspanteko, two ge-

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[9]Cf. the well-known cases of Creek and Cairene Arabic (e.g. Haas 1977, Halle & Vergnaud 1987, Hayes 1995, Martin & Johnson 2002, Teeple 2009, etc.), where foot structure is arguably necessary to determine the location of primary stress, even though non-head feet receive no (obligatory) phonetic realization.

netically and geographically distant EOS languages. Irish and Uspanteko are probably not alone among EOS languages in this regard. For example, Vaysman (2009) argues that Mwotlap (final stress) has foot-bounded vowel harmony. Kager (1999) analyzes iterative syncope in Southeast Tepehuan (initial stress) as a strategy for minimizing the number of unfooted syllables in the word (see Hall 2000 for a different, but nonetheless foot-based analysis). Finally, in French (final stress) variable schwa deletion may be conditioned by foot structure (e.g. Kimper 2011b and references therein), and nickname formation may also be foot-based (Nelson 1998; see also Goad & Buckley 2006 on foot structure in child French). It seems likely that a close examination of other EOS languages would reveal non-accentual evidence for foot structure of the sort presented here. Section 4.3.2 situates these facts in a broader theoretical context, arguing that the existence of foot structure in EOS languages is itself a fact in need of explanation.

4.3.2 The puzzle

Should the existence of foot structure in EOS languages be at all surprising? If we take a strong universalist stance on the prosodic hierarchy, the answer is clearly no. Under the assumption that all languages obligatorily instantiate every prosodic category (syllable, foot, ϕP, etc.), the existence of foot structure in e.g. English simply entails the existence of foot structure in Irish, Uspanteko, and other EOS languages.

This mode of explanation, however appealing, gets things exactly backwards. It is an empirical question whether or not the prosodic hierarchy is truly universal, a hypothesis that can be confirmed or disconfirmed by the available evidence. More to the point, it is a methodological error to take some putative property of Universal Grammar as a starting point for understanding linguistic phenomena. UG itself is simply the explanatory residue left behind after other sources of explanation — phonetic facts, domain-general properties of cognition, etc. — have had their shot (see Moreton 2008 for some enlightening discussion and relevant references). UG is the end of explanation, not the beginning.

Taking a more agnostic position on the cross-linguistic status of the prosodic hierarchy, we can ask whether the presence of any particular phonological phenomenon in a language should also lead us to expect the presence (or absence) of foot structure

in that language. To answer this question, it's worth considering what role foot structure plays in languages more generally. It is commonly assumed that the 'point' of feet is to arrange, group, or locate a sequence of prominent elements (like stressed syllables) within some larger constituent (like the word) (e.g. Liberman & Prince 1977). As Hayes (1995) puts it:

> "stress is the linguistic manifestation of rhythmic structure. . . an *organizing framework* for [the] utterance's phonological and phonetic realization. . . [exhibiting] substantial formal parallels with extra-linguistic rhythmic structures" (Hayes 1995:8-9, emphasis in original)

Note the close connection between footing and rhythm in this conception of the foot. There are perhaps two ways of construing this relationship. If, as Hayes (1995) seems to suggest, rhythm is somehow primary, foot structure ($\approx$ stress) is simply the expression of this prior, perhaps more cognitively general notion of 'Rhythm' (however defined; see also Liberman 1975). On the other hand, algorithmic approaches to stress assignment (e.g. Halle & Vergnaud 1987, Prince & Smolensky 1993/2004, Halle & Idsardi 1995, Buckley 2009, etc.) often begin with the construction of feet, and derive rhythmic stress from conditions on footing (though cf. Prince 1983, Selkirk 1984, Gordon 2002a, van der Hulst 2009, submitted). On this view the rhythmic character of stress is tied to its relational nature: if a syllable is only stressed by virtue of being more prominent than some other syllable in the same domain, then foot structure — as a grouping of relatively prominent and non-prominent elements — is something close to a logical necessity.

The tight conceptual linkage between rhythm and footing puts EOS languages in an odd position. A defining property of EOS systems is that they permit exactly one stress per word. But if each word contains only a single stress — i.e. only one 'prominent element' — then there is no accentual rhythm, and thus nothing for foot structure to organize.[10] And yet, in at least some EOS languages, there is robust evidence for foot

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[10]To the best of my knowledge, EOS languages like Irish and Uspanteko lack alternating segmental patterns (e.g. vowel lengthening, vowel reduction, syncope, aspiration, etc.) that could be construed as evidence for iterative foot structure. That is, there is no 'segmental rhythm', or any other non-accentual correlate of persistent footing. Such systems do exist: for example, Kashaya Pomo has iambic lengthening in non-head feet, but no secondary stress (Buckley 2009:401,412, Chapter 1; note that vowel length is otherwise contrastive in Kashaya). See also González (2003, 2005, 2007).

structure (see Section 4.3.1). The fact that these EOS languages evince foot structure without also evincing rhythmic stress (or foot-dependent primary stress) thus poses a puzzle for the standard conception of foot structure.[11]

Consider the same question, but from the perspective of the language learner. Descriptively speaking, primary stress in EOS systems can be assigned with reference to word edges alone. Now imagine a child acquiring an EOS system as her first language. The accentual system of the child's native language provides no positive evidence for footing. The question arises, then, why she would ever bother positing foot structure, since for purposes of stress assignment foot structure is thoroughly superfluous. Granted, the language could have evidence for foot structure in other domains. But that fact itself just pushes the burden of explanation back one step: since EOS languages (by definition) lack accentual evidence for foot structure, what explains the existence of foot-based phenomena in non-accentual domains?

Returning to specific EOS languages, we can ask how Irish, Uspanteko, etc. came to have foot-based phonological and morphological patterns in the first place. A possible diachronic scenario is that such languages descended from proto-languages that made use of rhythmic accentual systems with iterative footing. The existence of foot-based patterns in the modern languages could then be understood as a historical remnant of earlier stages where the accentual system did provide positive evidence for foot structure. (See Bach & Harms 1972 for related discussion of rule telescoping.)

However sensible this route of explanation may be, it most likely does not apply to Irish and Uspanteko. Irish has had a stable EOS system for well over 1000 years (Thurneysen 1946:27) — essentially as long as the historical record allows us to investigate. The EOS system of Uspanteko has a similar vintage: a rather conservative estimate might date the final stress pattern of Uspanteko to at least 1000 CE, the point at which Core K'ichean languages may have split from other languages in the Greater

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[11]The claim that EOS languages are non-rhythmic requires a brief caveat. The term 'rhythm' should be understood as referring to word-internal rhythmicity of the sort often attributed to foot structure in generative, metrical accounts of accent. There is another sense of 'rhythm', found in some experimental literature, that refers to the interval between any two stressed syllables regardless of intervening word boundaries. See e.g. Port, Cummins & Gasser (1995), O'Dell & Nieminen (1999), Barbosa (2002), Boucher (2006), and Tilsen (2009) for this potentially word-external notion of 'rhythm'.

K'ichean family (Kaufman 1976; see also (3) above). The development and persistence of foot-based prosodic and morphological phenomena in these languages thus clearly demands explanation.

Similar questions arise when we consider that some 'classic' tone languages also provide extensive evidence for foot structure. For example, some tone languages have foot-based segmental phonotactics[12] or foot-based restrictions on the distribution of tone.[13] Languages with lexical tone can also have foot-based prosodic morphology,[14] foot-based minimality requirements,[15] foot-dependent privative pitch accent,[16] foot-based poetic traditions,[17] and so on. None of these languages have stress, so *a fortiori* they lack foot-dependent stress as well.[18] Such languages recapitulate the puzzle posed by EOS languages: in the absence of a foot-based stress accent system, what is the underlying source of these myriad foot-based phonological patterns?

4.4 Explanation and experimentation

As framed in Section 4.3.2, the existence of foot structure in EOS languages *should* be surprising: speakers (at some stage) must have imposed or inferred foot structure even in the absence of positive evidence for footing from stress assignment. Since the learning data itself doesn't suggest the presence of footing, the innovation of foot structure must be due to speaker-internal pressures, or to the reanalysis of some phonetic or

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[12] E.g. Khoisan and Niger-Congo languages (Spaelti 1992, Downing 2004 and references therein); Mon-Khmer languages (Hayes 1995:261-2, Yip 2002); Kera (Pearce 2006); Awajún (McCarthy 2008b); Gokana (Hyman 2011).

[13] E.g. varieties of Chinese (Yip 1980, 2002:Ch.7); Yoruba (Awoyale 2000); Lamba and a Mahou language game (de Lacy 2002a); Khoisan languages (Downing 2004 and references therein); Kera (Pearce 2006); Gokana (Hyman 1985, 2011).

[14] E.g. Japanese (Poser 1990, Mester 1990, Itô & Mester 1992/2003, etc.); Hausa (Kurzyca 2011).

[15] E.g. Osaka Japanese (Haraguchi 1999); Khoisan languages (Downing 2004 and references therein).

[16] E.g. Cherokee (Johnson & Haag 2005); Japanese (Kubozono 2008).

[17] E.g. Mandarin Chinese (Yip 1980); Japanese (Poser 1990).

[18] One sometimes finds descriptions of tone languages that use the term 'stressed' to identify the syllable with the largest number of tonal or segmental contrasts (e.g. Yip 1980). As far as I can tell, this use of 'stress' is just shorthand for the abstract, structural prominence underlying the distribution of contrasts (i.e. the property of being a prosodic head). This sense of 'stress' is thus distinct from the phonetic notion of stress accent employed in this chapter (see e.g. Hyman 2006 for relevant discussion).

phonological phenomenon that was not originally foot-based.[19] Note, though, that this second possibility — a diachronic, foot-based reanalysis of existing data — raises exactly the same questions that it purports to address. If the data fails to implicate foot structure, the *de novo* emergence of the foot as a phonological primitive is itself mysterious. This is underscored by the fact that foot structure in EOS and tone languages adheres to constraints on footing — e.g. binarity, non-finality, edge-alignment, etc. (see Section 4.3.1) — that are familiar from foot-based stress accent systems. If the foot is simply invented anew (and independently) in each EOS or tone language with foot structure, it's not obvious why such formal parallels should exist. The typology of footing thus presents a 'projection problem' (Chomsky 1965, Peters 1972, Baker 1979; see also McCarthy 1981): what induces language learners to postulate rich, hidden metrical structure in words that do not provide overt phonetic evidence for that structure?

This line of reasoning is reminiscent of 'poverty of the stimulus' arguments (Chomsky 1980), in that the positive evidence available to the learner is insufficient to explain the full range of linguistic patterns and regularities that they acquire. Taking this point seriously forces us to at least entertain the idea that the existence of foot structure in EOS and tone languages is due to speaker-internal pressures on the acquisition of language (see e.g. Kiparsky 2008, de Lacy & Kingston to appear).

More concretely, we can ask whether humans have some kind of cognitive bias favoring the imposition of foot structure (or foot-based patterns) on linguistic data. This would be an ANALYTIC BIAS in Moreton's (2008) terms, because it concerns the kinds of formal or structural generalizations that speakers are predisposed to make about language. This putative bias for foot-based parsing could take a number of forms. One possibility is that the bias for foot structure belongs to Universal Grammar. On this view, EOS languages make use of feet because the innate phonological component of UG requires foot structure to be present in every phonological word. In generative phonology this requirement is often subsumed under a more general constraint known as HEADEDNESS (Selkirk 1996, McCarthy 2008b, Itô & Mester 2009, etc.). Formally

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[19]For instance, Hall (2006) discusses possible phonetic precursors to sonority-driven epenthesis in Irish. See also Section 4.8.

speaking, headedness requires every prosodic category of level *n* to dominate at least one element belonging to the prosodic category of level *n*-1 (its head). When paired with a strong universalist conception of the prosodic hierarchy (see Sections 4.3.1 and 4.3.2), headedness entails that every prosodic word must contain a foot. Since UG is claimed to be an autonomous cognitive module governing language competence alone, this is a *domain-specific* explanation for the presence of foot-structure in EOS languages and other languages lacking foot-dependent stress.

A second possibility is that any analytic bias for foot structure actually stems from more *domain-general* properties of cognition. Much research in psychology and related fields suggests that humans are quite broadly predisposed to structure information in hierarchically-organized — even binary — constituents. For example, there are strong parallels between the hierarchical structures found in phonology and syntax and those found in music (e.g. Martin 1972, Liberman 1975, Lerdahl & Jackendoff 1983, Hayes 1995, Katz & Pesetsky 2009, Slevc, Rosenberg & Patel 2009). Some structural properties of human language also have analogs in motor planning, visual pattern recognition, and other non-linguistic domains (e.g. Lashley 1951, Martin 1972, Liberman 1975, Pinker & Bloom 1990, Saffran 2002, Jackendoff & Pinker 2005, Jackendoff 2011). Finally, many complex systems outside of human cognition, even outside of biology altogether, show evidence of hierarchical organization, suggesting that the advantages accrued by exploiting hierarchical structure are wide-ranging (Simon 1962). Given these observations, any potential bias for foot structure might simply reflect core, task-indifferent properties of human cognition. On this view, even if the mind does have a specialized module for the acquisition and structuring of linguistic knowledge (namely, UG), it doesn't need to be called upon to explain the presence of footing in EOS or tone languages.[20]

The distinction between domain-specific and domain-general explanations for the proposed foot-based parsing bias is of course only relevant if such a bias actually exists; and the reality of a cognitive bias for foot structure is far from a foregone conclusion.

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[20]For discussion of the idea that human linguistic capacities belong to an autonomous cognitive module, see e.g. Pinker & Bloom (1990), Saffran, Johnson, Aslin & Newport (1999), and the numerous citations therein, especially the plethora of work by Noam Chomsky, Jerry Fodor, Ray Jackendoff, Steven Pinker, Alan Liberman, and Derek Bickerton on the topic.

The remainder of this chapter is devoted to investigating whether speakers are indeed subject to a positive bias for making foot-based generalizations about linguistic data. The experiments described in the following sections proceed on the assumption that if such a bias is real, it should be detectable in the laboratory.

4.4.1 Artificial grammar experiments

The experiments presented in this chapter made use of the artificial grammar (AG) paradigm (Esper 1925, Wolfle 1932, Reber 1967, 1989, Wilson 2006, Moreton 2008, among many others.) AG experiments have two basic components. First, participants are exposed to data from an artificial language designed by the researcher. This exposure phase may or may not involve overt instruction, depending on the goal of the experiment. Second, a testing phase checks whether participants learned specific patterns that (by design) were present in the data encountered during the exposure phase. Many AG experiments also have an additional testing phase that asks if (and how) participants extend those patterns to novel, often qualitatively different data.

The AG methodology was first popularized in psychology, where it has often been used to explore whether participants make implict (i.e. abstract and non-conscious) generalizations about patterns in complex stimuli (e.g. Reber 1989, Perruchet & Pacteau 1990, Brooks & Vokey 1991, Gomez & Schvaneveldt 1994, Redington & Chater 1996, Gomez & Gerken 1999, etc.). In the last decade or so AG methods have also become commonplace in linguistics, where they are widely used to detect biases or predispositions in how speakers approach language learning (e.g. Schane, Tranel & Lane 1975, Kapatsinski 2009, Coetzee 2009, and many other papers cited in this section). The central assumption of such studies is that pre-existing biases will manifest themselves as either the (relatively) easy acquisition of a particular pattern, or as the over-extension of a pattern to novel data.

This second strategy is sometimes called the POVERTY OF THE STIMULUS METHOD (Wilson 2006, Nevins 2010). AG experiments belonging to this category have the following logic: given (i) a restricted set of learning data (containing some pattern), and (ii) several competing hypotheses that all accurately capture the pattern in the learning data, do participants prefer one particular hypothesis over conceivable alterna-

tives? Different hypotheses about the learning data will often make differing predictions about the acceptability of novel forms, so researchers can probe which hypothesis participants favored by seeing how they respond to new kinds of stimuli.

For example, Wilson (2006) asked whether participants learning a rule of velar palatalization before mid vowels (k → t͡ʃ / __ e) would also apply the rule to [k] appearing before the high vowel [i]. Wilson found that participants did extend velar palatalization to [ki] sequences, suggesting that they formulated the palatalization rule in such a way that it applied before both mid and high vowels, rather than before mid vowels alone. Since participants were only trained on [ke] ∼ [t͡ʃe] sequences, over-extension of the velar palatalization rule to [ki] sequences cannot be attributed to patterns in the learning data — it must be the consequence of a bias (cognitive or otherwise) that the participants themselves brought to the experiment (see Wilson 2006 for more detailed discussion). The parallel with Chomsky's notion of the poverty of the stimulus is that the training data alone underdetermines the content of the grammar that participants ultimately acquire.

There are several advantages to using AG methods for testing hypotheses about phonological learning. First, there is a sizeable body of work suggesting that experimental participants are capable of learning novel phonotactic patterns after even extremely brief exposure to the relevant data (e.g. Bailey, Plunkett & Scarpa 1999, Onishi, Chambers & Fisher 2002, Pycha, Nowak, Shin & Shosted 2003, Taylor & Houghton 2005, Carpenter 2010). Second, phonotactic learning of this sort requires only passive exposure to stimuli, rather than an explicit learning task (e.g. Saffran, Newport & Aslin 1996, Saffran, Newport, Aslin, Tunick & Barrueco 1997, Saffran et al. 1999, Saffran 2002, Taylor & Houghton 2005). This point is underscored by the fact that even young infants (under 9 months) can quickly learn arbitrary, non-native phonotactic patterns (e.g. Aslin, Saffran & Newport 1998, Chambers, Onishi & Fisher 2003, Seidl & Buckley 2005, 2007, Cristià & Seidl 2008, Bergelson & Idsardi 2009, Cristià, Seidl & Francis 2011). A potential benefit of using implicit learning tasks is that, compared to explicit learning tasks, they are more likely to involve the same cognitive resources that speakers bring to first language acquisition.[21]

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[21]It is of course far from clear that speakers actually *do* recruit the same cognitive resources for AG

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AG methods are clearly well-suited for investigating cognitive biases in language learning, and are thus appropriate for testing the hypothesis that speakers are subject to a foot-based parsing bias. Section 4.5 presents an experiment that asks, using the poverty of the stimulus method, whether speakers are predisposed to make foot-based generalizations about segmental phonotactics.

4.5 Experiment 1

4.5.1 Stimuli

The stimuli used in Experiment 1 (as well as Experiment 2) were nonsense words composed of CV syllables, the consonants [p t k s], and the vowels [u i]. These six segments were combined pseudo-randomly to generate the stimulus set (details below).

As is standard in AG studies, the experiment was divided into a training phase and two testing phases. The training phase stimuli were all trisyllabic, and contained exactly one stressed syllable. There was one key phonotactic restriction on the stimuli presented to participants during the training phase: the syllable *following* the stressed syllable always had [i] as its nucleus.

(4)   Phonotactic restriction on training phase stimuli: only [i] in post-tonic syllable

   a.   CV́.Ci.CV

   b.   CV.CV́.Ci

This phonotactic condition was designed to mimic a foot-based restriction on vowel distributions: the weak branch of the foot can only contain [i], never [u].

Grammatical (observed in training)	Ungrammatical (not observed in training)
(CÝ.C**i**)CV	*(CÝ.C**u**)CV
CV(CÝ.C**i**)	*CV(CÝ.C**u**)

Table 4.1: Schematic 3σ training phase stimuli (with assumed foot boundaries)

There is good evidence that natural languages make use of foot-based phonotactics of exactly this sort. Much previous research argues that the foot can serve as the locus of phonotactic restrictions and/or phonological processes (e.g. Kiparsky 1979, Flemming 1994, Goedemans 1994, Jensen 2000, Harris 2004, and various citations in Section 4.3). It has sometimes been claimed that apparently foot-dependent phonotactics can be recast in terms of stress-based phonotactics without any loss of descriptive accuracy (e.g. Selkirk 1984:31, Beckman 1998:154,161, Smith 2005b:96-137, Flack 2009:272). However, there is converging evidence that not all foot-bounded phenomena can be reduced to stress-sensitivity (e.g. Jensen 2000, Davis & Cho 2003, Harris 2004, González 2003, 2005, 2007, Vaysman 2009). This point becomes especially clear for languages that lack stress accent but still exhibit foot-sensitive phonological processes (see the discussion in Section 4.3.1). There is also good evidence that the weak branch of a foot can be singled out for phonological purposes, to the exclusion of other unstressed syllables (e.g. Hayes 1981, Kager 1989:312-17, Itô et al. 1996, Kager 1997, Kenstowicz 1997, de Lacy 2002a, 2004, 2007, Gouskova 2003, Blumenfeld 2006, McCarthy 2008b, Norris 2010, Itô & Mester 2011a; see also Chapter 3). The typological incidence of phonotactic patterns resembling the restriction diagrammed in Table 4.1 thus justifies the use of such a phonotactic in the following experiments.

Importantly, the vowel quality phonotactic given in (4) had two possible interpretations: the weak branch of the foot cannot contain [u] (5a); or the post-tonic syllable cannot contain [u] (5b).

(5)   Possible statements of the vowel phonotactic

　　a. STRUCTURAL STATEMENT:

　　　　The weak branch of the foot cannot contain [u]:

$$
\begin{array}{ccc}
 & \text{F\tiny T} & \\
 & \diagup\diagdown & \\
s & & w \\
| & & | \\
{}^*(\text{CV} & & \text{Cu})
\end{array}
$$
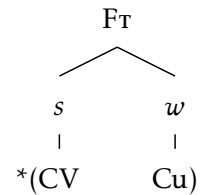
　　b. NON-STRUCTURAL STATEMENT:

　　　　The post-tonic syllable cannot contain [u]:　　　　*CV́.Cu

If there is a cognitive bias in favor of foot-based generalizations, then participants should prefer hypothesis (5a) over hypothesis (5b). The second testing phase of Experiment 1 (Section 4.5.2.3) was designed to tease apart which hypothesis the participants actually formulated during the training phase.

　　The stimuli in Experiment 1 had mobile stress, in the sense that stress was varied between initial and peninitial position. The use of mobile stress precluded phonotactic generalizations based on absolute position in the word, e.g. 'the second syllable always contains [i]'. Since speakers are clearly capable of learning such patterns (e.g. second-position clitics, regular penultimate accent, etc.), eliminating the possibility of syllable-counting generalizations removes a potential confound in the interpretation of the results. The lack of final stress was also intended to encourage a trochaic analysis of the learning data, since *[CV.CV.CV́] is not a possible word in languages with strictly binary trochaic footing.

　　The stimulus list and sound files were created using the Python programming language (`http://www.python.org/`) and MBROLA speech synthesis software (Dutoit 1997, MBROLA Project Development Team 2010). A Python script randomly combined all possible CV syllables to create stimuli, subject to two restrictions: no two adjacent syllables could be identical, and no word could have the same onset consonant for all three syllables. The distribution of individual phonemes was also balanced across stimuli, in order to avoid the inclusion of accidental phonotactic patterns in the training stimuli that might confound interpretation of the results. In stressed syllables and unfooted (i.e. unstressed but not immediately post-tonic) syllables, the two vowels [u i] occured with equal frequency. The consonants [p t k s] occurred with roughly

equal frequency in all three syllable onsets.

As mentioned above, all stimuli were generated with MBROLA speech synthesis software, using a German-language diphone database (`de6`). Vowel length and pitch were the only correlates of stress (e.g. Fry 1955, 1958, Berinstein 1979, Ladefoged 2006:243). Stressed vowels were about 215ms long, while unstressed vowels had a duration of about 140ms. House (1961) and Hillenbrand, Getty, Clark & Wheeler (1995) report comparable average durations for stressed [u i] in American English. Stressed vowels also had a pitch peak at 140Hz, while pitch during unstressed vowels was always below 95Hz. The pitch peak in stressed syllables was realized at the midpoint of the vowel, and was realized slightly earlier for unstressed syllables (at around 30% of total duration of the vowel). The MBROLA program does not allow for the manipulation of intensity, so both stressed and unstressed syllables had a peak amplitude of 70-75dB. Since intensity is often a very weak cue to stress (e.g. Cutler 2005), the lack of an amplitude-based correlate of stress was taken to be unproblematic. All consonants were 95ms in duration, regardless of stress. An overall length of 95ms is within the average range for English voiced stops, but is slightly shorter than the average range for English voiceless stops (Byrd 1993). The output sound files generated by MBROLA do not always precisely match the input phonetic values, so exact segmental durations varied slightly from token to token. The stimuli were all rendered as .wav files with a sampling rate of 22050Hz. Figure 4.1 illustrates the phonetic properties of a trisyllabic stimulus with initial stress from the training phase of Experiment 1.

Participants were told that the stimuli were from a newly-discovered language of Papua New Guinea.[22] After their participation in the experiment, participants were informed that the stimuli were in fact artificial. Many participants reported surprise at finding out that the stimuli had not been produced by an actual human speaker.

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[22]See Esper (1925) for a similar kind of experimental dishonesty in what is arguably the first artificial grammar experiment.
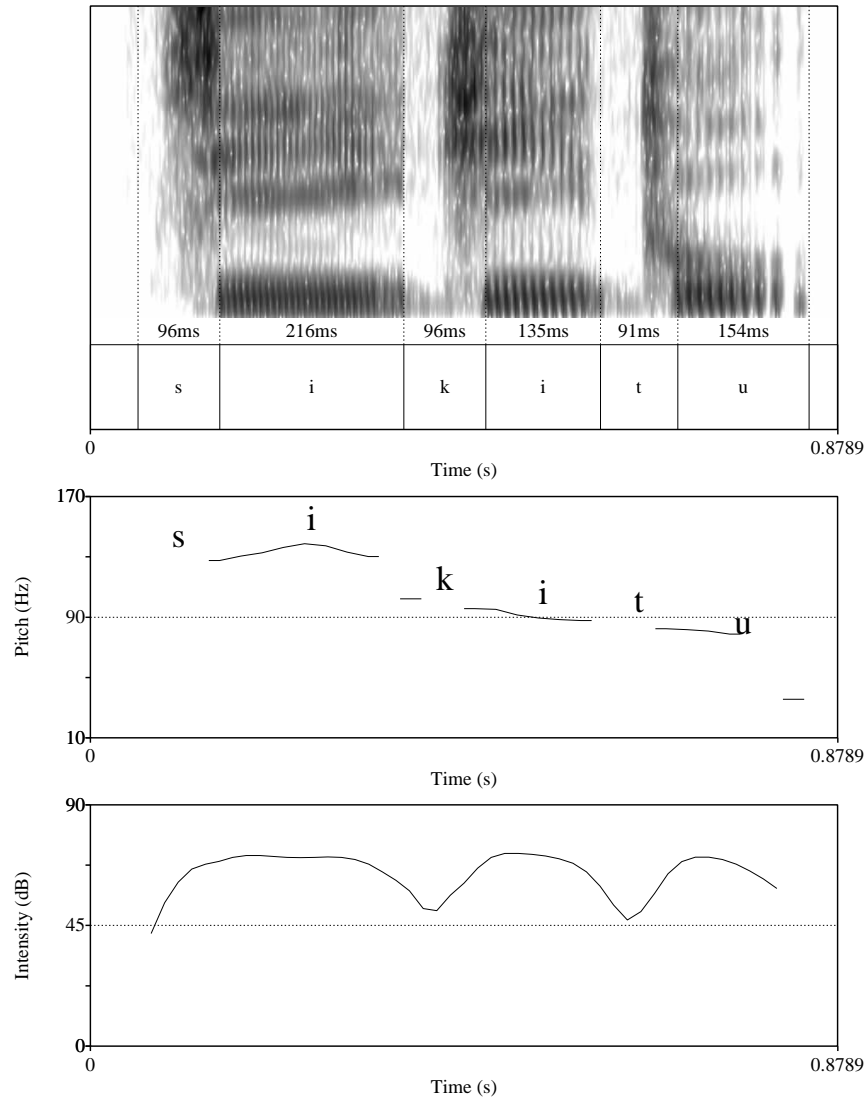
Figure 4.1: Spectrogram, pitch track, and intensity contour for [sí.ki.tu] (produced using Praat, Boersma & Weenink 2010)

4.5.2 Design

Experiment 1 (and all following experiments) consisted of three phases: a training phase, and two testing phases.

4.5.2.1 Training phase

As discussed in Section 4.5.1, all stimuli in the training phase were trisyllabic, and conformed to the foot-based vowel phonotactic schematized in Table 4.1. During the training phase participants listened to 100 3σ stimuli over headphones (50 with initial stress, 50 with peninitial stress), repeated twice in random order (200 total trials). To keep participants engaged in the listening task, they were asked to repeat each word into a headset microphone as if they were practicing speaking a new language. The spoken stimulus repetitions were not recorded, and participants were never explicitly told whether the microphone was (or was not) on. Still, many participants revealed after the experiment that they had assumed their speech was being recorded.

