Revisiting Yantai tone sandhi *

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Even though the lexical tones in Yantai are not many, the tone sandhi patterns are quite interesting. The previous analysis is based on the theory of Contour Tone Unit. Yantai tone sandhi is claimed to be triggered by register and contour dissimilation on adjacent Contour Tone Units. However, the theory of Contour Tone Unit had been questioned with a counterexample. Moreover, the previous analysis is ad hoc, too. Therefore, this paper provides an alternative analysis and Yantai tone sandhi can thus be explained without the theory of Contour Tone Unit. This alternative analysis proposes that only adjacent level tones in Yantai are triggered by OCP and go through tone sandhi. Other tone sandhi patterns are motivated by the minimization of tonal ups and downs. Since the alternative analysis is both cross-linguistically motivated and phonetically-based, it is preferred over the previous analysis.

1. Introduction

Yantai dialect is a Chinese dialect mainly spoken in Shandong province of Mainland China and the fieldwork was primarily done by Qian et al. (1982). Yantai dialect does not have many lexical tones. The three lexical tones in Yantai dialect are as follows (Bao 1999:58):¹

(1) a. 31 fu “man”
   b. 214 fa “method”
   c. 55 t’u “picture”

Even though the tonal inventory of Yantai dialect is small, the disyllabic tonal combinations in Yantai show interesting tone sandhi (Bao 1999:58):

(2) a. 31-31 $\rightarrow$ 35-31
    san p’o ‘hill slope’

* The author would like to thank James Myers for the helpful comments to this paper and the audience of ICEAL. All errors remained are my own responsibility.

¹ Following most discussions of tones in Mandarin dialects, tones are marked with Chao’s (1930) five tone system.
As shown in (2), when there are two underlying adjacent identical tones, the first tone in the bi-tonal combination will go through tone sandhi. Sandhi tones in (2b) and (2c) are subject to Structure Preservation and are therefore lexical tones. It is common for tone sandhi in Asian tone languages to be subject to Structure Preservation. Southern Min (also called Xiamen dialect) is also a Chinese dialect whose tone sandhi forms a chain-shift and does not include any non-lexical tone.\(^2\) The only post-lexical tone after tone sandhi in Yantai surfaces in (2d). There are totally nine pairs of the disyllabic tonal sequence and the post-sandhi disyllabic tonal patterns are summarized as follows:

(3) Post-sandhi disyllabic tonal patterns in Yantai (Bao 1999:58)

<table>
<thead>
<tr>
<th>Tone1</th>
<th>Tone2</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>31</td>
<td>214</td>
<td>55</td>
</tr>
<tr>
<td>31</td>
<td>31-31</td>
<td>31-214</td>
<td>31-55</td>
</tr>
<tr>
<td>214</td>
<td>35-31</td>
<td>55-214</td>
<td>214-55</td>
</tr>
<tr>
<td>55</td>
<td>55-31</td>
<td>55-214</td>
<td>31-55</td>
</tr>
</tbody>
</table>

The bolded fonts in (3) stand for tone sandhi of a disyllabic tonal combination, and other combinations remain unchanged on the surface. As summarized in (3), three out of the four tone sandhi patterns have two adjacent contour tones underlyingly. Bao (1999) thus claims that Yantai tone sandhi is triggered by Obligatory Contour Principle (OCP, Leben 1973) with the theory of Contour Tone Unit (CTU, Yip 1980, 1989). However, the theory of CTU has its inadequacy in explaining Yantai tone sandhi. Therefore, the goal of this paper is to propose a phonetically-based alternative analysis to tone sandhi of adjacent contour tones in Yantai.

The paper is organized as follows. In section 2, I will review the analysis proposed by Bao (1999). Following Yip (1980, 1989), Yantai tone sandhi is claimed as the evidence of CTUs and OCP of adjacent CTUs in Bao (1999) and I will argue against it. In section 3, I will propose an alternative analysis which claims that Yantai tone sandhi is based on phonetic motivations of minimizing articulatory efforts. Besides, the tonal reduction of contour tones on the first syllable of a disyllabic word since non-final syllable is phonetically shorter (Zhang 2002). In the end, the alternative analysis will be completed under the framework of Optimality Theory (Prince and Smolensky 2004) in section 4.

2. Problems of the analysis with OCP and CTU

Yip (1980, 1989) proposes a theory of CTU which claims that in Chinese and its dialects, the contour tone is a unit rather than two level tones in African tone languages.

