Explaining Branchingness Effects in Phrasal Phonology[1]

Marjorie Pak
University of Pennsylvania

A wide variety of languages have been shown to have phonological rules whose domains of application are larger than words but smaller than intonational phrases or utterances. Within the theory of prosodic phonology, such rules correspond to the level of the Phonological Phrase, and for convenience I will use the cover term *phrasal rules* for them. However, the goal of this paper is to show that these rules do not comprise a single uniform class, but rather have two distinct sets of properties, which are argued to correspond to two separate stages of domain specification. This treatment offers some explanation for *why* different phrasal rules have different properties, and brings to light several correlations of potential interest that are otherwise obscured.

1 Background: phrasal rules and prosodic hierarchy theory

One of the characteristic properties of phrasal rules is that their domains appear to be constrained by the syntax to a certain extent. As such, these rules provide a potential source of information about the nature of PF and the derivation from syntax to phonology. However, the general assumption in the literature is that phonological rules refer only *indirectly* to syntactic structure—i.e., phonological rules cannot 'see' the syntax directly but instead refer to a level of derived intermediate structure. Some frequently cited motivations for the indirect reference approach include (a) the fact that phonological domains do not always correspond to syntactic constituents, and (b) the fact that phonological rules do not operate on the full range of information available in a syntactic phrase marker.[2]

Within the theory of prosodic phonology (Nespor and Vogel, 1986, inter alia), the derived structure that phonological rules apply to is instantiated as a strictly layered hierarchy of prosodic constituents, with phrasal rules corresponding to the Phonological Phrase (ϕ) level:

(1) *Prosodic hierarchy* (subword constituents not shown):[3]

Utterance (*U*)	(----------)
Intonational Phrase (*I*)	(----------)(------)
Phonological Phrase (ϕ)	(--------)(----------)(------)
Prosodic Word (ω)	(--------)(------)(--------)(------)

The constituents in (1) are distinguished from one another both by their size and by the way they are derived. Specifically, each level is produced by a unique mapping algorithm, which extracts the relevant information from the syntax and translates it into prosodic structure.[4] An important assumption

[1]I am very grateful to Gene Buckley, David Embick, Bruce Hayes, Rolf Noyer, and Bill Poser for helpful comments and discussion. I would also like to thank Jinyoung Choi, Lucy Lee, James Mesbur, and Jonathan Wright (Mesbur and Wright, 2005) for their help with Korean judgments and recordings. All errors are my own.

[2]But cf. Poser (1990), who points out that neither of these tendencies entails an indirect-reference model.

[3]Various versions of the prosodic hierarchy have been proposed. Inkelas (1989) argues that the subword constituents (foot and syllable) belong to a separate metrical hierarchy, but including them in (1) would not affect the discussion here. Another proposal involves expanding ϕ into two or more levels (Beckman and Pierrehumbert, 1986; Downing, 2002; Selkirk, 1986, inter alia). While this move may be independently motivated for languages with evidence for multiple intermediate-sized domains arranged hierarchically, it does not lead to a better understanding of the patterns discussed in this paper; see §3.

[4]Alternatively, in an OT framework, the prosodic structure corresponds to relevant aspects of the syntactic structure based on a particular constraint ranking; see the end of §2 for discussion and references.

Cascadilla Proceedings Project
Completed December 16, 2005

of the theory is that these algorithms apply at a single stage; this entails that phonological rules parse the syntax in the same way and that their domains are not misaligned (Poser, 1990). Furthermore, since Inkelas (1989), the prevailing view has been that phonological rules apply *only* to the constituents in the prosodic hierarchy—there is no separate class of rules that can apply to another set of domains.

Since each level of the hierarchy is derived by a unique algorithm, the prediction is that the rules applying to a domain of a given size will be influenced by a common set of factors, while rules applying to domains of different sizes will not necessarily share any particular properties. If other patterns are found—if two different domain sizes are found to have rules with very similar properties, for example—prosodic hierarchy theory has little to say about them.