Presentation and randomization of the stimuli was carried out using the E-Prime software package. Participants were given a break after every 40 stimuli (in all phases of the experiment), and were provided a small amount of water to drink. No feedback or explicit instruction of any kind was given to participants during the listening task (see Reber 1967 and Section 4.4.1).

4.5.2.2 Testing phase 1

Following completion of the training phase, participants began the first of two testing phases. Stimuli in the first testing phase were once again trisyllabic. In contrast with the training stimuli, each individual test stimulus could be either 'grammatical' or 'ungrammatical'. Grammatical words obeyed the vowel phonotactic (4), in that the post-tonic syllable contained [i] as its nucleus. Ungrammatical words contained [u] in the post-tonic syllable, and thus violated the vowel phonotactic. All stimuli were balanced for phoneme frequency, and respected the same restrictions on overall word shape that were in force in the training phase. The stimuli were novel, as no stimulus from the training phase was repeated in any testing phase.

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The testing phase differed from the training phase in that, instead of repeating each stimulus, participants were asked to identify which words belonged to the language that they had practiced speaking in the first part of the experiment, and which were from a new (but similar) language. The assumption was that if participants had learned the vowel phonotactic that was active in the training data, they would be able to identify words violating that phonotactic as belonging to a 'different' language. The decision task relied on a simple Yes-No identification design: after hearing each stimulus, participants responded 'Yes' or 'No' on a button box, where 'Yes' corresponded to grammatical (i.e. from the language they had practiced speaking) and 'No' corresponded to ungrammatical (i.e. from a different language than the one they had practiced).

Participants were told that they had about three seconds to respond, and should respond as quickly as possible. If a participant took longer than three seconds on any given trial, a feedback screen asked them to respond more quickly. Because feedback was only intermittent, there was no consistent inter-trial interval for any testing phase. Participants did not receive any feedback regarding the accuracy of their responses. The stimulus set for the first testing phase contained 104 total test words (26 for each stress position and grammatical type) presented in random order.

4.5.2.3 Testing phase 2

The second testing phase asked whether participants would extend the phonotactic condition on vowels to longer words, where iterative footing is in principle possible. Since the vowel phonotactic was foot-based (see Table 4.1), words containing more than one foot would also contain more than one locus of potential ungrammaticality.

All stimuli in the second testing phase were 5 syllables long. These 5σ words still had only one stress peak, falling on either the initial or peninitial syllable.

(6)   Stress patterns on 5σ stimuli

a.   CV́.CV.CV.CV.CV

b.   CV.CV́.CV.CV.CV

The 5σ length was chosen because words with both initial and peninitial stress would

contain a sequence of a stressed syllable followed by three unstressed syllables — that is, a sequence of syllables that could be parsed as the two foot sequence $(\acute{\sigma}\sigma)(\sigma\sigma)$.

(7)   Possible foot structure for 5σ stimuli

   a.   (CV́.CV)(CV.CV)CV
   b.   CV(CV́.CV)(CV.CV)

Prosodic systems of this sort do exist: Capanahua has iterative footing, as diagnosed by various phonological processes, but only the leftmost foot bears phonetic stress (Loos 1969, González 2003).

   With two feet, there are two potential loci of ungrammaticality in the stimuli. Assuming iterative footing, then, these 5σ stimuli could be divided into three classes: grammatical, respecting the phonotactic in Table 4.1; ungrammatical, with [u] in the post-tonic syllable; and ungrammatical, with [u] in the weak branch of a phonetically unrealized, 'covert' foot.[23]

	Overt/stressed foot	Covert foot
Grammatical	(CV́.Ci)(CV.Ci)CV	
Ungrammatical	*(CV́.<u>Cu</u>)(CV.Ci)CV	*(CV́.Ci)(CV.<u>Cu</u>)CV

Table 4.2: Schematic 5σ test stimuli (initial stress only)

As just noted, the 5σ stimuli contained only one stressed syllable (the initial or peninitial syllable, as with the 3σ stimuli). Since only a single stress was present in each stimulus, there was no positive phonetic evidence for iterative footing in 5σ forms. If participants were to assume iterative footing for the 5σ stimuli, then they must necessarily assume covert footing as well.

   It is this second testing phase that qualifies the experiment as an example of the poverty of the stimulus method. Since the training phase only familiarizes participants with 3σ forms — where just one foot is possible, and footing and stress are confounded

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[23]For more background on covert footing, see Hayes (1995), Crowhurst (1996), Hyde (2002), Buckley (2009), Iosad (2009), and Chapter 2.

— the training data underdetermines their response to the 5σ stimuli. We can ask two questions about how participants might generalize from 3σ words to 5σ words (assuming that they do in fact learn the core vowel phonotactic for 3σ stimuli). First, do participants extend the basic ban on post-tonic [u] from the 3σ condition to the 5σ condition? And second, do participants *over*-extend this vowel phonotactic from post-tonic position to the covert foot in 5σ forms (see Table 4.2)? In other words, if they hear a stimulus in which [u] appears three syllables after the stressed syllable — i.e. (σ́σ)(σ Cu) — do they classify that stimulus as ungrammatical?

(8)   Grammaticality violations in ' feet

   a.   * (CV́.Ci)(CV.C**u**)CV

   b.   * CV(CV́.Ci)(CV.C**u**)

Since the 5σ stimuli allow the foot-based phonotactic to be decoupled from stress (at least in principle), the results of the second testing phase make it possible to probe whether participants made a foot-based or purely stress-based generalization about the training data.

The 5σ stimuli were constructed in exactly the same way as the 3σ stimuli, and were subject to the same conditions on overall word shape and individual phoneme frequency. (In the case of 5σ words, this meant that no three adjacent syllables began with the same consonant.) The stimulus set for the second testing phase contained 104 total test words (26 grammatical stimuli for each stress position, and 13 ungrammatical stimuli for each stress position and locus of ungrammaticality) presented in random order. The task was identical to the task used in the first testing phase.

All sessions were conducted in a sound-proof booth in the UC Santa Cruz Phonetics and Phonology Lab. Prior to the experiment, participants were informed that the identification task in the two testing phases would be very difficult, but that they should try their best. All stimuli were presented at a comfortable volume over a headset. Participants were self-selected, and were compensated with course-credit in an undergraduate linguistics course or with $5. The training phase of the experiment took roughly 20 minutes, and the experiment as a whole lasted approximately 35 min-

utes.

4.5.3 Predictions

This section takes a moment to clarify the predictions that the foot-based parsing hypothesis makes about participant performance in Experiment 1. The crucial question is whether participants extend the vowel phonotactic to the weak branch of the covert foot in 5σ forms. If so, then we can conclude (i) that participants do have a bias for foot-based phonotactic generalizations, and (ii) that participants also have a bias for iterative footing, even in the absence of phonetic correlates of non-head feet.[24]

Note that this is an 'all-or-nothing' design. If participants generalize the foot-based phonotactic beyond post-tonic position, we have empirical confirmation of two distinct foot-related biases. On the other hand, if participants fail to generalize beyond post-tonic position, we can't determine whether they learned a foot-based phonotactic (with overt footing only), or simply a stress-based restriction on post-tonic vowel nuclei (recall from Section 4.5.1 that many foot-based phonotactics are potentially reanalyzable as being stress-based). Thus, either both foot structure and iterativity biases are supported by the results, or nothing conclusive can be said either way.

Finally, it's worth noting that English lacks any vowel phonotactics that resemble the foot-based vowel restriction used in this study. Though American English does have rampant vowel reduction, it involves centralization (to [ə] or [ɨ]) rather than fronting or unrounding, and it applies to all unstressed syllables rather than post-tonic or foot-internal unstressed syllables alone (e.g. *banana* [bə(nǽ.nə)]; Hammond 1999). Consequently, any language-particular influence on the results of this experiment must be due to English-specific biases in the construction of feet, rather than biases related to the vowel phonotactic itself (see Section 4.7 for more discussion).

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[24]Some authors have expressed skepticism regarding the existence of non-iterative footing in any language (e.g. McCarthy 2003b:111-2). Much recent work has exploited the related idea that footing can be covert, i.e. that foot structure can be present while also lacking direct phonetic correlates (e.g. references in footnote 23). See Ní Chiosáin (2000) and Chapter 3 for arguments that Irish is best analyzed as having truly non-iterative footing, and see Section 4.8 for discussion of covert footing in Japanese.

4.5.4 Results

Forty-nine participants participated in Experiment 1. The analysis reports on 44 participants: one participant was excluded from the analysis for failing to identify any stimulus as ungrammatical, one for reading the debriefing sheet before the experiment was conducted, and three for not being native speakers of English (i.e. they began learning English after age 9).

Of the 44 participants whose results are analyzed here, 14 were male and 30 female; 40 were right-handed and 4 left-handed. Participant ages ranged from 18 to 28, with a median age of 20. Participants reported familiarity with various Germanic, Slavic, Romance, and Semitic languages, as well as Japanese, Cantonese, Mandarin, and Hindi. Competency in these languages ranged from very basic to native.

Participants were debriefed following completion of the experiment. The debriefing involved discussion of the experiment itself, as well as explicit discussion of the strategies that participants used to distinguish grammatical and ungrammatical stimuli. No participant correctly identified the vowel phonotactic (4), or anything like it, as being the operative difference between grammatical and ungrammatical words.

All statistics were calculated using the R statistical software package (R Development Core Team 2011).

4.5.4.1 Statistical procedure

The statistical procedure for Experiment 1 had several components. First, trials with abnormally long response times were excluded from analysis. The culling process was as follows. To begin, all response times (RTs) were normalized with the log transformation (e.g. Sokal & Rohlf 1995:218,260, Johnson 2008:231).[25] The raw RTs (in ms) were not normally distributed, in part because of the 0ms floor on possible response times. Then, for each participant, all trials with log-transformed RTs greater than 2.5 standard deviations from that participant's mean (in either direction) were eliminated from that participant's data (2.15% of total test trials were discarded in Experiment 1;

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[25]The log transformation was chosen over the inverse transformation because the log transformation resulted in a more normal distribution of RTs. See Ratcliff (1993) and Baayen & Milin (2010) for discussion.

elimination of these trials had no qualitative effects on the overall results). All subsequent statistics were calculated over this subset of total trials, with RTs retaining their log-transformed values.

To gauge whether participants were sensitive to the distinction between grammatical and ungrammatical stimuli, d′ was calculated for each participant and for each condition (e.g. Macmillan & Creelman 2005). The advantage of using d′ is that, unlike raw accuracy scores, d′ is not affected by response biases (e.g. a general propensity to respond 'Yes' on any given trial, regardless of the stimulus). This is because d′ is calculated on the basis of both 'Hits' (here, stimuli correctly identified as grammatical) and 'False Alarms' (stimuli wrongly identified as grammatical). A relatively high d′ value indicates relatively high sensitivity to the distinction being investigated. A d′ score of zero indicates chance performance.[26] (See Macmillan & Creelman 2005 for extended discussion of d′.)

A one-sided *t*-test was then run over the distribution of d′ scores in each condition, to see if the mean d′ score was significantly greater than zero (chance). The distribution of d′ scores in each condition is close to normal, so using a parametric *t*-test is justified. Significant *p*-values (at or below $p = .05$) are boldfaced in all subsequent tables.

4.5.4.2 d′ scores

The d′ scores for testing phase 1 are reported in Table 4.3.[27] Taken as a group, participants were very good at distinguishing grammatical 3σ stimuli from ungrammatical 3σ stimuli in the first testing phase ($p < .001$ for both initial and peninitial stress; $t(43) = 10.83$ and $t(43) = 7.88$, respectively). The position of stress had no discernable effect on performance, though the mean d′ is somewhat higher for 3σ stimuli with peninitial stress.

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[26]If a participant had 0 Hits (or 0 False Alarms) for a given condition, the number of Hits (or False Alarms) for that condition was adjusted upwards to .5 (and the corresponding number of False Alarms or Hits adjusted downward by .5 accordingly). This is because the calculation of d′ involves taking the inverse normal transformation of the Hit Rate (Hits divided by number of trials) and False Alarm Rate (False Alarms divided by number of trials), and the inverse normal transformation of zero is infinite.

[27]In the calculation of d′, Hits were 'Yes' responses to grammatical stimuli and False Alarms were 'Yes' responses to ungrammatical stimuli. There were thus two kinds of False Alarm (one for each locus of ungrammaticality), and one kind of Hit.

	3σ	
	Initial stress	Peninitial stress
Mean d′	0.707	0.900
p-value	< .001	< .001

Table 4.3: d′ results, 3σ condition, Exp. 1 ($n = 44$)

These results suggest that participants did learn the basic phonotactic for 3σ forms, namely that [u] is banned from the post-tonic syllable.

The d′ scores for testing phase 2 (with 5σ stimuli) are given in Tables 4.4 and 4.5. There is an apparent effect of stress position on the d′ scores, so the following discussion will address stimuli with initial and peninitial stress separately.

	5σ, **initial stress**	
	Stressed foot (CV́.C**u**)(CV.CV)CV	Covert foot (CV́.CV)(CV.C**u**)CV
Mean d′	0.113	0.116
p-value	< .11	< .07

Table 4.4: d′ results, 5σ condition, initial stress, Exp. 1 ($n = 44$)

	5σ, **peninitial stress**	
	Stressed foot CV(CV́.C**u**)(CV.CV)	Covert foot CV(CV́.CV)(CV.C**u**)
Mean d′	0.182	0.253
p-value	< .05	< .01

Table 4.5: d′ results, 5σ condition, peninitial stress, Exp. 1 ($n = 44$)

Focusing first on stimuli with peninitial stress (Table 4.5), we find that participants did extend the basic phonotactic to post-tonic position ($p = .02$, $t(43) = 2.19$). Furthermore, we also find that participants extended the basic vowel phonotactic to the position of the covert foot, at least in 5σ words with peninitial stress ($p = .01$, $t(43) = 2.44$). This result provides evidence that participants formulated a foot-based vowel phonotactic

during the training phase of the experiment, in line with the hypothesized bias for foot-based generalizations.

For 5σ test words with initial stress, participants showed less sensitivity to grammaticality distinctions. The mean d' scores are not significantly different from chance (zero) for either post-tonic position or for the covert foot, though there is a trend toward significance (post-tonic violations: $p = .11$ (*n.s.*), $t(43) = 1.26$; covert foot violations: $p = .06$ (*n.s.*), $t(43) = 1.56$). The source of the disparity between 5σ words with initial stress and those with peninitial stress is taken up in Section 4.5.5.

4.5.4.3 Response times

The assumption behind comparing response times is that participants, having learned an inviolable phonotactic rule in the training phase, should take longer to respond to stimuli that violate that rule even when they correctly identify such stimuli as ungrammatical. This presupposes that the violation of a learned rule should evoke a 'surprise' reaction in participants, slowing their overall response speed.[28] If no learning occurs, there should be no such 'surprise' effect, and response speed should be unaffected by grammaticality. Response times were calculated from the stimulus offset point. Mean RTs for Experiment 1 are given in Tables 4.6 and 4.7.

	3σ	
	Initial stress	Peninitial stress
Grammatical	444	426
Ungrammatical	487	525

Table 4.6: Mean RTs, 3σ condition, Exp. 1 (in ms; $n = 44$)

Separate linear mixed-effects models for RTs were constructed for the 3σ and 5σ stimuli, because the Grammaticality predictor has two levels for 3σ stimuli (grammatical and ungrammatical), but has three levels for 5σ stimuli (grammatical, ungrammatical (post-tonic), and ungrammatical (covert foot)). Syllable Count likely has an effect on

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[28]The idea that response times are slowed when participant expectations are not met is widespread in the cognitive sciences; see e.g. Hwang, Monahan & Idsardi (2010) for a recent example within linguistics.

	5σ			
	Initial stress		Peninitial stress	
	Stressed foot	Covert foot	Stressed foot	Covert foot
Grammatical	494		493	
Ungrammatical	466	525	476	518

Table 4.7: Mean RTs, 5σ condition, Exp. 1 (in ms; $n = 44$)

RT latency — a one-sided t-test finds that the mean RT for 5σ stimuli is significantly longer than the mean RT for 3σ stimuli, $p < .005$, $t(8948.415) = 2.85$, with Welch's approximation to degrees of freedom — but Syllable Count was not included as a fixed effect in the models presented here.

The linear mixed-effects models were built using the `lmer()` function, part of the `lme4` package for R (Bates, Maechler & Bolker 2011). The fixed-effects predictors Grammaticality, Stress, Trial, and Response were contrast coded, and were centered and normalized using the `scale()` function in R. Those four predictors, along with all possible interaction terms based on those predictors, were included as fixed effects in the models. A stepwise variable selection procedure, using the `anova()` function to compare nested models via the log-likelihood test, led to the inclusion of Participant as a random effect in the final model for 3σ stimuli, along with by-participant random slopes for Trial, Response, and their interaction. This final model has relatively low collinearity measures ($\kappa = 2.52$, VIF < 1.14 for all predictors).[29]

Table 4.8 reports the significant fixed-effects predictors of RT for 3σ stimuli (nonsignificant predictors, with $p > .05$, were left in the final model but are not presented here).[30]

Table 4.8 shows that Grammaticality is a statistically significant predictor of response

[29]Collinearity measures were calculated using R code from *mer-utils* by Austin Frank, available at `https://hlplab.wordpress.com/2011/02/24/diagnosing-collinearity-in-lme4/`. See also Baayen (2008:221).

[30]Because the statistics community has not agreed on a method for calculating exact p-values for models with random correlation parameters, p-values for this final model were estimated from the t statistic using an upper-bound 4445 degrees of freedom (4472 observations less the 27 parameters in the final model). See Baayen (2008:297) for discussion.

	Estimate β	SE(β)	t	p-value
(Intercept)	6.186	0.065	95.66	<.001
Response	0.069	0.012	5.92	<.001
Grammaticality	-0.039	0.012	-3.36	<.001
Grammaticality x Response	0.037	0.006	6.26	<.001
Grammaticality x Stress	-0.046	0.023	-2.00	.02
Grammaticality x Stress x Response	0.038	0.012	3.19	<.001

Table 4.8: Significant fixed-effects in RT model for 3σ test stimuli, Exp. 1

time for 3σ test words. This finding is consistent with the d' results for 3σ stimuli, which suggest that participants in Experiment 1 did learn the basic post-tonic vowel phonotactic. The effect of Response can be attributed to response bias: participants were in general slower to respond "No", regardless of the stimulus (mean RTs of 425ms for "Yes" responses, 545ms for "No" responses).

The interaction of Grammaticality and Response reflects the fact that "Yes" responses were faster for grammatical stimuli (mean of 395ms vs. 477ms for ungrammatical stimuli), and "No" responses were faster for ungrammatical stimuli (mean of 533ms vs. 571ms for grammatical stimuli) — that is, participants were faster to respond when their responses were accurate. This can be interpreted as further evidence that participants learned some version of the target phonotactic, because participants were quicker to respond when they correctly recognized the grammatical status of a given stimulus.

The interaction of Grammaticality and Stress stems from the fact that response times for grammatical and ungrammatical stimuli differed by a larger margin when stress was peninitial (initial stress: 43ms difference; peninitial stress: 99ms). This may be related to the observation that d' scores were somewhat higher for 3σ stimuli with peninitial stress: it seems that participants were perhaps more sensitive to grammaticality distinctions for 3σ words with peninitial stress than those with initial stress. The three-way interaction Grammaticality x Stress x Response has a similar interpretation: the response time differences between accurate and inaccurate responses were greater

when stress was peninitial (107ms difference) than when stress was initial (19ms difference).

The same model construction procedure was carried out for responses to 5σ stimuli. Stepwise variable selection resulted in a final model with a random effect for Participant, and by-participant slopes for Trial and Response. This model has low collinearity measures (κ = 1.57, VIF < 1.09 for all predictors). The significant fixed-effects predictors in this model are given in Table 4.9.[31]

	Estimate β	SE(β)	t	p-value
(Intercept)	6.207	0.073	85.48	<.001
Response	0.042	0.009	4.47	<.001
Stress x Trial	0.002	0.001	2.69	<.005
Grammaticality x Response	0.013	0.007	1.93	.03
Grammaticality x Stress x Response	0.037	0.013	2.75	<.005

Table 4.9: Significant fixed-effects in RT model for 5σ test stimuli, Exp. 1

The effect of Response again indicates participant bias in favor of "Yes" responses (mean RT was 73ms faster for "Yes" responses than for "No" responses). While there is no significant main effect of Grammaticality, the Grammaticality x Response interaction shows that participants were faster to respond when their responses were accurate (by a margin of 10ms). The three-way Grammaticality x Stress x Response interaction shows that this effect is largest for stimuli with peninitial stress (a 21ms difference, compared with a 1ms difference for initially-stressed 5σ stimuli). This finding is again consistent with the claim that participants were more sensitive to grammaticality distinctions in stimuli bearing peninitial stress, as evidenced by the d' scores for 5σ stimuli.

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[31]p-values were again estimated from the t statistic, using an upper-bound 4456 degress of freedom (4479 observations less the 23 parameters in the final model).

4.5.5 Experiment 1 discussion

The d′ scores for the first testing phase show that participants were able to correctly distinguish grammatical and ungrammatical 3σ words. We can conclude, then, that these participants were in fact sensitive to the basic vowel phonotactic, in at least some formulation.

The d′ scores for the second testing phase suggest that participants extended the basic vowel phonotactic from 3σ stimuli to post-tonic position in 5σ stimuli. Furthermore, participants generalized the vowel phonotactic from post-tonic position to the weak branch of a (hypothesized) covert foot in 5σ stimuli. This result is wholly consistent with the claim that participants learned a foot-based phonotactic rather than a stress-based phonotactic during the exposure phase, which in turn supports the hypothesis that language learning is guided by a foot-based parsing bias. Similarly, generalization of the vowel phonotactic from post-tonic position to the covert foot suggests that participants in Experiment 1 were inclined to assume iterative footing, even in the absence of phonetic evidence for more than one foot in the stimuli.[32]

The analysis of response times provides additional evidence that participants learned some version of the phonotactic and extended it to 5σ stimuli. For 3σ test words, participants were faster to respond to grammatical stimuli than to ungrammatical stimuli, and were faster to respond when their grammaticality judgments were accurate. These results provide another indication that participants learned the basic vowel phonotactic. For 5σ stimuli, stimulus grammaticality had no direct effect on response times, though participants were again faster to respond when their grammaticality judgments were accurate. The fact that accuracy had a significant effect on RTs for 5σ stimuli provides indirect evidence that participants extended the phonotactic to 5σ words, though by itself this finding does not tell us whether participants learned a foot-based or stress-based version of the target phonotactic. These results are nevertheless consistent with the hypothesis that participants (i) learned a foot-based version of the target vowel phonotactic, and (ii) assumed iterative, covert footing for the 5σ

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[32]Relatedly, it has been observed that people tend to perceive stress peaks as more evenly-spaced than they really are (Hayes 1995:31). This might also suggest that listeners impose a regular rhythmic structure on words even when none is present.

test stimuli, as suggested by the d′ scores.

However, these claims come with an important qualification: while the d′ scores for 5σ words with peninitial stress indicate that participants were sensitive to the vowel phonotactic, the d′ scores for 5σ words with initial stress showed only moderate evidence of learning. Why might participants be less sensitive to grammaticality distinctions for 5σ words with initial stress? One possibility is that this disparity stems from a task effect. Specifically, it may be more difficult for participants to process 5σ words when those words have initial stress. Boucher (2006) demonstrates that the presence of stress improves the serial recall of syllable sequences, presumably as a result of its demarcative function (hence Boucher's use of the term 'stress-group'; see also Frankish 1995, Reeves, Schmauder & Morris 2000, and work cited there).[33] It is relevant here that Boucher (2006) finds the effect disappears for stress-groups of larger than four syllables — exactly the size of the stress-group demarcated by peninitial stress in the 5σ test stimuli. In fact, Boucher (2006) reports that five syllable stress-groups — that is, groups consisting of one stressed syllable and a sequence of four unstressed syllables — were actually more difficult to recall than five syllable strings without any stress peak at all. In Experiment 1, initially-stressed 5σ stimuli constituted five syllable stress-groups of exactly this sort.

(9)   Five-syllable stress-group (Boucher 2006):
        CV́.CV.CV.CV.CV
            └─ No stress ─┘

It seems at least plausible, then, that it was more difficult for participants to recall the phonemic content of 5σ words when those words had initial stress than when they had peninitial stress. If participants couldn't reliably recall the distribution of vowel phonemes in initially-stressed 5σ words (and the positions of those vowels relative to

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[33]Boucher (2006) uses 'stress-group' to refer to a stressed syllable and all preceding syllables (the stimuli in Boucher's experiment had fixed final stress, presumably because his participants were French speakers). In this section I use 'stress-group' to refer to a stressed syllable and all *following* unstressed syllables, because the stimuli in Experiment 1 had initial or peninitial stress. I also assume, perhaps without warrant, that Boucher's (2006) findings would generalize to 'stress-groups' with initial rather than final stress.

stress), then they would obviously have been unable to make consistent vowel-based grammaticality judgments. I conclude that the decrement in d′ found for 5σ stimuli with initial stress might reflect limits on memory load; that is, participants may have been unable to recall initially-stressed 5σ words with sufficient accuracy to perform the identification task (or at least to perform the task as well as for 5σ words with peninitial stress).

This interpretation of the d′ scores also makes sense of the fact that participants were less sensitive to grammaticality distinctions in 5σ stimuli with initial stress even when the grammaticality violation occurred in the post-tonic syllable. The d′ scores for both 3σ stimuli and 5σ stimuli with peninitial stress suggest that participants no-ticed grammaticality violations in post-tonic syllables, and used them as the basis for their grammaticality judgments. If participants identified words with post-tonic [u] as ungrammatical for 3σ stimuli and some 5σ stimuli, it's not immediately clear why they wouldn't apply the same criterion to post-tonic position in 5σ words with initial stress. On the other hand, if the memory demands imposed by 5σ words with ini-tial stress interfered with the participants' ability to recall even the post-tonic syllable, then sensitivity to the vowel phonotactic should be diminished in post-tonic position as well.

There is another difference between 5σ stimuli with initial stress and those with peninitial stress. For 5σ stimuli with peninitial stress, there is no ambiguity in where the covert foot could appear, if participants assumed such a foot: it would have to immediately follow the overt, stressed foot.

(10)   Possible covert footing in 5σ words with peninitial stress:
        CV(CV́.CV)(CV.CV)

In contrast, there is a potential ambiguity in where the covert foot could appear in 5σ words with initial stress: it could appear immediately following the overt foot, or it could be separated from the overt foot by a single unfooted syllable.

(11)   Possible covert footing in 5σ words with initial stress:

    a.   Adjacent feet: (CV́.CV)(CV.CV)CV

    b.   Non-adjacent feet: (CV́.CV)CV(CV.CV)

Non-adjacent feet, as in (11b), actually square better with some analyses of foot construction in English (e.g. the 'initial dactyl effect', Selkirk 1984 and others) than the adjacent feet in (11a). But if participants assumed the footing (11b), then they would not have identified stimuli with penultimate [u] as being ungrammatical, even if they did learn a foot-based vowel phonotactic. This is because penultimate [u], under the footing (11b), would actually appear in the strong branch of the foot (i.e. the foot head), and would not therefore be subject to the vowel phonotactic at all. If there was such variability in footing — either across participants, or for an individual participant over the course of the experiment — it could help explain why d′ scores for the covert foot were reduced in 5σ words with initial stress. It would not, however, explain why d′ was also reduced for post-tonic position in initially-stressed 5σ words, because the presence of phonetic stress unambiguously indicates the position of the overt foot (i.e. word-initial [(CV́.CV)CV.CV.CV]).