The typological difference of contour tones between two tone language families is as follows (Yip 1989, cf. Yip 1980):

(4) a. Asian tone languages
   Tonal Height [+high] [-high]
   Register [+Upper]
   Tone Bearing Unit σ

b. African tone languages
   [+high] [-high]
   [+Upper] [+Upper]

As shown in (4), (4a) and (4b) both represent a high falling contour tone (i.e. high in register category [+Upper]; falling from [+high] to [-high]). However, since Asian tone languages treat contour tones as units, there is only a single association between a contour tone and a tone bearing unit. On the other hand, African tone languages have two associations between a contour tone and a tone bearing unit. With this theory, OCP applies differently to these two tone language families. Assuming that OCP checks both the register feature and features of the tonal height dominated by the register feature, 53.53 does not violate OCP in African tone languages because two high tones are gapped by the intermediate [-high] tone 3. However, 53.53 in Asian tone languages violates OCP since the [-high] tone 3 is actually dominated by a single register node and adjacent register features and features dominated by the register node are the same. A classic example of OCP on CTUs comes from the Third Tone Sandhi Rule of Beijing Mandarin as follows:

(5) a. xiao\textsuperscript{213} gou\textsuperscript{213} \rightarrow xiao\textsuperscript{24} gou\textsuperscript{213}
   ‘puppy’

b. mai\textsuperscript{213} jiu\textsuperscript{213} \rightarrow mai\textsuperscript{24} jiu\textsuperscript{213}
   ‘buy a bottle of wine’

c. ke\textsuperscript{213} yi\textsuperscript{213} \rightarrow ke\textsuperscript{24} yi\textsuperscript{213}
   ‘be able to’

In (5), the first tone of a disyllabic sequence of third tones (e.g. 213) goes through tone sandhi and changes to a rising contour 24 (or 35). Cheng (1973) claims the tone sandhi patterns in (4) clearly show that Third Tone Sandhi Rule is contour dissimilation triggered by OCP.\textsuperscript{3}

Following Yip (1980, 1989), Bao (1999) also claims that Yantai tone sandhi is evidence that shows the contour/register dissimilation. Bao (1999) proposes a tonal model which is also based on the theory of CTU, which represents lexical tones in Yantai as follows:

\textsuperscript{3} For other arguments for contour tone assimilation or contour tone spreading, see Yip (1989).
In (6), $r$ stands for the register node which can be specified with $H$ register or $L$ register; $c$ stands for the contour node which can be specified with $h$, $l$, $hl$ and $lh$. The features $h$ and $l$ represent level tones; the features $hl$ and $lh$ represent falling contours and rising contours respectively. In this model, OCP can apply to both $r$ node and $c$ node and it can therefore trigger contour/register dissimilation. The register and contour features correspond to [upper] and [high, low] in Yip (1989).

With Bao’s model, the argument is mainly based on two points. First, a tonally identical sequence goes through tone sandhi as in (2a), (2b) and (2c). Second, surface forms never have the same register height and pitch excursion. For example, in the surface form 35-31, the former is a high rising contour and the latter is a low falling contour. Moreover, (2d) further shows that register dissimilation triggered by OCP because the underlying /214-31/ has adjacent identical register feature which is low.

However, Bao’s analysis of tone sandhi is not satisfying and is also questionable for two reasons. First, register dissimilation is exceptional. In (3), it is clear that the underlying disyllabic tonal sequence /31-214/ remains unchanged on the surface. The pattern is problematic to Bao’s analysis since /31-214/ does not undergo register dissimilation as /214-31/ does. In order to solve this problem, Bao (1999) proposes a rule which is not applicable to 31-214:

\[(7) \quad \text{(Bao 1999:59)} \quad r \Rightarrow r / \, \text{__} \, 31 \]

\[\text{H} \]

The phonological rule in (7) says that the register node is assigned a $H$ feature only when the following tone is the low falling tone 31. Nevertheless, the register rising rule is ad hoc because it lacks the phonetic motivation and the rule is not generalized from a phonological natural class. In other words, there is no reason why the other low register contour 214 does not trigger the register dissimilation. The restricted behavior of register assimilation/dissimilation makes itself doubtful. In Pingyao dialect (Hou 1980), only /35-13/ and /13-53/ (2 of 9 disyllabic tonal combination) go through tone sandhi and surface as [13-13] and [35-423]. It seems to be the case of the register spreading from the second tone to the first tone. However, Yip (1995:484) questions it by claiming that “Pingyao remains the most convincing case of Register spread…but its restricted nature…makes it less than totally convincing”. One may argue that register dissimilation is quiet productive rather than ‘highly restricted’ in Yantai tone sandhi. However, the statistically major patterns (i.e. surface forms that have the different contour and register)
are still possibly confounded with other factors. Therefore, we should consider other motivations which can explain both regular alternations and exceptions better.

