Sino-Japanese and a Way to Shape up the Stem*
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1. Introduction

It is well-known that size of the stems in Sino-Japanese (SJ), one of the lexical strata in Japanese, is severely restricted. According to the Richness of the Base hypothesis (Prince & Smolensky 1993), such size restriction phenomena must be treated not by the constraints/rules held in the input, but by interaction of a set of constraints applicable to the output. In other words, while the output stem size in SJ is quite restricted, the input stem size, in principle, can be very large. In this paper, we are concerned with the proper characterization of the size restriction phenomena in SJ.

Sino-Japanese morphemes, which form a large part of the modern Japanese lexicon, have their origin in Classical Chinese. They were borrowed into Japanese around the 7th and 8th centuries when Japanese started to use Chinese characters (Oono 1994, Kato et al 1989).[1] It has been noted in the literature that morphemes in the SJ stratum have a strict templatic restriction as summarized in (1).

(1)   Morpheme-size is restricted in SJ (<u>bold face = moraic</u>).

Attested	Not Attested (among many others)	
(i) (C)**V** (ii) (C)**VV** (iii) (C)**VC** (iv) (C)**VCV**	(v) (C)**VVV** (vi) (C)**VVC** (vii) (C)**VVC** (viii) (C)**VCVCV** (ix) (C)**VCVV** (x) (C)**VVCV** (xi) (C)**VC**	

[1] SJ morphemes behave as nouns when compounded, and some of them are used as a part of verb by being attached *suru* 'do': *hattatu-suru* 'to develop', *hatuan-suru* 'to start an idea', etc. Also, being followed by a copula *da*, they become a predicate: *kenkoo-da* 'being healthy', *seiketu-da* 'being clean', etc. Characteristics of SJ are summarized in Tateishi (1990), McCawley (1968), and references cited therein.

In each case in (1), a morpheme-initial consonant may or may not be present (it is contrastive), and it is irrelevant with respect to size restriction. It is indeed clear that the moraic shape is limited to bimoraic, except for the first form (1i) that has only one mora. There are many unattested forms which are quite large in terms of moraic structure. In the literature, this fact is referred to as the *maximal bimoraicity* of the SJ morphemes. Another generalization we can draw is that coda consonants (if any) must carry a mora. For instance, (iii) and (xi) is a minimal pair with respect to this generalization. This generalization is not only observed in SJ, but also in other strata in Japanese. As for the maximal bimoraicity, it goes without saying that this property has its root in Chinese, in which every morpheme is presumably mono-syllabic. This kind of rigid size requirement is not regularly found in Yamato (the native vocabulary) or the Foreign strata (that consists of words mainly borrowed from European languages such as English, French, etc.).[2, 3]

As argued elsewhere (Prince & Smolensky 1993, McCarthy and Prince 1993, 1995), it goes against the spirit of Optimality Theory (OT) to assume that some kind of a "default SJ morpheme template" exists in the grammar of natural languages. It has been argued that in OT any templatic phenomena should be analyzed as derived from an interaction of phonological and prosodic constraints. In this sense, morpheme/stem-size restrictions in SJ should be the realization of constraint interactions, and it is then quite natural to consider that they are quite similar to phenomena such as reduplication or truncation, which have been extensively studied in the framework of OT.

In fact, we will look at the SJ morpheme-size restriction as an instance of much-attested truncation from the input to the output. As the driving force underlying such a radical shaping of stems in SJ, we will argue for a constraint MODIFIED HIERARCHICAL ALIGNMENT (MHA), which is a modified version of HIERARCHICAL ALIGNMENT originally proposed in Itô, Kitagawa & Mester (1996). We successfully explain the maximal bimoraicity in SJ recognized in the literature by an effective use of MHA combined with other alignment constraints.

Recently, Kurisu (2000) argued that the Richness of the Base hypothesis receives empirical endorsement based on data from SJ compounds. Although Kurisu's attempt is at first blush plausible, we will claim that Kurisu's analysis cannot capture the relevant morpheme-size restriction in SJ; hence the size-

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[2] Another stratum, the mimetic stratum, is known to obey certain templatic restrictions. However, they are independent from the shape restriction on Sino-Japanese morpheme that will be discussed in this paper. For discussion on Japanese mimetics, see Hamano (1998).