It's worth pointing out that the mean d′ scores for 5σ stimuli are fairly low, both in absolute terms and relative to the mean d′ scores for 3σ stimuli. This observation might indicate that the 5σ stimuli were generally more difficult to recall than the 3σ stimuli, even beyond the influence of stress found for 5σ words. Since 5σ stimuli are of course longer than 3σ stimuli, we should expect 5σ stimuli to place larger demands on working memory regardless of where stress falls. It's also possible that the prosodic profile of 5σ stimuli contributed to greater processing difficulty relative to the 3σ stimuli. The 5σ stimuli contain a long stretch of unstressed syllables, i.e. a stress lapse. Lapses of this size (3/4σ) are atypical in English, and perhaps cross-linguistically as well.[34] The presence of a long lapse may have interfered with on-line processing of the stimuli, either because words with long lapses are in general difficult to parse (see discussion of Boucher 2006 above), or because they are so drastically different from English that they are difficult for native English speakers to parse. This lapse-based

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[34]The typological dispreference for long lapses of this sort is sometimes formalized with constraints like Parse-2 and *Long-Lapse (Kager 1994). See also Kager (2005) and Buckley (2009).

explanation for reduced performance in the 5σ condition might also help explain why d′ scores were highest with peninitial stress: words with peninitial stress contain a smaller lapse following the stressed syllable, and thus may be easier for English speakers to process.

A second explanation for the relatively low 5σ d′ scores, suggested to me by Armin Mester, concerns the directionality of footing. Since all of the stimuli in Experiment 1 had unpredictable, mobile stress, stress was essentially 'lexical' in the artificial language. Still, participants may have assumed that the 3σ words were derived by right-to-left trochaic footing, as in English (Selkirk 1984). Trisyllabic words with initial stress would then be derived by lexically-determined final syllable extrametricality (i.e. $[(\acute{\sigma}\sigma)\langle\sigma\rangle]$), again as found in English (Liberman & Prince 1977, Selkirk 1984). For 5σ words, the same right-to-left stress assignment algorithm wrongly predicts penultimate or antepenultimate stress.[35] The fact that 5σ stimuli had initial and peninitial stress, contrary to the prediction made by right-to-left footing, could serve as a distracting influence. On the other hand, it has been shown that English speakers are biased toward perceiving initial primary stress (Berinstein 1979, Cutler 2005), in part because of the preponderance of initially-stressed words in English (Cutler & Carter 1987, Cutler 2005). The effect of a 'directionality clash' on performance in the 5σ condition is thus inconclusive.

To summarize, the analysis of participant responses and response times for Experiment 1 suggests that participants learned a foot-based formulation of the target vowel phonotactic, which they then extended to covert feet in 5σ words. While the results for initially-stressed 5σ stimuli provide less evidence for these conclusions than the results for 5σ stimuli with peninitial stress, the effect of stress position can plausibly be attributed to processing difficulties presented by 5σ words bearing only initial stress.

Still, there are reasons to be skeptical about these results. As mentioned above, d′ scores in the 5σ condition are fairly low — even if participants did learn a foot-based vowel phonotactic, it appears that they're not strongly sensitive to it, at least for 5σ stimuli. This might be an indication that participants used a wider variety of strategies

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[35]This assumes either (i) non-iterative footing (e.g. $^{*}\sigma\sigma\sigma(\acute{\sigma}\sigma)$), or (ii) that the rightmost, 'first' foot would be the stress-bearing foot (e.g. $^{*}\sigma(\sigma\sigma)(\acute{\sigma}\sigma)$).

for determining the grammaticality of 5σ stimuli than for judging 3σ stimuli. The fact that responses to 5σ stimuli were strongly influenced by the position of stress might provide additional reason to wonder whether participants really learned the basic, post-tonic phonotactic (putting aside questions of processing difficulty for initially-stressed 5σ stimuli). Following this line of thought, we might wonder whether the apparent use of a foot-based vowel phonotactic in Experiment 1 is illusory — that is, whether the same results could be mimicked by the interaction of some set of phonotactics making no reference to foot structure at all. If so, then the results of Experiment 1 would provide at best ambiguous evidence for the foot-based parsing bias outlined in Section 4.4.

One way to address these concerns is to explore which properties of the stimuli influenced whether participants would respond 'Grammatical' or 'Ungrammatical' on a given trial. This general approach allows us to ask whether participant responses were sensitive to foot structure, or were instead based solely on other phonological properties of the stimuli. The analytical method pursued here involves computational modeling of experimental behavior, using the Hayes & Wilson Maximum Entropy Phonotactic Learner.

4.6 Computational modeling: the Hayes & Wilson Maximum Entropy Phonotactic Learner

Hayes & Wilson (2008) develop a mathematical algorithm for learning surface phonotactics — the MAXIMUM ENTROPY PHONOTACTIC LEARNER (henceforth the MaxEnt learner).[36] Very informally, this algorithm does the following:

(i) Examines the phonotactic structure of some set of input data.

(ii) Identifies sound sequences that should appear in randomly constructed data, but which are missing or statistically underattested in the actual observed input.

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[36]The MaxEnt learner is available on Hayes' website: `http://www.linguistics.ucla.edu/people/hayes/Phonotactics/index.htm`. For more detailed (and more technical) discussion, see Wilson (2006), Hayes & Wilson (2008), and Daland, Hayes, White, Garellek, Davis & Norrmann (2011).

(iii) Formulates phonotactic constraints to explain why certain patterns are systematically missing or underattested in the input data (i.e. to explain the results of step (ii)). These phonological constraints are thus inductively learned from the input.

(iv) Assigns numerical weights to those constraints, as in Harmonic Grammar (Legendre, Miyata & Smolensky 1990, Smolensky & Legendre 2006, Pater 2009, Potts, Pater, Jesney, Bhatt & Becker 2010). This is roughly analogous to the notion of constraint ranking in classical Optimality Theory (Prince & Smolensky 1993/2004).

(v) Uses this constraint-based grammar to predict, in numerical terms, how well-formed novel words should be (using the maximum entropy variant of Harmonic Grammar; Della Pietra, Della Pietra & Lafferty 1997, Goldwater & Johnson 2003).

As shown by Hayes & Wilson (2008), the MaxEnt learner reliably identifies robust phonotactic patterns in the input data it is provided with. The MaxEnt algorithm can thus be used to discover alternative phonotactic constraints that participants might have used to make grammaticality judgments in Experiment 1. The tact taken in this section is to test, using the MaxEnt learner, whether the distribution of participant responses in Experiment 1 is better modeled by (a) a set of phonotactic constraints that are allowed refer to foot structure, or (b) a set of phonotactic constraints that cannot refer to foot structure at all. In other words, we can use the MaxEnt learner to ask whether a foot-based or a foot-free grammar more closely resembles the actual grammar(s) learned by participants in Experiment 1. If the addition of foot structure to the phonotactic model appreciably improves the fit between the experimental results and the predictions made by the MaxEnt learner, we can conclude that participant responses were plausibly conditioned by foot structure in Experiment 1.

The MaxEnt learner takes three input files:

(i) A list of input words used as the basis for generating a grammar.

(ii) A feature matrix, specifying the featural composition of all segments in the learning data.

(iii) A projection file, which allows the user to specify autosegmental tiers that the MaxEnt learner can use to state non-local phonotactics.

Here, the input data (i) was the set of 3σ stimuli from the training phase of Experiment 1. The feature specifications supplied to the MaxEnt learner (ii) are provided in the appendix. Projection files (iii) are useful because they allow the MaxEnt learner to express non-local phonotactic dependencies in a concise way; since the MaxEnt learner prefers short constraints to longer constraints, the inclusion of particular tiers makes it more likely that certain kinds of non-local phonotactics will be represented in the output grammar. All models described here were augmented with a vowel tier, so that non-local phonotactic dependencies involving stress — such as the target phonotactic, 'No [u] allowed in the syllable following a stressed syllable' — could be expressed concisely (see the appendix for an exact specification of the vowel tier).

The MaxEnt learner was instructed to learn two grammars consisting of 40 weighted phonotactic constraints each.[37] One of these grammars was constructed on the basis of input data which included annotations for stress, but which did not in any way represent foot structure. Call this GRAMMAR S (for stress). The second grammar was constructed on the basis of input data which included annotations for both stress and foot structure. Call this GRAMMAR F (for footing). The input data underlying Grammar F marked segments as being footed or unfooted; and for the class of footed segments, it also indicated position within the foot (head or non-head).[38]

The grammars returned by the MaxEnt learner are a species of Harmonic Grammar: they consist of numerically weighted constraints, which collectively assign different well-formedness scores ('harmony scores') to possible output forms. As such, Grammar S and Grammar F both make numerical predictions about how well-formed novel words should be. Since Grammar S and Grammar F are constructed on the basis of qualitatively different kinds of input data (i.e. different prosodic representations of the 3σ training stimuli), they make divergent predictions regarding the well-formedness of the 3σ and 5σ test items in Experiment 1. The harmony scores as-

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[37]The settings for the MaxEnt learner were as follows: maximum gram size = 3; maximum number of constraints = 40; maximum O/E ratio = .75. All other parameters were left at their default settings. The MaxEnt learner needs a fairly large data set ($\geq$ 3000 tokens) to construct an accurate grammar; since the number of training phase stimuli is relatively small (100 stimulus types), each stimulus was repeated 50 times in the training data supplied to the MaxEnt learner.

[38]Only vowels were coded as being stressed/unstressed, being footed/unfooted, or being a foot head/non-head. Consonants were marked as undefined for all of these properties.

signed by the two grammars can then be compared to the experimental results: for a given stimulus, we can ask how well its MaxEnt harmony score predicts the well-formedness judgments given by participants in Experiment 1. The question, then, is whether Grammar S or Grammar F produces harmony scores that more closely match the experimental results.

4.6.1 MaxEnt results

Grammar S and Grammar F were evaluated by calculating the predicted harmony scores for the 3σ and 5σ test stimuli in Experiment 1. The prosodic representation of the test stimuli matched the annotation scheme used to construct each grammar: Grammar S computed harmony scores for test items marked only for stress, while Grammar F computed harmony scores for test items marked for both stress and foot structure. Both stressed feet and hypothetical covert feet (as in Table 4.2) were coded in the 5σ test items provided to Grammar F.

The MaxEnt learning algorithm is stochastic, so n iterations of the MaxEnt learner over the same input data could in principle yield n distinct output grammars. To get a more reliable picture of how well each grammar predicts the experimental results, the MaxEnt learner constructed ten iterations each of Grammar S and Grammar F. Predicted harmony scores for the test stimuli were computed for all twenty of these grammars.

Both Grammar S and Grammar F learn one or more constraints that correspond to the target phonotactic (with varying degrees of directness and specificity). Table 4.10 includes some of these constraints, their frequency of occurrence in the output grammars, and a schematic interpretation of the kinds of configurations that they would penalize within the set of test stimuli used here. ('X' is shorthand for the feature specification [-word_boundary], i.e. any segment; segments mentioned in a given constraint are underlined in the interpretation column.) Both grammars also learn some trivial phonotactics that are satisfied by all experimental stimuli (e.g. all words must contain more than one vowel), as well as phonotactics that accidentally hold of the training stimuli (e.g. *[tŭs] and *[sŭs]), but which do not reliably distinguish grammatical and ungrammatical test stimuli.

Grammar S	Constraint (frequency)	Interpretation (for 3σ stimuli)
Vowel tier	*[+STRESS][+BACK] (10)	*CV́.Cu
	*[-STRESS] X [+BACK] (9)	*CV̌.CV́.Cu
No tier	*[+STRESS] X [+BACK] (7)	*CV́.Cu
	*[+LABIAL,-STRESS] X [-STRESS] (4)	*CV́.Cŭ.CV̌
	*[+STRESS] X [+LABIAL] (3)	*CV́.Cu
Grammar F		
Vowel tier	*[+FOOT HEAD][+BACK] (10)	*(CV́.CV)
	*[-STRESS] X [+BACK] (10)	*CV̌.CV́.Cu
No tier	*[+LABIAL,-STRESS,+FOOTED] (10)	*(CV́.Cu)
	*[+BACK] X [-FOOTED] (10)	*(CV.Cu)CV
	*[+FOOT HEAD] X [+LABIAL] (5)	*(CV́.Cu)
	*[+FOOTED] X [+LABIAL,+FOOTED] (3)	*(CV.Cu)
	*[+FOOT HEAD] X [+BACK] (1)	*(CV́.Cu)

Table 4.10: Versions of target phonotactic for Experiment 1 appearing in MaxEnt grammars

The empirical well-formedness score for a given stimulus in Experiment 1 was taken to be the percentage of trials on which that stimulus was identified as grammatical. These empirical well-formedness scores were correlated with the harmony scores for each iteration of each grammar; Table 4.11 reports the mean correlation level across the ten iterations of each grammar, and the associated standard deviations.[39]

		Grammar S	Grammar F	Difference
Initial stress	3σ test words	**.589** (.008)	.571 (.013)	.018
	5σ test words	.250* (.030)	**.283** (.026)	.033
Second-syllable stress	3σ test words	.720 (.006)	**.754** (.013)	.034
	5σ test words	.431 (.017)	**.520** (.015)	.089

Table 4.11: Correlation levels for MaxEnt scores (40 constraints) and empirical well-formedness scores from Exp. 1 (Spearman's ρ). Standard deviations are in parentheses. Non-significant correlations are marked with '*'.

All of the correlations reported in Table 4.11 are statistically significant, with the exception of the correlation between Grammar S and 5σ test stimuli with initial stress (with 52 comparisons in each cell, any correlation at or above .274 is significant at $p = .05$ or better; Ramsey 1989).

There are several things to notice about the correlation levels in Table 4.11. First, in three out of four conditions, Grammar F has a higher correlation with the experimental results than Grammar S. While Grammar S outperforms Grammar F for 3σ words with initial stress, the difference between the two correlation levels (.018) is the smallest of any by-condition comparison. The largest difference between the two grammars is found for 5σ test stimuli with peninitial stress, where Grammar F outperforms Grammar S by a margin of .089. Recall that the d′ scores for this condition (5σ words with peninitial stress) provided the initial evidence that participants learned a foot-based vowel phonotactic in Experiment 1 (see Table 4.5). In other words Grammar F, which has access to foot structure, more closely models participant responses in exactly the condition for which the d′ scores point toward a foot-based formulation

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[39]Correlations were calculated using Spearman's ρ, which is a robust non-parametric test for correlation. The distribution of harmony scores tends to cluster around 0 (i.e. perfectly well-formed), so Spearman's ρ is more appropriate than Pearson's r.

of the vowel phonotactic. The MaxEnt results, then, are consistent with the claim that participants prefered a foot-based statement of target phonotactic in Experiment 1.

To ensure that these findings are not an artifact of the size of the constraint set, the modeling procedure described above was repeated with MaxEnt grammars consisting of 100 constraints each.[40] Since the MaxEnt learner is designed to generate highly-effective constraints as early as possible, the resulting constraint sets were rough supersets of the 40 constraint MaxEnt grammars discussed above. The correlations between these 100 constraint grammars and participant responses in Experiment 1 are given in Table 4.12.

		Grammar S	Grammar F	Difference
Initial stress	3σ test words	.597 (.008)	**.607** (.011)	.010
	5σ test words	.243* (.035)	**.305** (.023)	.062
Second-syllable stress	3σ test words	.712 (.007)	.712 (.009)	.000
	5σ test words	.370 (.027)	**.494** (.012)	.124

Table 4.12: Correlation levels for MaxEnt scores (100 constraints) and empirical well-formedness scores from Exp. 1 (Spearman's ρ). Standard deviations are in parentheses. Non-significant correlations are marked with '*'.

When the MaxEnt learner is set to uncover 100 constraints, Grammar F models participant responses as well or better than Grammar S in all conditions. The differences between the two grammars are small for 3σ stimuli, but correlations achieved by Grammars S and F clearly diverge for 5σ test stimuli. Once again, the largest difference between the grammars is found for 5σ stimuli with peninitial stress, where Grammar F outperforms Grammar S by a sizeable margin of .124.

Assuming participants learned some version of the basic vowel phonotactic, then it comes as no surprise that Grammars S and F perform at roughly equal levels for 3σ test stimuli: stress-based formulations of the target phonotactic (e.g. no post-tonic [u]) are isomorphic to foot-based formulations (e.g. no [u] in the weak branch of the foot), in the sense that they penalize exactly the same configurations in 3σ words. But the two grammars make different predictions regarding participant responses to 5σ

[40]In order to prevent the MaxEnt algorithm from halting before learning 100 constraints, the O/E value was set at .85 for all iterations of the program. All other settings were unchanged.

stimuli. While both grammars penalize words containing post-tonic [u], only Grammar F can 'see' foot structure, hence only Grammar F directly penalizes 5σ words that contain [u] in the weak branch of a covert foot.[41] Grammar F thus makes a clear distinction between grammatical (12) and ungrammatical (13), while Grammar S does not.

(12)   Grammatical covert feet in Experiment 1

    a.   (CV́.Ci)(CV.C<u>i</u>)CV

    b.   CV(CV́.Ci)(CV.C<u>i</u>)

(13)   Ungrammatical covert feet in Experiment 1

    a.   *(CV́.Ci)(CV.C<u>u</u>)CV

    b.   *CV(CV́.Ci)(CV.C<u>u</u>)

In terms of expressive power, the key difference between Grammar F and Grammar S is that Grammar F can formulate constraints refering to a level of prosodic structure (footing) that Grammar S does not have access to. This difference in expressive power correlates with a difference in how closely each grammar matches the experimental results. Since the ability to refer to foot structure improves the MaxEnt learner's predictions regarding actual participant behaviour in Experiment 1, we can infer that the participants themselves also plausibly relied on foot structure in making their grammaticality judgments.

Specifically, if participants (i) assumed a foot-based vowel phonotactic, and (ii) assumed covert footing, we would expect Grammar F to outperform Grammar S for 5σ stimuli, because only Grammar F is able to capture grammaticality violations occurring within covert feet. On the other hand, if participants assumed a stress-based

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[41] Grammar S can penalize covertly footed (CV.Cu) as well, but only indirectly, by positing a constraint that disprefers the sequence [CV̌.CV.Cu] (e.g. the vowel-tier constraint *[-stress] X [+back]; see Table 4.10). Such a constraint correctly penalizes words of the shape [(CV́.CV)(CV.Cu)CV] and words of the shape [CV(CV́.CV)(CV.Cu)], but it also wrongly penalizes the sequence [(CV́.CV)(CV.Ci)Cu]. At any rate, Grammar F is capable of stating exactly the same constraint; since Grammar F also uncovers additional constraints targeting covert (CV.Cu) that cannot be stated by Grammar S, the two grammars do make different predictions about the well-formedness of covert (CV.Cu).

phonotactic, we would expect Grammar S to outperform Grammar F on 5σ stimuli, since Grammar F makes grammaticality distinctions in covert feet that are spurious from the perspective of a stress-based vowel phonotactic. In other words, if participants learned a stress-based phonotactic, then Grammar F would overpredict sensitivity to where [u] can appear, lowering the overall correlation level between the MaxEnt harmony scores and the empirical well-formedness scores. MaxEnt modeling of the experimental results shows that Grammar F is superior to Grammar S; this finding supports the claim that participants learned a foot-based grammaticality distinction in Experiment 1. I conclude that the MaxEnt computational model provides further support for the hypothesis that speakers are biased toward foot-based phonotactic generalizations.

Finally, it's worth noting that both grammars make predictions for initially-stressed 5σ stimuli that correlate poorly with the experimental results. The harmony scores generated by Grammar S reach only a non-significant level of correlation with the empirical well-formedness scores for 5σ stimuli with initial stress, whether the grammar consists of 40 or 100 constraints. Grammar F achieves its lowest correlations in the same condition, regardless of the size of the grammar. These results parallel the d' scores for Experiment 1, which showed a significant effect of grammaticality for 5σ words with peninitial stress, but not for 5σ words with initial stress.

In Section 4.5.5 I argued that the differing results for 5σ stimuli with initial stress and those with peninitial stress could be attributed to a processing factor: the sequence of four unstressed syllables found in initially-stressed 5σ words makes it difficult for participants to recall the syllabic (or phonemic) content of such stimuli. If participants were unable to accurately recall 5σ stimuli with initial stress, then they would have been unable to evaluate such stimuli in any consistent way. The participant responses to 5σ stimuli with initial stress should then contain more randomness (i.e. guessing) than the responses to 5σ stimuli with peninitial stress.

Under this view, it makes sense that Grammars S and F fail to model participant responses in just this condition: while the two grammars systematically evaluated initially-stressed 5σ words against a set of phonotactic constraints, the experimental participants were unable to do the same, given the processing difficulty associated with

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such stimuli. In other words, the MaxEnt models fail for initially-stressed 5σ words because they are attempting to fit systematic phonotactic predictions to experimental results that are themselves only partially systematic.

The results of Experiment 1 suggest that speakers do make use of foot structure when formulating phonotactic restrictions, even when the segmental distributions expressed by those phonotactics could be equally well captured by a phonotactic referring to the position of stress rather than to foot structure. This finding is consistent with the hypothesis that speakers are influenced by a cognitive bias that encourages language learners to look for foot-based phonological patterns in their target language. However, the possibility remains that these results were in some way influenced by the native English phonology of the participants in Experiment 1. Experiment 2 addresses this concern by replicating Experiment 1 with native Japanese speakers.

4.7   Experiment 2

The results of Experiment 1 are consistent with the hypothesis that speakers are subject to a bias that predisposes them to look for foot-based phonotactic generalizations. Still, there are several reasons to wonder whether the results of Experiment 1 simply reflect the native English phonology of the participants, without implicating any independent cognitive biases. First, Experiment 1 simulated trochaic footing, just as in English (Selkirk 1984, Hammond 1999).

(14)   Trochaic footing in English

  a.   *solid*   (sɔ́.lɪd)
  b.   *yellow*   (jɛ́.lo͡ʊ)
      etc.

Experiment 1 also found evidence that speakers are predisposed to assume iterative footing, even in the absence of phonetic cues for multiple feet. A potential confound for this interpretation of the results is that footing is iterative in English as well.

(15)   Iterative trochaic footing in English

    a. *bandana*   (bæ̀n)(dǽ.nə)
    b. *Apalachicola*   (æ̀.pə)(læ̀.t͡ʃə)(kóʊ̯.lə)
       etc.

Any bias toward iterativity might then represent specific knowledge of English prosodic
phonology rather than a more general bias for exhaustive footing.

    Third, and perhaps most important, is that English has several stress-conditioned
vowel phonotactics. For example, English has a highly robust process of unstressed
vowel reduction, which centralizes most unstressed full vowels to the weak vowels [ə]
or [ɨ].

(16)   Stress-conditioned vowel reduction in English

    a. *atom*   [ǽɾə̠m]
    b. *atomic* [ə̠tʰǽ̠mɪk]
       etc.

It is of course true that English vowel reduction isn't directly foot-based, as it targets
all unstressed syllables rather than stress-adjacent syllables alone (Hammond 1999,
Crosswhite 2001; see also Section 4.5.3). Further, unlike English vowel reduction,
the vowel color phonotactic of the artificial language (/V/ → [i] / (σ́ . __)) does
not manipulate vowel sonority, at least under the assumption that all high vowels are
equally sonorous (e.g. Jespersen 1904, Dell & Elmedlaoui 1985, Clements 1980, etc.).
Nevertheless, there is a strong connection between stress and vowel quality in English
which may have impacted the results of the study.

    More worrisome is the fact that English has at least one allophonic process, post-
tonic vowel deletion, that plausibly targets vowels in the weak branch of the foot.

(17)   Post-tonic vowel deletion in English (Hooper 1978)

    a. *family* [fǽmə̠li] ~ [fǽmli]
    b. *opener* [óʊ̯pə̠nɝ] ~ [óʊ̯pnɝ]
       etc.

Since footing is trochaic in English, in many cases post-tonic syllables will be parsed into the weak branch of a foot — exactly the position targeted by the core vowel phonotactic in Experiment 1. Consequently, it is at least possible that Experiment 1, which points toward the existence of a foot-based parsing bias, was compromised by the native English phonology of the participants.

The question, then, is whether the results of Experiment 1 could be replicated with speakers whose native language lacks stress-conditioned phonotactics. Experiment 2 explored this possibility by repeating Experiment 1 with native speakers of Japanese. There are several reasons why Japanese provides an excellent comparison case for English. Japanese is a prototypical pitch accent language, meaning that words can be either accented or unaccented, and when accent is present it is cued primarily by tonal excursions (e.g. McCawley 1968, Haraguchi 1999, Kubozono 2008, Hirayama 2009). This is in contrast with stress accent languages like English, which require every content word to contain at least one stressed syllable, usually cued by duration and intensity as well as pitch (Berinstein 1979, Cutler 2005). Since Japanese does not have a stress-based accentual system, it necessarily lacks stress-determined phonotactics as well. Furthermore, there are no accent-dependent segmental phonotactics in Japanese, in the sense that there are no patterns of segmental allophony that crucially refer to the presence, absence, or position of pitch accent. Indeed, at least one allophonic process — high vowel devoicing — occurs even when it might be antagonistic to the realization of pitch accent (see Hirayama 2009). If Japanese-speaking participants learn a foot-based vowel phonotactic during the experiment (or a stress-based vowel phonotactic, for that matter), such a result could not be as easily attributed to influence from the phonology of their native language.

4.7.1 Design

Experiment 2 replicated Experiment 1, but with native speakers of Japanese. Participants were recruited from undergraduate linguistics courses at International Christian University (ICU) in Tokyo, and from the National Institute for Japanese Language and Linguistics (NINJAL), also in Tokyo. ICU students are well-known for having relatively high levels of proficiency in English (more on this momentarily). Participants

recruited from NINJAL, all post-doctoral researchers, had English skills comparable to those of the ICU students participating in the experiment. Since these participants were able to conduct basic conversations and read written instructions in English, it was possible to repeat Experiment 1 essentially unchanged.

A word is in order regarding the stimuli used in Experiment 2. All stimuli were composed of CV syllables, and thus conformed to Japanese syllable structure requirements (maximally C_1VC_2, where C_2 is a moraic nasal or the first half of a geminate). The consonants [p t k s] and the vowels [u i] are all phonemic in Japanese, so the stimuli were also consistent with the Japanese segmental inventory (though Japanese [u] is more accurately unrounded [ɯ]). However, the stimuli contained numerous [si], [ti] and [tu] sequences, which in native Japanese words would be realized as [ʃi], [t͡ʃi] and [t͡su] respectively. (See Itô & Mester 2003:Ch.1 for an overview of Japanese segmental phonology.) At the prosodic level, all stimuli had initial or peninitial stress (as in Experiment 1). Since high pitch was used as a cue to stress, the tonal profile of the stimuli was similar, though not identical, to the tonal profile of Japanese words bearing initial or peninitial pitch accent: a high initial tone followed by a steady fall for stimuli with initial stress; and a rise followed by a steady fall for stimuli with peninitial stress.[42] Thus many stimuli, though not all, closely resembled possible words of Japanese.[43]

All experimental sessions were conducted in a quiet room at ICU or at NINJAL, using a laptop, button box, and headphones. Participants were compensated for their participation with ¥1000 each (≈ $12 U.S.). In all other respects, Experiment 2 was exactly identical to Experiment 1.

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[42]In Tokyo Japanese, pitch accent is realized as an H*L contour melody. Words appearing at the beginning of a phonological phrase are realized with an initial pitch rise (sometimes represented as an L% H-melody; see McCawley 1968 and much subsequent work). This initial LH contour is similar to the initial tonal contour found for stimuli with peninitial stress in Experiment 2.

[43]Though stressed vowels were significantly longer than unstressed vowels, they were probably not long enough to be interpreted as phonemic long vowels by Japanese speakers: the ratio of stressed to unstressed vowel duration in the stimuli was around 1.54, compared with an average ratio of around 2.5 for phonemic long vs. short vowels in Japanese (Hirata 2004).

4.7.2 Results

To mitigate the possible confound of extended L2 experience with English or other stress accent languages, participants were excluded from analysis if they began learning English before the age of 6, or if they had lived abroad in a country where the predominant language was a stress accent language (e.g. Spain, France, England, etc.) for more than 6 months before the age of 6. Participants were also excluded from analysis if their spoken English was near-fluent or better, as determined impressionistically in conversations before and after the experiment. Of the 43 participants who participated in Experiment 2, only 33 satisfied these criteria. One additional participant was excluded from consideration for having participated in an earlier pilot version of the experiment, so the analysis reports on 32 participants. Excluding the other 11 participants from analysis did not qualitatively effect the overall results, though reducing the number of participants did lower the overall significance levels somewhat.

Of the 32 participants whose results are analyzed here, 10 were male and 23 female; 31 were right-handed and 2 left-handed. Participant ages ranged from 18 to 44, with a median age of 19. All participants had some experience with English. Additionally, participants reported familiarity with German, Spanish, Finnish, Russian, Korean, Hindi, Tagalog, Indonesian, Thai, and Laotian. Competency in these languages ranged from very basic to native.