Second, there is a counterexample to the theory of CTU. Duanmu (1990, 1994) argued against CTUs by showing contour tone splitting in another Chinese dialect, New Shanghai, which is similar to most of African tone languages. Since New Shanghai and other dialects such as Yantai belong to the same language family, the theory of CTU, which is claimed as a typological difference between Asian and African tone languages, is doubtful.

To conclude this section, I argue that the analysis of Yantai tone sandhi based on the combination of OCP and CTU is not well-motivated and is possibly an illusion. In the next section, I will try to give an alternative analysis which is based on the phonetic explanation of tone sandhi of contours.

3. A phonetically-based analysis to tone sandhi of contours

In this section, I will propose an alternative analysis which is motivated by phonetics. Yantai tone sandhi can separate into three parts and two out of the three sandhi forms are phonetically-based. First, the tone sandhi of a 55-55 sequence is well-motivated by OCP-High which is cross-linguistically common, such as in Shona (Meeussen’s rule, Leben 1973).

Second, the complex contour tone 214 rarely occurs on the first syllable with an exception of 214-55 sequence. Moreover, 214 is never chosen as a target tone of tone sandhi and it is always that non-final tones undergo tone sandhi. For example, 55-55 tone sandhi is triggered by OCP, but the output is 31-55 rather than 214-55. According to Bao (1999), 214-55 is able to be the target tone of tone sandhi for /55-55/ since 214 has different register height and contour from 55. Moreover, Qian et al. (1982) shows that there are three melodies for trisyllabic non-compound words, which are chosen by the last underlying tone of the word. In these three fixed trisyllabic melodies, 214 never occurs on the first or the second syllable. Therefore, the restriction of 214 on the first syllable of a disyllabic sequence may be motivated by phonetics. Zhang (2002) proposes that the tone bearing ability is highly related to the phonetic duration of a syllable. In Zhang’s proposal, the phonetic data shows that the phonetic duration of a syllable becomes shorter as a word becomes longer. That is, non-final syllables of a polysyllabic word are shorter than the syllable of a monosyllabic word. Therefore, Zhang’s proposal supports that the non-final tone sandhi of 214 is restricted on the first syllable in a disyllabic word in Yantai because a complex contour requires longer syllable duration. Since the phonetic duration of the syllable is shortened in a disyllabic word, it is no longer able to bear the complex contour 214 in Yantai. On the other hand, 214 is not restricted on the second syllable of a disyllabic word because it is a word-final syllable which is supported by the final lengthening.

I will start the third point by Hakha Lai tone sandhi since Hakha Lai provides

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4 For example, Myers (2006) runs an experiment on OCP of prevocalic and postvocalic glide within Mandarin syllables such as *uou. The negative effect of OCP is significant, but it is confounded with lexical density.

5 214 occurs in the first or the second syllable of trisyllabic compound words. In this case, 214 might be protected by the output-output faithfulness constraint (Benua 1995, 1997).
another phonetically-based motivation for tone sandhi. Hakha Lai is a tone language of Tibeto-Burman group, which also has three lexical tones: L, HL and LH (Hyman and Vanbik 2002, 2004). The disyllabic tonal patterns are as follows:

(8) Post-sandhi disyllabic tone patterns in Hakha Lai (Hyman and Vanbik 2004:825)

<table>
<thead>
<tr>
<th>Tone 1</th>
<th>Tone 2</th>
<th>HL</th>
<th>LH</th>
<th>L</th>
</tr>
</thead>
<tbody>
<tr>
<td>HL</td>
<td>HL-L</td>
<td>HL-LH</td>
<td>HL-L</td>
<td></td>
</tr>
<tr>
<td>LH</td>
<td>LH-HL</td>
<td>LH-HL</td>
<td>L-L</td>
<td></td>
</tr>
<tr>
<td>L</td>
<td>L-L</td>
<td>L-L</td>
<td>L-L</td>
<td></td>
</tr>
</tbody>
</table>

As shown in (8), there is no tonal gap between two adjacent tones in surface forms by changing one of the two underlying tones (bolded font). If the analysis is based on the tonal model proposed by Bao (1999), Hakha Lai contour tone sandhi /LH-LH/ \[\Rightarrow [HL-LH]\] will be treated as the contour tone dissimilation. Nevertheless, Hyman and Vanbik (2004) propose that “This constraint is thus a syllable-contact phenomenon driven by an articulatory tendency to minimize tonal ups and downs” (Hyman 1978:261). Hakha Lai tone sandhi is triggered by such a phonetic tendency and tones are changed with tonal metathesis or deletion. It is then formalized as NO JUMP principle in Hyman and Vanbik (2004). A Chinese dialect, Danyang (Lu 1980), represents the similar tonal alternation to Hakha Lai. There are six surface forms of the disyllabic tonal combination which are 11-11, 42-11, 42-24, 33-33, 24-55, 55-55 and show almost no tonal gap.