In this paper I show that such patterns do in fact exist. At the ϕ level, there is a considerable amount of cross-linguistic variation in terms of the kinds of information that rules refer to. I show that one subclass of phrasal rules is distinguished by having the characteristic properties of a different level of the hierarchy, the Intonational Phrase. This is a correlation of potential interest that is not easily explained in a theory where rule categories are partitioned by domain size. In the alternative model developed here, there are (at least) two fundamentally different kinds of phrasal rules, whose domains are specified at different stages in PF and are therefore sensitive to different kinds of information.

2 Variability in domain formation

An abundant literature on phrasal rules has been produced, largely in an effort to determine whether there is a single ϕ-level mapping algorithm that works cross-linguistically. Such a result would support the idea that the levels of the prosodic hierarchy are primitives, i.e., that rules are classified primarily by domain size and that their other properties follow from this classification. What this literature has shown instead is that there is a considerable amount of variation in terms of what factors contribute to the formation of phrasal rule domains. Furthermore, when these various case studies are examined as a whole, several patterns emerge that are difficult to account for within prosodic hierarchy theory.

One significant point of variation, noted by Inkelas and Zec (1995), is that some phrasal rules operate within or across syntactic constituents without regard for their internal complexity, while others appear to be sensitive to syntactic *branching*. I illustrate the first part of this generalization with a phrasal rule from Chimwi:ni (Bantu). This rule causes potential vowel length (in boldface) to be neutralized everywhere except in the penult or antepenult of a phrasal domain:

(2) a. *Isolation forms:* shik**a:**ni ‘seize’, m**a:**limu ‘teacher’, w**a:**saba ‘seventh.PART.’
b. *Phrasal context:* shik**a**ni m**a**limu w**a:**saba ‘seize the seventh teacher’

The phrasing in (2b) is correctly predicted by the *end-based* (edge-based) algorithm. When set to mark right edges, this algorithm groups together everything up to the boldfaced NP bracket in (3b):

(3) a. *End-based algorithm* (Chen, 1987; Selkirk, 1986): Align the right/left edge of a syntactic XP with the right/left edge of a ϕ.
b. $_{VP}[$ shik**a**ni $_{NP}[$ m**a**limu w**a:**$_{NP}[$saba **]**$_{NP}]_{NP}]_{VP}$ (Example and bracketing from Selkirk, 1986)

But other proposed algorithms make incorrect predictions here. *Branching-based* (arboreal) algorithms group syntactic sisters together, working from the most deeply embedded constituent up; ‘left-over’ words then either form their own phrases or get grouped together, depending on the proposal. Either way, the incorrect phrasing is produced for the Chimwi:ni example:

(4) a. *Branching-based algorithm* (Inkelas and Zec, 1995): From the bottom up, branching nodes are mapped onto ϕ’s.
b. * (shik**a:**ni) (m**a**limu w**a:**saba)[5]

[5]This phrasing treats *wa:saba* as a single head. If the particle *wa:* is a separate head, the algorithm still produces the wrong phrasing—either (5b), if leftover heads form their own ϕ’s, or ***(shikani ma:limu)(wa:saba)**, if they are grouped together.

Similarly, *relation-based* algorithms predict incorrect phrasings for Chimwi:ni—either they produce the phrasing in (4b), or they form three ϕ's (5b), depending on whether restructuring takes place:

(5) a. *Relation-based algorithm* (Nespor and Vogel, 1986; Hayes, 1989): Group each lexical head X (N,V,A) together with any phonological words on its nonrecursive side, up to the first head that is outside the maximal projection of X. *Restructuring:* A nonbranching phrase that is the complement of a head X on its recursive side may join X in a ϕ.

b. Default phrasing: * (shik**a:**ni) (m**a:**limu) (w**a:**saba)

c. Restructured phrasing: * (shik**a:**ni) (m**a**limu w**a:**saba)

Notice that the restructuring operation in (5a) is also branching-sensitive: it allows two ϕ's to be grouped together just in case one is a head and the other is a nonbranching complement. Like the branching-based algorithm itself, this requirement limits the number of words that can be grouped together to two—in this case producing the wrong result.

The opposite situation is shown in (6). Stress retraction in Brazilian Portuguese applies in (6b), where the verb has a nonbranching complement, but is blocked in (6c), where the complement branches (example from Sandalo and Truckenbrodt (2002); stress indicated as V́):

(6) a. *Isolation forms:* vendéu 'he.sold', lívros 'books', nóvos 'new'

b. (v**é**ndeu lívros) 'He sold books.'

c. (vend**éu**) (lívros nóvos) 'He sold new books.'