The statistical procedure for Experiment 2 was identical to the statistical procedure for Experiment 1. As in Experiment 1, for each participant, all trials with log-transformed RTs greater than 2.5 standard deviations from that participant's mean (in either direction) were eliminated from that participant's data (1.74% of total test trials were discarded in Experiment 2; elimination of these trials had no qualitative effects on the overall results).

4.7.2.1 d′ scores

The d′ scores for testing phase 1 are reported in Table 4.13. Taken as a group, participants were again very good at distinguishing grammatical 3σ stimuli from ungrammatical 3σ stimuli in the first testing phase ($p < .001$ for both initial and peninitial stress; $t(31) = 8.05$ and $t(31) = 10.35$, respectively). The position of stress had no dis-

cernable effect on performance, though the mean d′ is notably higher for 3σ stimuli with peninitial stress.

	3σ	
	Initial stress	Peninitial stress
Mean d′	0.999	1.316
p-value	**< .001**	**< .001**

Table 4.13: d′ results, 3σ condition, Exp. 2 ($n = 32$)

The d′ scores for testing phase 2 (with 5σ stimuli) are given in Tables 4.14 and 4.15. Again, we see an apparent effect of stress position: the d′ scores for 5σ stimuli with peninitial stress show evidence of learning along with evidence of extension to the covert foot (stressed foot, $t(31) = 2.03$, $p = ,03$; covert foot, $t(31) = 1.93$, $p = .03$); but the d′ scores for initially-stressed 5σ stimuli are only significantly different from chance for stimuli with grammaticality violations located in the covert foot, and not for violations located in the overt, stressed foot (stressed foot, $t(31) = 0.55$, $p = .29$; covert foot, $t(31) = 3.16$, $p = .002$).

	5σ, initial stress	
	Stressed foot (CV́.C**u**)(CV.CV)CV	Covert foot (CV́.CV)(CV.C**u**)CV
Mean d′	0.063	0.356
p-value	**< .30**	**< .005**

Table 4.14: d′ results, 5σ condition, initial stress, Exp. 2 ($n = 32$)

	5σ, peninitial stress	
	Stressed foot CV(CV́.C**u**)(CV.CV)	Covert foot CV(CV́.CV)(CV.C**u**)
Mean d′	0.243	0.178
p-value	**< .05**	**< .05**

Table 4.15: d′ results, 5σ condition, peninitial stress, Exp. 2 ($n = 32$)

4.7.2.2 Response times

Response times, calculated from the stimulus offset point, were again analyzed separately for 3σ and 5σ test stimuli. Unlike Experiment 1, it appears that responses to 3σ test stimuli were overall slower than responses to 5σ test stimuli (mean RT for 3σ stimuli = 610ms, mean RT for 5σ stimuli = 575ms; $p < .005$, $t(6537.909) = 2.76$, with Welch's approximation to degrees of freedom). Mean RTs for Experiment 2 are given in Tables 4.16 and 4.17.

	3σ	
	Initial stress	Peninitial stress
Grammatical	554	593
Ungrammatical	653	643

Table 4.16: Mean RTs, 3σ condition, Exp. 2 (in ms; $n = 32$)

	5σ			
	Initial stress		Peninitial stress	
	Stressed foot	Covert foot	Stressed foot	Covert foot
Grammatical	567		558	
Ungrammatical	563	554	627	615

Table 4.17: Mean RTs, 5σ condition, Exp. 2 (in ms; $n = 32$)

Linear mixed-effects models over RTs were constructed following the procedure outlined in Experiment 1. For 3σ stimuli, stepwise variable selection resulted in a final model with a random effect for Participant, and by-participant slopes for Trial, Response, and Stress. This model has fairly low collinearity measures ($\kappa = 2.40$, VIF < 1.31 for all predictors). The significant fixed-effects predictors in this model are given in Table 4.18.[44]

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[44]p-values were again estimated from the t statistic, using an upper-bound 3252 degress of freedom (3279 observations less the 27 parameters in the final model).

	Estimate β	SE(β)	t	p-value
(Intercept)	6.457	0.084	76.79	<.001
Response	0.076	0.015	4.93	<.001
Grammaticality x Response	0.041	0.007	5.87	<.001
Grammaticality x Stress	0.053	0.026	2.06	.02

Table 4.18: Significant fixed-effects in RT model for 3σ test stimuli, Exp. 2

Once more we find a main effect of Response, indicating that participants in Experiment 2 were somewhat hesitant to respond "No" (mean RT of 548ms for "Yes" responses, 724ms for "No" responses). Though there is no main effect of Grammaticality, there is evidence that grammaticality distinctions had an impact on RTs. Participants were slower to respond to ungrammatical 3σ stimuli than to 3σ grammatical stimuli, whether stress was initial ($p < .001$, $t(1638.777) = -3.82$) or peninitial ($p = .02$, $t(1634.946) = -2.01$; both p-values are from a one-sided t-test with Welch's approximation to degrees of freedom). The effect of Grammaticality appears to be larger for stimuli with initial stress, hence the significant interaction of Grammaticality and Stress in the linear mixed-effects model. The Grammaticality x Response interaction again reflects the fact that participants were faster to respond when their responses were accurate (mean RT of 584ms for accurate responses, 670ms for inaccurate responses; see discussion in Section 4.5.4.3). The analysis of RTs thus provides further evidence that participants learned the target vowel phonotactic, consistent with the d' results for 3σ test stimuli.

For 5σ test stimuli, a similar stepwise variable selection procedure resulted in a final model with a random effect for Participant, and by-participant slopes for Trial and Response. This model has low collinearity measures ($\kappa = 1.48$, VIF < 1.24 for all predictors). The significant fixed-effects predictors in this model are given in Table 4.19.[45]

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[45]p-values were again estimated from the t statistic, using an upper-bound 3238 degress of freedom (3261 observations less the 23 parameters in the final model).

	Estimate β	SE(β)	t	p-value
(Intercept)	6.362	0.077	82.33	<.001
Response	0.047	0.011	4.33	<.001
Trial	-0.002	0.001	-3.17	<.001
Stress	0.043	0.025	1.73	.04
Grammaticality x Stress	-0.065	0.030	-2.17	.02
Grammaticality x Response	0.017	0.008	2.17	.02
Stress x Trial x Response	0.001	0.000	2.07	.02

Table 4.19: Significant fixed-effects in RT model for 5σ test stimuli, Exp. 2

First, we find a now-familiar response bias leading to overall slowed RTs for "No" responses (the effect of Response). The main effect of Trial reflects a small trend toward faster response times over the course of the second testing phase (i.e. there is a negative correlation between Trial and RT, $r = -0.065$). We also find an effect of Stress: participants were slightly faster to respond to stimuli with initial stress (mean RT of 563ms vs. 589ms for stimuli with peninitial stress).

The interaction of Grammaticality and Stress is revealing, because like the d′ scores for Experiment 2, response times are only clearly affected by grammaticality for stimuli with peninitial stress (see Table 4.17). Looking first at initially-stressed 5σ stimuli, response times for grammatical stimuli are not significantly different from the response times for ungrammatical stimuli, whether the grammaticality violation is post-tonic ($t(792.63) = 0.15$, $p = .88$ (*n.s.*)) or in the covert foot ($t(834.858) = 0.47$, $p = .64$ (*n.s.*)). In contrast, for 5σ stimuli bearing peninitial stress, responses to grammatical stimuli were faster than responses to ungrammatical stimuli, for both stimuli with a post-tonic locus of violation ($t(774.961) = -2.26$, $p = .02$), and for stimuli with a grammaticality violation in the covert foot ($t(811.52) = -1.98$, $p = .05$). The RT results thus provide a strong parallel to the d′ results for 5σ stimuli, in that participants were most sensitive to the target phonotactic when stress was peninitial.

As in the previous RT models, the interaction term Grammaticality x Response probably reflects an effect of accuracy: "No" responses were faster when accurate (mean RT of 641ms vs. 649ms for inaccurate "No" responses), as were "Yes" responses

(mean RT of 518ms vs. 550ms for inaccurate "Yes" responses). Once again, the effect of accuracy plausibly indicates that participants were in fact employing some version of the target phonotactic in making their grammaticality judgments.

4.7.2.3 Experiment 2 discussion

As in Experiment 1, the d′ scores for 3σ stimuli in Experiment 2 strongly suggest that participants learned some version of the basic vowel phonotactic. This result is further supported by the analysis of RTs, which shows that stimulus grammaticality has a reliable effect on RT latency.

The d′ scores for 5σ stimuli in Experiment 2 show evidence of both learning and extension to the covert foot — that is, evidence that participants learned a foot-based phonotactic — but once again, this result is limited to 5σ stimuli with peninitial stress. For initially-stressed 5σ stimuli, participants showed essentially no sensitivity to grammaticality distinctions in the post-tonic syllable. Strangely (and unlike Experiment 1), participants apparently *were* sensitive to grammaticality violations occurring in the covert foot in initially-stressed 5σ words, despite the non-significant mean d′ for more basic post-tonic grammaticality violations.

While the results of Experiment 2 support the claim that participants once again learned a foot-based vowel phonotactic during training, the d′ results for initially-stressed stimuli are difficult to interpret. It is possible, however, that these results also reflect a sort of task effect. In Section 4.5.5 I suggested that initially-stressed 5σ stimuli may place a greater burden on working memory than than 5σ stimuli with peninitial stress. A common finding in experimental research on the serial recall of ordered sequences is that items at the end of a list are easier to remember than list-medial items — this is known as the 'recency effect' (see e.g. Greene 1986). It is also independently known that list edges play a central role in serial recall (Ebbinghaus 1885/1913; see Brown, Neath & Chater 2007 and Nevins 2010 for brief overviews of relevant literature), and it has been shown that participants in artificial grammar experiments sometimes attend to word edges when learning novel phonotactics (e.g. Perruchet & Pacteau 1990, Gomez & Schvaneveldt 1994, Redington & Chater 1996, Aslin et al. 1998, Saffran et al. 1999, Bailey et al. 1999, Pothos & Bailey 2000; etc.). Given

the well-documented existence of a recency effect in serial recall, it seems likely that syllables at the end of 5σ stimuli may have been easier for participants to remember than syllables at the beginning of those stimuli. The strength of the recency effect in Experiment 2, then, may have mitigated any difficulties stemming from the prosodic profile of initially-stressed 5σ stimuli, but only for grammaticality violations occurring near the end of the word. This would explain why participants were sensitive to grammaticality distinctions in the covert foot of initially-stressed 5σ stimuli, despite not being sensitive to grammaticality distinctions located earlier in the word.

More suggestive evidence for a recency effect comes from the fact that mean d′ scores for 3σ stimuli were higher in both Experiments 1 and 2 when stress was peninitial, i.e. when the grammaticality violation occurred in the word-final syllable (see Tables 4.3 and 4.13). Similarly, response times in Experiments 1 and 2 showed larger effects of grammaticality and/or accuracy when stress was peninitial (see Section 4.5.4.3); this too could be evidence of a recency effect in participant responses.

An obvious question is why the d′ scores for English-speaking participants in Experiment 1 did not show a comparable recency effect for 5σ words with initial stress. I am not entirely sure how to account for this difference, apart from the fact that L1 influence from English footing may have had an additional impact on the reduced d′ scores for this condition (see the discussion in Section 4.5.5). Recall that the English-speaking participants in Experiment 1 may have sometimes assumed the footing [(CV́.CV)CV(CV.CV)] for 5σ words with initial stress, rather than the expected footing [(CV́.CV)(CV.CV)CV]. This is made plausible by the fact that English has strong tendencies toward both initial and penultimate stress (Hayes 1981, Selkirk 1984, Cutler & Carter 1987, Cutler 2005), consistent with the footing [(CV́.CV)CV(CV.CV)]. Furthermore, many five-syllable words in English bearing initial stress also have stress on the penult rather than the antepenult (Selkirk 1984:Ch. 3.3.2). (These are words of the *abracadabra* type, which have light medial syllables and show a dactylic stress pattern, e.g. [æ̀.bɹə.kə.dǽ.bɹə]). If English speakers were attending to the 'wrong' syllable (the ultima rather than the penult), then the contribution of a recency effect in recall would have been moot.

As Junko Itô (p.c.) rightfully points out, this structural ambiguity may not have

arisen for Japanese speakers. There is a large statistical preference for antepenulti-
mate pitch accent in Japanese, especially in the non-native vocabulary (Kubozono &
Ogawa 2004, Kubozono 2008; see also Section 4.8.2). A widespread view in the study
of Japanese phonology is that antepenultimate pitch accent is assigned to the head
of a right-tropic, but non-final trochaic foot, e.g. [...(CV́.CV)CV] (see, again, Sec-
tion 4.8.2). There is also suggestive evidence from prosodic morphology that Japanese
prefers left-aligned footing (Itô & Mester 1992/2003). Taken together, these obser-
vations predict that L1 influence from Japanese should favor the expected footing
[(CV́.CV)(CV.CV)CV] for 5σ words with initial stress in Experiment 2. Consequently,
we might reasonably *expect* to observe a recency effect in the results of Experiment 2,
but not Experiment 1.

Experiment 2 thus provides qualified evidence that Japanese speakers, like the
English speakers in Experiment 1, are biased in favor of foot-based phonotactic gener-
alizations. To shore-up the claim that participants in Experiment 2 did indeed learn a
foot-based vowel phonotactic, Section 4.7.3 compares the experimental results to the
predictions made by the two Maximum Entropy grammars presented in Section 4.6.

4.7.3 MaxEnt modeling of Experiment 2

Section 4.6 compared the results of Experiment 1 to the response patterns predicted by
two different Maximum Entropy grammars: Grammar S, which can formulate phono-
tactic constraints referring to stress but not foot structure; and Grammar F, which can
formulate phonotactic constraints referring to stress, foot structure, or both. Since the
stimulus set was identical for Experiments 1 and 2, the MaxEnt grammars trained on
that stimulus set can be used to model the results of either experiment.

Table 4.20 shows how well Grammar S and Grammar F model the response pat-
terns for Experiment 2 when the MaxEnt learner generates 40 constraints for each
grammar (the procedure for determining correlation levels was as described in Sec-
tion 4.7.3). Once again, Grammar F, which allows reference to foot structure, tends to
outperform Grammar S, which does not.

		Grammar S	Grammar F	Difference
Initial stress	3σ test words	**.591** (.012)	.556 (.011)	.035
	5σ test words	.388 (.049)	**.531** (.015)	.143
Peninitial stress	3σ test words	.724 (.009)	**.748** (.018)	.024
	5σ test words	.255* (.009)	**.342** (.017)	.087

Table 4.20: Correlation levels for MaxEnt scores (40 constraints) and empirical well-formedness scores from Exp. 2 (Spearman's ρ). Standard deviations are in parentheses. Non-significant correlations are marked with '*'.

The same basic pattern of results holds for grammars consisting of 100 constraints: again we find that Grammar F tends to outperform Grammar S across conditions.

		Grammar S	Grammar F	Difference
Initial stress	3σ test words	.608 (.009)	**.623** (.009)	.015
	5σ test words	.392 (.046)	**.544** (.021)	.152
Second-syllable stress	3σ test words	**.746** (.010)	.738 (.013)	.008
	5σ test words	.256* (.019)	**.313** (.016)	.057

Table 4.21: Correlation levels for MaxEnt scores (100 constraints) and empirical well-formedness scores from Exp. 2 (Spearman's ρ). Standard deviations are in parentheses. Non-significant correlations are marked with '*'.

While Grammar S does surpass Grammar F in how well it predicts participant responses to 3σ stimuli with peninitial stress, the difference between correlation levels is very small (only .008). The most conspicuous differences between the two grammars are found found for 5σ stimuli, where Grammar F outperforms Grammar S by much larger margins (.152 for 5σ stimuli with initial stress; .057 for 5σ stimuli with peninitial stress).

As in Experiment 1, computational models of participant responses in Experiment 2 clearly improve when they are allowed to refer to foot structure. This provides evidence that participants in Experiment 2 used foot structure when making phonotactic well-formedness judgments. Importantly, adding foot structure to the model achieves the greatest predictive gains for 5σ stimuli. Since the main difference in expressive power between Grammars S and F lies in the ability of Grammar F to recognize gram-

maticality violations in covert feet in 5σ forms, these MaxEnt modeling results suggest that participants in Experiment 2 were also sensitive to covert footing, and that participants used such footing as a basis for grammaticality judgments. This finding indicates that the Japanese-speaking participants in Experiment 2, like the English-speaking participants in Experiment 1, learned a foot-based vowel phonotactic during the exposure phase of the experiment.

4.8   General discussion

Experiment 1 found evidence that language learning is influenced by a foot-based parsing bias: when confronted with a novel vowel phonotactic that was ambiguous between a stress-based and a foot-based restriction on [u], participants prefered the foot-based formulation. Since either phonotactic would suffice to capture the distribution of vowels in the artificial language, the preference for a foot-based statement of the vowel phonotactic must stem from a prexisting learning bias that participants brought to the experiment: namely, a bias for foot-based phonotactic generalizations.

A potential objection to this interpretation of the results is that English, the native language of the participants, has stress-based and possibly foot-based vowel phonotactics itself. The results of Experiment 1 might then reflect knowledge of English phonology rather than a more general bias for foot-based phonotactics. However, this objection cannot be raised against the results of Experiment 2, which replicated the results of Experiment 1 with native Japanese speakers. Since Japanese has no foot-dependent or accent-dependent phonotactics, the results of Experiment 2 cannot be chalked-up to the influence of L1 phonological knowledge. Taken together, Experiments 1 and 2 provide strong evidence for the existence of a foot-based parsing bias.

The apparent existence of a foot-based parsing bias goes some way toward explaining why foot structure is found in many languages lacking foot-dependent stress (Section 4.3). Assume that language learners are indeed predisposed to look for foot-based phonological patterns in their target language, independent of whether the accentual system of the target language provides clear evidence for the foot. This predisposition will then lead learners to analyze some phonological phenomena as being foot-based, even if those phenomena were not actually foot-based in the grammars of

the previous generation of speakers. For example, sonority-driven epenthesis in Irish (Chapter 3) probably grew out of a transitional vocoid produced by patterns of gestural coordination in stressed syllables, as in many languages with similar processes of vowel epenthesis (e.g. Dorsey's Law in Hocank; see Hall 2006 for thorough discussion). Unlike a very similar phenomenon in Scots Gaelic (e.g. Ladefoged et al. 1998), sonority-driven epenthesis in Irish has been phonologized: the transitional vocoid has become a full-fledged syllabic vowel, subject to foot-based distributional constraints. The prevalence of foot structure, then, is at least partially due to diachronic reanalysis: in some cases, language learners reinterpret non-metrical phonological phenomena as being foot-based; the pressure driving such reinterpretation is a cognitive bias directing learners to look for foot-based phonological patterns in their target languages.

The logic of this argument depends on the validity of a particular assumption: namely, that there really are foot-based phonological patterns in languages without foot-based accent. In the following section I entertain, then reject two alternative views of foot-based phonotactics in EOS languages.

4.8.1 Alternative explanations for footing in EOS languages

If putatively foot-based phenomena like sonority-driven epenthesis in Irish are not actually conditioned by footing, why might analysts have arrived at the (potentially mistaken) conclusion that foot structure is relevant for such phenomena? One obvious answer is that at least some of these processes make reference to stress; and as many phonologists have pointed out, the conditioning environments for some phonological processes are systematically ambiguous between foot-based and stress-based triggers (e.g. Selkirk 1984:31, Beckman 1998:154,161, Smith 2005b:96-137, Flack 2009:272).[46] Can the apparent existence of foot-sensitive phonological patterns in EOS languages be reduced to stress-sensitivity? And can stress alone explain the emergence of phonological alternations that refer to 'foot-like' configurations in languages without foot-dependent accent?

Tackling diachrony first, the question is whether there are any linguistic pre-

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[46]Witness the long-standing debate over tapping in English, which has been variously described as stress-based (Kahn 1976, among others) and as foot-based (Kiparsky 1979, again among others).

cursors that could give rise to phonological processes that target foot-like structures. Again, a natural candidate is stress: many processes targeting stressed or stress-adjacent syllables will have the misleading appearance of targeting particular positions within the foot. One can easily think of phonetic precursors that could be grammaticalized as categorical phonological processes targeting stressed or stress-adjacent syllables. For example, many perseveratory phonetic phenomena have been phonologized as non-iterative spreading processes: peak delay in the realization of high tone, (e.g. Hyman & Schuh 1974, Myers 1998); V-to-V coarticulation of roundness, backness, and tenseness (e.g. Cole 2009); N-to-V vowel nasalization (Cohn 1993); and so on. (See Kaplan 2008 for extended discussion of non-iterative phonological processes of this sort.) A subset of such non-iterative spreading processes are triggered only by stressed syllables — presumably, because stress enhances perceptibility, so stressed syllables will be better 'hosts' for the features that undergo spreading, or will provide more robust phonetic precursors for phonologization than unstressed syllables (e.g. Flemming 1994, Beckman 1998). At any rate, stressed syllables have distinctive phonetic properties, both acoustic and articulatory, that set them apart from unstressed syllables; such phonetic distinctions could surely lead to the grammaticalization of phonological patterns targeting only stressed and/or stress-adjacent syllables.

Remember, too, that the presence of stress facilitates the memorization of nearby syllable sequences (Section 4.5.5). One possible inference from these facts is that phonotactic patterns occurring 'in the neighborhood' of stress should be easier to learn than phonotactics active elsewhere in the word (see also Newport & Aslin 2004 on the relevance of syllable adjacency for phonotactic learning). Phonotactic patterns that are easier to learn are also more likely to persist over time (e.g. Saffran 2002, Kiparsky 2008). Taken together, these facts entail that stress-dependent phonotactic patterns (i) are reasonably likely to arise, given the existence of common phonetic precursors, and (ii) should be relatively stable from a diachronic standpoint, given the psycholinguistic strength of stressed syllables. We might then entertain a different sort of historical account for the putative appearance of foot structure in EOS languages. As just noted, phonotactic patterns targeting stress-adjacent syllables may evolve spontaneously from gradient phonetic precursors, and should be relatively likely to survive

from one generation to the next. These robust stress-adjacent phonotactics could then be misinterpreted by the analyst as being dependent on foot structure, though footing need not actually be invoked to capture the phonotactic in question.

This route of explanation is subject to at least three objections. First, this kind of explanation fails to account for the fact that footing in EOS languages shares a host of structural properties with footing in languages with rhythmic stress. Without a specific, contentful bias for foot structure, the diachronic scenario sketched above will need further mechanisms to explain why footing in e.g. Irish is subject to conditions on binarity, non-finality, grouping harmony, and so on (see e.g. Prince 1991, Hayes 1995, Prince & Smolensky 1993/2004 and Hyde 2007 for discussion of these notions). The sub-word prosodic constituents we find in EOS languages like Irish aren't just 'foot-like' — they are metrical feet *par excellence*. As pointed out in Chapter 3, foot-free alternatives must resort to various *ad hoc* devices to capture the same range of facts. On the other hand, if foot structure is just one level in a universal hierarchy of prosodic constituents (the 'strong UG' view), then it comes as no surprise that footing in EOS languages shows evidence of being shaped by cross-linguistically common constraints on foot form.

The second objection concerns the role of the foot in languages lacking stress accent altogether. The evidence surveyed in Section 4.3.2 firmly establishes that 'classic' tonal and pitch accent languages make use of metrical foot structure in myriad phonological domains. Since these languages lack stress accent — and sometimes lack any obligatory word-level accent at all (Hyman 2006) — the diachronic, stress-based alternative to footing does not obviously apply. In contrast, the proposed foot-based parsing bias should apply equally to stress accent, pitch accent, and tonal languages, so it does a better job of unifying the typological facts than the diachronic alternative sketched above.

Finally, the stress-oriented reanalysis of footing in EOS languages has nothing to say about the results of Experiments 1 and 2: it is essentially a diachronic account, and one that does not bear on synchronic patterns of phonotactic generalization. At the very least, this view of footing in EOS languages contributes nothing to our understanding of why participants in Experiments 1 and 2 extended the basic vowel phono-

tactic to covert feet, which are not cued by stress. In contrast, the foot-based parsing bias helps explain *both* the typological facts and the experimental results discussed here.

Another 'emergent' explanation for the appearance of footing in EOS languages is that foot-like structures are found independently in patterns of child speech production. As documented in Gerken (1991), Demuth (1996), and much related research, child speech in many languages is characterized by a foot-like template consisting of two syllables, or in some cases a single heavy syllable.

(18)   Foot-like truncations in child English (Gerken 1991, Demuth 1996)

      a.   *giraffe* [d͡ʒəɹǽf] → Child: [ɹǽf]

      b.   *eraser* [əɹéɪsɚ] → Child: [ɹáɪsə]

      c.   *elephant* [ɛ́ləfɪnt] → Child: [ɛ́lfʌn]
         etc.

Remember that morphological templates of this sort have also provided an important source of evidence for foot structure in EOS, pitch accent, and tonal languages. For example, hypocoristics and at least one language game in Japanese make use of morphological targets consisting of one or more bimoraic trochees.

(19)   Japanese hypocoristics: Ft*-*chan* template (Poser 1990, Mester 1990)

      a.   hiroko → (hii)-chan, (hi.ro)-chan, *(hi)-chan

      b.   masako → (maa)-chan, (ma.sa)-chan, *(ma)-chan

      c.   kenzaburoo → (ken)-chan, (ken)(za.bu)-chan, *(ke)-chan, *(ken)za-chan

(20)   Japanese reversal argot ('zuuja-go'): Ft+{Ft, σ_μ} template (Itô et al. 1996)

      a.   ko:hi: → (ho:)(ki:) 'coffee'

      b.   takushi → (shi:)(ta.ku) 'taxi'

      c.   sake → (ke:)sa, *(ke.sa) 'rice wine'

      d.   jido:kan → (kan)(ji.do), *(kan)(ji:)do 'children's hall'

Could child speech be the *origin* of apparently foot-based morphological targets in

adult speech? After all, it is perhaps unsurprising that hypocoristics and child speech often conform to similar prosodic templates, given that both structures are likely to occur in conversations between parents and their children. Perhaps the adult use of foot-like prosodic morphology reflects a generalization of patterns found in child phonology. On this view, there is no need to invoke a foot-based parsing bias to account for the cross-linguistic prevalence of foot-like morphological targets: such templates emerge from independent facts about the phonological productions of children.

While there is no doubt some connection between the morpho-prosodic templates found in child and adult speech, something still must be said about *why* child speech conforms to foot-like targets in the first place. Demuth (1996) argues convincingly that perceptual and articulatory factors are not sufficient to explain templatic effects in early word production. Instead, she proposes that young children conflate prosodic words and footing in their productions: child speech is subject to a constraint demanding that all words consist of one and only one well-formed foot. On this view, adult patterns of prosodic morphology resemble early child productions precisely because both phenomena are driven by foot-based morphological templates. Since this account of templatic effects in child speech presupposes that children have access to the foot as a prosodic constituent, it is clearly compatible with the existence of a foot-based parsing bias, as argued here.

4.8.2   Are there any languages without feet?

The previous section noted that Japanese, a prototypical pitch accent language, has patterns of prosodic morphology that implicate the bimoraic trochee. Similar evidence for bimoraic footing comes from loanword truncation and other canonical word size effects (Haraguchi 1999, Itô & Mester 1996, 1992/2003 and references therein), as well as reduplication, mimetics, and poetry (Poser 1990). There is also accentual evidence for bimoraic footing: for example, default antepenultimate accent in Tokyo Japanese is arguably foot-based (where 'antepenultimate' means 'syllable containing the antepenultimate mora'). Kubozono (2008) (drawing on McCawley 1968, Kubozono 1995, and much related work) makes the following generalizations about default ac-

cent placement in Tokyo Japanese:[47]

(21)   Default accent rules for Tokyo Japanese (TJ) (Kubozono 2008)

    a.   Accent the rightmost, non-final foot.

    b.   [In compounds]: Within the rightmost, non-final foot, accent the syllable
        that is closer to the word-internal morpheme boundary.

Kubozono (2008) argues that rule (21a) is active both for native words (especially
nouns) and for loanwords, yielding antepenultimate accent in forms like (22).

(22)   Default accent for native and loanword vocabularies in TJ (Kubozono 2008)

    a.   (í.no)ti 'life'

    b.   a(zá.ra)si 'harbor seal'

    c.   su(tó.re)su 'stress'

    d.   ba.do(mín)(ton) 'badminton'

Similarly, rule (21b) successfully predicts the position of pitch accent in compounds
composed of two underlyingly unaccented words (23). (Further conditions are re-
quired to account for accent placement in compounds built on one or more indepen-
dently accented words.)