Hyman (1975) also argues against that Third Tone Sandhi in Beijing Mandarin as in (5) is triggered by OCP of two identical contours. In Beijing Mandarin, two adjacent complex contours /214-214/ becomes [35-214] on the surface. Hyman argues that it is also because of the phonetic tendency of minimizing the articulatory efforts. Underlyingly, /214-214/ forms three tonal curves which are 214, 141 and 414. The surface form [35-214] shows the decrease in tonal ups and downs because it only forms two tonal curves which are 352 and 514.

With the similar phonetic tendency, Yantai tone sandhi can be triggered by minimizing tonal ups and downs. The post-sandhi disyllabic patterns of Yantai are recalled from (3) as follows:

(9) Post-sandhi disyllabic tone patterns in Yantai (Bao 1999:58)

<table>
<thead>
<tr>
<th>Tone 1</th>
<th>Tone 2</th>
<th>31</th>
<th>214</th>
<th>55</th>
</tr>
</thead>
<tbody>
<tr>
<td>31</td>
<td>35-31</td>
<td>31-214</td>
<td>31-55</td>
<td></td>
</tr>
<tr>
<td>214</td>
<td>35-31</td>
<td>55-214</td>
<td>214-55</td>
<td></td>
</tr>
<tr>
<td>55</td>
<td>55-31</td>
<td>55-214</td>
<td>31-55</td>
<td></td>
</tr>
</tbody>
</table>

As shown in (9), eight out of the nine disyllabic patterns only form a tonal curve (For example, 351 in [35-31]); the exceptional one [31-214] forms three tonal curves (e.g. 312, 121 and 214) with a small pitch bounce (i.e. 121) from the bottom. This phonetic explanation allows us to analyze Yantai tone sandhi without the theory of CTU.

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6 For example, LH-L \[\Rightarrow L-L\] is a deletion of the high tone of the underlying LH.
After clarifying the possible phonetic motivations, I will try to formalize them as phonological constraints in the next section. Meanwhile, under the framework of Optimality Theory, the interaction between markedness constraints and faithfulness constraints can explain why a surface form is chosen.

4. An Optimality-Theoretic account

In this section, I will discuss every different disyllabic combination and how constraints are ranked to generalize an optimal output of that combination. In 4.1, I will argue that 214 in Yantai is underlyingly /315/ which undergoes the reduction of tonal steepness. With this assumption, the analysis of tone sandhi can be simplified. In 4.2, I will analyze the underlying high tone sequence /55-55/ as the cross-linguistic violation of OCP. In 4.3, the reduction of the complex contour on non-final syllables will be discussed. In 4.4, I will integrate the phonetic motivation of minimizing tonal ups and downs into the OT analysis.

4.1. Reduction of tonal steepness

In Yantai, tones in surface disyllabic combinations include 55, 31, 214 and 35. Except 214, all tones are composed of 1, 3 or 5. If we assume that 214 is derived from underlying /315/, we are able to generalize simpler underlying tonal contrasts (i.e. a three-level contrast) in Yantai. Zhang (1998) proposes an OT analysis which formalizes the reduction of tonal steepness. For example, contour tones 35 and 53 in Pingyao dialect are reduced to 24 and 54 on the checked syllable (i.e. syllables which end in one or more obstruent coda) which has shorter syllable duration. Zhang (1998) proposes a markedness constraint family that evaluates the tonal steepness of a contour:

\[
*\text{STEEPNESS} = x
\]  
(cf. \*GESTURE(distance = x) in Myers and Tsay 2003)

The tonal steepness of a contour cannot be more than \(x\).

For examples, if there is a contour 53, it violates \*STEEPNESS = 2 because (5 – 3) = 2. If there is a complex contour 242, it violates \*STEEPNESS = 4 because ((4 – 2) + (4-2)) = 4. Moreover, since smaller tonal steepness is easier to be articulated, there is an intrinsic ranking hierarchy in this constraint family:

\[
*\text{STEEPNESS} = x >> *\text{STEEPNESS} = y \iff x \text{ is more than } y.
\]

The constraint family of tonal steepness interacts with the faithfulness constraints and the typology of tonal steepness can be derived.

