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1 Introduction

In this article, I examine the effect of the length of constituents on phonology and syntax within a theory of prosodic phrasing in the minimalist framework. In particular, I discuss how the theory explains the phenomena of secondary stress and Heavy NP Shift in English. In addition, I argue that the theory can be an alternative to Hawkins's (1994) analysis of word order in terms of Early Immediate Constituents.

2 Syntax-Phonology Mapping and Prosodic Phrasing

Let us first look at the phrasing patterns in (1). The sentence may be divided into one or more prosodic phrases:

(1) a. (Alice loves hamsters)
b. (Alice) (loves hamsters)
c. (Alice) (loves) (hamsters)

Let us consider how we can explain the optionality of phrasing. In Tokizaki (1999), I proposed the syntax-phonology mapping rule as shown in (2).

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

This rule changes syntactic boundaries into prosodic boundaries, irrespective of their direction, right or left. For example, the sentence in (1) has (3a) as its

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syntactic structure. The mapping rule (2) interprets the brackets in (3a) and changes them into prosodic boundaries as in (3b).

(3) a. [[Alice] [[loves] [hamsters]]]
b. // Alice /// loves // hamsters ///

I assume here that phrase structure is bare in the sense of Chomsky (1995). This is a consequence of the operation Merge, and as Chomsky (1995:246) notes "there is no such thing as a non-branching projection." I also assume that phonologically null elements (e.g. trace, PRO, and Infl) are invisible to phonological rules. Then the mapping rule (2) applies to the "completely bare" structure (3a), not to the X-bar theoretic structure with phonologically null elements (4).

(4) $[_{IP}\,[_{NP}[_{N'}\,[_{N}$ Alice]]]$_i$ $[_{I'}$ I $[_{VP}\,t_i\,[_{V'}\,[_{V}$ loves] $[_{NP}[_{N'}\,[_{N}$ hamsters]]]]]]]

Now let us consider how phonology divides the sentence into prosodic phrases. The phrasing rule I proposed in Tokizaki (1999) is given in (5).

(5) Delete *n* boundaries between words. (*n*: a natural number)

This phrasing rule deletes a number of boundaries between words to make longer prosodic phrases. If we apply this rule with n=1 to (3b), it deletes one boundary between words to give (6a). The three words are still separated by boundaries, and each word makes a prosodic phrase by itself.

(6) a. / Alice // loves / hamsters // (n=1) → (Alice) (loves) (hamsters)
b. Alice / loves hamsters / (n=2) → (Alice) (loves hamsters)
c. Alice loves hamsters (n=3) → (Alice loves hamsters)

I assume here that the number of boundaries to be deleted corresponds to the speed of utterance. If we suppose that n=2, that is, when the speaker talks faster, then we get (6b) as the result of applying the deletion rule (5). If n=3, the fastest in this case, the whole sentence is included in a prosodic phrase, because there is no boundary left between words after deletion.[1]

[1] I do not discuss the level of prosodic phrases here. We could argue that *n* relates to the levels of prosodic categories. If *n* is larger, then (5) makes larger prosodic domains (e.g. phonological phrases or intonational phrases). We could also argue that

In this way, the rules explain the optionality of phrasing with the assumption that the phrase structure is (completely) bare. I argued in Tokizaki (1999) that the phrasing data from a number of languages give empirical support for bare phrase structure. I also discussed some consequences of this theory, listed in (7).

(7) i. No reference to branchingness in phrasing rules
ii. Deriving the edge parameter from the head parameter
iii "Rightward movements" in right branching languages (e.g. Heavy NP Shift)
iv. Focus and phrasing

Below I show another consequence of the theory, namely secondary stress in English, and also discuss Heavy NP Shift in more detail.[2]

3 Secondary Stress in English

Let us look at the data in (8) from Selkirk (1995:565) and Zubizarreta (1998:166). The sentence (8a) has secondary stress on the first word and primary stress on the last word. If we make the VP longer as in (8b), secondary stress moves from *nineteen* to *linguists*.[3]

(8) a. Nìneteen thousand linguists síng.
b. Nineteen thousand lìnguists sing the Marseilláise.
c. Linguists from Grèece síng.