(23)   Compound accent in TJ (Poser 1990, Kubozono 1995, 2008)

    a.   minami + amerika → mi.na.mi-(á.me)(ri.ka) 'South America'

    b.   kuwagata + musi → ku.wa.(ga.tá)-(mu.si) 'stag beetle'

Finally, evidence for the foot in Japanese also comes from conditions on *unaccentedness*.
Kubozono & Ogawa (2004) observe that there is a strong statistical preference for loan-
words consisting of exactly four light syllables to be unaccented. The preference for
unaccentedness in four-mora LLLL loanwords isn't a general effect of word length, be-
cause trisyllabic LLL and pentasyllabic LLLLL loanwords show no such preference. Itô
& Mester (2011b) analyze this fact as follows. Assuming bimoraic foot structure, LLLL
loanwords should be footed (LL)(LL). The rightmost foot in (LL)(LL) words is thus also

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[47]For presentational reasons, some further conditions on compound accent are omitted from (21).

the final foot. The default accentuation rule (21a) prefers to accent the rightmost foot in the word, provided that foot is non-final. Since LLLL loanwords are exhaustively footed, foot non-finality can't be satisfied by retracting the rightmost foot one syllable to the left (cf. odd-parity words like (22a)). There is thus no way for accented LLLL loanwords to satisfy the default accentuation rule (21a). Since unaccentedness trivially satisfies (21a), LLLL loanwords tend to lack accent altogether, rather than violate the foot-based conditions on accentuation.

Foot-based approaches to Japanese are thus quite successful at capturing a range of morphological and phonological phenomena. But if these foot-based analyses are correct, then we're driven to the conclusion that Japanese is overflowing with feet that have no phonetic realization. For example, completely accentless words are still subject to foot-based size requirements and other aspects of prosodic morphology (19), (20). Right-aligned footing is needed for pitch accent placement, but the pitch accent itself sometimes falls outside of the rightmost foot (22), (23). Perhaps most compellingly, foot structure also explains unaccentedness in words of particular prosodic profiles. Many of these foot-based analyses hinge on the availablity of iterative footing in Japanese; and since Japanese words can contain at most one pitch accent, iterative footing necessarily entails phonetically non-realized — that is, covert — feet.[48]

One could argue, then, that the results of Experiment 2 fail to demonstrate the existence of a foot-based parsing bias: like Experiment 1, they may simply reflect the application of L1 phonological knowledge, which for Japanese speakers would involve exhaustive, partially covert footing of the experimental stimuli into bisyllabic trochees. In order to provide truly conclusive evidence for a foot-based parsing bias, then, it would be necessary to replicate the results of Experiments 1 and 2 with a population of speakers whose native language does not employ foot structure at all.

While the methodological point is well-taken, the question remains whether there *are* any languages in which the foot is truly irrelevant for phonological patterning. Indeed, if the foot-based parsing hypothesis is correct, it may be the case that all lan-

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[48]As Junko Itô points out to me, many accented Japanese words sometimes appear as unaccented, due to deaccenting effects triggered by compound formation and certain suffixes. If we assume that footing is consistent in a given word whether or not its underlying accent is phonetically realized on the surface, then even lexically accented words provide examples of covert footing in some contexts.

guages make use of the foot in at least some small corner of their morpho-phonology — or alternatively, that all speakers mentally subdivide words into feet, whether or not this subdivision has any further phonological consequences (see also Schiering et al. 2010).

As Hyman (2011) frames the issue (with respect to syllable structure, in his case), even if the foot does not play an obvious role in the phonological organization of a given language, it does not follow that the foot is actually absent from that language. That is, there are two distinct facets to the question of prosodic universals: first, whether all languages have *access* to prosodic constituents like the foot; and second, whether all languages make use of those constituents to the same degree — in Hyman's (2011) terms, whether languages differ in the extent to which a given prosodic constituent is *activated* in the phonology. It is clear that the phonological activity of prosodic constituents does vary from language to language. For example, the foot plays at most a small role in the phonology of EOS languages like Hungarian, Polish, and French, despite the centrality of footing to the morpho-phonology of English, Japanese, and many other languages. Hyman (2011) makes similar points regarding the 'visibility' of syllable structure in the word-level phonology of Gokana. The key point here is that the existence of some prosodic constituent in a given language is logically separable from the extent to which languages deploy that constituent in their phonology. And since both of these issues concern properties of *languages*, rather than properties of *speakers*, they are also logically independent from the question of whether language learners might be predisposed to look for foot-based phonological patterns during acquisition.

To illustrate, consider Tz'utujil, a Guatemalan Mayan language closely related to Uspanteko. Tz'utujil has basically exceptionless final stress, at least in native words, and no secondary stress (Dayley 1985:29). I know of no conclusive evidence for foot structure in Tz'utujil; however, there are some phonological phenomena in the language that are suggestive of footing. As one example, in the dialect of Tz'utujil spoken in Santiago Atitlán all unstressed (i.e. non-final) short vowels undergo deletion (Dayley 1985:45). This is very much the mirror image of syncope in Southeast Tepehuan (initial stress), which Kager (1999) analyzes as a strategy for minimizing the number

of unfooted syllables in a word. But the same facts are probably also compatible with an analysis in which syncope is simply across-the-board deletion of unstressed short vowels (setting aside some further conditions on syncope that either account must deal with; see Dayley 1985).

Now imagine that the results of Experiments 1 and 2 had been replicated again, this time with Tz'utujil speakers. How should the results be interpreted? Can we be sure that Tz'utujil lacks foot structure? What if footing is present, but only weakly and ambiguously activated in the language? And even if Tz'utujil itself does not make use of footing, isn't it still possible that Tz'utujil *speakers* mentally chunk words into smaller, foot-sized units? Indeed, a central conclusion of this chapter is that speakers may include foot structure in the mental representation of lexical items even when the linguistic evidence at hand provides only ambiguous evidence for footing.

The methodological claim here is that it is very difficult — though certainly not impossible — to isolate a particular language or community of speakers as a plausible counterexample to the view that footing is universal (see again Schiering et al. 2010 for related discussion). To echo another point raised by Hyman (2011), "if one looks hard enough an apparent counterexample may ultimately show weak traces of evidence for the universal" (83).[49] As a result, finding speakers who have no native-language experience with footing is far from a trivial task. Until we discover a language that unambiguously eschews the foot, the only way to move forward is to test our prosodic hypotheses against a range of languages with diverse surface phonologies, thereby increasing our confidence in their generality. This has long been common practice in generative phonology, and the experiments described here are no exception.

In this light, it would be certainly be valuable to repeat the experiments described in this chapter with participants whose native language shows *less* evidence for the foot than English and Japanese. If, for example, Polish-speaking participants showed no preference for foot-based phonotactic generalizations, it would cast doubt on the claim that the parsing bias I propose here is independent of native language experience. For the moment, I must leave such experiments for future research.

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[49]Such evidence need not even be phonological; for example, Shaw (2007) finds subphonemic differences in affrication for foot-initial and foot-medial [t͡ʃi] in Japanese (Chapter 2). See Buckley (2009:411) for related discussion of Latvian.

4.8.3 Consequences for prosodic constituency

I have argued that the results of Experiments 1 and 2 support the existence of a foot-based parsing bias. This conclusion is motivated by the fact that participants applied the post-tonic vowel phonotactic from the artificial language to portions of novel words that did not contain any stress prominence at all (i.e. to covert feet in 5σ test stimuli). In other words, participants applied the vowel phonotactic on the basis of abstract phonological structure, even in the absence of phonetic reflexes for such structure. This finding suggests that feet and stress, though intimately related, can be dissociated (e.g. Crowhurst 1996, Buckley 2009, Iosad 2009).

These results are thus consistent with theoretical frameworks that include autonomous prosodic constituents in their ontology of phonological objects. Prosodic hierarchy theory (Selkirk 1980, McCarthy & Prince 1986/1996, Itô & Mester 1992/2003, Selkirk 1996, etc.) is clearly one such framework, since it takes the foot to be a phonological primitive. Simplified bracketed grid theory (SBG; Halle & Vergnaud 1987, Halle & Idsardi 1995) is another: while prosodic constituents in SBG are algorithmically derived rather than primitive, they can still be targeted and manipulated by phonological rules, apart from the computation of stress itself. Like prosodic hierarchy theory, SBG privileges binary metrical constituents (via the iterative constituent construction parameter of Halle & Idsardi 1995; see Chapter 1), so both frameworks are also consistent with the claim that participants assumed exhaustive binary footing in Experiments 1 and 2.

Prosodic hierarchy theory and SBG theory are both 'metrical frameworks', in the sense that they countenance rhythmic prosodic structure below the word. It may be possible to accommodate the results of Experiments 1 and 2 in non-metrical frameworks as well, though doing so requires ancilliary assumptions that lack any independent motivation. In the grid-only theories of Prince (1983) and Selkirk (1984), word-level prominence is assigned without any reference to internal prosodic constituents like the foot (though both theories accept the need for syllable structure). van der Hulst (2009, submitted) also proposes that rhythmic accent can be assigned with reference to grid structure alone (a claim put forward in many of his earlier publications as well; see Walker 1995, 1996 and Gordon 2002a for related views). While van der

Hulst (2009, submitted) does allow for some metrical constituents, these constituents are only used to determine the location of primary stress: they have no independent status, and there is no exhaustive parsing of words into feet.

How would a non-metrical framework account for the results of Experiments 1 and 2? Since non-metrical theories do not allow for abstract foot structure as such, it is only possible to formulate the the experimental vowel phonotactic in terms of stress. This is a problem, since the experimental results showed that participants applied the vowel phonotactic even in the absence of stress. It seems to me, then, that to capture the experimental results in a non-metrical framework we would need to assume that participants learned three different phonological rules:

- A procedure for placing rhythmic secondary stress.

- A stress-based vowel phonotactic.

- A rule of destressing that eliminates all but the initial stress peak.

These rules, applying in that order, determine the ungrammaticality of *[tú.pi.ki.t<u>u</u>.si] as follows:

(i) Place primary stress on the initial syllable (given).

```
Level 2     *
Level 1     *
Level 0     *     *     *     *     *
         t  u  p  i  k  i  t  u  s  i
```

(ii) Assign alternating rhythmic secondary stresses left-to-right, beginning at the position of primary stress.

```
Level 2     *
Level 1     *           *           *
Level 0     *     *     *     *     *
         t  u  p  i  k  i  t  u  s  i
```

(iii) If the gridmark following any Level 1 gridmark (i.e. any stress peak) dominates [u], mark that word as ungrammatical:[50] *[tú.pi.<u>kì.tu</u>.sì]

(iv) Remove all Level 1 gridmarks, subject to the Continuous Column Constraint (i.e. no removing Level 1 gridmarks dominated by a Level 2 gridmark; Prince 1983, Hayes 1995). This returns the grid to the state in (i).

There are several things to note about this non-metrical procedure for checking the grammaticality of experimental stimuli. First, it is unclear how participants would have arrived at the conclusion that the artificial language makes use of a 'Duke-of-York' derivation (Pullum 1976, McCarthy 2003a) that assigns, then summarily removes secondary stresses. After all, there were no secondary stresses in the experimental stimuli, and the placement of primary stress did not depend on the assumption of hypothetical, phonetically inert secondary stresses (i.e. the artificial language was not a count system like Cairene Arabic or Creek; Hayes 1995, van der Hulst 2009 and related work). Note that the SBG account of Experiments 1 and 2 is open to similar objections: like non-metrical theories, the bottom-up procedure for determining primary stress in SBG would require the initial assignment of alternating secondary stresses (Level 1 gridmarks), which must then be erased subsequent to the placement of primary stress. This counts as a point in favor of prosodic hierarchy theory, though perhaps not a decisive one.[51]

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[50]Given the destressing rule (iv), this could be simplified to 'Mark a word as ungrammatical if it contains [u] not dominated by a Level 1 gridmark'.

[51]The reader might object that gridmark removal of this sort is equivalent in theoretical parsimony to covert footing, thereby negating the advantages of prosodic hierarchy theory for explaining these experimental results. There is, however, a slight contrast: both prosodic hierarchy theory and SBG assume something like covert footing — prosodic constituents that are present in surface forms but which do not contain stress prominence — but only SBG assumes an intermediate stage where those covert feet bear secondary stress.

```
Level 2        *
Level 1    ‖   *               ∦           ∦
Level 0    ‖   *       *   ‖   *       *   ‖   *
               t   u   p   i   k   i   t   u   s   i
```

Table 4.22: Destressing in SBG ('∦' indicates eliminated gridmarks)

Second, in non-metrical theories application of the vowel phonotactic is often opaque, because the conditioning stress peaks are not always present on the surface. Since opacity presents well-known learning problems (Kiparsky 1971, 1973), it is troubling that these theories need to assume that participants in Experiment 1 and 2 learned an opaque generalization about the distribution of [u]. Application of the vowel phonotactic to covert feet, on the other hand, is not opaque as such, though it does require the assumption of phonetically null prosodic structure.

I conclude that both metrical and non-metrical theories of prosodic structure can accommodate the experimental results presented here, but only prosodic hierarchy theory can do so without stipulating *ad hoc* destressing rules that are not motivated by the actual experimental stimuli. Experiments 1 and 2 thus provide indirect evidence in favor of prosodic hierarchy theory.

4.8.4   Conclusions

To borrow a sentiment from Saffran (2002), the pervasiveness of foot structure "represents a fascinating learning problem, because the child must somehow arrive at non-linear structure that is richer than is immediately suggested by the serial structure of the input" (Saffran 2002:173). This chapter began with the observation that a number of languages without foot-dependent stress accent — EOS languages, pitch accent languages, and tone languages — nevertheless show strong evidence for foot structure. For the standard view of foot structure, which assumes a tight linkage between footing and rhythmic stress, the existence of feet in such languages is somewhat mysterious. Furthermore, footing in EOS languages has detailed structural parallels with with footing in languages with rhythmic stress: it is subject to conditions on binarity,

Framework	Banned configuration
Prosodic hierarchy theory:	$(\sigma_{head} \quad \sigma)$ | | V u
Simplified bracketed grid theory:	|| * * V u
Grid/prominence-only theories (version 1):	* * * V u
Grid/prominence-only theories (version 2):	* u

Table 4.23: Prohibited phonotactic configuration from Experiments 1 and 2 in three prosodic frameworks

grouping harmony, non-finality, and so on.

Two artificial grammar experiments tested the hypothesis that foot structure in languages without foot-dependent stress emerges from a cognitive bias for foot-based generalizations. These experiments found that both English and Japanese speakers preferred a foot-based vowel phonotactic over a descriptively equivalent stress-based phonotactic, and that participants were willing to apply this foot-based phonotactic even in covert feet lacking direct phonetic correlates. This result is consistent with the existence of a foot-based parsing bias. As discussed in Section 4.8.3, these findings can be modeled in both metrical and non-metrical approaches to prosodic structure, though the metrical approach embodied by prosodic hierarchy theory, which allows for a degree of independence between stress and prosodic constituent structure, is perhaps best equipped to explain the experimental results.

While these experiments support the existence of a cognitive bias for foot struc-ture, the domain-specific or domain-general nature of this bias remains undetermined.

These results are consistent with universalist standpoints on the prosodic hierarchy (Section 4.3.2), but they are also consistent with the view that this foot-based parsing bias is related to more domain-general hierarchical properties of cognition. That said, the typology of foot-conditioned phenomena suggests that fairly fine-grained properties of foot structure — binarity, non-finality, grouping harmony, initial prominence, etc. — recur again and again in the metrical systems of the world (see also Chapters 2 and 3). I am unsure how domain-general explanations for the pervasiveness of foot structure could account for these more parochial properties of footing, which seem to be truly phonological in nature. As always, this question is a promising avenue for future research.

One obvious extension of this research would be to carry out similiar experiments with speakers of languages that show little or no evidence for foot structure of any sort. For example, stress in French is famous for being a phrase-level rather than word-level phenomenon, and as far as I know the surface-level phonology of French has no blatant indications of foot structure. But as discussed in Section 4.8.2, even seemingly 'foot-free' languages may turn out to have foot structure after all: Nelson (1998), Goad & Buckley (2006), and Kimper (2011b) provide evidence from various domains that French does in fact make use of footing. It is thus unclear whether there are any truly 'foot-free' languages; still, it could be valuable to investigate whether the degree to which the foot is 'activated' in a given language correlates with how its speakers perform in artificial grammar tasks like this one. Similarly, it could be worthwhile to investigate whether the extent of covert footing in a speaker's language has any affect on their willingness to posit covert footing for artificial languages. The answer may be no — the experiments presented here found no major qualititative differences between English and Japanese speakers, even though Japanese differs from English in having widespread covert footing — but more research is called for.

There is also a methodological point to be made. Without formal analyses of EOS languages like Irish and Uspanteko, there would have been no motivation for conducting a study of this sort in the first place. There is no fundamental incompatability between generative phonology in the Chomskyan tradition and experimental research (see e.g. Ohala 1986, Kawahara 2011 for related discussion). Theoretical phonology,

at its best, states hypotheses in a rigorous, predictive way, thereby delimiting a space of research questions that can be addressed by experimentation. Moreover, any formal theory that purports to have psychological reality can be supported or refuted in the laboratory.[52] In that spirit, this project represents some first steps toward using experimental methods to test hypotheses about prosodic typology and possible analytic biases in the metrical domain (see also Woodrow 1909, Rice 1992, Hayes 1995, Bailey et al. 1999, Carpenter 2010).

Finally, there may be perceptual and articulatory factors that contribute to the bias for foot structure found in this study. For example, cyclic hierarchical structure in motor planning (e.g. Lashley 1951, Tilsen 2009) might be a source for the rhythmic, relational properties of footing, and the apparent omnipresence of footing cross-linguistically. Similarly, we might look to rhythmic properties of perception, such as the cyclic activation of the auditory nerve (e.g. Silverman 1997, Smith 2005b), for further phonetic grounding of the foot-based cognitive bias discussed here. Such phonetic factors might also play a role in determining other putative typological (a)symmetries in foot-based linguistic phenomena. While only a vague prospect at this point, it would no doubt be fruitful to explore what role issues of phonetic substance play in the construction of formal, cognitive objects like the foot.

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[52]Of course, this is not to suggest that formal theories are only valid if they make claims about human cognition. See de Saussure (1915/1966), Katz & Postal (1991), Postal (2003), and Goldsmith (2007) for discussion.

Chapter 5

Conclusion

This dissertation has taken several steps toward a simple, but sometimes elusive goal: the establishment of the metrical foot as an unquestionable component of synchronic phonology. The recalcitrance of this problem can be attributed in part to the difficulty of isolating the foot as an independent conditioning factor for phonological processes. As has often been observed, most (if not all) stress systems can be formally modeled without any reference to prosodic constituency. The burden of proof is therefore on adherents of the foot to provide evidence for the proposed system of prosodic structure from outside the domain of stress assignment itself. The obvious places to look for such non-accentual, but potentially foot-conditioned phenomena are the realms of morphology and segmental phonotactics. The search for foot-sensitive phenomena in these domains is of course the central concern of the present work.

While I have presented a number of arguments that foot structure plays a crucial role in some segmental and morphological generalizations, I am certainly not the first researcher to do so. Seminal work like Kiparsky (1979) and McCarthy & Prince (1986/1996) compiled an initial body of empirical data in support of foot-level prosodic constituency, which was built upon by many other researchers in the following decades. However, as Prince (1983:87) once commented, many non-accentual arguments for the foot "simply fail to reckon with competing, nonstructural explanations". Many putative cases of foot-conditioned segmental phonotactics can be seamlessly translated into descriptively equivalent, stress-based analyses. Consequently, some previous work on foot-conditioned segmental phonotactics serves as a proof of

concept ('pattern X *could* be foot dependent') rather than a demonstration that the foot is truly needed in phonological theory ('pattern X *must* be foot dependent'). The incompleteness of such arguments for the foot has left the door open for non-metrical accounts of the same data. Indeed, skepticism over prosodic constituency has revived in recent years, with some authors denying the universality of the foot or even questioning its existence altogether (e.g. Prince 1983, Selkirk 1984, Walker 1995, 1996, Gordon 2002b, Samuels 2009, van der Hulst 2009, submitted; see the discussion in Chapter 1).

In Chapters 2 and 3 I argued that three languages — Huariapano, Uspanteko, and Irish — have grammatical phenomena that are indisputably foot-based in character. It is my hope, then, that this work will help settle the long-standing controversy over whether foot structure exists in natural language. If my analysis of the facts in Chapters 2 and 3 is correct, then there can be no question that stress is assigned within the hierarchical prosodic constituent known as the foot. This work therefore represents another salvo in the more general debate over prosodic constituency in phonological theory — in my mind a conclusive one, but probably not the last.

At a finer level of detail, I have argued for a fairly restrictive view of metrical organization in natural language. In Chapter 2 I defended the UNIFORMITY OF FOOTING HYPOTHESIS: no language makes use of multiple, distinct systems of metrical organization. The uniformity of footing hypothesis is grounded in the conceptual claim that the foot is intrinsically linked to its role as the structural determinant of stress placement. Just as there can be no stress without footing, there can be no foot structure existing on a separate plane from stress assignment.

While there are some rhythmic phenomena that would appear to challenge the uniformity of footing hypothesis, I have argued that at least one such phenomenon — coda [h] epenthesis in Huariapano — can be accommodated within the same system of metrical organization needed to account for for stress placement. Reconciling stress assignment in Huariapano with rhythmic [h] epenthesis requires three ancillary assumptions about foot structure: footing may be recursive; feet may vary between iambs and trochees within a single language, even in individual words; and foot-initial position counts as a phonologically prominent position. These first two assumptions are

uncontroversial. The last claim — that foot-initial elements are prominent — represents a novel contribution of the thesis, and one that is supported by foot-conditioned segmental phenomena in a range of languages.

Having argued that foot structure is unique in any given language (the uniformity of footing hypothesis), I turned my attention to the possibility that it is also obligatory. The morpho-phonological systems of Irish and Uspanteko (Chapter 3) provide evidence that the cross-linguistic distribution of binary foot structure is actually broader than the distribution of rhythmic stress. This is a puzzling finding: in the absence of foot-dependent, alternating stress, what explains the emergence of foot-conditioned phonological patterns in these languages? In Chapter 4 I argued that the striking cross-linguistic prevalence of foot structure might be due to the existence of a foot-based parsing bias: in an series of artificial grammar studies, participants learned a stress-conditioned vowel phonotactic in terms of foot structure rather than stress *per se*. The existence of such a bias, if correct, would help explain how and why foot-conditioned patterns develop in languages that otherwise lack foot-dependent stress. Further, these experiments provide empirical confirmation of the psychological reality of foot structure as part of synchronic phonological knowledge.

The obvious implication of this claim is that at least some properties of foot structure must be given innately. Otherwise, it is far from clear how a foot-based parsing bias could be in effect for speakers of a language that did not already manifest foot-based phonological or morphological phenomena of some sort. The question of innateness, by its very nature, raises the issue of universality. While I am hesitant to fully endorse the universality of foot structure, I do believe that the cross-linguistic evidence for binary foot structure is more widespread than is commonly acknowledged. This is a fact in need of explanation, and one that receives a natural account under the view that foot-like prosodic structure is part of universal grammar. What's more, in Chapter 4 I argued that it can be very difficult to distinguish between phonological systems in which the foot is truly absent, and qualitatively similar systems in which the foot is present, but has only a marginal impact on surface phonological structure. Additionally, whether a particular language makes use of the foot is in principle separable from whether *speakers* of that language use the foot as an organizing device in

the construction of phonological representations. I thus believe that the universality of the foot *qua* cognitive object remains an open question.

These findings also have important ramifications for the debate over phonological explanation. In particular, the results of this dissertation suggest that there are contentful formal restrictions on possible prosodic systems, or at least cross-linguistic tendencies in metrical typology that result from phonological biases that are given *a priori*. Accepting this conclusion does not amount to denying the importance of phonetic or functionalist pressures in sound change, or the role of diachronic factors in explaining synchronic phonological patterns. My claim is somewhat more modest: in order to understand how prosodically-conditioned segmental phonetics are phonologized as productive, categorical aspects of synchronic grammars, we need to assume that some prosodic constituents (like the foot) are available to language learners from the get-go, as domains that phonological generalizations can be stated over. Furthermore, the artificial grammar experiment described in Chapter 4 provides some initial evidence that language learners might prefer to learn structurally-determined phonotactics over otherwise adequate, string-linear alternatives. When you're holding a hammer, everything looks like a nail; when you have prosodic structure, everything looks like a constituent.

Appendix A

MaxEnt specifications

The feature matrices for the MaxEnt models described in Chapter 4 were specified (following Hayes 2009) as in Table A.1. Feature values are +, -, or 0/undefined).

All models were augmented with the following vowel tier:

(1)   `Vowel +syllabic:round,back,stress,(footed,foot head,)word_boundary`
       `Grams:3`

	syllabic	continuant	coronal	labial	dorsal	high	round	back	stress	(footed)	(foot head)
p	-	-	-	+	-	0	-	0	0	0	0
t	-	-	+	-	-	0	-	0	0	0	0
k	-	-	-	-	+	+	-	+	0	0	0
s	-	+	+	-	-	0	-	0	0	0	0
ú, stressed foot head	+	+	-	+	+	+	+	+	+	+	+
í, stressed foot head	+	+	-	-	+	+	-	-	+	+	+
ú, covert foot head	+	+	-	+	+	+	+	+	-	+	+
í, covert foot head	+	+	-	-	+	+	-	-	-	+	+
ŭ, footed	+	+	-	+	+	+	+	+	-	+	-
ĭ, footed	+	+	-	-	+	+	-	-	-	+	-
ŭ, unfooted	+	+	-	+	+	+	+	+	-	-	0
ĭ, unfooted	+	+	-	-	+	+	-	-	-	-	0

Table A.1: Feature specifications for MaxEnt models (Chapter 4)

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Bibliography

Aion, Nora. 2003. *Selected topics in Nootka and Tübatulabal phonology*: City University of New York dissertation.

Akinlabi, Akinbiyi & Eno Urua. 2003. Foot structure in the Ibibio verb. *Journal of African languages and linguistics* 24(2). 119–160.

Alderete, John. 1995. Faithfulness to prosodic heads. Ms., University of Massachusetts, Amherst. Available online as ROA-94, Rutgers Optimality Archive, http://roa.rutgers.edu/.

Alderete, John. 2001a. Dominance effects as transderivational anti-faithfulness. *Phonology* 18(2). 201–253.

Alderete, John. 2001b. *Morphologically governed accent in Optimality Theory*. Routledge.

Altshuler, Daniel. 2009. Quantity-insensitive iambs in Osage. *International Journal of American Linguistics* 75(3). 365–398.

Anderson, Stephen. 1982. The analysis of French shwa: or, how to get something for nothing. *Language* 534–573.

Anttila, Arto. 2002. Morphologically conditioned phonological alternations. *Natural Language and Linguistic Theory* 20(1). 1–42.

Archangeli, Diana & Douglas Pulleyblank. 1994. *Grounded phonology*. Cambridge, MA: MIT Press.

Aslin, Richard, Jenny Saffran & Elissa Newport. 1998. Computation of conditional probability statistics by 8-month-old infants. *Psychological Science* 9(4). 321–324.

Awoyale, Yiwola. 2000. The phonological structure of Yoruba ideophones. In Orin Gensler & H. Ekkehard Wolff (eds.), *Proceedings of the 2nd world congress of African linguistics*, Koln: Rudiger Koppe Verlag.

Baayen, R. H. & Petar Milin. 2010. Analyzing reaction times. *International Journal of Psychological Research* 3(2). 12–28.

Baayen, R. Harald. 2008. *Analyzing linguistic data: A practical introduction to statistics using R*. Cambridge, UK: Cambridge University Press.

Bach, Emmon & Robert T. Harms. 1972. How do languages get crazy rules? In Robert P. Stockwell & Ronald K.S. Macaulay (eds.), *Linguistic change and generative theory: Essays*, 1–21. Bloomington: Indiana University Press.

Bailey, Todd, Kim Plunkett & Ester Scarpa. 1999. A cross-linguistic study in learning prosodic rhythms: Rules, constraints, and similarity. *Language and Speech* 42(1). 1.

Baker, C.L. 1979. Syntactic theory and the projection problem. *Linguistic Inquiry* 10(4). 533–581.