In Yantai, we assume that [214] is derived from underlying /315/. It implies that Yantai does not allow tonal steepness of ((3 – 1) + (5 – 1)) = 6, but allows tonal steepness of ((2 –1) + (4 – 1)) = 4. Thus, we can conclude that the faithfulness constraint IDENT-T interacts with \*STEEPNESS = x as follows:

\[
*\text{STEEPNESS} = 6 >> *\text{STEEPNESS} = 5 >> \text{IDENT-T} >> *\text{STEEPNESS} = 4
\]

Moreover, since the reduction of tonal steepness cannot be fixed through the tonal
deletion, we can conclude the faithfulness constraint $\text{MAX-T}$ is also high-ranked. The OT analysis is as follows:

$\text{(13) } /315/ \rightarrow [214]$  

<table>
<thead>
<tr>
<th></th>
<th>$\text{MAX-T}$</th>
<th>$*\text{STEEP} = 6$</th>
<th>$*\text{STEEP} = 5$</th>
<th>$\text{IDENT-T}$</th>
<th>$*\text{STEEP} = 4$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\varnothing$</td>
<td>[214]</td>
<td></td>
<td></td>
<td>**</td>
<td>*</td>
</tr>
<tr>
<td>[215]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>[314]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>[315]</td>
<td>*!</td>
<td></td>
<td>*</td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>[31]</td>
<td>*!</td>
<td></td>
<td>*</td>
<td></td>
<td>*</td>
</tr>
</tbody>
</table>

In (13), [214] is the optimal output since it only violates lower-ranked $\text{IDENT-T}$ twice and $*\text{STEEPNESS} = 4$ once. The last candidate is ruled out since it violates higher-ranked $\text{MAX-T}$ with tonal deletion; other candidates are ruled out since they have larger tonal steepness.

Following the above analysis, the underlying representation of lexical tones in Yantai can be assumed to be 55, 31 and 315. The simplification of the underlying representation of lexical tones in Yantai will also simplify the following analysis in 4.3 and 4.4.

4.2. OCP and the high tone sequence

This section will discuss the tone sandhi pattern /55-55/ $\rightarrow$ [31-55] in Yantai. As mentioned in section 3, high tone dissimilation is cross-linguistically triggered by OCP such as in Shona. There are few constraints which play important roles here:

(14) a. **OCP**
Adjacent identical tones are forbidden.

b. **IDENT-T**
Underlying tonal height must be preserved on the surface.

c. **DEP-L**
A surface low tone must have an underlying correspondence.

The alternation from /55-55/ to [31-55] involves the tonal change from underlying /55/ to the surface mid tone [3] and an insertion of the surface low tone [1]. Therefore, in the above constraints, **OCP** must outrank faithfulness constraints **IDENT-T** and **DEP-L**. Besides, it should be noticed that the underlying high tone sequence does not change to [214-55]. As reviewed in section 3, Zhang (2002) proposes a phonetic motivation that an extremely long tone (i.e. complex contour tone) is highly marked on non-final syllables. The argument can be further formalized into the following constraint:

(15) $*\text{COMPLEXC-σ}_{\text{Non-final}}$
Complex contours cannot occur non-finally.

---

Traditionally, a level tone is transcribed as a long level such as 55, which does not stand for two 5 tones.
The constraint in (15) is also higher-ranked and rules out the candidate [214-55]. The analysis is as follows:\(^8\)

(16) /55-55/ → [214-55]

<table>
<thead>
<tr>
<th>/55-55/</th>
<th><strong>COMPLEXC-σ\textsubscript{Non-final}</strong></th>
<th>OCP</th>
<th>IDENT-T</th>
<th>DEP-L</th>
</tr>
</thead>
<tbody>
<tr>
<td>[31-55]</td>
<td>*</td>
<td></td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>[55-55]</td>
<td></td>
<td>*!</td>
<td></td>
<td></td>
</tr>
<tr>
<td>[35-55]</td>
<td></td>
<td>*!</td>
<td></td>
<td></td>
</tr>
<tr>
<td>[214-55]</td>
<td></td>
<td>*!</td>
<td>*</td>
<td>**</td>
</tr>
</tbody>
</table>

In (16), [31-55] is the optimal output since it only violates two lower-ranked faithfulness constraints IDENT-T and DEP-L. On the other hand, [55-55] and [35-55] both violate higher-ranked OCP. The last candidate [214-55] violates another high-ranked constraint **COMPLEXC-σ\textsubscript{Non-final}**.

