

Prosodic Hierarchy and Prosodic Boundary

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In this paper I will point out a number of problems with prosodic hierarchy theory (cf. Selkirk 1984 among others) and will propose an alternative theory based on prosodic boundaries.¹ I will also show that the boundary-based theory explains phonological data straightforwardly and that it allows us to derive the effects of the strict layer hypothesis (Selkirk 1984) from a simple phrasing rule.

1. Problems with the prosodic hierarchy theory

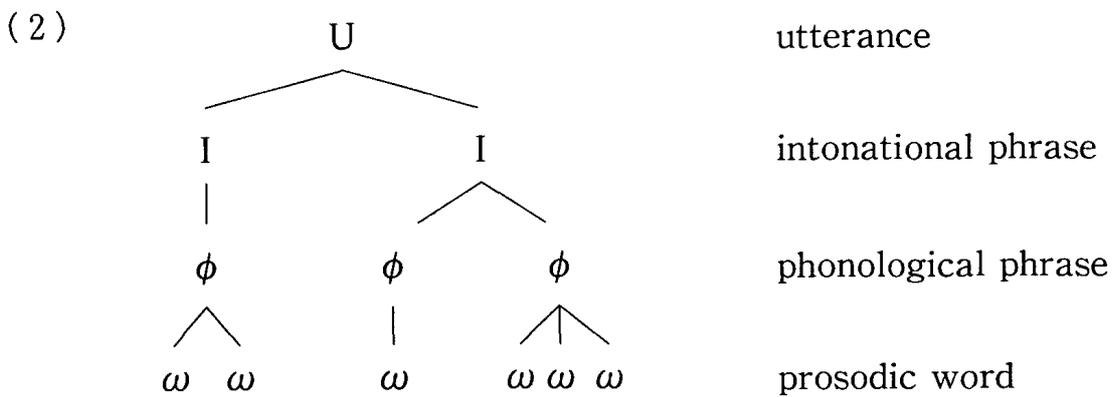
Based on the idea that there are categories in prosody as well as in syntax, Selkirk (1984:26) shows the list of prosodic categories for English as in (1).

- (1) a. intonational phrase (IP)
- b. phonological phrase (PhP)

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- c. prosodic word (Wd)
- d. foot (Ft)
- e. syllable (Syl)

To illustrate the hierarchy, let us consider the following sentence:



In Pakistan, Tuesday is a holiday

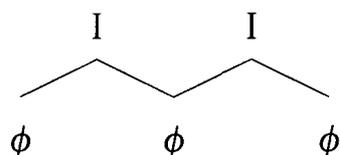
In (2), the node U immediately dominates Is, the next level category, which in turn immediately dominate ϕ s. Selkirk (1984) proposes the strict layer hypothesis (SLH) to the effect that a category of level i in the hierarchy immediately dominates (a sequence of) categories of level $i-1$. Here I show the formulation of SLH by Nespor and Vogel (1986:7) (cf. Hayes 1989:204).

- (3) a. A given nonterminal unit of the prosodic hierarchy, X^P , is composed of one or more units of the immediately lower category, X^{P-1} .
- b. A unit of a given level of the hierarchy is exhaustively contained in the superordinate unit of which it is a part.

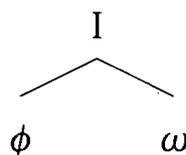
The hierarchy in (2) conforms to the hypothesis. If this hypothesis is

correct, as Ladd (1996:239) argues, the following types of hierarchies cannot be allowed in the prosodic hierarchy theory.

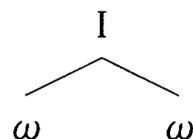
(4) a. Multiple domination



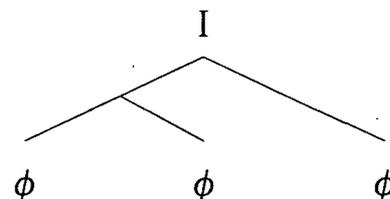
b. Heterogeneous sisters



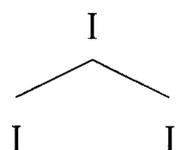
c. Skipping of levels



d. Unlabelled nodes



e. Recursion



(4b), (4c), (4d), and (4e) violate (3a), and (4a) violates (3b).