Bakovič, Eric. 1998. Unbounded stress and factorial typology. In Ron Artstein & Madeline Holler (eds.), *RuLing papers I: Working papers from Rutgers University*, 15–28. New Brunswick, NJ: Department of Linguistics, Rutgers University. Reprinted 2004 in *Optimality Theory in Phonology: A reader*, ed. John J. McCarthy, 202-214. Oxford: Blackwell. Available online as ROA-244, Rutgers Optimality Archive, http://roa.rutgers.edu/.

Bakovič, Eric. 1999. Deletion, insertion, and symmetrical identity. Ms., Harvard University. Available online as ROA-300, Rutgers Optimality Archive, http://roa.rutgers.edu/.

Bane, Max. 2011. How many language types are there? Talk presented at the 85th Linguistic Society of America Annual Meeting, Pittsburgh.

Barbosa, Plínio. 2002. Explaining cross-linguistic rhythmic variability via a coupled-oscillator model of rhythm production. In Bernard Bel & Isabelle Marlien (eds.), *Proceedings of the Speech Prosody 2002 conference*, 163–166.

Barnes, Jonathan. 2006. *Strength and weakness at the interface: positional neutralization in phonetics and phonology*. Berlin: Mouton de Gruyter.

Bates, Douglas, Martin Maechler & Ben Bolker. 2011. *lme4: Linear mixed-effects models using S4 classes*. Version 0.999375-41, retrieved from http://CRAN.R-project.org/package=lme4.

Becker, Michael, Andrew Nevins & Jonathan Levine. to appear. Asymmetries in generalizing alternations to and from initial syllables. *Language* .

Beckman, Jill. 1998. *Positional faithfulness*: University of Massachusetts, Amherst dissertation.

Bendor-Samuel, David. 1963. A phonemic analysis of Guajajara. *Arquivo Linguístico* 28. Available online at http://www.sil.org/americas/brasil/publcns/ling/GJPhonem.pdf.

Bennett, Ryan, Emily Elfner & Jim McCloskey. in prep. Lightest to the right: an anomalous displacement in Irish. Ms., University of California, Santa Cruz and University of Massachusetts, Amherst.

Bennett, Ryan & Robert Henderson. to appear. Accent in Uspanteko. *Natural Language and Linguistic Theory* .

Bennett, Ryan, Grant McGuire, Máire Ní Chiosáin & Jaye Padgett. 2012. Secondary articulation in Conemara Irish. Ms., University of California, Santa Cruz and University College Dublin.

Benua, Laura. 2000. *Phonological relations between words*. New York: Garland.

Bergelson, Elika & William Idsardi. 2009. Structural biases in phonology: infant and adult evidence from artificial language learning. In Jane Chandlee, Michelle Franchini, Sandy Lord & Gudrun-Marion Rheiner (eds.), *Proceedings of the 33rd Boston University Conference on Child Language Development (BUCLD 33)*, vol. 33, 85–96. Somerville, MA: Cascadilla Press.

Berinstein, Ava E. 1979. *A cross-linguistic study on the perception and production of stress*. University of California Los Angeles MA thesis. Available online at http://escholarship.org/uc/item/0t0699hc.

Bermúdez-Otero, Ricardo. to appear. The architecture of grammar and the division of labour in exponence. In Jochen Trommer (ed.), *The morphology and phonology of exponence: the state of the art*, Oxford, UK: Oxford University Press.

Black, H. Andrew. 1993. *Constraint-Ranked Derivation: A Serial Approach to Optimization*: University of California, Santa Cruz dissertation.

Blaho, Sylvia & Dániel Szeredi. 2011. Secondary stress in Hungarian: (morpho-)syntactic, not metrical. In Mary Byram Washburn, Katherine McKinney-Bock, Erika Varis, Ann Sawyer & Barbara Tomaszewicz (eds.), *West Coast Conference on Formal Linguistics (WCCFL) 28*, 51–59. Somerville, MA: Cascadilla Press. Available online at http://www.lingref.com/, document #2435.

Blevins, Juliette. 2004. *Evolutionary phonology: the emergence of sound patterns*. Cambridge, UK: Cambridge University Press.

Bloom, Paul. 1993. Overview: controversies in language acquisition. In Paul Bloom (ed.), *Language acquisition: core readings*, 5–48. Cambridge, MA: MIT Press.

Blumenfeld, Lev. 2006. *Constraints on phonological interactions*: Stanford University dissertation.

Boersma, Paul & David Weenink. 2010. Praat: doing phonetics by computer (version 5.1.32). Computer program. Retrieved from http://www.praat.org/.

Bollinger, Dwight. 1958. A theory of pitch acent in English. *Word* 14. 109–149.

Boucher, Victor J. 2006. On the function of stress rhythms in speech: Evidence of a link with grouping effects on serial memory. *Language and Speech* 49(4). 495–519.

Breatnach, Risteard. 1947. *The Irish of Ring, Co. Waterford*. Dublin: The Dublin Institute for Advanced Studies.

Brooks, Lee & John Vokey. 1991. Abstract analogies and abstracted grammars: Comments on Reber (1989) and Mathews et al. (1989). *Journal of Experimental Psychology* 120(3). 316–323.

Brown, Gordon, Ian Neath & Nick Chater. 2007. A temporal ratio model of memory. *Psychological Review* 114(3). 539–576.

Buckley, Eugene. 1992. Kashaya closed-syllable shortening and prosodic syllabification. In Dawn Bates (ed.), *West Coast Conference on Formal Linguistics (WCCFL) 10*, 65–74. Stanford, CA: CSLI Publications.

Buckley, Eugene. 1994a. Persistent and cumulative extrametricality in Kashaya. *Natural Language and Linguistic Theory* 12(3). 423–464.

Buckley, Eugene. 1994b. *Theoretical aspects of Kashaya phonology and morphology*. Stanford, CA: CSLI Publications.

Buckley, Eugene. 1997. Optimal iambs in Kashaya. *Rivista di linguistica* 9. 9–52.

Buckley, Eugene. 1998. Iambic lengthening and final vowels. *International Journal of American Linguistics* 64(3). 179–223.

Buckley, Eugene. 2009. Locality in metrical typology. *Phonology* 26(3). 389–435.

Buckley, Eugene & John Gluckman. 2012. Syntax and prosody in Kashaya phrasal accent. In *Proceedings of the 35th annual Penn Linguistics Colloquium*, vol. 18 1, Article 4.

Bye, Patrik & Paul de Lacy. 2008. Metrical influences on fortition and lenition. In Joaquim Brand ao de Carvalho, Tobias Scheer & Philippe Ségéral (eds.), *Lenition and fortition*, 173–206. Berlin: Mouton de Gruyter.

Byrd, Dani. 1993. 54,000 American stops. In *UCLA working papers in phonetics*, vol. 83, 97–116.

Caballero, Gabriela. 2008. *Choguita Raramuri (Tarahumara) phonology and morphology*: University of California, Berkeley dissertation.

Cairns, Charles. 2002. Foot and syllable in Southern Paiute. Ms.

Can Pixabaj, Telma. 2006. *Gramática descriptiva Uspanteka*. Oxlajuuj Keej Maya' Ajtz'iib' (OKMA).

Carnie, Andrew. 2008. *Irish nouns: a reference guide*. Oxford: Oxford University Press.

Carnie, Andrew. 2010. *Constituent structure* Oxford Surveys in Syntax and Morphology. Oxford, UK: Oxford University Press 2nd edn.

Carpenter, Angela. 2010. A naturalness bias in learning stress. *Phonology* 27(3). 345–392.

Cassimjee, Farida & Charles Kisseberth. 2007. Optimal domains theory and Bantu tonology: a case study from Isixhosa and Shingasidja. In Larry Hyman & Charles Kisseberth (eds.), *Theoretical aspects of Bantu tone*, 33–132. Stanford, CA: CSLI Publications.

Chambers, Kyle E., Kristine H. Onishi & Cynthia Fisher. 2003. Infants learn phonotactic regularities from brief auditory experience. *Cognition* 87. B69–B77.

Cho, Taehong & Peter Ladefoged. 1999. Variation and universals in VOT: evidence from 18 languages. *Journal of Phonetics* 27(2). 207–229.

Chomsky, Noam. 1965. *Aspects of the theory of syntax*. Cambridge, MA: MIT press.

Chomsky, Noam. 1980. *Rules and representations*. New York: Columbia University Press.

Chomsky, Noam. 1986. *Knowledge of language: its nature, origin, and use*. New York: Praeger Publishers.

Chomsky, Noam & Morris Halle. 1968. *The sound pattern of English*. Harper & Row.

Churchyard, Henry. 1999. *Topics in Tiberian Biblical Hebrew metrical phonology and prosodics*: University of Texas, Austin dissertation.

Clements, G.N. 1980. *Vowel harmony in nonlinear generative phonology: an autosegmental model*. Indiana University Linguistics Club.

Clements, G.N. 1986. Syllabification and epenthesis in the Barra dialect of Gaelic. In Koen Bogers, Harry van der Hulst & Maarten Mous (eds.), *The phonological representation of suprasegmentals: Studies on African languages offered to John M. Stewart on his 60th birthday*, 317–336. Dordrecht: Foris.

Clements, G.N. 1990. The role of the sonority cycle in core syllabification. In John Kingston & Mary Beckman (eds.), *Papers in laboratory phonology I: Between the grammar and the physics of speech*, 283–333. Cambridge, UK: Cambridge University Press.

Coetzee, Andries. 2009. Learning lexical indexation. *Phonology* 26(1). 109–145.

Cohn, Abigail. 1993. Nasalisation in English: phonology or phonetics. *Phonology* 10(1). 43–81.

Cole, Jennifer. 2009. Emergent feature structures: Harmony systems in exemplar models of phonology. *Language Sciences* 31(2-3). 144–160.

Cole, Jennifer & Charles Kisseberth. 1994. An optimal domains theory of harmony. *Studies in the Linguistic Sciences* 24(2). 1–13. Available online as ROA-22, Rutgers Optimality Archive, http://roa.rutgers.edu/.

Cristià, Alejandrina & Amanda Seidl. 2008. Is infants' learning of sound patterns constrained by phonological features? *Language Learning and Development* 4. 203–227.

Cristià, Alejandrina, Amanda Seidl & Alexander L. Francis. 2011. Phonological features in infancy. In G.N. Clements & Rachid Ridouane (eds.), *Where do phonological contrasts come from? Cognitive, physical and developmental bases of phonological features*, 303–326. Amsterdam: Benjamins.

Crosswhite, Katherine. 2000. Vowel reduction in Russian: A unified account of standard, dialectal, and "dissimilative" patterns. In Katherine Crosswhite & Joyce McDonough (eds.), *University of Rochester working papers in the language sciences*, vol. 1, 107–172. Rochester, NY: Department of Linguistics, University of Rochester. Available online at www.ling.rochester.edu/wpls/s2000n1/crosswhite.pdf.

Crosswhite, Katherine. 2001. *Vowel reduction in Optimality Theory*. Routledge.

Crowhurst, Megan. 1996. An optimal alternative to conflation. *Phonology* 13(3). 409–424.

Crowhurst, Megan & Lev Michael. 2005. Iterative footing and prominence-driven stress in Nanti (Kampa). *Language* 81(1). 47–95.

Cutler, Anne. 2005. Lexical stress. In David Pisoni & Robert Remez (eds.), *The handbook of speech perception*, 264–289. Malden, MA: Blackwell.

Cutler, Anne & David M. Carter. 1987. The predominance of strong initial syllables in the English vocabulary. *Computer Speech and Language* 2(3-4). 133–142.

Daland, Robert, Bruce Hayes, James White, Marc Garellek, Andrea Davis & Ingrid Norrmann. 2011. Explaining sonority projection effects. *Phonology* 28(2). 197–234.

Dalton, Martha & Ailbhe Ní Chasaide. 2005. Tonal alignment in Irish dialects. *Language and Speech* 48(4). 441.

Dalton, Martha & Ailbhe Ní Chasaide. 2007. Melodic alignment and micro-dialect variation in Connemara Irish. In Carlos Gussenhoven & Tomas Riad (eds.), *Tones and tunes*, vol. 2, 293–315. Berlin: Mouton de Gruyter.

Davis, Stuart. 2003. The controversy over geminates and syllable weight. In Caroline Féry & Ruben van de Vijver (eds.), *The syllable in optimality theory*, 77–98. Cambridge, UK: Cambridge University Press.

Davis, Stuart & Mi-Hui Cho. 2003. The distribution of aspirated stops and /h/ in American English and Korean: an alignment approach with typological implications. *Linguistics* 41(4). 607–652.

Dayley, Jon P. 1985. *Tzutujil grammar*, vol. 107 University of California Publications in Linguistics. Berkeley, CA: University of California Press.

de Chene, Brent & Stephen Anderson. 1979. Compensatory lengthening. *Language* 55(3). 505–535.

de Lacy, Paul. 2001. Prosodic markedness in prominent positions. Ms. Available online as ROA-432.i, Rutgers Optimality Archive, http://roa.rutgers.edu/.

de Lacy, Paul. 2002a. The interaction of tone and stress in Optimality Theory. *Phonology* 19(1). 1–32.

de Lacy, Paul. 2002b. *The formal expression of markedness*: University of Massachusetts Amherst dissertation.

de Lacy, Paul. 2004. Markedness conflation in Optimality Theory. *Phonology* 21(2). 145–199.

de Lacy, Paul. 2007. The interaction of tone, sonority, and prosodic structure. In *The Cambridge handbook of phonology*, 281–307. Cambridge, UK: Cambridge University Press.

de Lacy, Paul & John Kingston. to appear. Synchronic explanation. *Natural Language and Linguistic Theory* .

Dell, François. 1995. Consonant clusters and phonological syllables in French. *Lingua* 95(1-3). 5–26.

Dell, François & Mohamed Elmedlaoui. 1985. Syllabic consonants and syllabification in Imdlawn Tashlhiyt Berber. *Journal of African Languages and Linguistics* 7(2). 105–130.

Della Pietra, Stepehen, Vincent Della Pietra & John Lafferty. 1997. Inducing features of random fields. *IEEE Transactions: Pattern Analysis and Machine Intelligence* 19(4). 380–393.

Demers, Richard, Fernando Escalante & Eloise Jelinek. 1999. Prominence in Yaqui words. *International Journal of American Linguistics* 65(1). 40–55.

Demuth, Katherine. 1996. The prosodic structure of early words. In James L. Morgan & Katherine Demuth (eds.), *Signal to syntax: Bootstrapping from speech to grammar in early acquisition*, 171–184. Mahwah, N.J.: Lawrence Erlbaum Associates.

Dixon, R.M.W. 2011. *The languages of Australia*. Cambridge, UK: Cambridge University Press.

Doherty, Cathal. 1991. Munster Irish stress. In Armin Mester & Scarlett Robbins (eds.), *Phonology at Santa Cruz*, 18–32. UC Santa Cruz Linguistics Research Center.

Downing, Laura. 1998. On the prosodic misalignment of onsetless syllables. *Natural Language and Linguistic Theory* 16(1). 1–52.

Downing, Laura. 2004. What African languages tell us about accent typology. In Susanne Fuchs & Silke Hamann (eds.), *ZAS papers in linguistics*, vol. 37, 101–136. Berlin: ZAS.

Dresher, Elan & Harry van der Hulst. 2002. Head-dependent asymmetries in phonology: complexity and visibility. *Phonology* 15(3). 317–352.

Dutoit, Thierry. 1997. *An introduction to text-to-speech synthesis*. Springer Netherlands.

Ebbinghaus, Hermann. 1885/1913. *Memory: A contribution to experimental psychology*. New York: Teachers College, Columbia University. Originally published 1885 in German. Translated by Henry A. Ruger and Clara E. Bussenius.

Edwards, Jan, Mary Beckman & Janet Fletcher. 1991. The articulatory kinematics of final lengthening. *The Journal of the Acoustical Society of America* 89(1). 369–382.

Elfner, Emily. 2005. The role of sonority in Blackfoot phonotactics. In Ilana Mezhevich, Heather Bliss & Michael Dobrovolsky (eds.), *Calgary papers in linguistics*, vol. 26, 27–91. Department of Linguistics, University of Calgary.

Elfner, Emily. 2012. *Syntax-prosody interactions in Irish*: University of Massachusetts, Amherst dissertation.

Elfner, Emily. to appear. Stress-epenthesis interactions in Harmonic Serialism. In John McCarthy & Joe Pater (eds.), *Harmonic Grammar and Harmonic Serialism*, London: Equinox. Available online as ROA-1047, Rutgers Optimality Archive, http://roa.rutgers.edu/.

Elias-Ulloa, José. 2006. *Theoretical aspects of Panoan metrical phonology: Disyllabic footing and contextual syllable weight*: Rutgers University dissertation.

Elordieta, Gorka. 2007. Minimum size constraints on intermediate phrases. In J. Trouvain & W. Barry (eds.), *Proceedings of the 16th international congress of the phonetic sciences*, 1021–1024. Saabrücken, Germany.

Embick, David. 2010. *Localism versus globalism in morphology and phonology*. Cambridge, MA: MIT Press.

Esper, Erwin. 1925. A technique for the experimental investigation of associative interference in artificial linguistic material. *Language* 1. 1–47.

Ferguson, Charles. 1957. Word stress in Persian. *Language* 33(2). 123–135.

Ferman, Sara, Elite Olshtain, Edna Schechtman & Avi Karni. 2009. The acquisition of a linguistic skill by adults: Procedural and declarative memory interact in the learning of an artificial morphological rule. *Journal of Neurolinguistics* 22(4). 384–412.

Flack, Kathryn. 2009. Constraints on onsets and codas of words and phrases. *Phonology* 26(2). 269–302.

Flemming, Edward. 1994. The role of metrical structure in segmental rules. In Mercè Gonzàlez (ed.), *North East Linguistic Society (NELS) 24*, 97–110.

Flemming, Edward. 1995. *Auditory representations in phonology*: University of California, Los Angeles dissertation.

Fougeron, Cécile & Patricia Keating. 1997. Articulatory strengthening at edges of prosodic domains. *The Journal of the Acoustical Society of America* 101(6). 3728–3740.

François, Alexandre. 2005. A typological overview of Mwotlap. *Linguistic Typology* 9(1). 115–146.

Frankish, Clive. 1995. Intonation and auditory grouping in immediate serial recall. *Applied Cognitive Psychology* 9. S5–S22.

Frazier, Lyn, Katy Carlson & Charles Clifton, Jr. 2006. Prosodic phrasing is central to language comprehension. *Trends in Cognitive Sciences* 10(6). 244–249.

French, Koleen Matsuda. 1988. *Insights into Tagalog: Reduplication, infixation, and stress from nonlinear phonology*. Summer Institute of Linguistics.

Fry, Dennis. 1955. Duration and intensity as physical correlates of linguistic stress. *The Journal of the Acoustical Society of America* 27(4). 765–768.

Fry, Dennis. 1958. Experiments in the perception of stress. *Language and speech* 1. 126–152.

Gabas, Nilson, Jr. 1999. *A grammar of Karo, Tupí (Brazil)*: University of California, Santa Barbara dissertation.

Gerken, LouAnn. 1991. The metrical basis for children's subjectless sentences. *Journal of Memory and Language* 30(4). 431–451.

Giavazzi, Maria. 2010. *The phonetics of metrical prominence and its consequences for segmental phonology*: Massachusetts Institute of Technology dissertation.

Gick, Bryan. 1999. A gesture-based account of intrusive consonants in English. *Phonology* 16(1). 29–54.

Goad, Heather & Meaghen Buckley. 2006. Prosodic structure in child French: Evidence for the foot. *Catalan Journal of Linguistics* 5. 109–142.

Goedemans, Rob. 1994. An Optimality account of onset sensitivity in QI languages. Ms. Available online as ROA-26, Rutgers Optimality Archive, http://roa.rutgers.edu/.

Goedemans, Rob & Harry van der Hulst. 2009. Stresstyp: A database for word accentual patterns in the world's languages. In Martin Everaert, Simon Musgrave & Alexis Dimitriadis (eds.), *The use of databases in cross-linguistic research*, 235–282. New York/Berlin: Mouton de Gruyter.

Goldsmith, John. 1976. *Autosegmental phonology*: Massachusetts Institute of Technology dissertation. Published by Garland, 1979.

Goldsmith, John. 1990. *Autosegmental and metrical phonology*. Blackwell.

Goldsmith, John. 2007. Towards a new empiricism. *Recherches Linguistiquesa Vincennes* 36. 9–36.

Goldwater, Sharon & Mark Johnson. 2003. Learning OT constraint rankings using a maximum entropy model. In Jennifer Spenador, Anders Eriksson & Östen Dahl (eds.), *Proceedings of the Stockholm workshop on variation within Optimality Theory*, 111–120. Stockholm: Stockholm University.

Gomez, Rebecca & LouAnn Gerken. 1999. Artificial grammar learning by 1-year-olds leads to specific and abstract knowledge. *Cognition* 70(2). 109–135.

Gomez, Rebecca & Roger Schvaneveldt. 1994. What is learned from artificial grammars? Transfer tests of simple association. *Journal of Experimental Psychology* 20(2). 396–410.

González, Carolina. 2003. *The effect of stress and foot structure on consonantal processes*: University of Southern California dissertation.

González, Carolina. 2005. Phonologically-conditioned allomorphy in Panoan: Towards an analysis. In Jeffrey Heinz, Andrew Martin & Katya Pertsova (eds.), *UCLA working papers in linguistics*, vol. 11 Papers in phonology 6, 39–56. University of California, Los Angeles.

González, Carolina. 2007. Typological evidence for the separation between stress and foot structure. *New Challenges in Typology: Broadening the Horizons and Redefining the Foundations* 55–75.

Gordon, Matthew. 1999. *Syllable weight: Phonetics, phonology, and typology*: University of California, Los Angeles dissertation.

Gordon, Matthew. 2000. The tonal basis of final weight criteria. In Akira Okrent & John P. Boyle (eds.), *Chicago linguistics society (cls) 36*, 141–156. Chicago Linguistic Society.

Gordon, Matthew. 2002a. A factorial typology of quantity-insensitive stress. *Natural Language and Linguistic Theory* 20(3). 491–552.

Gordon, Matthew. 2002b. A phonetically driven account of syllable weight. *Language* 78(1). 51–80.

Gordon, Matthew. 2003. The phonology of pitch accents in Chickasaw. *Phonology* 20(2). 173–218.

Gouskova, Maria. 2003. *Deriving economy: syncope in Optimality Theory*: University of Massachusetts Amherst dissertation.

Gouskova, Maria. 2004. Minimal reduplication as a paradigm uniformity effect. In *Proceedings of the 23rd West Coast Conference on Formal Linguistics*, 101–114.

Green, Antony Dubach. 1996. Stress placement in Munster Irish. In Lise Dobrin, Kora Singer & Lisa McNair (eds.), *Chicago linguistics society (cls) 32*, vol. 1, 77–91. Available online as ROA-120, Rutgers Optimality Archive, http://roa.rutgers.edu/.

Green, Antony Dubach. 1997. *The prosodic structure of Irish, Scots Gaelic, and Manx*: Cornell University dissertation.

Green, Antony Dubach. 2006. The independence of phonology and morphology: The Celtic mutations. *Lingua* 116(11). 1946–1985.

Green, Christopher. 2010. *Prosodic phonology in Bamana (Bambara): syllable complexity, metrical structure, and tone*: Indiana University dissertation.

Green, Christopher, Stuart Davis, Boubacar Diakite & Karen Baertsch. 2009. Syncope and the drive toward minimization in Colloquial Bamana. In Jonathan Anderson, Christopher Green & Samuel Obeng (eds.), *African linguistics across the discipline*, vol. 8 Indiana University Working Papers in Linguistics, 109–131. Bloomington, IN: IULC publications.

Greene, Robert L. 1986. Sources of recency effects in free recall. *Psychological Bulletin* 99(2). 221–228.

Gurevich, Naomi. 2004. *Lenition and contrast: the functional consequences of certain phonetically conditioned sound changes* Outstanding Dissertations in Linguistics. New York: Garland.

Gussenhoven, Carlos. 2004. *The phonology of tone and intonation*. Cambridge, UK: Cambridge University Press.

Gussmann, Edmund. 2002. *Phonology: analysis and theory*. Cambridge, UK: Cambridge University Press.

Haas, Mary. 1977. Tonal accent in Creek. In Larry Hyman (ed.), *Studies in stress and accent*, vol. 4 Southern California Occasional Papers in Linguistics, 195–. Los Angeles: Department of Linguistics, University of Southern California.

Hale, Mark & Charles Reiss. 2008. *The phonological enterprise*. Oxford, UK: Oxford University Press.

Hall, Nancy. 2000. Max-Position drives iterative footing. In *West Coast Conference on Formal Linguistics (WCCFL) 20*, 248–261. Somerville, MA: Cascadilla Press.

Hall, Nancy. 2006. Cross-linguistic patterns of vowel intrusion. *Phonology* 23(3). 387–429.

Halle, Morris. 1990. Respecting metrical structure. *Natural Language and Linguistic Theory* 8(2). 149–176.

Halle, Morris & William Idsardi. 1995. General properties of stress and metrical structure. In John Goldsmith (ed.), *The handbook of phonological theory*, 403–443. Oxford.

Halle, Morris & Michael Kenstowicz. 1991. The Free Element Condition and cyclic versus noncyclic stress. *Linguistic Inquiry* 22(3). 457–501.

Halle, Morris & Jean-Roger Vergnaud. 1980. Tiered phonology. Unpublished ms., MIT, Cambridge, Massachusetts.

Halle, Morris & Jean-Roger Vergnaud. 1987. *An essay on stress*. Cambridge, MA: MIT Press.

Hammond, Michael. 1986. The obligatory-branching parameter in metrical theory. *Natural Language and Linguistic Theory* 4(2). 185–228.

Hammond, Michael. 1999. *The phonology of English: a prosodic optimality-theoretic approach*. Oxford, UK: Oxford University Press.

Hammond, Mike. 1997. Vowel quantity and syllabification in English. *Language* 1–17.

Hansen, Kenneth C. & Lesley E. Hansen. 1969. Pintupi phonology. *Oceanic Linguistics* 8(2). 153–170.

Haraguchi, Shosuke. 1999. Accent. In Natsuko Tsujimura (ed.), *The handbook of Japanese linguistics*, 1–30. Oxford, UK: Blackwell.

Harley, Heidi. 2007. The bipartite structure of verbs cross-linguistically (or: why Mary can't exhibit John her paintings). Ms. Available online at http://ling.auf.net/lingBuzz/000435.

Harris, James. 1977. Remarks on diphthongization in spanish. *Lingua* 41. 261–305.

Harris, John. 2004. Release the captive coda: the foot as a domain of phonetic interpretation. In John Local, Richard Ogden & Rosalind Temple (eds.), *Phonetic interpretation: Papers in laboratory phonology 6*, 103–129. Cambridge, UK: Cambridge University Press.

Harris, John & Eno Urua. 2001. Lenition degrades information: consonant allophony in Ibibio. In Andrew Faulkner, Stuart Rosen & Martyn Holland (eds.), *Speech, hearing and language: work in progress*, vol. 13, 72–105. Available online at http://www.phon.ucl.ac.uk/home/shl13/pdffiles/harrisU.pdf.

Hayes, Bruce. 1981. *A metrical theory of stress rules*. Bloomington, Indiana: Distributed by Indiana University Linguistics Club. Revised version of 1980 MIT Ph.D. thesis.

Hayes, Bruce. 1982. Extrametricality and English stress. *Linguistic Inquiry* 13(2). 227–276.

Hayes, Bruce. 1984. The phonology of rhythm in English. *Linguistic Inquiry* 15(1). 33–74.

Hayes, Bruce. 1989. Compensatory lengthening in moraic phonology. *Linguistic inquiry* 20(2). 253–306.

Hayes, Bruce. 1995. *Metrical stress theory*. The University of Chicago Press.

Hayes, Bruce. 2009. *Introductory phonology*. Blackwell/Wiley.

Hayes, Bruce & Donca Steriade. 2004. The phonetic bases of phonological Markedness. In Bruce Hayes, Robert Kirchner & Donca Steriade (eds.), *Phonetically based phonology*, 1–33. Cambridge, UK: Cambridge University Press.

Hayes, Bruce & Colin Wilson. 2008. A maximum entropy model of phonotactics and phonotactic learning. *Linguistic Inquiry* 39(3). 379–440.

Hercus, Luise. 1994. *A grammar of the Arabana-Wangkangurru language, Lake Eyre Basin, South Australia*. Canberra.