These phrasings are correctly predicted by branching-based algorithms, as well as by relation-based algorithms if restructuring applies. End-based algorithms, however, predict that the entire utterance in (6c) will form a single domain for retraction:

(7) ?* (v**é**ndeu lívros nóvos)

The fact that ϕ-level rule domains cannot be uniformly predicted by a single algorithm is not a fatal problem for prosodic hierarchy theory—it is possible to simply concede that different languages have different ways of deriving prosodic structure. A somewhat more serious problem for the theory is that there are some rule domains that *no* algorithm can consistently predict because they vary too much from utterance to utterance.

An example of such a rule is Korean obstruent voicing. The obstruents /p/, /t/, /k/, and /tʃ/ in Korean are regularly voiced between voiced segments word-internally, as well as word-initially in some phrasal contexts. Cho (1990) claims that the environment for obstruent voicing can be predicted by a modified branching-based algorithm, but Jun (1996, 1998) shows that the domains for phrasal obstruent voicing are much more flexible than this algorithm predicts, and that they are conditioned largely by nonsyntactic factors like speech rate and prosodic weight. For example, the phrasings in (8b) and (8c) are both attested, with the larger domain in (8c) occurring in fast speech:

(8) a. *Isolation forms:* adʒu 'very', tʃoɯm 'good', kɯrim 'picture'

b. (igən) (adʒu) (**tʃ**oɯm) (**k**ɯrimija) 'This is a very good picture.'

c. (igən) (adʒu **dʒ**oɯm **g**ɯrimija) 'This is a very good picture.'

Korean also allows some apparently non-tempo-dependent variability; both of the phrasings in (9), for example, are grammatical:

(9) a. (adʒu **dʒ**oɯm) (**k**ɯrim) 'very good picture'

b. (adʒu) (**tʃ**oɯm **g**ɯrim) 'very good picture'

Although phrasing in Korean is not completely unconstrained (i.e., there are some syntactic configurations that can never form a voicing domain), the variability found in (8) and (9) presents a clear problem for theories in which prosodic structure is derived from the syntax in a one-to-one manner.

One way to solve this problem might be to create an algorithm that underdetermines phrasing. In other words, the algorithm could mark off larger strings in which the rule *could* apply, and then the rule itself could simply be described as applying 'optionally' within its domain. The problem with this solution is that it cannot handle attested clustering effects, where several rules apply to the same domain. In Korean, for example, the domain for obstruent voicing *always* coincides with the domain for tonal melody, and several other segmental rules target this domain as well (Jun, 1998; Kim, 2002). If we simply stated that obstruent voicing applied 'optionally' to a larger domain, we would have to restate this optionality for every other rule that applied to the same domain, and there would be no way to capture the fact that they always coincide. The problem thus remains: some phrasal rules apply to 'inherently variable' domains that are not mapped from the syntax in a consistent way from utterance to utterance.

Again, this is not necessarily a debilitating problem for prosodic hierarchy theory. Both of the problems presented in this section can be handled in an OT grammar, for example, in which the syntactic structure corresponds to one or more possible phrasings (and vice versa) depending on the language-specific ordering of universal constraints. In such approaches, branching-based and end-based algorithms are recast as binary and alignment constraints, respectively (Sandalo and Truckenbrodt, 2002; Selkirk, 2000; Truckenbrodt, 1995, 1999). For rules with variable domains, constraints can be reranked at different tempos, left unranked, or allowed to overlap (Féry, 2003; Prieto, forthcoming).

Such treatments can account for the facts presented so far, but they do so at the risk of missing several generalizations of potential interest. I turn to these next.

3 An alternative hypothesis

The hypothesis offered here is based on the following correlations, which emerge from a survey of phrasal rules cited in the literature:

(10) a. *Correlation 1:* Phrasal rules that appear to be branching-sensitive are consistently described as variable in application, depending on tempo, weight, eurythmy and/or style. These properties are shared by a number of other phrasal rules as well.

b. *Correlation 2:* The properties listed in (10a) are typically associated with the Intonational Phrase (*I*) level of the prosodic hierarchy.