(8a, b) show that the length of VP has an effect on the placement of secondary stress in the subject NP. Notice that the direction of branching also has

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with this theory we could dispense with prosodic category hierarchy altogether. I will not try to develop this proposal further here, however.

[2] See also Zubizarreta (1998) and Akasaka and Tateishi (to appear) for discussion of this construction from the phonological point of view.

[3] In fact, Selkirk's representation of (8a) is (i) (IP=intonational phrase; MaP=major phrase).

(i)

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                                        x
            x                           x
            x           x               x
            x     x     x               x
IP(MaP((Nineteen thousand)(linguists))MaPMaP((sing))MaP)IP
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an effect on the placement of secondary stress. Compare (8a) with (8c). The phrase structure of (8a) is shown below in (9a) where the subject is left-branching. The structure of (8c) is (9c) where the subject is right-branching. In (8a) secondary stress is on the leftmost element in the subject, *nineteen*, while in (8c) it is on the rightmost element, *Greece*. Then we can say that the length of VP and the direction of branching have effects on the placement of secondary stress. However, Zubizarreta does not give any explanation for these data.

Now I will show that the theory of mapping and phrasing presented here gives an explanation for the data in (8). The phrase structures of (8a–c) are (9a–c), respectively. Henceforth I omit the boundaries on both sides of a word to simplify the representations.

(9) a. [[[Nineteen thousand] linguists] sing]
b. [[[Nineteen thousand] linguists] [sing [the Marseillaise]]]
c. [[Linguists [from Greece]] sing]

The syntax-phonology mapping rule (2) applies to (9a–c) and gives (10a–c) as their phonological representations.

(10) a. /// Nineteen thousand / linguists / sing /
b. /// Nineteen thousand / linguists // sing / the Marseillaise ///
c. // Linguists / from Greece // sing /

Notice that in (10a) there is only one boundary between the subject and the verb, that is, between *linguist* and *sing*. On the other hand, in (10b) and (10c), there are two boundaries between the subject NP and the verb *sing*. If we delete one boundary between words by the phrasing rule (5) with n=1, we get (11) and expect the phrasing shown in (12).

(11) a. // Nineteen thousand linguists sing
b. // Nineteen thousand linguists / sing the Marseillaise //
c. / Linguists from Greece / sing

(12) a. (Nineteen thousand linguists sing)
b. (Nineteen thousand linguists) (sing the Marseillaise)
c. (Linguists from Greece) (sing)

In (11a), all the brackets in the sentence are deleted, and the whole sentence is in a prosodic phrase as shown in (12a). In (11b) and (11c), there is one boundary left between the subject NP and the verb *sing*. This boundary divides the sentence into two prosodic phrases as shown in (12b) and (12c). Now let us assume the primary and secondary stress assignment rules given in (13a) and (13b).

(13) a. Assign primary stress to the rightmost lexical element in a prosodic phrase.
b. Assign secondary stress to the leftmost lexical element in a prosodic phrase.

Then we can give an explanation for the data in (8). In (12a), which consists of only one prosodic phrase, the rule (13a) assigns primary stress to the rightmost lexical element, *sing*, and (13b) assigns secondary stress to the leftmost lexical element, *nineteen*. In (12b), which consists of two prosodic phrases, the rule (13a) assigns primary stress to *linguists* and *Marseillaise* because they are the rightmost elements in their prosodic phrases. (13b) assigns secondary stress to the leftmost element in each prosodic phrase, namely, *nineteen* and *sing*. (12c) also consists of two prosodic phrases. *Greece* and *sing* are the rightmost lexical elements in their prosodic phrases and are assigned primary stress by (13a). *Linguists*, the leftmost element in the first prosodic phrase, is assigned secondary stress by (13b).[4]