The prosodic hierarchy theory has been widely accepted in the literature.² However, a number of questions arise with the nature and kinds of prosodic categories. First, what is the status of each prosodic category? Ladd (1996:237) compares those categories with Halliday's (1967) prosodic units. We can understand that Selkirk's utterance, intonational phrase, foot, and syllable corresponds to Halliday's utterance, tone group, foot, and

² For a critical review of the theory, see Inkelas and Zec (1995) among others.

syllable, respectively. However, the rest of the categories listed in (1), i.e. phonological phrase and prosodic word, do not have their corresponding categories in Halliday's list of prosodic units.

Second, how many prosodic categories are necessary? To the list (1), Nespor and Vogel (1986) add clitic group as a further prosodic category between phonological phrase and prosodic word. Condravdi (1990) and Kanerva (1990) also claim that further prosodic domains such as minimal phrase and focal phrase are needed. However, we should avoid the proliferation of categories if possible. A still more attractive assumption is that there are no prosodic categories per se in the theory. I would like to pursue the idea in the following.

I will present the bare mapping theory in Section 2, which gives us simple answers to the questions above. Prosodic categories are the derived notion of the strings demarcated by prosodic boundaries. We do not have to posit different prosodic categories between intonational phrase and foot. The theory claims that application of phonological rules is blocked not by prosodic categories but by prosodic boundaries themselves.³

Besides the conceptual problems mentioned above, the prosodic hierarchy theory has some empirical problems. First, Gussenhoven and Jacobs (1998:245) show the following examples:⁴

³ Akasaka and Tateishi (1999) also suggest that prosodic categories may only be boundary markers.

⁴ L shows low pitch, H high pitch, and H*L bitonal tone with pitch accent. See Pierrhumbert and Beckman (1988) and Ladd (1996) for the details of notation.

ence in assimilation between (5a) and (5b).

- (7) a. (_{?P} Why don't you sell Janet_? _{?P}) (_{?P} your Honour _{?P})
 b. (_{?P} Why don't you sell Janet_? your honour _{?P})

However, it is ad hoc to propose a new category to explain just one case, and it leads to proliferation of prosodic categories without sufficient grounds.

In fact, Gussenhoven and Jacobs suggest that instead of postulating a further constituent between phonological phrase and intonational phrase, we should define intonational phrase on the basis of syntactic and length criteria. They also show similar examples in (8).

- (8) a. _i(Tonight_? your name will be on everybody's lips)_i [tj] *[tʃ]
 b. _i(Write_? your name on this envelope)_i [tj] or [tʃ]

In (8a) *tonight* is a sentential adverb and *your* is a constituent of the subject. In (8b) *write* is a verb and *your* is a constituent of its direct object. Assimilation between the word final [t] and the word initial [j] may occur in (8b) but not in (8a). If we assume that phonological phrase corresponds to syntactic phrase (XP) as above, we have a phonological phrase boundary just before the NP *your name* in (8b) as well as in (8a).

- (9) a. (_{Ph} Tonight_? _{Ph}) (_{Ph} your name _{Ph}) ...
 b. (_{Ph} Write_? _{Ph}) (_{Ph} your name _{Ph}) ...

Thus we cannot explain why assimilation is possible not in (8a) but in (8b).

Again it is ad hoc and is undesirable to postulate a new prosodic category higher than phonological phrase and lower than intonational phrase.

- (10) a. (?_P Tonight_?) (?_P your name ?_P) ...
 b. (?_P Write_? your name ?_P) ...

Second, examples problematic to the strict layer hypothesis are reported by Chen (1987) and Hyman *et al.* (1987). Consider the data in Xiamen, for example.