[3] Poser (1990) discusses many instances of truncation in Japanese (in the Yamato stratum). He argues for the relevance of foot formation to explain such truncation patterns in Japanese. That would be one case where the notion of "size" is relevant in the Yamato stratum. See also Itô, Kitagawa & Mester (1996) for *zu-jya go* 'jazz-man's language', which is another special pattern found in Japanese.

restriction phenomenon proper deserves another analysis. The essence of the new treatment provided in this paper is based on the Richness of the Base hypothesis to the extent that morpheme-size restriction found in SJ is not given as an input, but rather constitutes a derived phenomenon through the constraint hierarchy. While Kurisu's analysis seems to be based on the Richness of the Base hypothesis, we claim that his analysis depends on an inappropriate assumption.

This paper is organized as follows: section 2 summarizes Kurisu's analysis, and some problems will be pointed out based on the inaccurate assumption (from the view of the Richness of the Base hypothesis) regarding the morpheme size in SJ. Thus, we argue that one of Kurisu's goals in his paper—to give empirical support to the Richness of the Base hypothesis—has not been achieved because of the shortcoming of his argument. The new analysis regarding the SJ morpheme-size restriction will be proposed in section 3. The new prosodic analysis sheds light into the nature of the morpheme-size restriction in the SJ stratum. In fact, we argue that the analysis proposed in this paper will provide strong empirical support for the Richness of the Base hypothesis. In section 4, two theoretical consequences will be shown. First, we will argue that the hierarchical alignment-based analysis is superior to the foot-based analysis, typically used for the size restriction phenomenon. Data on SJ provide the crucial case to prove that the foot-based analysis predicts an empirically-incorrect results. Second, our analysis leads us to claim that the "core-periphery" structure of the strata system in Japanese (Itô & Mester 1995a, b, 1999a, b) cannot hold. Specifically, Itô & Mester's "ranking consistency" raises a serious problem to the size-restriction in SJ. Section 5 concludes the whole discussion.

2. Kurisu (2000)

2.1 Kurisu's Analysis

Let us review Kurisu's main proposals. Since his focus is the compound process in SJ, his discussion is mainly on the SJ morphemes of type CVC and their alternation between the CVC and CVCV form. Kurisu acknowledges that there has been a controversy among researchers regarding the underlying shape for those morphemes (especially in the pre-OT period). Given the highly predictable nature of the final vowel in the CVCV form, that is, it is limited to either *i* or *u*, some claim that the underlying representation should be /CVC/ (so that the final vowel is epenthetic for advocates of this approach), others yet claim that the underlying representation should be /CVCV/ (a vowel deletion rule applies when necessary). Kurisu argues that under the Richness of the Base hypothesis, the choice should not matter. In fact, the constraint ranking proposed by Kurisu

successfully selects the correct output regardless of the input choice between /CVC/ and /CVCV/. (2) illustrates one of Kurisu's points.

(2)   Size and the Richness of the Base

| /hat/ | [.hat. …] | -- | if coda C is part of a geminate |
| /hatu/ | [.ha.tu. …] | -- | otherwise |

Suppose that we would like to derive two different forms [hat] and [hatu] depending on the phonological environment. As the first morpheme in compounds, the CVC form [hat] is the correct form when the coda *t* is allowed to be part of the geminate, otherwise [hatu] is the correct form. In his system, the correct output is not bound by the input choice; from /hat/ it is possible to derive either [hat] or [hatu] depending on the phonological environment and from /hatu/ it is possible to derive either [hat] or [hatu] likewise. Therefore, he concludes that this constitutes a strong piece of support for the Richness of the Base Hypothesis.

One of Kurisu's important claims is that the driving force of gemination observed in the compounding processes in SJ is a constraint which plays the role of a size restrictor. According to Kurisu, the reason why the attested compound [.hat.ta.tu.] (/hat/ + /tat/) is more optimal than the unattested [.ha.tu.ta.tu.] is that the former contains fewer syllables. However, gemination—which allows the compound to contain fewer syllable—is blocked in some cases, depending upon the combination of consonants at the morpheme boundary. What is crucial here is that gemination is observed whenever the phonological environment allows it. Therefore, it is reasonable to conclude that a size restrictor is in order for the SJ compounding process. Here are the relevant constraints used by Kurisu:

(3)   Constraint set (McCarthy & Prince 1995)
        a. MAX-IO-C: Every consonant of the input must have a correspondent in the output.
        b. MAX-IO-V: Every vowel of the input must have a correspondent in the output.
        c. ALIGN (SYLL, L, PRWD, L): The left edge of every syllable must correspond to the left edge of a prosodic word.

ALIGN-SYLL works as a size restrictor in Kurisu's analysis. The fewer syllables candidates (i.e., prosodic words) contain, the better candidates perform. Here is a tableau for an input of the form CVCV-CVCV (compounding).