Based on these correlations, I argue that (a) branching-sensitive rules are a subcase of a larger class of rules that apply to inherently variable domains; and (b) the dichotomy between branching-sensitive and non-branching-sensitive rules is better framed as a distinction between two different stages of rule domain formation, with non-tempo-sensitive domains defined before tempo-sensitive domains. As we will see, this approach provides some explanation for *why* certain phrasal rules have distinctive properties, a fact that is unexplained in other treatments.

3.1 Correlation 1: Branching-sensitive rule domains are also inherently variable

When cases of apparent branching-sensitivity are examined as a whole, they are found to share a set of properties that distinguish them from other phrasal rules. Specifically, branching-sensitive rule domains are consistently described as 'variable' or 'optional,' and this variability is consistently described as being conditioned by speech rate, style, prosodic weight, and/or eurythmy—i.e., the factors that condition the inherently variable rule domains described above.

Cho's analysis and Jun's reanalysis of Korean obstruent voicing illustrate this point: an apparently branching-sensitive domain is found upon further inspection to vary with speech rate and prosodic weight. Brazilian Portuguese also follows this pattern: Sandalo and Truckenbrodt show that speech rate and eurythmic requirements can override the apparent branching-sensitivity shown in (6).

Another relevant case study is Tuscan Italian Raddoppiamento Sintattico (RS), which geminates the initial consonant of a word preceded by a word that ends with a stressed vowel:

(11) a. (i caribù **n:**ani) (sono estinti) 'Dwarf caribou are extinct.'

b. (i caribù) (**n**ani) (sono estinti)

Nespor and Vogel (1986) argue that the phrasing in (11b) is produced by a branching-sensitive restructuring operation (see (5)). However, Ghini (1993) points out that nonsyntactic factors like speech rate, eurythmy, and prosodic weight play an important role in phrasing as well, sometimes overriding the boundaries that would be produced by Nespor and Vogel's algorithm; and Absalom et al. (2002) show that RS can potentially cross syntactic boundaries throughout an utterance. As in Korean and Brazilian Portuguese, the domain is shown to vary depending on external factors, and syntactic branching is shown to play a secondary role or perhaps none at all.

Other rules with apparent branchingness effects are European Portuguese beat insertion (Frota, 1997), English rhythm rule (Gussenhoven, 1991; Hayes, 1989; Inkelas and Zec, 1995; Monaghan, 1994), Japanese initial lowering (Tokizaki, 1999), Kinyambo H deletion (Bickmore, 1989, 1990), and Mandarin third tone sandhi (Cheng, 1987; Chen, 2000).[6] All of these rules are described as applying to variable domains, conditioned by speech rate, style, eurythmy and/or weight. This pattern suggests that rules that appear to be branching-sensitive are in fact a subcase of a larger class of phrasal rules that apply to inherently variable domains, which are in turn to be distinguished from phrasal rules whose domains do not vary in this way. I use the terms *Type 1 rules* and *Type 2 rules* to make this partition:

(12) *Two types of phrasal rules:*

a. TYPE 1 rule domains are consistently mapped from the syntactic structure without regard for performance-related factors like speech rate.[7]

b. TYPE 2 rule domains vary in size depending on speech rate, style, eurythmy, and prosodic weight, and consequently have a one-to-many correspondence with the underlying syntax.

I leave open the question of whether branching-sensitivity is a real phenomenon or not. In some cases it has been suggested that what appears to be a syntactic branchingness requirement is actually a prosodic weight requirement (Chen, 2000; Downing, 2002; Elordieta et al., 2003; Frota, 1997). If syntactic branching does turn out to play a role in phrasing, an important question for further research will be why syntactic binarity relations condition Type 2 rule domains in particular.

3.2 Correlation 2: Type 2 rules have intonational-phrase properties

We have seen that Type 2 rules share a number of properties that distinguish them from other phrasal rules. As it turns out, these are the very properties that are typically attributed to the Intonational Phrase (*I*) level of the prosodic hierarchy.