- (11) a. () () IP
 () () () TG
 lao tsim-a-po m siong-sin ying-ko e kong-we
 old lady Neg believe parrot can talk
 ‘The old lady doesn’t believe parrots can talk.’
- b. () () IP
 () () () TG
 Lim kao-siu si tsit e gian-giu pe-hu gam e tsuan-ka
 Lim professor be a Cl investigate skin cancer E specialist
 ‘Professor Lim is a skin cancer specialist.’

Chen argues that in Xiamen intonational phrases (IP) and tone groups (TG) are not strictly layered in the sense of (3). (11a) and (11b) are cases of multiple domination (4a) which is prohibited by the strict layer hypothesis. In (11a) and (11b) the second tone group is dominated by both the first and the second intonational phrase, which is a violation of (3b).

Third, Ladd (1996:237-240) argues that we should allow the recursion of

prosodic categories which is also prohibited by the strict layer hypothesis as shown in (4e). He shows the following sentence with prosodic boundaries (|).

(12) | This is the dog | that chased the cat | that killed the rat | that ate
the malt | that lay in the house that Jack built |

He also observes a weaker boundary between *house* and *that* in (12). He argues that there is no good way to indicate this percept of a weaker boundary under the usual assumptions about prosodic phrasing.

In sum, the prosodic hierarchy theory with the strict layer hypothesis has a number of problems both conceptual and empirical. I will explore an explanation without prosodic categories in the next section.

2. Explanation with prosodic boundaries

We can explain the examples we have looked at in Section 1 with the bare mapping theory which does not rely on prosodic categories. First, let us assume a mapping rule from syntactic structure onto prosodic structure as in (13).⁵

(13) Interpret boundaries of syntactic constituents [...] as prosodic boundaries /.../.

⁵ For the details of the mapping theory with the rules (13) and (16), see Tokizaki (1999, 2000).

Assuming that functional categories with no phonetic features and their projections are invisible to the mapping rule (13), the bare phrase structures of (5a) and (5b) are (14a) and (14b).⁶

- (14) a. [[Why [don't [you [sell Janet]]]], [your Honour]]
 b. [Why [don't [you [sell [Janet [your honour]]]]]]

If we apply (13) to (14a) and (14b), the results are (15a) and (15b), respectively.

- (15) a. // why / don't / you / sell Janet ///// your Honour //
 b. /why / don't / you / sell / Janet / your honour /////

Let us also assume a rule which deletes a number of boundaries in sequences of boundaries as shown in (16).

- (16) Delete n boundaries between words. (n : a natural number)

This rule applies to basic prosodic structure mapped from syntactic structure and makes a variety of prosodic phrases by deleting all the boundaries between words. If we apply (16) with $n=1$ to (15a) and (15b), then we get (17a) and (17b).

- (17) a. / why don't you sell Janet_//// your Honour / ($n=1$) [tj] *[tʃ]
 b. why don't you sell Janet_your honour ///// ($n=1$) [tj] or [tʃ]

⁶ On bare phrase structure, see Chomsky (1995) among others.

If we assume that assimilation applies to the representation (17a) and (17b), we can argue that the boundaries between *Janet* and *your* block assimilation in (16a). To get one intonational contour over the entire sentence, we can delete five boundaries between words in (15a) and (15b).

- (18) a. why don't you sell Janet your Honour ($n=5$)
 b. why don't you sell Janet your honour / ($n=5$)

Now in (18a) and (18b) there is no boundary in the sentence to divide the intonational contour into two. Thus we can predict that the whole sentences can be pronounced with one intonational contour $L_1 H^*L H_1$ as shown in (5a) and (5b).

Next, let us consider (8a) and (8b) above. Their phrase structures are shown in (19a) and (19b).⁷

- (19) a. [Tonight [[your name][will [be [on [everybody's lips]]]]]]]
 b. [Write [your name][on [this envelope]]]

⁷ I assume that the phrase structure of (8b) is (19b) in which the VP is tertiary branching, and not (i) in which the VP is binary branching (cf. Kayne 1994).