(4)   Tableau /CVCV+CVCV/: (17) in Kurisu (2000)

	/hatu-tatu/	MAX-C	ALIGN-SYLL	MAX-V
a.	{.ha.tu.-ta.tu.}		*/**/*!**	
b. ☞	{.hat.-ta.tu.}		*/**	*
c.	{.ha.-ta.}	*!*	*	**
d.	{.ha.}	*!**		***
e.	{.ha.tu.-tu.}	*!	*/**	*
f.	{.hat.-tu.}	*!	*	**

This tableau shows a case where gemination is observed in the compound. Morphemes ending with *t* are able to have a coda consonant when the second stem starts with *t*; in fact, a candidate that has a coda consonant (and so a geminate) is preferred in such a case since the number of syllables can be minimized within a given prosodic word. The crucial candidate (although it is not the final winner) is the candidate (4a). The CVCV form in the first morpheme is not an "always loser," but in fact it is the form that we observe when gemination is not allowed. In Kurisu's ranking, MAX-C is ranked higher than ALIGN-SYLL; therefore it is preferred for the compound to be smaller as long as there is no deletion of consonants. This ranking also enables us to select the correct output for an input of the shape CVC-CVC. That is shown in Tableau (5), equipped with the constraint set in (6).

(5)   Tableau /CVC+CVC/: (20) in Kurisu (2000)

	/hat-tat/	CODA COND	MAX-C	ALIGN-SYLL	DEP-V
a. ☞	.hat.-ta.tɯ.			*/**	*
b.	.hat.-ta.		*!	*	
c.	.hat.-tat.	*!		*	

(6)   Constraint Set (Itô 1986, McCarthy and Prince 1993)
       a. CODA CONDITION: Coda consonants are not allowed unless they are
                           nasals or part of geminates.[4]
       b. DEP-V: No addition of a vowel.

In this case, the second stem needs an epenthetic vowel to satisfy one of the undominated constraints, namely CODACOND. By ranking DEP-V relatively low in the hierarchy, Kusiru's analysis successfully derives the correct output forms.

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[4] This is a somewhat simplified version sufficient for the discussion in this paper. The full-fledged definition can be found in the work by Itô.

2.2   Problems

One implicit but crucial assumption in Kurisu's analysis is that the input takes either CVC or CVCV form: noticeably, both are of bimoraic shape.[5]   In all relevant tableaux presented in his paper, the input takes either form (i.e., /CVC/ or /CVCV/). As Kurisu predicts and as illustrated in section 2.1, the choice between those two input forms does not have any effects on the selection of the optimal forms. Notice, however, that the input forms selected by Kurisu clearly obey a template, namely, the "maximally bimoraic" shape; it is this kind of templates that the Richness of the Base hypothesis specifically tries to avoid in the input.

Now in SJ, suppose that we have a hypothetical input whose shape is larger than CVC or CVCV. For example, imagine an input such as /CVCVCV/. This is a legitimate experiment to figure out how the native speakers of Japanese know that a SJ morpheme cannot be larger than bimoraic. Can the constraint ranking proposed by Kurisu eliminate candidates that are faithful to those hypothetical inputs? the answer is negative given the fact that MAX-C dominates ALIGN-SYLL in his ranking.

(7)   Tableau: Wrong Prediction by Kurisu

/…-CVCVCV/	MAX-C	ALIGN-SYLL	MAX-V
a. ❽ {…CV.CV.CV.}		*/**	
b. {…CV.CV.}	*!	*	*

This is a hypothetical situation where the second morpheme of the compounding has an underlying form /CVCVCV/.[6]   Since the size restriction in the SJ morpheme forces every morpheme to be maximally bimoraic, the optimal output should be of the form CVCV.[7]   However, as Tableau (7) shows, the constraint ranking proposed by Kurisu wrongly predicts that {CVCVCV} is the optimal output.   The problematic ranking MAX-C » ALIGN-SYLL is independently motivated to explain other patterns as we saw in Tableau (4), but this ranking blocks the elimination of "large-size" candidates such as (7a).

Essentially, this result is unavoidable given Kurisu's constraint ranking. This problem did not arise in his paper because Kurisu's analysis is based on the

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[5] The second C in the CVC forms appears as a part of a geminate. One point worth mentioning here is that in the CVC forms, the coda consonants carry a mora; therefore, it is argued that CVC morphemes are bimoraic as well as CVCV morphemes.

[6] I use this CVCVCV for the end of the prosodic word to avoid the complexity generated from the gemination and the coda condtion.