The *I* is agreed to be the domain for optional boundary pause insertion, intonational contour and boundary tone, final lengthening, and certain segmental rules. Both Nespor and Vogel (1986) and Selkirk (1986) notice that the *I* is distinguished from other constituents in the prosodic hierarchy by a high degree of variability—i.e., there is a one-to-many mapping between syntax and phonology, with a given syntactic structure corresponding to more than one possible prosodic phrasing. This seems to be a universal tendency, perhaps arising 'for physiological reasons having to do with breath capacity and for reasons related to the optimal chunks for linguistic processing' (Nespor and Vogel, 1986, p. 194). Although the

[6] In Bickmore (1990) and Cheng (1987), branching-sensitivity is framed as a *minimality* requirement on ϕ's, entailing that a ϕ contain *at least* a branching constituent. The correlation still holds: domains in both Kinyambo and Mandarin vary according to speech rate (Bickmore, p.c.; Chen, 2000). Incidentally, such analyses underscore the fact that apparently branching-sensitive domains can be both larger and smaller than end-based domains, so that the problem of conflicting algorithms cannot be solved by simply adding a level corresponding to 'branching constituent' to the prosodic hierarchy.

Another attested case of branching-sensitivity is Mende consonant mutation (Cowper and Rice, 1987), but see Tateishi (1990) for evidence that the rule applies only in a limited set of morphologically conditioned environments. The branching-based algorithm has also been extended to Hausa particle placement and English heavy NP shift (Zec and Inkelas, 1990). I put these cases aside for now, because the idea that such operations necessarily refer to phonological domains in the first place is a complex issue that cannot be fully explored here.

[7] Presumably, if speech is so slow that it is completely disconnected, Type 1 rules are also blocked. My claim is that in the wide range of tempos available in connected speech, Type 2 domains vary while Type 1 domains do not.

underlying syntactic structure is relevant insofar as certain parses are impossible (Taglicht, 1998; Watson and Gibson, 2004, inter alia), the choice of a given phrasing depends largely on 'such nonsyntactic factors as the length of a given *I* [and] the rate and style of speech' (Nespor and Vogel, 1986, p. 217).[8]

As we have seen, these are also the characteristic properties of a number of *phrasal* rules—domains for Type 2 rules like Korean obstruent voicing and Italian RS are inherently flexible, with speech rate and prosodic weight affecting phrasing in the expected way (larger phrases at faster rates). This shows that the distinction between tempo-sensitive and non-tempo-sensitive rules cross-cuts the category of ϕ-level rules, blurring the line between the ϕ level and the *I* level and undermining the idea that each level of the hierarchy operates on a distinct set of principles. If we categorize rules by the information that they seem to operate on, rather than by the size of their domains, we arrive at a new partition: Type 2 rule domains and intonational phrases are defined by one set of principles, while Type 1 rule domains are defined by another. In the model presented here, these distinct sets of principles correspond to different stages of domain formation in an articulated model of PF.

3.3 Hypothesis: Type 2 rules apply later than Type 1 rules

The correlations reviewed in §3.1 and §3.2 support the idea that ϕ-level and *I*-level rules should be recategorized, with Type 2 domains and *I*'s on the one hand and Type 1 domains on the other. The further hypothesis explored here is that Type 2 domains (and *I*'s) are formed *later* than Type 1 domains, and that Type 1 and Type 2 rules consequently make reference to different kinds of information.[9]

I am assuming that all languages require the use of an intonational chunking mechanism that divides the speech stream into manageable units for performance. The chunks produced by this mechanism correspond to *I*'s in prosodic hierarchy theory—that is, they frequently serve as the domain for final lengthening, tonal melody, and other processes—and I refer to them simply as 'intonational phrases.' In some languages there is evidence that these chunks can be broken down into smaller units, associated with their own tonal melodies or segmental rules. In the current proposal, these smaller units are the domains for Type 2 phrasal rules.

Within a derivational model of PF, such as that laid out in Embick and Noyer (2001, 2004), a constrained set of morphological operations can occur postsyntactically; for example, local rebracketings can occur, and certain types of nodes can be added. These operations are ordered with respect to other PF processes that convert syntactic structure into phonetic strings—e.g., information about linear order is added, and left-adjacency relations are established between pairs of complex heads. Since intonational chunking is conditioned by external factors like rate of speech, I argue that it takes place at the very end of the PF derivation, after complex heads have been chained together for input to the performance system. Type 1 rule domains, on the other hand, are specified *earlier* in the PF derivation and therefore are not predicted to be conditioned by such factors. More explicitly:

(13) a. TYPE 1 rules apply to domains that are determined by information available in the morphosyntactic structure.
b. TYPE 2 rules apply at a later stage, when intonational chunking is done, and are influenced by the metrical properties of linearly adjacent items during online speech production.