(i) [Write [[your name][on [this envelope]]]]

If we assume (i) instead of (19b), we get (ii) as the result of mapping.

(ii) / Write // your name // on / this envelope ////

Then we cannot make difference between (19a) and (19b) in the number of brackets immediately before *your*. Compare (20a) and (ii). I will leave the matter open here.

(19a) and (19b) are mapped onto the prosodic structures (20a) and (20b) by (13).

- (20) a. / Tonight // your name // will / be / on / everybody's lips /////
 b. / Write / your name // on / this envelope ///

If we apply (16) with $n=1$ to (20a) and (20b), we get (21a) and (21b), respectively.

- (21) a. Tonight₁ / your name / will be on everybody's lips /////
($n=1$) [tj] * [tf]
 b. Write₁ your name / on this envelope // ($n=1$) [tj] or [tf]

In (21a) *your* is separated from *tonight* by a boundary, and in (21b) *your* is adjacent to *write* without no boundary. Thus we correctly predict that assimilation does not occur in (21a) but in (21b).

3 Deriving the effects of the strict layer hypothesis

Another advantage of the boundary theory is that we can derive the effects of the strict layer hypothesis from the deletion rule (16) above. Let us consider a schematic example (22a) and its prosodic structure (22b).

- (22) a. [[[A][B]][[C][[D][E]]]]
 b. /// A // B //// C /// D // E ////

Let us suppose that the boundary deletion rule (16) applies to (22b) with a

The phrasing patterns Selkirk (1984) shows are (26a-d) (= (2)).

- | | | | |
|------|----|--|---------------------|
| (26) | a. | (In Pakistan Tuesday is a holiday) | utterance |
| | b. | (In Pakistan) (Tuesday is a holiday) | intonational phrase |
| | c. | (In Pakistan) (Tuesday) (is a holiday) | phonological phrase |
| | d. | (In) (Pakistan) (Tuesday) (is) (a) (holiday) | prosodic word |

The phrasing in (25a), (25b), and (25d) corresponds to that in (26a), (26b), and (26d), respectively. One might argue that our (25c) is different from Selkirk's (26c) in that there is a boundary between *is* and *a* in (25c). However, *is* is a function word and is difficult to be independent phonologically. Thus *is* is incorporated into the following phonological phrase together with *a holiday* as in (26c) despite the boundary between *is* and *a* shown in (25c). One might also wonder why *is* is not likely to be incorporated into the preceding phonological phrase together with *Tuesday*, as shown in (27).

- (27) (In Pakistan) (Tuesday is) (a holiday).

One possible answer to the question is that the phrasing in (26c) is better than that in (27) because (26c) conforms to the principle of increasing unit proposed by Ghini (1993). In (26c) the third phonological phrase *is a holiday* is longer than the second phonological phrase *Tuesday*. In (27) the second and the third phonological phrases are about the same in length. Thus the theory presented here correctly predicts the phrasing patterns in (26).⁸

⁸ Selkirk (1986:388-389) suggests that prosodic structure could be constructed from silent demibeat structure (cf. Selkirk 1984, Tokizaki 1988). (*next page*)

More problematic is the case of Xiamen mentioned in Section 1. We have seen that (11) is a counter example to the strict layer hypothesis. If we are on the right track in deriving the hypothesis from the boundary-based theory, how can we explain the reported facts in the language?

Following the idea of derivation by phase with cyclic Spell-Out investigated by Chomsky (1998, 1999), let us assume that the rule (13) applies cyclically at each phase level, CP or *v*P. Then the syntactic structures of (11a) and (11b) are roughly (28a) and (28b).⁹

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- (i) a. [_S [_{NP}fw N [_{PP}fw [_{NP} N]]] [_{VP}[_?V [_{NP}N]] [_{NP}N]]]
 b.**.....*****.....**.....***.....*****
 c. () () () () () PWd
 d. () () () PPh

She suggests that this could be done by making the ends of a particular prosodic constituent coincide with two successive sequences of silent demibeats with matching cardinality of a particular magnitude. However, ‘with the hunch in mind’, she instead adopts the end-based theory that takes prosodic categories as basic units.