[7] The form CVC is independently eliminated due to the highly-ranked CODACOND. In general, obstruents cannot appear at the end of the word in Japanese.

assumption that every SJ morpheme is *originally* maximally bimoraic from the input. Recall that such an assumption cannot hold under the Richness of the Base hypothesis. Thus we conclude that Kurisu's analysis is not completely consistent with the Richness of the Base hypothesis, for the set of inputs Kurisu considers is not "rich" enough, but is already restricted from the beginning.

3.   An Alternative Approach

3.1   Hierarchical Alignment

In the previous section, we pointed out that the analysis proposed by Kurisu cannot properly capture size restriction on SJ morphemes. His constraint ranking cannot select the correct winning candidate when a hypothetical, yet legitimate, input that could be provided by the Richness of the Base hypothesis.

In this section, we propose a new constraint, which is a modified version of HIERARCHICAL ALIGNMENT (HA), originally proposed by Itô, Kitagawa & Mester (1996) (henceforth IKM).[8] IKM proposes a constraint schema HA to derive binarity in various prosodic structures. Following the prosodic hierarchy proposed by Selkirk (1980), IKM try to implement, within OT, the idea of the binarity illustrated below.

(8)   a. Foot   ✓ ( )   ✓ (   )   *(   )
        b. Syllable   ✓ .μ.   ✓ .μμ.   *.μμμ.

(8) illustrates the observations that in many languages, a foot can contain either one or two syllables, but not three, and a syllable can contain either one or two moras, but not three. Even in languages that allow three moras within a syllable, it will be a highly marked case, and we will not expect to find it everywhere in a given language.[9] IKM proposes a constraint schema HA stating that a prosodic

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[8] I am grateful to Bernard Tranel for pointing out to me the relevance of Hierarchical Alignment to the SJ data.

[9] Let me give some cases where apparently a syllable can incorporate three moras in Japanese. I should emphasize that this is rather marked. We can find three moras in a syllable when a morpheme *-kko* 'a person from x' follows a stem (usually a name of place) which ends with a heavy syllable (i.e., it contains two moras.). This kind of suffix is quite peculiar in that it starts with a geminate, which is expected to be attached to some other stem. Another point which makes this example so marked is that the penultimate syllable has a complex coda, which is flatly prohibited in Japanese in general (as well as complex onset).

(i)   .lon.don. 'London' + -kko =   lon.donk.ko.
          te.ne.sii. 'Tennessee' + -kko =   te.ne.siik.ko.

category is licensed if it is incorporated in higher prosodic categories and if it aligns to the edge of the immediately dominating category.[10] For instance, what is wrong with a foot with three syllables is the medial syllable, since it is not aligned to either edge of the immediately dominating category, i.e., a foot. The first and the third syllable are legitimate since they are at an edge of the foot. In case of a foot with one syllable, there is no problem with respect to the alignment since the unique syllable is aligned to the edges of the foot. In the same fashion, the problem of a tri-moraic syllable is that the medial mora does not align to either edge of the syllable. The first and the third mora do not cause any problem since they stand at the edge of the syllable. IKM successfully derive the binarity effects with this HA schema.

In this paper, we will modify HA to derive the maximal bimoraicity for SJ stems. Specifically our MODIFIED HIERARCHICAL ALIGNMENT (MHA) focuses on mora, and the target of alignment is edge of the stem. Naturally, we can formalize MHA by using the alignment schema.

(9) MODIFIED HIERARCHICAL ALIGNMENT
   (cf. Itô, Kitagawa & Mester 1996, Ussishkin 2000)
   ALIGN (Mora, Stem)
   Either edge of every mora must correspond to an edge of a stem containing the mora.

This constraint is satisfied if a stem contains either one or two moras. If a stem contains three moras, the medial mora will violate this constraint since it does not align to either edge of the stem. The original HA is a constraint on the relation between one prosodic category and another (Ussishkin 2000). MHA is different since it is a constraint on the alignment relation between one prosodic category

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Notice that the penultimate syllable in each case has three moras: two from the original stem and one from the suffix. Another such suffix is *-ppoi* 'seemingly'. Again it starts with a geminate.

(ii)   ten.nen. 'natural' + -ppoi =   ten.nenp.poi.
         tai.fuu. 'typhoon' + -ppoi =   tai.fuup.poi.

Even more surprisingly, if the last syllable contains three moras as in *ha.ri.keen*. 'hurricane', such suffix can create a syllable which contains four moras.

(iii)   ka.me.ruun. 'Cameroon' + -kko = ka.me.ruunk.ko.
         ha.ri.keen. 'hurricane' + -ppoi = ha.ri.keenp.poi.

[10] As noted by IKM, this is a conceptually desired result in that we can avoid a grammar which "counts" the number to decide whether an object is in the grammar or not. In such a case, we have to ask questions such as why two is optimal, but why not three or seven. Deriving the binarity effects without counting makes those questions irrelevant.