The idea that phonological domains can be specified at different stages is at odds with most versions of prosodic hierarchy theory, in which all domains are parsed at the same time. But the advantage of this model is that it offers the beginnings of an explanation for *why* intonational phrases and Type 2

[8] It has also been claimed that *I* formation is guided by semantic principles. Selkirk (1984, 1986), for example, argues for removing the *I* level from the prosodic hierarchy because it is defined by *sense units* rather than syntactic structure. This idea has not been pursued recently to my knowledge (see e.g. Watson and Gibson, 2004), and I do not adopt it here because it is unclear how a semantic unit could be broken down further to form domains for Type 2 phrasal rules (see below). On a related point, both intonational phrases and Type 2 domains appear to be constrained by focus structure; in particular, focused constituents tend to project extra boundaries. I have not yet determined if this is an *exclusively* Type 2 feature, however. If focus structure is marked in the syntax, Type 1 rules might be able to make this distinction as well. This is an important question for future research.

[9] See Seidl (2001) for another approach that allows for early and late rules at different stages in PF.

rules have their characteristic properties. Within prosodic hierarchy theory, there is no obvious reason why *I*-level properties should sometimes show up in rules at other levels, and at the ϕ level in particular. The theory technically allows for a situation in which these properties are associated with non-adjacent levels of the hierarchy—e.g., where *I* and ω are both tempo-sensitive but are always separated by a non-tempo-sensitive level, ϕ—but such situations do not seem to occur. Of course, generalizations about these tendencies can be made in any framework (cf. Nespor and Vogel's statement that higher levels of the hierarchy are guided by more general principles), but ideally we would like an explanation for why these particular tendencies exist rather than others.[10] In the current model, a universal chunking mechanism operates late, producing units corresponding to *I*'s which can in turn be broken down into Type 2 domains.[11] Type 1 domains are defined earlier, under a different set of conditions, and have little in common with Type 2 domains other than the fact that they are both intermediate in size.

4 Implications

The model advanced here makes the following prediction: Since Type 2 domain formation is concurrent with and parasitic on intonational chunking, Type 2 domains should always be exhaustively contained by (or coextensive with) intonational phrases. In other words, if a language has more than one rule with Type 2 properties (e.g., tempo-sensitivity), their domain boundaries should always be aligned.

This prediction is borne out in Korean. As demonstrated in Jun (1996, 1998), the domain for obstruent voicing always coincides with the domain for tonal melody. This domain is in turn always exhaustively contained within a larger intonational phrase, which has its own boundary tones and is marked by final lengthening. My own data show that these boundaries remain aligned even when the information structure of the sentence is manipulated to produce unusual phrasings; we never find, for example, an intonational-phrase boundary tone in the middle of an obstruent voicing domain.

Of course, while these facts are compatible with my hypothesis, they are also compatible with many versions of prosodic hierarchy theory, including Jun's (see fn. 11). What distinguishes the current proposal from prosodic hierarchy theory is that it makes a further prediction: It should be possible for a single language to have both Type 1 and Type 2 rules, where the Type 1 boundaries do *not* necessarily coincide with Type 2 or intonational-phrase boundaries. The result would be a 'domain mismatch' (Seidl, 2001), as shown schematically below with square brackets corresponding to one rule domain and parentheses corresponding to another:

(14) [(- -) (–][–) (- -)]

Such cases are strictly ruled out by prosodic hierarchy theory, but are accommodated by models that allow for more than one parse of an utterance, such as this treatment or the treatment in Seidl (2001). And in fact, such cases are attested. One particularly relevant case for present purposes is found in Xiamen, where tone sandhi can cross intonational-phrase boundaries (Chen, 1987):

(15) tian-po # tsing-bing yi si % So-lian # pai-lai # e tik-bu
telegram prove he be USSR send *e* spy
'The telegram proves that he is a spy sent by the USSR.'