In Bao’s (1999) analysis, the reason why /55-55/ does not change to [35-55] is possibly because 35 and 55 both are high in the register category and therefore violate OCP on the register height.\(^9\) Instead of OCP on the register height, the alternative analysis takes the general view that [35-55] violates OCP with adjacent high tones, which is less controversial. Moreover, the phonetically motivated constraint **COMPLEXC-σ\textsubscript{Non-final}** helps ruling out the candidate [214-55] which was unexplained in the previous analysis.

4.3. Reduction of non-final contour

In the previous section, the analysis showed that the alternation from underlying /55-55/ to surface [31-55] is not only because of the violation of OCP. The surface form [214-55] is ruled out because the phonetic restriction of non-final complex contours. In this section, tone sandhi of the non-final complex contour 214 in Yantai will be discussed with the same phonetic motivation.

In 4.1, I assume that the surface [214] is derived from the underlying /315/. Therefore, the underlying form of the post-sandhi tonal sequence [35-31] is /315-31/. The phonetic motivation of the non-final complex contour reduction is clear in 4.2, but the question is how the complex contour is reduced. In this case, the alternation from /315-31/ to [35-31] involves the deletion of the underlying low tone /1/. Therefore, we can conclude that if a complex contour has to be reduced, a low tone is preferred to be deleted over the high tone deletion. Therefore, the constraint **COMPLEXC-σ\textsubscript{Non-final}** is expected to interact with following faithfulness constraints:

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\(^8\) I ignore candidates which change the final 55 to avoid OCP because final tones never undergo tone sandhi in Yantai. Those candidates might be ruled out with the higher-ranked RIGHTPROMINENCE constraint (Hyman and Vanbik 2004).

\(^9\) [35-55] does not violate OCP on contours in Bao’s analysis since 35 is a CTU which has different contour features with level tones.
(17) a. **MAX-H**
An underlying high register tone must have a surface correspondence.

b. **MAX-L**
An underlying low register tone must have a surface correspondence.

(17a) preserves 5, 4 and 3 which are in the high register category; (17b) preserves 2 and 1 which are in the low register category. Since the high tone of a complex contour is preferred to be deleted in the complex contour reduction, **MAX-H** is the highest-ranked and **MAX-L** is the lowest-ranked. The complete analysis is as follows:

| (18) /315-31/ \(
| \begin{array}{ccc}
| \text{315-31/} & \text{MAX-H} & * \text{COMPLEXC-} \sigma_{\text{Non-final}} & \text{MAX-L} \\
| \hline
| \text{\[35-31\]} & * & * & * \\
| \text{\[214-31\]} & * & * & * \\
| \text{\[31-31\]} & * & * & * \\
| \end{array}
| \)

In (18), the optimal output \[35-31\] only violates lower-ranked **MAX-L** and the faithful candidate \[214-31\] crucially violates \(* \text{COMPLEXC-} \sigma_{\text{Non-final}}\). How underlying /315/ is reduced to a smaller contour \[214\] with the limited syllable duration is ignored here. The last candidate \[31-31\] deletes the underlying high tone and become a shorter falling contour 31, but crucially violates **MAX-H**. The analysis simplifies Yantai tone sandhi since it claims \[35-31\] involves merely tonal deletion rather than OCP on the register height and contours of a CTU.

However, as in \[214-55\] tonal sequence, /315/ is not reduced to a simple contour on the first syllable. If the underlying /315/ is simplified to \[35\] or \[31\], it is unnecessary to reduce the steepness of the complex contour. That is, neither does \[35\] nor \[31\] violate higher-ranked \(* \text{STEEPNESS} = 5\) or so on. Nevertheless, the tonal simplification of the complex contour in /315-55/ will surface as \[35-55\] which fatally violates higher-ranked OCP. \[31-55\] does not have any OCP violation, but crucially violates **MAX-H** as in (18). At the first, there is no evidence of the ranking among OCP, **MAX-H** and \(* \text{COMPLEXC-} \sigma_{\text{Non-final}}\) in (16) and (18). Nevertheless, the optimal output \[214-55\] here suggests that OCP and **MAX-H** outranks \(* \text{COMPLEXC-} \sigma_{\text{Non-final}}\). The complete OT analysis is as follows:

| (19) /315-55/ \(
| \begin{array}{cccc}
| \text{315-55/} & \text{*STEEP} = 5 & \text{MAX-H} & \text{OCP} & \text{*COMPLEXC-} \sigma_{\text{Non-final}} \\
| \hline
| \text{\[214-55\]} & * & * & * & * \\
| \text{\[35-55\]} & * & * & * & * \\
| \text{\[31-55\]} & * & * & * & * \\
| \text{\[315-55\]} & * & * & * & * \\
| \end{array}
| \)