(mora) and one morphological category (stem).[11] This constraint can eliminate "large-size" candidates, which Kurisu's analysis is unable to do so. The figure below illustrates how this constraint evaluates candidates.

(10)   Illustration
      a. | μ | b. | $\mu\mu$ | satisfied
           | stem | | stem |

      c. | $\mu\mu\mu$ | violated
           | stem |

(10a) and (10b) are the cases where the MHA is satisfied. In (10a) there is one mora in the stem, and obviously this mora aligns to both edges of the stem. In (10b) there are two moras, and the mora on the left-hand side aligns to the left side of the stem, and the mora on the right-hand side aligns to the right side of the stem. Therefore, this constraint is satisfied. By contrast, in (10c) MHA is violated, since the middle mora does not align to either edge of the stem. Also, it should be noted that MHA should be evaluated at the moraic level, that is, the presence of an onset is completely irrelevant to MHA's evaluation.

       Below, we are going to present a detailed analysis as to how MHA works in our analysis. In short, we add MHA to Kurisu's constraint hierarchy and successfully achieve our goal: To incorporate much wider input forms than Kurisu's analysis can.

3.2   Moraic Contrast

The primary goal in this section is to show that our constraint ranking neutralizes various inputs (which never surface faithfully) to one of the four attested SJ stem forms. Quite interestingly, whatever the size of the input is, the constraint ranking never generates any non-existing forms in SJ, such as *CVC, *CVVC, *CVVCV, or *CVCVCV (among many others).[12] It is precisely the result that Kurisu cannot achieve in his analysis. Therefore, we claim that the present analysis is empirically superior to Kurisu's analysis. At the end of this section, it will be argued that both ALIGN-SYLL and MHA are necessary to complete the analysis. For the sake of simplicity in the following illustrations, abstract forms such as CVC will be used instead of specific forms such as *hat*.

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[11] It goes without saying that MHA also departs from the original HA conception of "immediate domination," also used by Ussishkin (2000).

[12] As noted in the introductory section, moraic segments are represented in bold face. Furthermore, morpheme-initial consonants are irrelevant.

Let us start from a hypothetical (and interesting) case such as /CVVCV/. This form is obviously unattested in SJ, and the constraint hierarchy must neutralize it to some attested form. Tableau (11) illustrates shaping of /CVVCV/ into [CVCV].

(11)   Tableau /CVVCV/ to derive [.**CV**.**CV**.]

/-CVVCV/	MHA	Max-V
a. .**CVV**.**CV**.}	*!	
b. ☞ .**CV**.**CV**.}		*

Suppose that this morpheme appears at the end of the compound. CODA CONDITION must be satisfied at the end of a prosodic word. Both (11a) and (11b) satisfy CODA CONDITION. Candidate (11a) violates MHA since it contains three moras in the output. Tableau (11) therefore establishes the ranking MHA » MAX-V.

Tableau (12) illustrates the case where gemination is observed. An additional constraint is needed in order to eliminate unattested SJ stem forms.

(12)   Tableau /CVVCV/ to derive [.**CVC**.]

/CVVCV-/	MHA	WEIGHT	Max-V
a. {.**CVVC**.	*!		*
b. {.**CVC**.		*!	**
c. ☞ {.**CVC**.			**

As noted in the introductory section, there is a generalization holding in Japanese that coda consonants (if any) must be moraic. This is taken to be a piece of evidence for the claim that a constraint WEIGHT-BY-POSITION is undominated in Japanese regardless the strata.

(13)   WEIGHT-BY-POSITION (cf. Hayes 1989)
        Coda consonants must be moraic.

Given the assumption that WEIGHT-BY-POSITION is undominated in Japanese, candidate (12b) is eliminated by fatally violating WEIGHT-BY-POSITION. Candidate (12a) satisfies this constraint with a moraic coda; nevertheless, this candidate is not optimal in that it fatally violates MHA. Candidate (12c) satisfies these two dominant constraints and is the winner.

Next, we will discuss inputs such as /CVCVC/ and /CVCVCVC/. Notice that such inputs never surface faithfully in SJ, and the constraint ranking we propose will shrink them to the bimoraic form. This is also a very important case

since it is precisely this case that Kurisu's analysis cannot handle by his constraint ranking.

Let us start from the case where the input has three consonants. The input in Tableau (14) contains three consonants.