Hewitt, Mark S. 1994. Deconstructing foot binarity in Koniag Alutiiq. Available online as ROA-12, Rutgers Optimality Archive, http://roa.rutgers.edu/.

Hickey, Raymond. 1984. Syllable structure and sonority hierarchies in Irish. In *Papers for the fifth international phonology meeting*, 123–128.

Hickey, Raymond. 1985a. The interrelationship of epenthesis and syncope: evidence from Dutch and Irish. *Lingua* 65(3). 229–249.

Hickey, Raymond. 1985b. Reduction of allomorphy and the plural in Irish. *Ériu* 36. 143–162.

Hillenbrand, James, Laura A. Getty, Michael J. Clark & Kimberlee Wheeler. 1995. Acoustic characteristics of American English vowels. *The Journal of the Acoustical Society of America* 97(5). 3099–3111.

Hirata, Yukari. 2004. Effects of speaking rate on the vowel length distinction in Japanese. *Journal of Phonetics* 32(4). 565–589.

Hirayama, Manami. 2009. *Postlexical prosodic structure and vowel devoicing in Japanese*: University of Toronto dissertation.

Hooper, Joan. 1978. Constraints on schwa-deletion in American English. In Jacek Fisiak (ed.), *Recent developments in historical phonology*, The Hague: Mouton.

House, Arthur S. 1961. On vowel duration in English. *The Journal of the Acoustical Society of America* 33(9). 1174–1178.

Hsu, Chai-Shune & Sun-Ah Jun. 1998. Prosodic strengthening in Taiwanese: Syntagmatic or paradigmatic? In *UCLA working papers in phonetics*, vol. 96, 69–89. Los Angeles: University of California, Los Angeles.

Hume, Elizabeth, Jennifer Muller & Aone van Engelenhoven. 1998. Non-moraic geminates in Leti. *Phonology* 14(3). 371–402.

Hwang, So-One, Philip Monahan & William Idsardi. 2010. Underspecification and asymmetries in voicing perception. *Phonology* 27(02). 205–224.

Hyde, Brett. 2002. A restrictive theory of metrical stress. *Phonology* 19(3). 313–359.

Hyde, Brett. 2007. Non-finality and weight-sensitivity. *Phonology* 24(2). 287–334.

Hyde, Brett. 2008. Alignment continued: Distance-sensitivity, order-sensitivity, and the midpoint pathology. Ms., Washington University. Available online as ROA-998, Rutgers Optimality Archive, http://roa.rutgers.edu/.

Hyde, Brett. 2009. Another look at iterative foot optimization and the case against parallelism. Ms., Washington University. Available online as ROA-1062, Rutgers Optimality Archive, http://roa.rutgers.edu/.

Hyde, Brett. 2012. Alignment constraints. *Natural Language and Linguistic Theory* .

Hyman, Larry. 1976. Phonologization. In A. Juilland (ed.), *Linguistic studies presented to Joseph H. Greenberg*, 407–418. Saratoga: Anma Libri.

Hyman, Larry. 1977. On the nature of linguistic stress. In Larry Hyman (ed.), *Studies in stress and accent*, vol. 4 Southern California Occasional Papers in Linguistics, 37–82. Los Angeles: Department of Linguistics, University of Southern California.

Hyman, Larry. 1981. Tonal accent in Somali. *Studies in African linguistics* 12(2). 169–203.

Hyman, Larry. 1985. *A theory of phonological weight*. Foris Publications.

Hyman, Larry. 2006. Word-prosodic typology. *Phonology* 23(2). 225–257.

Hyman, Larry. 2007. Universals of tone rules: 30 years later. In Tomas Riad & Carlos Gussenhoven (eds.), *Tones and tunes: typological studies in word and sentence prosody*, vol. 1, 1–34. Berlin: Mouton De Gruyter.

Hyman, Larry. 2009. How (not) to do phonological typology: the case of pitch-accent. *Language Sciences* 31(2-3). 213–238.

Hyman, Larry. 2011. Does Gokana really have no syllables? Or: what's so great about being universal? *Phonology* 28(1). 55–85.

Hyman, Larry & Armindo Ngunga. 1994. On the non-universality of tonal association 'conventions': evidence from Ciyao. *Phonology* 11(1). 25–68.

Hyman, Larry & Russ Schuh. 1974. Universals of tone rules: evidence from West Africa. *Linguistic Inquiry* 5(1). 81–115.

Inkelas, Sharon. 1990. *Prosodic constituency in the lexicon*. New York: Garland.

Inkelas, Sharon & Orhan Orgun. 2003. Turkish stress: a review. *Phonology* 20(1). 139–161.

Inkelas, Sharon & Cheryl Zoll. 2005. *Reduplication: Doubling in morphology*. Cambridge University Press.

Inkelas, Sharon & Cheryl Zoll. 2007. Is grammar dependence real? A comparison between cophonological and indexed constraint approaches to morphologically conditioned phonology. *Linguistics* 45(1). 133–171.

Iosad, Pavel. 2009. Complexity, locality, and recursion in prosody: an account of Munster Irish stress. Ms.

Iosad, Pavel. to appear. Vowel reduction in Russian: no phonetics in phonology. *Journal of Linguistics* .

Itô, Junko. 1989. A prosodic theory of epenthesis. *Natural Language and Linguistic Theory* 7(2). 217–259.

Itô, Junko, Yoshihisa Kitagawa & Armin Mester. 1996. Prosodic faithfulness and correspondence: Evidence from a Japanese argot. *Journal of East Asian Linguistics* 5(3). 217–294.

Itô, Junko & Armin Mester. 1992/2003. Weak layering and word binarity. In Takeru Honma, Masao Okazaki, Toshiyuki Tabata & Shin ichi Tanaka (eds.), *A new century of phonology and phonological theory: A festschrift for Professor Shosuke Haraguchi on the occasion of his sixtieth birthday*, 26–65. Tokyo: Kaitakusha. Originally published 1992 as Linguistic Research Center LRC-92-09, University of California, Santa Cruz.

Itô, Junko & Armin Mester. 1996. Stem and word in Sino-Japanese, 13–44. Berlin: Mouton de Gruyter.

Itô, Junko & Armin Mester. 2003. *Japanese morphophonemics*. Cambridge, MA: MIT Press.

Itô, Junko & Armin Mester. 2007. Prosodic adjunction in Japanese compounds. In Yoichi Miyamoto & Masao Ochi (eds.), *Formal approaches to Japanese linguistics (FAJL) 4*, 97–111. Cambridge, MA: MITWPL.

Itô, Junko & Armin Mester. 2009. The extended prosodic word. In Janet Grijzenhout & Barış Kabak (eds.), *Phonological domains: Universals and deviations*, 135–194. Berlin: Mouton de Gruyter.

Itô, Junko & Armin Mester. 2010. The onset of the prosodic word. In Steve Parker (ed.), *Phonological argumentation: Essays on evidence and motivation*, 227–260. London: Equinox.

Itô, Junko & Armin Mester. 2011a. A note on unstressability. Ms., University of California, Santa Cruz.

Itô, Junko & Armin Mester. 2011b. The perfect prosodic word and the sources of unaccentedness. Ms., University of California, Santa Cruz.

Itô, Junko & Armin Mester. 2012a. Prosodic subcategories in Japanese. Ms., University of California, Santa Cruz.

Itô, Junko & Armin Mester. 2012b. Recursive prosodic phrasing in Japanese. In Toni Borowsky, Shigeto Kawahara, Takahito Shinya & Mariko Sugahara (eds.), *Prosody matters: Essays in honor of Elisabeth Selkirk*, London: Equinox.

Jackendoff, Ray. 2011. What is the human language faculty?: Two views. *Language* 87(3). 586–624.

Jackendoff, Ray & Steven Pinker. 2005. The nature of the language faculty and its implications for evolution of language (reply to Fitch, Hauser, and Chomsky). *Cognition* 97(2). 211–225.

Jacobson, Steven. 1985. Siberian Yupik and Central Yupik prosody. In Michael Krauss (ed.), *Yupik Eskimo prosodic systems: descriptive and comparative studies*, 25–46. Fairbanks, AK: Alaska Native Language Center, University of Alaska.

Jensen, John. 2000. Against ambisyllabicity. *Phonology* 17(2). 187–235.

Jesney, Karen. to appear. Positional Faithfulness, non-locality, and the Harmonic Serialism solution. In Suzi Lima, Kevin Mullin & Brian Smith (eds.), *North East Linguistic Society (NELS) 39*, Amherst, MA: GLSA.

Jespersen, Otto. 1904. *Lehrbuch der phonetik*. Leipzig: B.G. Teubner.

Johnson, Keith. 2008. *Quantitative methods in linguistics*. Malden, MA: Blackwell.

Johnson, Keith & Marcia Haag. 2005. Tone and prosodic organization in Cherokee nouns. *The Journal of the Acoustical Society of America* 117(4). 2489–2489.

Jun, Sun-Ah. 2005. Prosodic typology. In Sun-Ah Jun (ed.), *Prosodic typology: The phonology of intonation and phrasing*, 430–458. Oxford, UK: Oxford University Press.

Jun, Sun-Ah & Cécile Fougeron. 2002. Realizations of accentual phrase in French intonation. *Probus* 14(1). 147–172.

Kager, René. 1989. *A metrical theory of stress and destressing in English and Dutch*. Dordrecht: Foris.

Kager, René. 1992. Are there any truly quantity-insensitive systems? In Laura Buszard-Welcher, Lionel Lee & William Weigel (eds.), *Proceedings of the 18th annual meeting of the berkeley linguistics society*, 123–132. Berkeley, CA: University of California Press.

Kager, René. 1993a. Alternatives to the iambic-trochaic law. *Natural Language and Linguistic Theory* 11(3). 381–432.

Kager, René. 1993b. Shapes of the generalized trochee. In Jonathan Mead (ed.), *West Coast Conference on Formal Linguistics (WCCFL) 11*, 298–312. Stanford, CA: CSLI Publications.

Kager, René. 1994. Ternary rhythm in alignment theory. Available online as ROA-35, Rutgers Optimality Archive, http://roa.rutgers.edu/.

Kager, René. 1996. On affix allomorphy and syllable counting. In Ursula Kleinhenz (ed.), *Interfaces in phonology*, 155–171. Berlin: Akademie Verlag.

Kager, René. 1997. Rhythmic vowel deletion in Optimality Theory. In Iggy Roca (ed.), *Derivations and constraints in phonology*, 463–499. Oxford: Oxford University Press.

Kager, René. 1999. *Optimality theory*. Cambridge University Press.

Kager, René. 2001. Rhythmic directionality by positional licensing. Handout at Fifth HIL Phonology Conference, University of Potsdam.

Kager, René. 2005. Rhythmic licensing theory: an extended typology. In *Proceedings of the third international conference on phonology*, 5–31. Seoul: The Phonology-Morphology Circle of Korea.

Kahn, Daniel. 1976. *Syllable-based generalizations in English phonology*: Massachusetts Institute of Technology dissertation. Published by Garland Press, New York, 1980.

Kaisse, Ellen & Patricia Shaw. 1985. On the theory of Lexical Phonology. *Phonology yearbook* 2. 1–30.

Kakumasu, James. 1986. Urubu-Kaapor. In Desmond Derbyshire & Geoffrey Pullum (eds.), *Handbook of Amazonian languages*, vol. 1, 326–403. Berlin: Mouton de Gruyter.

Kakumasu, James & Kiyoko Kakumasu. 1988. *Dicionário por tópicos Kaapor-Português*. Cuiabá: Associação Internacional de Lingüística, SIL Brazil. Available online at http://www.sil.org/americas/brasil/publcns/dictgram/UKDict.pdf.

Kapatsinski, Vsevolod. 2009. Testing theories of linguistic constituency with configural learning: The case of the English syllable. *Language* 85(2). 248–277.

Kaplan, Aaron. 2008. *Noniterativity is an emergent property of grammar*: University of California, Santa Cruz dissertation. Available online as ROA-977, Rutgers Optimality Archive, http://roa.rutgers.edu/.

Katz, Jerrold & Paul Postal. 1991. Realism vs. conceptualism in linguistics. *Linguistics and Philosophy* 14. 515–554.

Katz, Jonah & David Pesetsky. 2009. The identity thesis for language and music.

Kaufman, Terrence. 1976. Archaeological and linguistic correlations in Mayaland and associated areas of Meso-America. *World Archaeology* 8(1). 101–118.

Kavitskaya, Darya. 2002. *Compensatory lengthening: phonetics, phonology, diachrony*: University of California, Berkeley dissertation.

Kavitskaya, Darya. 2010. *Crimean Tatar*. Munich: LINCOM Europa.

Kavitskaya, Darya. 2011. Opacity and prominence in Crimean Tatar. Presentation given at the CUNY Conference on the Phonology of Endangered Languages, January 12th-14th, 2011. Available online at http://www.cunyphonologyforum.net/ENDANPAPERS/Kavitskaya.pptx.

Kawahara, Shigeto. 2011. Experimental approaches in theoretical phonology. In Marc van Oostendorp, Colin Ewen, Beth Hume & Keren Rice (eds.), *The Blackwell companion to phonology*, 2283–2303. Malden MA: Wiley-Blackwell.

Kawahara, Shigeto & Takahito Shinya. 2008. The intonation of gapping and coordination in Japanese: Evidence for Intonational Phrase and Utterance. *Phonetica* 65(1-2). 62–105.

Keating, Patricia. 1990. Phonetic representations in a generative grammar. *Journal of phonetics* 18(3). 321–334.

Keating, Patricia, Taehong Cho, Cécile Fougeron & Chai-Shune Hsu. 2004. Domain-initial articulatory strengthening in four languages. In John Local, Richard Ogden & Rosalind Temple (eds.), *Phonetic interpretation: Papers in laboratory phonology 6*, 145–163. Cambridge, UK: Cambridge University Press.

Kenstowicz, Michael. 1994. Sonority-driven stress. Ms. Available online as ROA-33, Rutgers Optimality Archive, http://roa.rutgers.edu/.

Kenstowicz, Michael. 1997. Quality-sensitive stress. *Rivista di Linguistica* 9(1). 157–187.

Kimper, Wendell. 2011a. *Competing triggers: transparency and opacity in vowel harmony*: University of Massachusetts, Amherst dissertation.

Kimper, Wendell. 2011b. Locality and globality in phonological variation. *Natural Language and Linguistic Theory* 29(2). 423–465.

Kiparsky, Paul. 1971. Historical linguistics. In William O. Dingwall (ed.), *A survey of linguistic science*, 576–642. College Park, MD: Department of Linguistics, University of Maryland.

Kiparsky, Paul. 1973. Abstractness, opacity, and global rules. In Osamu Fujimura (ed.), *Three dimensions of linguistic theory*, 57–86. Tokyo: TEC.

Kiparsky, Paul. 1979. Metrical structure assignment is cyclic. *Linguistic Inquiry* 10(3). 421–441.

Kiparsky, Paul. 2000. Opacity and cyclicity. *The Linguistic Review* 17. 351–367.

Kiparsky, Paul. 2008. Universals constrain change; change results in typological generalizations. In Jeff Good (ed.), *Linguistic universals and language change*, 23–53. Oxford, UK: Oxford University Press.

Kiparsky, Paul. 2011. Chains or strata? The case of Maltese. Ms., Stanford. Available online at http://ling.auf.net/lingBuzz/001379.

Klatt, Dennis. 1976. Linguistic uses of segmental duration in English: Acoustic and perceptual evidence. *The Journal of the Acoustical Society of America* 59. 1208–1221.

Kondo, Riena. 2001. Guahibo stress: both trochaic and iambic. *International Journal of American Linguistics* 67(2). 136–166.

Krämer, Martin. 2003. *Vowel harmony and correspondence theory*. Berlin: Mouton de Gruyter.

Kubozono, Haruo. 1995. Constraint interaction in Japanese phonology: Evidence from compound accent. In Rachel Walker, Ove Lorentz & Haruo Kubozono (eds.), *Phonology at Santa Cruz*, vol. 4, 21–38. UC Santa Cruz Linguistics Research Center.

Kubozono, Haruo. 2004. Tone and syllable in Kagoshima Japanese. In *Kobe papers in linguistics*, vol. 4, 69–84. Department of Linguistics, Kobe University.

Kubozono, Haruo. 2008. Japanese accent. In Shigeru Miyagawa & Mamoru Saito (eds.), *The handbook of Japanese linguistics*, 165–191. New York: Oxford University Press.

Kubozono, Haruo & Shinji Ogawa. 2004. Emergence of unaccented words in Japanese. In Bernard Bel & Isabelle Marlien (eds.), *Proceedings of* Speech prosody *2004*, International Speech Communication Association (ISCA).

Kurisu, Kazutaka. 2012. Fell-swoop onset deletion. *Linguistic Inquiry* 43(2). 309–321.

Kurzyca, Bartosz. 2011. Iambic templates in Hausa morphology. Available online as ROA-1128, Rutgers Optimality Archive, http://roa.rutgers.edu/.

Labrune, Laurence. 2012. Questioning the universality of the syllable: evidence from Japanese. *Phonology* 29(1). 113–152.

Ladd, D. Robert. 2008. *Intonational phonology*. Cambridge, UK: Cambridge University Press 2nd edn.

Ladefoged, Peter. 2006. *A course in phonetics*. Boston, MA: Thomson Wadsworth 5th edn. [1975].

Ladefoged, Peter, Jenny Ladefoged, Alice Turk, Kevin Hind & St. John Skilton. 1998. Phonetic structures of Scottish Gaelic. *Journal of the International Phonetic Association* 28(1-2). 1–41.

Lahiri, Aditi & B. Elan Dresher. 1999. Open syllable lengthening in West Germanic. *Language* 75(4). 678–719.

Lashley, Karl. 1951. The problem of serial order in behavior. In Lloyd Jeffress (ed.), *Cerebral mechanisms in behavior*, 112–131. New York: Wiley.

Lavoie, Lisa. 2001. *Consonant strength: Phonological patterns and phonetic manifestations* Outstanding Dissertations in Linguistics. New York: Garland.

Leben, William. 2002. Tonal feet, vol. 1 Bielefeld Occasional Papers in Typology, 27–40. Available online at http://www.spectrum.uni-bielefeld.de/TAPS/Leben02.pdf.

Lee, Sunghwa. 2008. Disyllabicity in nuuchahnulth. In Susie Jones (ed.), *Proceedings of the annual conference of the Canadian Linguistic Association*, .

Leer, Jeff. 1985a. Evolution of prosody in the Yupik languages. In Michael Krauss (ed.), *Yupik Eskimo prosodic systems: descriptive and comparative studies*, 135–158. Fairbanks, AK: Alaska Native Language Center, University of Alaska.

Leer, Jeff. 1985b. Prosody in Alutiiq. In Michael Krauss (ed.), *Yupik Eskimo prosodic systems: descriptive and comparative studies*, 77–134. Fairbanks, AK: Alaska Native Language Center, University of Alaska.

Leer, Jeff. 1985c. Toward a metrical interpretation of Yupik prosody. In Michael Krauss (ed.), *Yupik Eskimo prosodic systems: descriptive and comparative studies*, 159–173. Fairbanks, AK: Alaska Native Language Center, University of Alaska.

Legendre, Géraldine, Yoshiro Miyata & Paul Smolensky. 1990. Harmonic Grammar: A formal multi-level connectionist theory of linguistic well-formedness: An application. In *Proceedings of the 12th annual conference of the cognitive science society*, 884ï£¡891. Hillsdale, NJ: Erlbaum.

Lehiste, Ilse. 1970. *Suprasegmentals*. Cambridge, MA: MIT Press.

Lerdahl, Fred & Ray Jackendoff. 1983. *A generative theory of tonal music*. MIT Press.

Liberman, Mark. 1975. *The intonational system of English*: Massachusetts Institute of Technology dissertation.

Liberman, Mark & Alan Prince. 1977. On stress and linguistic rhythm. *Linguistic Inquiry* 8(2). 249–336.

Loos, Eugene. 1969. *The phonology of Capanahua and its grammatical basis*: University of Texas, Austin dissertation. Available online at http://www.sil.org/acpub/repository/11508.pdf.

Loos, Eugene. 1999. Pano. In R.M.W. Dixon & Alexandra Aikhenvald (eds.), *The Amazonian languages*, 227–50. Cambridge, UK: Cambridge University Press.

Lunden, Anya. 2006. *Weight, final lengthening, and stress: a phonetic and phonological case study of Norwegian*: University of California, Santa Cruz dissertation. Available online as ROA-833, Rutgers Optimality Archive, http://roa.rutgers.edu/.

Macmillan, Neil & C. Douglas Creelman. 2005. *Detection theory: A user's guide*. Mahwah, New Jersey: Lawrence Erlbaum Associates 2nd edn.

Martin, Jack & Keith Johnson. 2002. An acoustic study of "tonal accent" in Creek. *International Journal of American Linguistics* 68(1). 28–50.

Martin, James G. 1972. Rhythmic (hierarchical) versus serial structure in speech and other behavior. *Psychological Review* 79(6). 487–509.

Martínez-Paricio, Violeta. 2012. Superfeet as recursion. Presentation given at WCCFL 30, University of California, Santa Cruz.

Mascaró, Joan. 1996. External allomorphy as emergence of the unmarked. In Jacques Durand & Bernard Laks (eds.), *Current trends in phonology: Models and methods*, 473–483. Salford, Manchester: University of Salford, European Studies Research Institute. Reprinted 2004 in *Optimality Theory in Phonology: A reader*, ed. John J. McCarthy, 513-522. Oxford: Blackwell.

Mascaró, Joan. 2007. External allomorphy and lexical representation. *Linguistic Inquiry* 38(4). 715–735.

MBROLA Project Development Team. 2010. MBROLA speech synthesizer. Computer program. Retrieved from http://tcts.fpms.ac.be/synthesis/mbrola.html.

McCarthy, John. 1986. OCP effects: gemination and antigemination. *Linguistic Inquiry* 17(2). 207–263.

McCarthy, John. 1993. A case of surface constraint violation. *Canadian Journal of Linguistics* 38. 169–195.

McCarthy, John. 1999. Sympathy and phonological opacity. *Phonology* 16(3). 331–399.

McCarthy, John. 2003a. Sympathy, cumulativity, and the Duke-of-York gambit. In Caroline Féry & Ruben van de Vijver (eds.), *The syllable in optimality theory*, 23–76. Cambridge, UK: Cambridge University Press.

McCarthy, John. 2006. Restraint of analysis. In Eric Bakovič Junko Itô & John McCarthy (eds.), *Wondering at the natural fecundity of things: essays in honor of Alan Prince*, Santa Cruz, CA: Linguistics Research Center, University of California, Santa Cruz. Available online at http://repositories.cdlib.org/lrc/prince/10.

McCarthy, John. 2007. *Hidden generalizations: phonological opacity in Optimality Theory*. London: Equinox.

McCarthy, John. 2009. Harmony in Harmonic Serialism. Ms., University of Massachusetts, Amherst.

McCarthy, John. to appear. Autosegmental spreading in Optimality Theory. In John Goldsmith, Elizabeth Hume & Leo Wetzels (eds.), *Tones and features*, Berlin: Mouton de Gruyter. Available online as ROA-1050, Rutgers Optimality Archive, http://roa.rutgers.edu/.

McCarthy, John, Kevin Mullin & Brian Smith. 2010. Implications of Harmonic Serialism for lexical tone association. Ms., University of Massachusetts, Amherst. Available online as ROA-1096, Rutgers Optimality Archive, http://roa.rutgers.edu/.

McCarthy, John, Joe Pater & Kathryn Pruitt. to appear. Cross-level interactions in Harmonic Serialism. In John McCarthy & Joe Pater (eds.), *Harmonic Grammar and Harmonic Serialism*, London: Equinox.

McCarthy, John & Kathryn Pruitt. 2012. Sources of phonological structure. In Hans Broekhuis & Ralf Vogel (eds.), *Linguistic derivations and filtering: Minimalism and optimality theory*, London: Equinox.

McCarthy, John J. 1979. On stress and syllabification. *Linguistic Inquiry* 10(3). 443–465.

McCarthy, John J. 1981. The role of the evaluation metric in the acquisition of phonology. In C.L. Baker & John J. McCarthy (eds.), *The logical problem of language acquisition*, 218–248. Cambridge, MA: MIT Press.

McCarthy, John J. 1982. Prosodic structure and expletive infixation. *Language* 58. 574–590.

McCarthy, John J. 2002. *A thematic guide to Optimality Theory*. Cambridge, UK: Cambridge University Press.

McCarthy, John J. 2003b. OT constraints are categorical. *Phonology* 20. 75–138.

McCarthy, John J. 2004. Headed spans and autosegmental spreading. Ms., University of Massachusetts, Amherst. Available online as ROA-685, Rutgers Optimality Archive, http://roa.rutgers.edu/.

McCarthy, John J. 2008a. The gradual path to cluster simplification. *Phonology* 25(2). 271–319.

McCarthy, John J. 2008b. The serial interaction of stress and syncope. *Natural Language and Linguistic Theory* 26(3). 499–546.

McCarthy, John J. & Alan Prince. 1986/1996. Prosodic morphology. Tech. rep. Rutgers University Center for Cognitive Science.

McCarthy, John J. & Alan Prince. 1990. Foot and word in prosodic morphology: the Arabic broken plural. *Natural Language and Linguistic Theory* 8(2). 209–283.

McCarthy, John J. & Alan Prince. 1993a. Generalized alignment. *Yearbook of Morphology* 79–154. ROA 7.

McCarthy, John J. & Alan Prince. 1993b. Prosodic morphology I: Constraint interaction and satisfaction. Tech. Rep. 3 Rutgers University Center for Cognitive Science. Available at http://works.bepress.com/john_j_mccarthy/53.

McCarthy, John J. & Alan Prince. 1994. The emergence of the unmarked: Optimality in prosodic morphology. *Proceedings of NELS* 24. 333–379.

McCarthy, John J. & Alan Prince. 1995. Faithfulness and reduplicative identity. In Jill Beckman, Laura Walsh Dickey & Suzanne Urbanczyk (eds.), *University of Massachusetts occasional papers in linguistics*, 249–384.

McCarthy, John J. & Alan Prince. 1999. Faithfulness and identity in prosodic morphology. In René Kager, Harry van der Hulst & Wim Zonneveld (eds.), *The prosody morphology interface*, 218–309. Cambridge: Cambridge University Press.

McCawley, James. 1968. *The phonological component of a grammar of Japanese*: Massachusetts Institute of Technology dissertation.

McGarrity, Laura. 2003. *Constraints on patterns of primary and secondary stress*: Indiana University dissertation. Available online as ROA-651, Rutgers Optimality Archive, http://roa.rutgers.edu/.

Mester, Armin. 1990. Patterns of truncation. *Linguistic Inquiry* 21(3). 478–485.

Mester, Armin. 1994. The quantitative trochee in Latin. *Natural Language and Linguistic Theory* 12(1). 1–61.

Meyer, Kuno. 1909. *A primer of Irish metrics*. Dublin: School of Irish Learning.

Mills, Elizabeth. 1984. *Senoufo phonology, discourse to syllable (a prosodic approach)*, vol. 72 SIL publications in linguistics. Summer Institute of Linguistics and University of Texas at Arlington.

Moreton, Elliott. 2008. Analytic bias and phonological typology. *Phonology* 25. 83–127.

Muller, Jennifer. 2001. *The phonology and phonetics of word-initial geminates*: The Ohio State University dissertation.

Myers, Scott. 1987. Vowel shortening in English. *Natural Language and Linguistic Theory* 5(4). 485–518.

Myers, Scott. 1997. OCP effects in Optimality Theory. *Natural Language and Linguistic Theory* 15(4). 847–892.

Myers, Scott. 1998. Surface underspecification of tone in Chichewa. *Phonology* 15(3). 367–391.

Myers, Scott & Benjamin Hansen. 2007. The origin of vowel length neutralization in final position: Evidence from finnish speakers. *Natural language and linguistic theory* 25(1). 157–193.

Nelson, Nicole. 1998. Mixed anchoring in French hypocoristic formation. In Ron Artstein & Madeline Holler (eds.), *RuLing papers I: Working papers from Rutgers University*, 185–199. New Brunswick, NJ: Department of Linguistics, Rutgers University.

Nelson, Nicole. 2003. *Asymmetric anchoring*: Rutgers dissertation.

Nespor, Marina & Irene Vogel. 1986. *Prosodic phonology*. Dordrecht: Foris Publications. Reprinted 2008 by Mouton de Gruyter.