In this example, an intonational phrase break (%, diagnosed by final lengthening and/or pause) can optionally occur in the middle of the tone sandhi domain *tsing-bing yi si So-lian* (delimited by

[10] One proposal is given by Jun (1998), who hypothesizes that the prosodic hierarchy is 'intonationally cued' in some languages and 'syntactically cued' in others, depending on whether the language uses intonational features solely to mark prosodic boundaries or not—i.e., languages like Korean are at one end of a continuum and tone languages are at the other (p. 222). However, this correlation cannot be absolute, because tone languages *can* have phrasal rules with *I*-level properties (e.g., Mandarin (Chen, 2000), Bantu (Bickmore, p.c.)). Within the current proposal, there are different stages of rule application, rather than different types of languages, and it is possible for a single language to have both Type 1 and Type 2 rules. Some evidence in favor of this approach is given in §4.

[11] In some languages, e.g. Japanese (Beckman and Pierrehumbert, 1986; Venditti et al., 1996), there is evidence that Type 2 domains are further broken down into smaller units. I have abstracted away from such phenomena for expository purposes, but nothing in this model rules them out.

#). Interestingly, Chen points out that while intonational phrasing is variable, the tone sandhi domains remain constant: '[tone sandhi] applies across the verb and its complement, regardless of intonational phrasing' (p. 143). This is also the case in the closely related Haifeng dialect, where 'even if there is a pause after the verb, the verb must be linked to the following object in one single tone group' (Yang and Chen, 1981, cited and translated in Chen, 1987).

This is just the pattern we should expect given the current hypothesis. If a language has two rules applying to misaligned domains, and if the domain for one of the rules varies under performance-related conditions, then the domain for the other should not.

5 Conclusion

In this paper I have sketched the beginnings of a theory of variability in phrasal phonological rule domains. A unique class of phrasal rules is distinguished whose domains can vary under performance-related conditions (Type 2 rules), and it is argued that these domains are specified *later* than domains for other (Type 1) phrasal rules. This proposal assumes a model of PF in which different kinds of information are available at different stages (see e.g. Embick and Noyer (2001, 2004)). Type 2 domains are formed at the very end of the PF derivation, when intonational chunking is done.

Many questions remain open. The exact nature of the intonational chunking mechanism—how it is constrained, how it relates to PF operations, and what kinds of syntactic information get carried through to this late stage—has yet to be spelled out. Furthermore, I have said very little about Type 1 rules. We have seen two examples of Type 1 rules that apply to end-based domains (Chimwi:ni and Xiamen), but it is unlikely that all Type 1 rules follow this pattern. In (13) I claim that Type 1 rules refer to 'information available in the morphosyntactic structure,' and one interesting possibility is that some Type 1 rule domains correspond to domains for *syntactic* operations. This type of proposal is found in Seidl (2001), who argues that phonological rules in some Bantu languages apply to the phase; Arregi (2004), who argues that stress assignment in Northern Bizkaian Basque applies to a syntactic island; and Kenstowicz (1987), who shows that elision and tone shift in Tangale can diagnose *wh*-movement. Such analyses suggest that Type 1 rules in particular could provide more direct and transparent information about the underlying syntactic structure than is assumed to be available in prosodic hierarchy theory.

The idea that phonological rule domains may be defined at different stages in the derivation from syntax to phonology is not new. Kaisse (1985), for example, distinguishes between 'rules of external sandhi' and 'fast speech rules,' and argues that the former precede the latter. There is precedent for this idea within prosodic hierarchy theory as well: Nespor and Vogel (1986) allow for 'phonosyntactic' rules to apply directly to the syntax before prosodic constituents are formed; and Selkirk (1986) argues for a separate class of 'rules of phonetic implementation' that do not apply to constituents in the prosodic hierarchy. In more recent work, however, the attempt is made to constrain *all* phonological domains to the constituents in the prosodic hierarchy. I have shown that such approaches neither predict nor explain the patterns that emerge when the distinctive properties of phrasal rules are examined. The alternative approach outlined here offers an explanation for these correlations based on the idea that different kinds of information are available at different stages in an articulated model of PF.

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