(14)   Tableau: /CVCVC/ to [.**CV.CV.**]
        MHA » MAX-C

/-CVCVC/	MHA	MAX-C
a. .**CV.CV.CV.**}	*!	
b. ☞ .**CV.CV.**}		*

This tableau shows that by assuming undominated MHA, we can successfully obtain a winning candidate of appropriate size. In Kurisu's analysis, this result cannot be obtained since in his ranking, MAX-C is too-highly ranked. In my analysis, MAX-C is violable. Tableau (14) shows that MHA is crucially higher ranked than MAX-C.

The next two tableaux show the cases where a coda consonant is allowed in a geminate structure.

(15)   Tableau: /CVCVC/ to [.**CVC.**] part I.
        WEIGHT-BY-POSITION » MAX-C

/CVCVC-/	MHA	WT BY POS	MAX-C
a. {.**CV.CVV.**	*!		*
b. {.**CV.CVC**	*!		
c. {.**CV.CVC**		*!	
d. ☞ {.**CVC.**			*

Tableau (15) shows how we get the CVC form. By ranking WEIGHT-BY-POSITION and MHA above MAX-C, we get a bimoraic form as a winner. The next tableau is particularly interesting since it shows the necessity of ALIGN-SYLL, especially if one thinks that it is kind of redundant to have two different size restrictors (MHA and ALIGN-SYLL). By ranking ALIGN-SYLL just above MAX-V, we get the correct output.

(16)   Tableau: CVCVC to [.**CVC.**] part II.
        ALIGN-SYLL » MAX-V (e vs. f)

/CVCVC-/	MAX-C	ALIGN-SYLL	MAX-V
e. {.**CV.CV.**	*	*!	
f. ☞ {.**CVC.**	*		*

The basic pattern we can observe in (15) is that MHA is very powerful and effective for the large size input with respect to the moraic structure. MHA plays a very crucial role to eliminate many unattested SJ stems noted in (1). ALIGN-SYLL is still important as well for the decision among the candidates which satisfy MHA as we saw in (16). Therefore, we have successfully demonstrated why stems in SJ are under the severe size restriction by the constraint hierarchy proposed in the current study. This conclusion strongly supports the adequacy of the Richness of the Base hypothesis in that we truly do not have to pose any specification on input unless contrastive. As for the SJ stem size, the size of the input can be quite large regardless of the surface observation that stems in SJ are of maximally bimoraic form. The nature of size restriction in SJ simply results from constraint interaction, and is not the property of the input by any means.

4.   Theoretical Consequences

4.1   Foot-Based vs. Hierarchical Alignment-Based Approach

In the literature, there are two different approaches proposed for the size restriction phenomena. The first approach, which we will call the "foot-based" approach, has claimed that size restriction should be dealt with by utilizing the foot structure of the languages (McCarthy and Prince 1990, 1999, among many others). The second approach, the "hierarchical alignment-based" approach, has been proposed by researchers such as Itô & Mester (1992). The approach advocated in this paper belongs to this second approach. Prima facie, it is hard to observe any empirical differences between the two approaches. It appears that these approaches cover the same empirical domain. In this paper, however, we would like to argue that the data on SJ compound formation enable us to observe an empirical difference between the two approaches; furthermore, we argue that only the hierarchical alignment-based approach can correctly capture the data on SJ compound formation.

As noted in section 1 and discussed extensively in this paper, SJ stems are restricted to maximally bimoraic size. Given such a restriction, the patterns in compound formation are also restricted. Let us limit our attention to the cases in which two stems are involved in compounds. Patterns can be summarized as follows.

(17) a. CV + CV   b. CVV + CV
              + CVV   + CVV
              + CVCV   + CVCV
      c. CVC + CV   d. CVCV + CV
               + CVV   + CVV
               + CVCV   + CVCV

For the first stem in a compound, all four forms are possible; but the CVC form cannot appear as the second stem since it violates CODACOND.

What would a foot-based approach say regarding size restriction in SJ stems? A possible analysis is to assume that each stem is restricted in terms of size because each stem is basically a foot. In OT terms, we can explain this by posing the interaction of PARSE-SYLL ALL-FOOT-LEFT, FOOT-BIN, and MAX (cf. McCarthy and Prince 1999).

(18)   a. PARSE-SYLL: Syllables are parsed by feet.
        b. ALL-FOOT-LEFT: Every foot stands at the left edge of the PrWd.
        c. FOOT-BIN: A foot must be binary.

(19)   PARSE-SYLL, ALL-FOOT-LEFT, FOOT-BIN » MAX

Given the ranking shown in (19), the best prosodic word consists of a single foot, which in turn is a stem itself. This foot-based analysis further claims that a compound will consist of two feet and that each foot is a prosodic word by itself as shown in (20). (21), then, summarizes the two main predictions made by the foot-based approach.