Nesset, Tore. 2002. Dissimilation, assimilation and vowel reduction: constraint interaction in East Slavic dialects with so-called dissimilative *akan'e* and *jakan'e*. *Poljarnyj Vestnik* 5. 77–101.

Nevins, Andrew. 2010. Two case studies in phonological universals: A view from artificial grammars. *Biolinguistics* 4(2). 217–232. Papers from the workshop *Human universals as constraints on language diversity*.

Newlin-Łukowicz, Luiza. 2011. Polish stress: looking for phonetic evidence of a bidirectional system. Ms.

Newport, Elissa & Richard Aslin. 2004. Learning at a distance i. statistical learning of non-adjacent dependencies. *Cognitive psychology* 48(2). 127–162.

Ní Chiosáin, Máire. 1999. Syllables and phonotactics in Irish. In Harry van der Hulst & Nancy Ritter (eds.), *The syllable: views and facts*, 551–575. Berlin: Mouton de Gruyter.

Ní Chiosáin, Máire. 2000. Prosodic well-formedness and sonority constraints: epenthesis in Irish. Available online as ROA-89, Rutgers Optimality Archive, http://roa.rutgers.edu/.

Ní Chiosáin, Máire & Jaye Padgett. 2001. Markedness, segment realization, and locality in spreading. In Linda Lombardi (ed.), *Segmental phonology in optimality theory: constraints and representations*, 118–156. Cambridge, UK: Cambridge University Press.

Ní Chiosáin, Máire & Pauline Welby. 2009. An investigation of syllabification in irish. Presentation at Formal Approaches to Celtic Linguistics (FACL) Conference.

Ní Chiosáin, Máire, Pauline Welby & Robert Espesser. 2012. Is the syllabification of Irish a typological exception? An experimental study. *Speech Communication* 54. 68–91.

Norris, Mark. 2010. The architecture of derivational OT: Evidence from Icelandic syncope. Ms., University of California, Santa Cruz. Available online at http://people.ucsc.edu/~mnorris/research/syncope_nels_paper.pdf.

Ó Siadhail, Mícheál. 1991. *Modern Irish: grammatical structure and dialectal variation*. Cambridge, UK: Cambridge University Press.

Ó Siadhail, Mícheál. 1995. *Learning Irish: An introductory self-tutor*. New Haven: Yale University Press.

Ó Buachalla, Breandán. 2003. *An teanga bheo: Gaeilge Chléire*. Baile Átha Cliath (Dublin): Institiúid Teangeolaíochta Éireann.

Ó Cuív, Brian. 1944. *The Irish of West Muskerry, Co. Cork: a phonetic study*. The Dublin Institute for Advanced Studies.

Ó Curnáin, Brian. 2007. *The Irish of Iorras Aithneach*, *County Galway*. Dublin: The Dublin Institute for Advanced Studies.

O'Dell, Michael & Tommi Nieminen. 1999. Coupled oscillator model of speech rhythm. In *Proceedings of the xivth international congress of phonetic sciences*, vol. 2, 1075–1078.

Ó Dochartaigh, Cathair. 1987. *Dialects of Ulster Irish*. Belfast: Queens University of Belfast, Institute of Irish Studies.

Ohala, John. 1981. The listener as a source of sound change. In Carrie S. Masek, Roberta A. Hendrick & Mary Frances Miller (eds.), *Papers from the parasession on language and behavior*, 178–203. Chicago: Chicago Linguistics Society.

Ohala, John. 1986. Consumer's guide to evidence in phonology. *Phonology Yearbook* 3. 3–26.

Ohala, John & Haruko Kawasaki-Fukumori. 1997. Alternatives to the sonority hierarchy for explaining segmental sequential constraints. In Stig Eliasson & Ernst Håkon Jahr (eds.), *Language and its ecology: Essays in memory of Einar Haugen*, 343–366. Berlin: Mouton De Gruyter.

Onaka, Akiko, Sallyanne Palethorpe, Catherine Watson & Jonathan Harrington. 2002. Acoustic and articulatory difference of speech segments at different prosodic positions. In *Proceedings of the 9th australian international conference on speech science and technology*, 148–153.

Onishi, Kristine, Kyle Chambers & Cynthia Fisher. 2002. Learning phonotactic constraints from brief auditory experience. *Cognition* 83(1). B13–B23.

O'Rahilly, Thomas F. 1932. *Irish dialects past and present: with chapters on Scottish and Manx*. Dublin: Dublin Institute for Advanced Studies. Reprinted 1976.

Ó Sé, Diarmuid. 2000. *Gaeilge Chorca Duibhne*. Baile Átha Cliath (Dublin): Institiúid Teangeolaíochta Éireann.

Osumi, Midori. 1995. *Tinrin grammar* Oceanic Linguistics Special Publications. University of Hawai'i Press.

Padgett, Jaye & Scott Myers. 2011. Experimental support for domain generalization. Presentation given at the annual meeting of the Linguistic Society of America, January 8th, 2011.

Padgett, Jaye & Marija Tabain. 2005. Adaptive dispersion theory and phonological vowel reduction in Russian. *Phonetica* 62. 14–54.

Pak, Marjorie. 2008. *The postsyntactic derivation and its phonological reflexes*: University of Pennsylvania dissertation.

Pandey, Pramod Kumar. 1990. Hindi schwa deletion. *Lingua* 82. 277–311.

Parker, Stephen. 2002. *Quantifying the sonority hierarchy*: University of Massachusetts Amherst dissertation.

Parker, Steve. 1994. Coda epenthesis in Huariapano. *International Journal of American Linguistics* 60(2). 95–119.

Parker, Steve. 1998a. Disjoint metrical tiers and positional markedness in Huariapano. Ms.

Parker, Steve. 1998b. On the phonetic duration of Huariapano rhymes. *Work papers of the Summer Institute of Linguistics, University of North Dakota session* 42. Available online at http://www.und.nodak.edu/dept/linguistics/wp/1998Parker.PDF.

Partee, Barbara, Alice G.B. ter Meulen & Robert Wall. 1990. *Mathematical methods in linguistics*. Dordrecht: Kluwer Academic Publishers.

Paster, Mary. 2006. *Phonological conditions on affixation*: University of California, Berkeley dissertation.

Pater, Joe. 2000. Non-uniformity in English secondary stress: the role of ranked and lexically specific constraints. *Phonology* 17(2). 237–274.

Pater, Joe. 2009. Weighted constraints in generative linguistics. *Cognitive Science* 33(6). 999–1035.

Pearce, Mary. 2006. The interaction between metrical structure and tone in Kera. *Phonology* 23(2). 259–286.

Perruchet, Pierre & Chantal Pacteau. 1990. Synthetic grammar learning: Implicit rule abstraction or explicit fragmentary knowledge? *Journal of Experimental Psychology* 119(3). 264–275.

Peters, Stanley. 1972. The projection problem: how is a grammar to be selected? In Stanley Peters (ed.), *Goals of linguistic theory*, 171–188. Prentice-Hall.

Pierrehumbert, Janet & Mary Beckman. 1988. *Japanese tone structure*. Cambridge, MA: MIT Press.

Pike, Eunice. 1986. Tone contrasts in Central Carrier (Athapaskan). *International Journal of American Linguistics* 52(4). 411–418.

Pinker, Steven & Paul Bloom. 1990. Natural language and natural selection. *Behavioral and brain sciences* 13. 707–784.

Popjes, Jack & Josephine Popjes. 1971. Phonemic statement of Canela. *Arquivo Linguístico* 112. Available online at http://www.sil.org/americas/brasil/publcns/ling/CNPhonem.pdf.

Popjes, Jack & Josephine Popjes. 1986. Canela-Krahô. In Desmond Derbyshire & Geoffrey Pullum (eds.), *Handbook of Amazonian languages*, vol. 1, 128–199. Berlin: Mouton de Gruyter.

Port, Robert, Fred Cummins & Michael Gasser. 1995. A dynamic approach to rhythm in language: Toward a temporal phonology. In Barbara Luka & Barbara Need (eds.), *Chicago linguistics society (cls) 31*, 375–397. Department of Linguistics, University of Chicago.

Poser, William J. 1984. *The phonetics and phonology of tone and intonation in Japanese*: Massachusetts Institute of Technology dissertation.

Poser, William J. 1990. Evidence for foot structure in Japanese. *Language* 78–105.

Postal, Paul. 2003. Remarks on the foundations of linguistics. *The Philosophical Forum* 34(3-4). 233–252.

Pothos, Emmanuel & Todd Bailey. 2000. The role of similarity in artificial grammar learning. *Journal of Experimental Psychology* 26(4). 847–862.

Potts, Christopher, Joe Pater, Karen Jesney, Rajesh Bhatt & Michael Becker. 2010. Harmonic Grammar with linear programming: From linear systems to linguistic typology. *Phonology* 27(1). 77–117.

Pride, Kitty & Leslie Pride. 1964. Tataltepec Chatino syllables. Ms. Available online at http://www.sil.org/acpub/repository/cta Chatino Syllables.pdf.

Pride, Leslie. 1984a. Chatino: Tono y contraste en la penúltima sílaba en Tataltepec. *Anales de Antropología* 21. 281–306.

Pride, Leslie. 1984b. Tone contrast on the penultimate syllable in Tataltepec Chatino. In *SIL Mexico workpapers*, vol. 6, 73–92. Summer Institute of Linguistics in Mexico. Available online at http://www.sil.org/mexico/workpapers/scans/WS06/WS0603-PrideL.pdf.

Prince, Alan. 1975. *The phonology and morphology of Tiberian Hebrew*: Massachusetts Institute of Technology dissertation.

Prince, Alan. 1976. Applying stress. Ms., MIT.

Prince, Alan. 1983. Relating to the grid. *Linguistic Inquiry* 14(1). 19–100.

Prince, Alan. 1985. Improving tree theory. In *Berkeley Linguistic Society (BLS) 11*, 471–490.

Prince, Alan. 1991. Quantitative consequences of rhythmic organization. In Karen Deaton, Manuela Noske & Michael Ziolkowski (eds.), *Cls 26(2): Papers from the parasession on the syllable in phonetics and phonology*, 355–398. Chicago: Chicago Linguistics Society.

Prince, Alan. 2002. Arguing optimality. *Papers in Optimality Theory II* 269–304.

Prince, Alan & Paul Smolensky. 1993/2004. *Optimality theory*. Blackwell.

Pruitt, Kathryn. 2010. Serialism and locality in constraint-based metrical parsing. *Phonology* 27(3). 481–526.

Pulgram, Ernst. 1970. *Syllable, word, nexus, cursus*. The Hague: Mouton.

Pulleyblank, Douglas. 1986. *Tone in lexical phonology*. Dordrecht: D. Reidel.

Pullum, Geoffrey. 1976. The Duke of York gambit. *Journal of Linguistics* 12(1). 83–102.

Pycha, Anne, Pawel Nowak, Eurie Shin & Ryan Shosted. 2003. Phonological rule-learning and its implications for a theory of vowel harmony. In *West Coast Conference on Formal Linguistics (WCCFL) 22*, 101–114. Somerville, MA: Cascadilla Press.

Pye, Clifton. 1983. Mayan telegraphese: Intonational determinants of inflectional development in Quiche Mayan. *Language* 59(3). 583–604.

R Development Core Team. 2011. *R: A language and environment for statistical computing*. R Foundation for Statistical Computing Vienna, Austria. Version 2.13.1, retrieved from http://www.R-project.org/.

Ramsey, Philip H. 1989. Critical values for Spearman's Rank Order Correlation. *Journal of Educational Statistics* 14(3). 245–253.

Rappaport, Malka. 1984. *Issues in the phonology of Tiberian Hebrew*: Massachusetts Institute of Technology dissertation.

Ratcliff, Roger. 1993. Methods for dealing with reaction time outliers. *Psychological Bulletin* 114(3). 510–532.

Reber, Arthur S. 1967. Implicit learning of artificial grammars. *Journal of verbal learning and verbal behavior* 6. 855–863.

Reber, Arthur S. 1989. Implicit learning and tacit knowledge. *Journal of Experimental Psychology* 118(3). 219–235.

Redington, Martin & Nick Chater. 1996. Transfer in artificial grammar learning: A reevaluation. *Journal of Experimental Psychology* 125(2). 123–137.

Reeves, Carolyn, A. René Schmauder & Robin Morris. 2000. Stress grouping improves performance on an immediate serial list recall task. *Journal of Experimental Psychology* 26(6). 1638–1654.

Revithiadou, Anthi. 2004. The iambic/trochaic law revisited: lengthening and shortening in trochaic systems. In Boban Arsenijevic, Noureddine Elouazizi, Martin Salzmann & Mark de Vos (eds.), *Leiden papers in linguistics*, vol. 1 1, 37–62.

Rhodes, Russell. 2010. Vowel harmony as agreement by correspondence. Ms., University of California, Berkeley.

Rice, Curt. 1992. *Binarity and ternarity in metrical theory: Parametric extensions*: University of Texas, Austin dissertation.

Rice, Curt. 2007. The roles of GEN and CON in modeling ternary rhythm. In Sylvia Blaho, Patrik Bye & Martin Krämer (eds.), *Freedom of analysis?*, 233–255. Berlin: Walter de Gruyter.

Richards, Michael. 2003. *Atlas lingüístico de Guatemala*. Instituto de Lingüístico y Educación de la Universidad Rafael Landívar.

Rose, Sharon & Rachel Walker. 2004. A typology of consonant agreement as correspondence. *Language* 80(3). 475–531.

Rose, Sharon & Rachel Walker. 2011. Harmony systems. In John Goldsmith, Alan Yu & Jason Riggle (eds.), *The handbook of phonological theory*, 240–290. Malden MA: Wiley-Blackwell 2nd edn.

Rosenthall, Samuel & Harry van der Hulst. 1999. Weight-by-position by position. *Natural Language and Linguistic Theory* 17(3). 499–540.

Saffran, Jenny. 2002. Constraints on statistical language learning. *Journal of Memory and Language* 47(1). 172–196.

Saffran, Jenny, Elizabeth Johnson, Richard Aslin & Elissa Newport. 1999. Statistical learning of tone sequences by human infants and adults. *Cognition* 70(1). 27–52.

Saffran, Jenny, Elissa Newport & Richard Aslin. 1996. Word segmentation: The role of distributional cues. *Journal of memory and language* 35. 606–621.

Saffran, Jenny, Elissa Newport, Richard Aslin, Rachael Tunick & Sandra Barrueco. 1997. Incidental language learning: Listening (and learning) out of the corner of your ear. *Psychological Science* 8(2). 101–105.

Salamanca, Danilo. 1988. *Elementos de gramática del miskito*: Massachusetts Institute of Technology dissertation.

Samuels, Bridget. 2009. *The structure of phonological theory*: Harvard University dissertation.

de Saussure, Ferdinand. 1915/1966. *Course in general linguistics*. New York: McGraw Hill.

Schane, Sanford, Bernard Tranel & Harlan Lane. 1975. On the psychological reality of a natural rule of syllable structure. *Cognition* 3(4). 351–358.

Scheer, Tobias. to appear. Chunk definition in phonology: prosodic constituency vs. phase structure. In Maria Bloch-Trojnar & Anna Bloch-Rozmej (eds.), *Modules and interfaces*, Lublin, Poland: Catholic Univesity of Lublin (Katolicki Uniwersytet Lubelski).

Schiering, René, Balthasar Bickel & Kristine Hildebrandt. 2010. The prosodic word is not universal, but emergent. *Journal of Linguistics* 46(3). 657–709.

Seidl, Amanda. 2001. *Minimal indirect reference: a theory of the syntax-phonology interface* Outstanding Dissertations in Linguistics. New York: Garland.

Seidl, Amanda & Eugene Buckley. 2005. On the learning of arbitrary phonological rules. *Language Learning and Development* 1. 289–316.

Seidl, Amanda & Eugene Buckley. 2007. Complexity, not naturalness, in infant phonological pattern learning. Unpublished manuscript, Purdue University.

Selkirk, Elisabeth. 1978. On prosodic structure and its relation to syntactic structure. In T. Fretheim (ed.), *Nordic prosody ii*, 111–140. Trondheim: TAPIR.

Selkirk, Elisabeth. 1980. The role of prosodic categories in English word stress. *Linguistic Inquiry* 11(3). 563–605.

Selkirk, Elisabeth. 1984. *Phonology and syntax: The relation between sound and structure.* Cambridge, MA: MIT Press.

Selkirk, Elisabeth. 1986. On derived domains in sentence phonology. *Phonology* 3(1986). 371–405.

Selkirk, Elisabeth. 1996. The prosodic structure of function words. In Jill Beckman, Laura Walsh Dickey & Suzanne Urbanczyk (eds.), *Papers in Optimality Theory*, 439–470. Amherst, MA: GLSA Publications. Also in Signal to Syntax: Bootstrapping from Speech to Grammar in Early Acquisition, eds. James L. Morgan and Katherine Demuth, 187-214.

Selkirk, Elisabeth. 2011. The syntax-phonology interface. In John Goldsmith, Jason Riggle & Alan Yu (eds.), *Handbook of phonological theory* Blackwell Handbooks in Linguistics Series, 435–484. Malden MA: Wiley-Blackwell 2nd edn.

Shaw, Jason. 2007. /ti/∼/tʃi/ contrast preservation in Japanese loans is parasitic on segmental cues to prosodic structure. In J. Trouvain & W. Barry (eds.), *Proceedings of the 16th international congress of the phonetic sciences*, 1365–1368. Saabrücken, Germany.

Shaw, Jason. 2009. Compensatory lengthening via mora preservation in OT-CC: theory and predictions. In Anisa Schardl, Martin Walkow & Muhammad Abdurrahman (eds.), *North East Linguistic Society (NELS) 38*, 297–310. Amherst, MA: GLSA.

Shaw, Jason, Adamantios Gafos, Philip Hoole & Chakir Zeroual. 2009. Syllabification in Moroccan Arabic: evidence from patterns of temporal stability in articulation. *Phonology* 26(1). 187–215.

Shaw, Patricia. 1985. Coexistent and competing stress rules in Stoney (Dakota). *International Journal of American Linguistics* 51(1). 1–18.

Shell, Olive. 1965. *Pano reconstruction*: University of Pennsylvania dissertation. Spanish translation available online at http://www.sil.org/americas/peru/pubs/slp12.pdf.

Sherer, Tim. 1994. *Prosodic phonotactics*: University of Massachusetts, Amherst dissertation.

Silverman, Daniel. 1997. Laryngeal complexity in Otomanguean vowels. *Phonology* 14(2). 235–261.

Silverman, Kim & Janet Pierrehumbert. 1990. The timing of pre-nuclear high accents in English. In John Kingston & Mary Beckman (eds.), *Papers in laboratory phonology I: Between the grammar and the physics of speech*, 72–106. Cambridge, UK: Cambridge University Press.

Simon, Herbert A. 1962. The architecture of complexity. *Proceedings of the American Philosophical Society* 106(6). 467–482.

Slevc, L. Robert, Jason Rosenberg & Aniruddh Patel. 2009. Making psycholinguistics musical: self-paced reading time evidence for shared processing of linguistic and musical syntax. *Psychonomic bulletin & review* 16(2). 374–381.

Smith, Jen. 2005a. *Phonological augmentation in prominent positions*. Routledge.

Smith, Jennifer. 2005b. *Phonological augmentation in prominent positions*. Routledge.

Smith, Jennifer. 2011. Category-specific effects. In Marc van Oostendorp, Colin Ewen, Beth Hume & Keren Rice (eds.), *The Blackwell companion to phonology*, 2439–2463. Malden MA: Wiley-Blackwell.

Smith, Norval. 1999. A preliminary account of some aspects of Leurbost Gaelic syllable structure. In Harry van der Hulst & Nancy Ritter (eds.), *The syllable: views and facts*, 577–630. Berlin: Mouton de Gruyter.

Smolensky, Paul & Géraldine Legendre. 2006. *The harmonic mind*. MIT Press.

Sokal, Robert R. & F. James Rohlf. 1995. *Biometry: the principles and practice of statistics in biological research*. New York: W.H. Freeman 3rd edn.

Spaelti, Philip. 1992. A feature geometric account of !Xóõ Bushman. Ms., University of California, Santa Cruz. Available at http://ksw.shoin.ac.jp/~spaelti/Papers/spaelti_Bushman.pdf.

Staubs, Robert. to appear. The pathology of feature-driven stress. In Yelena Fainleib, Nick LaCara & Yangsook Park (eds.), *North East Linguistic Society (NELS) 41*, Amherst, MA: GLSA.

Stenson, Nancy. 1978. Plural formation in Ráth Cairn. *Éigse* 17. 495–536.

Steriade, Donca. 1999. Alternatives to syllable-based accounts of consonantal phonotactics. In Osamu Fujimura, Brian Joseph & Bohumil Palek (eds.), *Item order in language and speech*, 205–242. Prague: Karolinum.

Steriade, Donca. 2001. Directional asymmetries in place assimilation: a perceptual account. In Keith Johnson & Elizabeth Hume (eds.), *The role of speech perception in phonology*, 219–250. New York: Academic Press.

Suzuki, Keiichiro. 1998. *A typological investigation of dissimilation*: University of Arizona dissertation. Available online as ROA-281, Rutgers Optimality Archive, http://roa.rutgers.edu/.

Taft, Marcus & Kenneth Forster. 1975. Lexical storage and retrieval of prefixed words. *Journal of verbal learning and verbal behavior* 14(6). 638–647.

Tajima, Keiichi & Robert Port. 2004. Speech rhythm in English and Japanese. In John Local, Richard Ogden & Rosalind Temple (eds.), *Phonetic interpretation: Papers in laboratory phonology 6*, 322–339. Cambridge, UK: Cambridge University Press.

Taylor, Conrad & George Houghton. 2005. Learning artificial phonotactic constraints: Time course, durability, and relationship to natural constraints. *Journal of Experimental Psychology* 31(6). 1398–1416.

Teeple, David. 2009. *Biconditional prominence correlation*: University of California, Santa Cruz dissertation.

Thráinsson, Höskuldur. 1978. On the phonology of Icelandic prespiration. *Nordic Journal of Linguistics* 1(1). 3–54.

Thurneysen, Rudolf. 1946. *A grammar of Old Irish*. Dublin: Dublin Institute for Advanced Studies. Reprinted 1961, 1990.

Tilsen, Samuel. 2009. *Hierarchical spatiotemporal dynamics of speech rhythm and articulation*: University of California, Berkeley dissertation.

Topintzi, Nina. 2008. On the existence of moraic onset geminates. *Natural Language and Linguistic Theory* 26(1). 147–184.

Tranel, Bernard. 1991. CVC light syllables, geminates and moraic theory. *Phonology* 8(2). 291–302.

Tranel, Bernard. 1996. French liaison and elision revisited: a unified account within Optimality Theory. In *Aspects of Romance linguistics: selected papers from the Linguistic Symposium on Romance Languages XXIV*, 433–455. Washington, DC: Georgetown University Press. Available online as ROA-15, Rutgers Optimality Archive, http://roa.rutgers.edu/.

Treiman, Rebecca & Catalina Danis. 1988. Syllabification of intervocalic consonants. *Journal of Memory and Language* 27(1). 87–104.

Trommer, Jochen & Angela Grimm. 2004. Albanian word stress. Presentation at given at Manchester Phonology Meeting (mfm) 12.

Trubetzkoy, Nikolai. 1939. *Grundzüge der phonologie*. Travaux du cercle linguistique de Prague. English translation published 1969 as *Principles of phonology*, trans. C.A.M. Baltaxe. Berkeley: University of California Press.

Truckenbrodt, Hubert. 1999. On the relation between syntactic phrases and phonological phrases. *Linguistic Inquiry* 30(2). 219–255.

Uwano, Zendo. 2007. Two-pattern accent systems in three Japanese dialects. In Tomas Riad & Carlos Gussenhoven (eds.), *Tones and tunes: typological studies in word and sentence prosody*, vol. 1, 147–165. Berlin: Mouton De Gruyter.

van de Vijver, Ruben. 1998. *The iambic issue: iambs as a result of constraint interaction*. The Hague: Holland Academic Graphics.

van der Hulst, Harry. 2009. Brackets and grid marks, or theories of primary accent and rhythm. *Contemporary views on architecture and representations in phonology* 225–245.

van der Hulst, Harry. 2010. A note on recursion in phonology. In Harry van der Hulst (ed.), *Recursion and human language*, 301–342. Berlin: Mouton de Gruyter.

van der Hulst, Harry. submitted. Representing accent. *Phonological Studies (Journal of the Phonological Society of Japan)* .

van der Hulst, Harry & Norval Smith. 1988. *The variety of pitch accent systems: Introduction* ix–xxiv. Dordrecht: Foris Publications.

Van Lancker, Diana, Jody Kreiman & Dwight Bolinger. 1988. Anticipatory lengthening. *Journal of Phonetics* 16. 339–347.

Vaysman, Olga. 2009. *Segmental alternations and metrical theory*: Massachusetts Institute of Technology dissertation.

Veerman-Leichsenring, Annette. 1991. *Gramática del Popoloca de Metzontla (con vocabulario y textos)*. Amsterdam: Editions Rodopi.

Vogel, Irene. 2009. Universals of prosodic structure. In Sergio Scalise, Elisabetta Magni & Antonietta Bisetto (eds.), *Universals of language today*, 59–82. Springer.

Wagner, Michael. 2010. Prosody and recursion in coordinate structures and beyond. *Natural Language and Linguistic Theory* 28(1). 183–237.

Walker, Douglas. 1975. Word stress in French. *Language* 51(4). 887–900.

Walker, Rachel. 1995. Mongolian stress: typological implications for nonfinality in unbounded systems. In Rachel Walker, Ove Lorentz & Haruo Kubozono (eds.), *Phonology at Santa Cruz*, vol. 4, 85–102. UC Santa Cruz Linguistics Research Center.

Walker, Rachel. 1996. Prominence-driven stress. Ms., University of California, Santa Cruz. Available online as ROA-172, Rutgers Optimality Archive, http://roa.rutgers.edu/.

Walker, Rachel. 2010. Nonmyopic harmony and the nature of derivations. *Linguistic Inquiry* 41(1). 169–179.

Walsh, John. 2010. *Contests and contexts: the Irish language and Ireland's socio-economic development*. Bern, Switzerland: Peter Lang AG.

Weidman, Scott & Sharon Rose. 2006. A foot-based reanalysis of edge-in tonal phenomena in Bambara. In Donald Baumer, David Montero & Michael Scanlon (eds.), *West Coast Conference on Formal Linguistics (WCCFL) 25*, 426–434. Somerville, MA: Cascadilla Press. Available online at http://www.lingref.com/, document #1476.

Welmers, William E. 1959. Tonemics, morphotonemics, and tonal morphemes. *General Linguistics* 4(1). 2–11.

Willett, Elizabeth. 1982. Reduplication and accent in Southeastern Tepehuan. *International Journal of American Linguistics* 48(2). 168–184.

Wilson, Colin. 2006. Learning phonology with substantive bias: An experimental and computational study of velar palatalization. *Cognitive Science* 30. 945–982.

Wolf, Matthew. 2008. *Optimal interleaving: Serial phonology-morphology interaction in a constraint-based model*: University of Massachusetts, Amherst dissertation.

Wolfle, Dael Lee. 1932. The relation between linguistic structure and associative interference in artificial linguistic material. *Language* 8(1). 5–55.

Woodrow, Herbert. 1909. *A quantitative study of rhythm: The effect of variations in intensity, rate and duration*. New York: The Science Press.

Yip, Moira. 1980. *The tonal phonology of Chinese*: Massachusetts Institute of Technology dissertation.

Yip, Moira. 1988. Template morphology and the direction of association. *Natural Language and Linguistic Theory* 6(4). 551–577.

Yip, Moira. 2002. *Tone*. Cambridge, UK: Cambridge University Press.

Yu, Alan. 2004. Reduplication in English Homeric infixation. In Keir Moulton & Matt Wolf (eds.), *North East Linguistic Society (NELS) 34*, 619–633. Amherst, MA: GLSA.

Zec, Draga. 2003. Prosodic weight. In Caroline Féry & Ruben van de Vijver (eds.), *The syllable in optimality theory*, 123–143. Cambridge, UK: Cambridge University Press.

Zoll, Cheryl. 1997. Conflicting directionality. *Phonology* 14(2). 263–286.

Zoll, Cheryl. 1998. Positional asymmetries and licensing. Available online as ROA-282, Rutgers Optimality Archive, http://roa.rutgers.edu/.