The bare mapping theory allows us to take the other way. The bare phrase structure of (i) is (ii a) which is mapped onto the prosodic representation (ii b). Applying the phrasing rule with *n*=1, 2, and 3, we get (ii c, d, e), respectively.

- (ii) a. [[[[fw][N]][[fw][N]]][[V][N]][N]]
 b. //// fw // N //// fw // N // V // N /// N ///
 c. // fw / N /// fw / N // V / N // N // (*n*=1)
 d. / fw N // fw N //// V N / N / (*n*=2)
 e. fw N / fw N /// V N N (*n*=3)

The predictions in (ii c, d, e) are not the same as Selkirk’s (i c,d). However, it is still possible to predict the boundaries which block the application of phonological rules.

⁹ See Tokizaki (1999, 2000) for the details of mapping with cyclic Spell-Out.

- (28) a. () () IP
 () () () TG
 [lao tsim-a-po][m siong-sin][ying-ko][e kong-we]]
 old lady Neg believe parrot can talk
 ‘The old lady doesn’t believe parrots can talk.’
- b. () () IP
 () () () TG
 [[Lim kao-siu] [si [tsit e [[gian-giu [pe-hu gam]] e tsuan-ka]]]]
 Lim professor be a Cl investigate skin cancer E specialist
 ‘Professor Lim is a skin cancer specialist.’

The mapping rule (13) applies to (28a) and (28b) to give (29a) and (29b), respectively.

- (29) a. / lao tsim-a-po // m siong-sin // ying-ko // e kong-we //
 b. // Lim kao-siu // si / tsit e // gian-giu / pe-hu gam // e tsuan-ka ////

We observe that the boundaries between intonational phrases and the boundaries between tone groups in (28) occur complementarily in the positions where two prosodic boundaries occur in (29). In other words, Xiamen expresses syntactic phrase structure through prosodic structure with two types of prosodic phenomena. Prosodic boundaries are reflected either in intonation (lengthening and pause) or in rhythm (tone sandhi).

As for Ladd’s (1996) observation on the sentence (12), the boundary-based theory proposed here gives a fresh insight into the problem. The phrase structure of the sentence is (30) if we assume multiple Spell-Out.

(30) [This [is [the dog]]][that [chased [the cat]]][that [killed [the rat]]][that [ate [the malt]]][that [lay [in [the house]]]][that [Jack built]]

The rule (13) applies to (30) to give (31).

(31) / This / is / the dog /// / that / chased / the cat /// / that / killed / the rat /// / that / ate / the malt /// / that / lay / in / the house //// / that / Jack built //

In (31) there are no less boundaries between *house* and *that* than the other positions before *that*. Our theory in itself does not predict a weaker boundary between *house* and *that*. If we delete three boundaries between words by the rule (16) ($n=3$), we get (32).

(32) This is the dog / that chased the cat / that killed the rat / that ate the malt / that lay in the house // that Jack built

However, we may ascribe the observed weakness of the last boundary to Ghini's (1993) principle of increasing unit. The last relative clause *that Jack built* is shorter than the other relative clauses in that it does not contain a direct object or a prepositional phrase. Making the last boundary weaker helps to make well-balanced sentence prosody for (30). Alternatively, the degree of boundary strength might be a matter of performance. I will not go into detail here, but the point is that the boundary-based theory can deal with the problem of weaker boundary which the prosodic category theory cannot.

4. Conclusion

We have pointed out problems with the prosodic hierarchy theory and have proposed an alternative theory based on prosodic boundaries. An advantage of the theory is that we can avoid the problem of how many prosodic categories are needed. We have seen that we can derive the effects of the strict layer hypothesis from the simple rules of syntax-phonology mapping and phrasing. I have to admit that the data discussed here are limited and the analysis is not without problems. However, this line of research is fruitful and promising in that the analysis presented here restricts the theory of grammar, especially the syntax-phonology interface.

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