(20)   [$_{PrWd}$ (stem)] | [$_{PrWd}$ (stem)]
        where the size of the stem is maximally bimoraic.

(21)   Foot-based approach to size restriction in SJ
        a. Each stem is a foot.
        b. Each stem is a prosodic word.

In cases such as (22), the predictions made by the foot-based approach are well respected.

(22)   [$_{PrWd}$ (.**CVC.**)] | [$_{PrWd}$ (.**CV.CV.**)]

This compound in (22) consists of two stems. Each stem is a bimoraic foot. Due to the constraint ALL-FOOT-LEFT, each foot is a prosodic word.

However, we would like to show that there are cases where it is hard believe that (21) is respected. In other words, size restriction in SJ should not be considered to be under the generalization noted in (21). The question arises as to what the foot structure is in case of CV + CV compounds. We can think of at least two candidates for the foot formation of such compounds.

(23)   a.   [PrWd (.CV.)] | [PrWd (.CV.)]
        b.   [PrWd (.CV.|.CV.)]

Both candidates satisfy PARSE-SYLL; all syllables are parsed into feet. Yet, it is quite noticeable that (23a) has a strange configuration; the whole compound is composed of two degenerate feet. Given the natural assumption that syllables are parsed into feet in binary fashion (i.e., due to FOOT-BIN), (23b) seems to be unmarked with respect to the foot formation.[13]   In fact, (23b) represents a plausible and correct foot structure of CV + CV compounds. However, (23b) does not conform to (21) at all.

First, in (23b), each stem is not a foot, but the compound as a whole is a foot. Second, in (23b), each stem is not a prosodic word, but the compound as a whole is a prosodic word. These discrepancies leads us to wonder how stems can be restricted with respect to size. Note that the foot-based approach specifically assumes that SJ stems are under the severe size restriction since stems are feet. We can conclude that the foot-based approach fails to give a plausible explanation to the cases such as (23b).

Turning to our hierarchical alignment-based approach, the foot configuration in (23b) is perfectly acceptable. As for the size restriction on the CV forms, the hierarchical alignment-based approach says that it is acceptable since it satisfies MHA, as demonstrated in (24)

(24)   Tableau: CV + CV compound

/CV+CV/	MHA	FT-BIN	MAX
a. {(CV)}|{(CV)}		*!	
b. ☞ {(CV|CV)}			
c. {(CV)|(CV)}		*!	

In Tableau (24), all candidates satisfy MHA. The loosing candidates (24a) and (24c) will be dealt with by FOOT-BIN, assumed to play a role in general in the Japanese language. In short, it is clear that the foot-based approach fails to explain cases like (23), while the hierarchical alignment-based approach does explain such cases successfully. In other words, (23) is a very important case by

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[13] Another justification for preferring (23b) could be that (23b) contains fewer feet than (23a).

which we can observe empirical differences between the two approach toward the size restriction, and it enables us to claim that the hierarchical alignment approach is more adequate than the foot-based approach toward the SJ stem size restriction.

4.2   Strata System in Japanese

One of the issues debated in great detail in Japanese phonology and morphology concerns the nature of the strata system. Itô & Mester (1995b: 187) propose an implementation within OT where the strata system is characterized by the "core-periphery" structure as illustrated as in (25) (slightly modified):

(25)   Strata system

Yamato	Sino-Jpn	Foreign
*VoiGem	*VoiGem	**Faith**
PostNasVoi	**Faith**	*VoiGem
Faith	PostNasVoi	PostNasVoi

*VoiGem is a constraint barring voiced geminates such as *dd*, *gg*, or *bb*. PostNasVoi is a constraint that prohibits an occurrence of a voiceless obstruent after a nasal. In Yamato, both constraints are well respected and then highly ranked; a voiced geminate is barred and clusters such as *nt* or *nk* are not observed. In SJ, *VoiGem is similarly high-ranked, but PostNasVoi is dominated by a faithfulness constraint (or a group of such constraints), so that we do find clusters such as *nt* or *nk*. Finally in the Foreign stratum, both markedness constraints are dominated by a faithfulness constraint (again, it could be a group of such constraints), and we can thus observe voiced geminates as well as clusters of a nasal and a voiceless obstruent. Itô & Mester (1995a, b) view Yamato forms as the "core" vocabulary in Japanese while a stratum such as Foreign forms the "peripheral" vocabulary. The crucial point we will focus on here is the idea that whatever markedness constraint which is observed in SJ (more periphery) must also be observed in Yamato (more core), but not vice versa.