(14) a. (Nìneteen thousand linguists síng)
b. (Nìneteen thousand línguists) (sìng the Marseilláise)
c. (Lìnguists from Gréece) (síng)

In (14), I underline two of the most prominent words in each sentence. (14a) is straightforward; it is the same as the observed prominence in (8a). In (14b) *linguists* is assigned primary stress in the first prosodic phrase. However, this stress is heard as secondary stress in the domain of the sentence, because *Marseillaise* is also assigned primary stress in the second prosodic phrase. *Marseillaise* is more prominent than *linguists* because it is uttered with sentence-final falling intonation (See Bing 1979:140). Similarly in (14c) *Greece*

[4] In fact, *sing* in (14c) is both leftmost and rightmost in the one-membered prosodic phrase. I assume here that (13b) applies to an element vacuously if (13a) also applies to it.

is assigned primary stress in the first prosodic phrase, but it is heard as secondary stress in the whole sentence. Thus we can explain the prominence in (8a–c) with the theory of phrasing presented here. The point is that long constituents have a number of brackets at their ends. These brackets are interpreted as prosodic boundaries which separate the constituent from the rest of the sentence.

4 Heavy NP Shift

Let us turn to another topic of the syntax-phonology interface. (15a) contains a long NP object and a short PP. So-called "Heavy NP Shift" changes the order of these phrases as shown in (15b).

(15) a. Ken gave [a book about golden hamsters] [to Alice]
b. Ken gave [to Alice] [a book about golden hamsters]

It is well known that the object NP must be long in order for "Heavy NP Shift" to apply, as in (15). However, it has not been clear how we can define the length of constituents. In this section I argue that the mapping theory can do it straightforwardly.

I assume Larson's (1988) analysis for Heavy NP Shift, or Light Predicate Raising in his terms. (15a) and (15b) have (16) in common at the point of their derivation.

(16) [Ken [*e* [a [book [about [golden hamsters]]]] [$_{V'}$ gave [to Alice]]]]

The verb *gave* may move up to the empty verb position to derive (17a) with the unmarked word order.

(17) a. [Ken [gave$_i$ [[a [book [about [golden hamsters]]]] t_i [to Alice]]]]
b. [Ken [[$_{V'}$ gave [to Alice]] [a [book [about [golden hamsters]]]] t_i]]

If V' Reanalysis applies to the V' *gave to Alice* in (16) and reanalyzes it into V, Verb Raising moves the V up to the empty verb position as shown in (17b).

(17a), however, is not perfect from the phonological point of view, because there are five brackets between *hamsters* and *to*. The brackets in (17a) and (17b) are changed into prosodic boundaries as in (18a) and (18b) by the mapping rule (2).

(18) a. / Ken / gave / a / book / about / golden hamsters ///// to Alice ////
b. / Ken // gave / to Alice /// a / book / about / golden hamsters //////

The boundaries between *hamsters* and *to* in (18a) lead us to expect a long pause there, but such a long pause in a clause is not preferable. Let us assume that there is a preference rule to the effect that a long pause in a clause should be avoided. We might call it "Avoid Pause." If Heavy NP Shift (or V' Reanalysis and Light Predicate Raising) applies, we get a better representation, shown in (18b). The maximum number of brackets in the sentence is three, between *Alice* and *a book*. In this way we can explain in specific terms why (18b) sounds more natural than (18a). Larson assumes that V' Reanalysis is optional, and we are assuming a preference rule "Avoid Pause." Thus we can also explain why Heavy NP Shift is basically optional.

Now let us consider what happens when the object NP is not long enough, as in (19). Notice that there is only one bracket between words in (19a).