\(^{10}\) Some theories categorize the mid tone 3 into the low register category such as Woo (1969) and Yip (1980). However, mid level tone 33 interacts with voiceless onsets which induce a higher initial pitch in many tone languages (Yip 1995). It could be possible that 33 is phonetically 22 and those theories are based on it. Here I assume the mid tone 3 has the high register in Yantai dialect.
Since /315/ will be forced to reduce to [214] in (19), it avoids violating OCP by reducing the final high tone 5 to a lowered high tone 4. Therefore, [214-55] is the optimal output and either [35-55] or [31-55] is ruled out if /315/ is shortened on the surface.

In this section, I have discussed tonal sequences which are relevant to the phonetic restriction on the non-final complex tone. There is another relevant tonal sequence /315-315/ which alternates to [55-214] and I will leave it to the next section.

4.4. Minimizing tonal ups and downs

The last part of Yantai tone sandhi in this alternative analysis is the effect of minimizing the tonal gap. As reviewed in section 3, Hyman (1975, 1978) proposes that tone sandhi might be triggered by the phonetic tendency of minimizing articulatory efforts which are tonal ups and downs here. For example, Third Tone Sandhi rule in Mandarin changes /214-214/ to [35-214] and simplifies tonal ups and downs in the surface form. Based on the argument, I propose a markedness constraint family in OT as follows:

\[(20)\quad \text{**CURVE} = x \quad \text{A tonal sequence cannot form } x \text{ tonal curve(s) in a prosodic domain (foot, prosodic word, etc.).}\]

A rising-falling tonal curve is formed when there is a tonal sequence \( \alpha - \beta - \gamma \), and tone \( \beta \) is higher than tone \( \alpha \) and tone \( \gamma \). On the other hand, a falling-rising tonal curve is formed when tone \( \beta \) is lower than tone \( \alpha \) and tone \( \gamma \). Since less tonal ups and downs are preferred, there is an intrinsic ranking hierarchy with this constraint family as phonetically-based **STEEPNESS = x in 4.1:

\[(21)\quad \text{**CURVE} = x \quad > > \quad \text{**CURVE} = y \quad \text{iff } x \text{ is more than } y.\]

For example, since a tonal curve is preferred over two tonal curves, **CURVE = 2 must outranks **CURVE = 1. In Mandarin, the underlying tonal sequence /214-214/ forms three tonal curves which are 214, 142 and 214; /214-214/ surfaces as [35-214] which forms two tonal curves 352 and 214. In terms of OT, the faithfulness constraint must be ranked between **CURVE = 3 and **CURVE = 2 and the OT-analysis is as follows:

\[(22)\quad \text{Third tone sandhi rule in Mandarin}\]

<table>
<thead>
<tr>
<th>/214-214/</th>
<th>**CURVE = 3</th>
<th>MAX-T</th>
<th>**CURVE = 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>[35-214]</td>
<td>*</td>
<td>**</td>
<td>*</td>
</tr>
<tr>
<td>[55-214]</td>
<td></td>
<td></td>
<td>**!</td>
</tr>
<tr>
<td>[214-214]</td>
<td>*!</td>
<td></td>
<td>*</td>
</tr>
</tbody>
</table>

In (22), [35-214] is the optimal output since it simplifies tonal ups and downs. [55-214] is ruled out because it is over-simplified. The faithfulness candidate [214-214] is also ruled out because of too many tonal ups and downs. The similar analysis can also apply to Yantai tone sandhi.
In Yantai, the underlying /31-31/ surfaces as [35-31] which forms a single tonal curve 353. Besides, the surface disyllabic tonal sequences in (3) all form only a single curve or merely a falling slope as in [55-31]. Therefore, it can be concluded that the constraint *CURVE = 2 is higher-ranked than both the faithfulness constraint IDENT-T and *CURVE = 1. The OT-account of the /31-31/ → [35-31] tone sandhi is as follows:

(23) /31-31/ → [35-31]

<table>
<thead>
<tr>
<th>/31-31/</th>
<th>*CURVE = 2</th>
<th>IDENT-T</th>
<th>*CURVE = 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>[35-31]</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>[214-31]</td>
<td>*!</td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>[31-31]</td>
<td>*!</td>
<td></td>
<td>*</td>
</tr>
</tbody>
</table>

In (23), candidates that violate *CURVE = 2 are ruled out. The optimal output is therefore the one which only forms a single tonal curve. The analysis simply shows a typological difference between Mandarin and Yantai dialect. Mandarin allows two or less tonal curves, but Yaitai dialect only allows a single tonal curves. The typological difference is able to be predicted with the interaction between faithfulness constraints and the constraint family *CURVE = x.