There is at least one problem in their analysis. In OT, the constraint ranking in a given language is assumed to be uniform. Nevertheless, Itô & Mester (1995a, b) must allow "re-ranking" of constraints within a language, such as Japanese. Itô & Mester (1999b) come up a solution to this apparent paradox without utilizing the reranking of constraints.   In their new system, each faithfulness constraint is indexed for each stratum so that there is only one ranking available in Japanese. They posit four strata in Japanese, and each with its own faithfulness constraints, as illustrated below:

(26)   Itô & Mester 1999b
            SYLLSTRUC
                | FAITH/Unassimilated foreign (UAF)
            *VOIGEM
                | FAITH/Assimilated foreign (AF)
            NO-P
                | FAITH/Sino-Japanese (SJ)
            POSTNASVOI
                                            FAITH/Yamato (Y)

The highest ranked markedness constraint, SYLLABLE STRUCTURE, is respected in all strata, since it dominates all faithfulness constraints. On the other hand, POST NASAL VOICING, the lowest ranked in the above figure, only dominates the faithfulness constraint indexed to Yamato. This means that it is only respected in Yamato, but it can be violated in the other strata.

To conserve the core-periphery structure in Japanese, Itô & Mester (1999b) argue that the ranking among markedness constraints are uniform. They further argue that differently-indexed faithfulness constraints cannot be ranked freely, but the ranking among them is maintained in a specific consistent manner. The basic tenet of ranking consistency is as follows. Suppose that there is one faithfulness constraint: e.g., DEP-V. Since there are four strata, DEP-V is indexed accordingly; now there are four DEP-V. The ranking among those is restricted so that the DEP-V indexed on a "more peripheral" stratum cannot be dominated by the DEP-V indexed on a "more core" stratum. Thus, those four DEPs must be ranked in the following way.

(27)   a. DEP-V/UAF » DEP-V/AF » DEP-V/SJ » DEP-V/Y
         b. * … … DEP-V/Y » DEP-V/SJ

The ranking (27b) is not acceptable since it does not conform to the core-periphery structure. The faithfulness constraint indexed on the core stratum (i.e., Yamato) must be dominated by the same faithfulness constraint indexed on a more peripheral stratum (i.e., SJ).

Our SJ analysis contradicts their proposal. We have seen that MHA is undominated in SJ, but apparently not in Yamato (and other strata such as Unassimilated Foreign). We need the constraint ranking illustrated below[14]:

(28)   FAITH-SIZE/UAF, AF, Yamato » MHA » FAITH-Size/SJ

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[14] Fukazawa, Kitahara & Ota (1998) also point out that this is one of the cases where the core-periphery structure collapses (although they did not provide any detailed analysis on SJ).

According to Itô and Mester (1999b), the ranking (28) should never be available in Japanese. In fact, Itô and Mester kept silent regarding size restriction in SJ. We do not have any solid answer for this issue, but it seems clear that their analysis has a problem.[15]

5. Conclusion

We would like to conclude this paper by pointing out the main advantages of our hierarchical alignment-based analysis compared with the analysis proposed by Kurisu (2000). In Kurisu's analysis, although it is mentioned that there is some kind of a driving force to restrict the size of morphemes in SJ (when they are compounded), it is not clear why it is restricted to "maximally bimoraic" size. In the analysis elaborated here, bimoraicity is reduced to satisfaction of the constraints MHA and ALIGN-SYLL. The constraint ranking argued in this paper is able not only to capture the basic alternation facts between CVC and CVCV, but also to have an explanation why morphemes in SJ are restricted in such a way; all unattested forms are explained.

We have seen that the analysis entertained in this paper has at least two interesting theoretical consequences. First, stem-size restriction in SJ provides a case where we can see the difference between the foot-based approach and the hierarchical alignment-based approach. Although in many cases discussed in the literature, it is quite difficult to tease apart the difference between the two competing approaches, the present analysis gives support for the hierarchical alignment-based approach. In other words, it is impossible for the foot-based approach to make a correct prediction for compounding in SJ; the problem never arises in the hierarchical alignment-based approach. Second, it has been shown that size-restriction in SJ does not conform to the core-periphery structure extensively discussed in Itô & Mester (1995a, b, 1999a, b). Although we are unable to provide a concrete solution to the problem, it seems clear that size-restriction in SJ must be incorporated in any unified account on the strata system in Japanese.

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[15] Fukazawa, Kitahara & Ota (1998) suggest a solution to dispense with the ranking consistency proposed by Itô & Mester; they allow each faithfulness constraint be ranked completely freely. It seems to me that it allows too many choices for the grammar with respect to the lexical stratification, namely, there are too many strata being able to exist within a language. I leave this issue for further research.

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