(19) a. [Ken [gave [that [to Alice]]]]
b. ? [Ken [[gave [to Alice]] that]]

Heavy NP Shift makes the sentence worse as shown in (19b), where there are two boundaries between *Alice* and *that*. The outputs of applying the mapping rule (2) to (19a, b) are (20a, b).

(20) a. / Ken / gave / that / to Alice ////
b. / Ken // gave / to Alice // that //

Then we can argue that Heavy NP Shift can apply only if it makes a phonologically better construction. (18b) is better than (18a), but (20b) is not better than (20a).

Zec and Inkelas (1990:377) propose a constraint on Heavy NP Shift to the effect that the heavy NP must consist of more than one phonological phrase (PhP). This is illustrated in the examples (21a) and (21b).

(21) a. ? Mark showed to John ($_{PhP}$ some letters)
b. Mark showed to John ($_{IntP}$ ($_{PhP}$ some letters) ($_{PhP}$ from Paris))

In (21a), the NP *some letters* makes only one phonological phrase and the sentence is awkward. In (21b) the NP *some letters from Paris* is divided into two phonological phrases, making one intonational phrase (IntP).

We can also explain the acceptability of these sentences with the mapping theory outlined here. (22a, b) are the structures of (21a, b), and (23a, b) are the unmarked counterparts of (22a, b), respectively.

(22) a. ? [Mark [[showed [to John]] [some letters]]]
b. [Mark [[showed [to John]] [some [letters [from Paris]]]]]

(23) a. [Mark [showed [[some letters] [to John]]]]
b. [Mark [showed [[some [letters [from Paris]]] [to John]]]]

For reasons of space, I do not show the phonological representations. If we compare (22a) with (23a), (22a) is worse than (23a). There are three brackets between *John* and *some* in (22a), while the maximum number of brackets between words in (23a) is two. On the other hand, if we compare (22b) with (23b), (22b) is better than (23b). The maximum number of boundaries between words in (22b) is three, which is smaller than that in (23b), that is, four. Heavy NP Shift makes a phonologically better sentence in this case. Hence (22b) is acceptable while (22a) is marginal.

Let us consider the case where the PP is longer than the heavy NP.

(24) a. [Mark [showed [[some [letters [from Paris]]] [to [the [man [who [was [sitting [next [to him]]]]]]]]]]]

b. ? [Mark [[showed [to [the [man [who [was [sitting [next [to him]]]]]]]]] [some [letters [from Paris]]]]]

The object NP in (24b) is the same as that in (23b), which is a natural sentence. Zec and Inkelas's constraint does not explain the awkwardness of (24b). Their constraint is not violated in (24b) because the NP has two phonological phrases. Then they would wrongly predict that (24b) is an acceptable sentence.

Our analysis can predict the awkwardness of (24b). If the PP is long, there are a number of brackets at the right end of that PP. If the PP is longer than the NP, Heavy NP Shift or Light Predicate Raising makes a worse sentence, moving the long PP along with the V to the left of the object NP as shown in (24b). The representations in (24) show that (24b) is worse than

(24a) because there are as many as ten brackets between the PP and the following NP. In this way we can explain that the applicability of Heavy NP Shift is determined by the relative length of NP and PP, not by the length of NP alone.

So far I have proposed a theory of syntax-phonology mapping and prosodic phrasing in the minimalist framework. I argued that the theory explains the data of secondary stress and Heavy NP Shift straightforwardly. I also argued that the theory can deal with the length of constituents and its effects on these phenomena in specific terms.

5 An Alternative to Early Immediate Constituents Analysis

Finally, let us consider how the theory can be an alternative to Hawkins's Early Immediate Constituents (EIC) analysis. EIC is defined as in (25).

(25) *Early Immediate Constituents* (EIC)
The human parser prefers linear orders that maximize the IC-to-non-IC ratios of constituent recognition domains. (Hawkins 1994: 77)

For illustration, let us look at (26a, b).