The evaluation of tonal ups and downs does not merely trigger /31-31/ → [35-31] tone sandhi. It also affects /315-315/ → [55-214] tone sandhi which was left to be explained in the previous section. The tone sandhi pattern shows an overapplication of complex contour tone reduction. The ranking hierarchy in (18) will therefore predict the wrong output:

(24) /315-315/ → [55-214], Wrong Prediction

<table>
<thead>
<tr>
<th>/315-315/</th>
<th>MAX-H</th>
<th>*COMPLEXC-σNon-final</th>
<th>MAX-L</th>
</tr>
</thead>
<tbody>
<tr>
<td>[35-214]</td>
<td>*!</td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>[31-214]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>[214-214]</td>
<td>*!</td>
<td></td>
<td>*</td>
</tr>
</tbody>
</table>

In (24), the optimal output is wrongly predicted as [35-214] because the real optimal output is ruled out by violating higher-ranked constraint MAX-H. Nevertheless, the wrongly predicted output [35-214] forms two tonal curves which are 352 and 514. Thus, it is still possible to predict the real output by ranking *CURVE = 2 higher than MAX-H:

(25) Revisiting /315-315/ → [55-214]

<table>
<thead>
<tr>
<th>/315-315/</th>
<th>*CURVE = 2</th>
<th>MAX-H</th>
<th>*COMPLEXC-σNon-final</th>
<th>MAX-L</th>
</tr>
</thead>
<tbody>
<tr>
<td>[55-214]</td>
<td>*!</td>
<td></td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>[35-214]</td>
<td>*!</td>
<td></td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>[214-214]</td>
<td>*!</td>
<td></td>
<td></td>
<td>*</td>
</tr>
</tbody>
</table>

In (25), since [35-214] forms two tonal curves, it is ruled out by *CURVE = 2. The optimal output [55-214] can therefore be correctly predicted. This pattern supports the above argument that the evaluation of tonal curves plays an important role in triggering
tone sandhi or deciding how the surface tone is chosen after tone sandhi in Yantai dialect.

The last unexplained disyllabic tonal pattern in Yantai dialect is /31-214/ which does not go through tone sandhi. According to Bao (1999), it is because the ad hoc rule (7) does not apply to the disyllabic tonal sequence as reviewed in section 2. In this section, the evaluation seems not able to explain the disyllabic tonal sequence either since [31-214] seem to form three tonal curves which are 312, 121 and 214. However, the tonal curve 121 is merely a small bounce from the bottom. Therefore, the tonal pattern [31-214] might ignore the relatively small tonal curve and be treated as a single tonal curve 314 or 324. If it is true, than it will only violate lower-ranked *\textsc{curve} = 1 and will not go through tone sandhi. The constraint family is probably able to be fixed to be more phonetically detailed to describe the scale of tonal curves. In sum, a more complete phonetic explanation to [31-214] is preferred over the ad hoc rule (7) based on the questionable theory of CTU.

5. Conclusion

In this paper, I shortly discussed an alternative approach to Yantai tone sandhi which is phonetically-based. Nevertheless, even though the analysis is well-motivated by phonetics, it is still not well enough. For example, since the phonetic data is not available, it is unknown whether the phonetic pitch is the same as the transcription. Therefore, a phonetic study of Yantai tone sandhi is definitely worth doing. However, we are still possible to decide which analysis is more explanatory even if the phonetic data is not available. I argue that the theory of CTU is apparently not reliable basically for two reasons. First, the theory of CTU claims that there are two kinds of contour tones for some unknown reasons. From the perspective of Universal Grammar, it is more proper to assume that universally all the contour tones are phonologically the same. Tone sandhi patterns that seem to be based on the theory of CTU can be explained alternatively by other cross-linguistic principles or constraints or so on. Second, as I kept emphasizing previously, Duanmu (1990, 1994) found the counterexample from New Shanghai dialect. I therefore reanalyze Yantai tone sandhi with cross-linguistic tendencies which are motivated by phonetics. I expect that more typological differences of tone sandhi can be predicted with such phonetically-based approach.

References

Benua, Laura. 1997. Transferderivational Identity: Phonological Relations between Words. Doctoral dissertation, University of Massachusetts Amherst, Amherst, MA.

\footnote{11 I am grateful to Michael Kenstowicz and Feng-fan Hsieh who pointed this out to me.}