(26) a. # [$_S$ [$_{S'}$ That Bill was frightened] [$_{VP}$ surprised [$_{NP}$ Mary]]]
|_____2/5=40%_____| |_2/2=100%| Agg=70%

b. [$_S$ It [$_{VP}$ surprised [$_{NP}$ Mary] [$_{S'}$ that Bill was frightened]]]
|2/2=100%| |__3/3=100%__| Agg=100%

In (26a), immediate constituents of the root S are the subject S' and the VP. The parser recognizes these constituents when he or she hears the verb *surprised*. Thus in order to recognize two immediate constituents of S, he or she has to hear five words, giving a ratio of 2/5=40%. Similarly, there are two immediate constituents in the VP, and the parser has to hear two words to recognize the structure. This time the ratio is 2/2=100%. The aggregate of the two ratios is 70%. On the other hand, in (26b) the aggregate is 100%. Thus (26b) is preferred to (26a).

Another pair of sentences discussed by Hawkins is (27a, b).

(27) a. [$_S$[$_{NP}$ Mary-ga] [$_{VP}$[$_{S'}$[$_S$ kinoo John-ga kekkonshita] to] itta]
M-Nom yesterday J-Nom got married C said
2/2=100%|___|

(27) a. [$_S$[$_{NP}$ Mary-ga] [$_{VP}$[$_{S'}$[$_S$ kinoo John-ga kekkonshita] to] itta]
M-Nom yesterday J-Nom got married C said
2/2=100%
2/6=33.3%
'Mary said that John got married yesterday.' Agg=66.7%

b. [$_S$[$_{S'}$[$_S$ Kinoo John-ga kekkonshita] to] [$_{NP}$ Mary-ga] [$_{VP}$ itta]]
yesterday J-Nom got married C M-Nom said
1/1=100%
3/3=100%
'Mary said that John got married yesterday.' Agg=100%

Hawkins claims that (27b) is preferred to (27a) because the aggregate of the ratios is 100%. However, about the half of the Japanese speakers I asked answered that (27a) is preferred to (27b). The point is that (27a) is not so awkward even though the sentence has a center-embedded S'. How can we explain this fact? EIC does not give us any explanation.

According to the mapping theory presented, we can say that the number of prosodic boundaries make the sentence awkward in violation of "Avoid Pause." The bare structures of (26a, b) and (27a, b) are (28a, b) and (29a, b), respectively.

(28) a. [[That [Bill [was frightened]]] [surprised Mary]]
b. [It [[surprised Mary] [that [Bill [was frightened]]]]]

(29) a. [Mary-ga [[[kinoo [John-ga kekkonshi-ta]] to] it-ta]]
b. [[Kinoo [John-ga kekkonshi-ta]] to] [Mary-ga it-ta]]

In English, (28a) has a sequence of four brackets, while the largest number of brackets in (28b) is two. (28a) is awkward because it violates "Avoid Pause." Extraposition of *that*-clause makes a phonologically better sentence (28b). In Japanese, (29a) has a sequence of three brackets, while the largest number of brackets in (29b) is two. We can argue that the violation of "Avoid Pause" in (29a) is not fatal and that Scrambling of embedded S' makes a slightly better sentence, as shown in (29b).

6 Conclusion

I have argued that the theory of syntax-phonology mapping and prosodic phrasing can deal with the effects of constituent length on phonology and syntax. The theory can also be an alternative to Hawkins's EIC analysis of word order.

The mapping rule proposed here is reminiscent of Cheng's (1966) depth of syntactic boundaries and Clements's (1978) depth of embedding. Those ideas were based on rather simple phrase structure prior to X-bar theory and empty functional categories. The current analysis was made possible with bare phrase structure theory and the assumption that phonologically null elements are invisible to phonological rules.

Finally, if the analysis presented here is on the right track, then we can argue that constituent length is a matter of grammar, not a matter of performance as Hawkins (1994) argues. Of course we need discussion of more phenomena relating to constituent length. I will leave this for future research.

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