The Falling of the Rising Tone in Mandarin Chinese*

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This paper mainly examines four issues within the framework of Optimality Theory (Prince and Smolensky 1993, McCarthy and Prince 1993): the nature of the changed Tone 2, Tone 2 Sandhi (T2S), Tone 3 Sandhi (T3S), the interaction with T2S and T3S. T2S refers to the phenomenon in which the contour of final Tone 2s produced by Southern Min (SM) speakers in Taiwan becomes falling. In this paper, T2S is treated as a weakening/neutralization process in final positions. Phonetic evidence shows that the changed Tone 2 does fall. Evidence from perception and its interaction with T3S imply that changed Tone 2 is phonologically Tone 3. For T2S, the constraint *Rising [], which disallow rising contour in final positions, is proposed to be the triggering constraints. To avoid violating *Rising [], a final Tone 2 is forced to change. This paper shows that this T2S, as well as its interaction with T3S, can be well captured in OT.

Key words: tone sandhi, second tone sandhi, third tone sandhi, sandhi interaction

1. Introduction

This paper is aimed to discuss an unexplored sandhi phenomenon—The Second Tone Sandhi (henceforth T2S) which occurs in the Mandarin Chinese spoken by Southern Min (henceforth SM) speakers in Taiwan.¹ T2S manifests itself by changing the rising contour of a second tone to a falling one² in final positions when not preceded

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¹ In Mandarin, there are four phonemic tones: Tone 1, Tone 2, Tone 3, and Tone 4, which are represented in this article as H, LH, L, HL, respectively. The three Chinese dialects spoken in Taiwan are Southern Min, Hakka, and Mandarin. The population of Southern Min speakers is about 76% of all the people in Taiwan.

² For distinction, the sandhi tone derived from the second tone is marked as *ML, reflecting the falling contour in phonetics.
by a third tone. See the data below.

(1) UR → PR Glossary

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<tbody>
<tr>
<td>a.</td>
<td>i.  ( t^b \text{ian}^H \text{t}^a \text{an}^LH )</td>
<td>→</td>
<td>i.  ( t^b \text{ian}^H \text{t}^a \text{an}^{*ML} )</td>
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<td></td>
<td>ii. ( \text{tci}a^H \text{nian}^LH \text{xua}^LH )</td>
<td>→</td>
<td>ii. ( \text{tci}a^H \text{nian}^LH \text{xua}^{*ML} )</td>
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<td>b.</td>
<td>i.  ( \text{t}^\circ \text{ian}^H \text{nian}^LH \text{xua}^LH )</td>
<td>→</td>
<td>i.  ( \text{t}^\circ \text{ian}^H \text{nian}^LH \text{xua}^{*ML} )</td>
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<td>ii.  ( \text{t}^\circ \text{ie}^L \text{tie}^LH \text{lun}^LH )</td>
<td>→</td>
<td>ii.  ( \text{t}^\circ \text{ie}^L \text{tie}^LH \text{lun}^{*ML} )</td>
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<td>c.</td>
<td>i.  ( \text{ci}^H \text{tie}^LH )</td>
<td>→</td>
<td>i.  ( \text{ci}^H \text{tie}^{*ML} )</td>
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<td></td>
<td>ii.  ( \text{wu}^H \text{tie}^LH )</td>
<td>→</td>
<td>ii.  ( \text{wu}^H \text{tie}^{*ML} )</td>
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<tr>
<td>d.</td>
<td>i.  ( \text{yn}^L \text{shi}^{LH} )</td>
<td>→</td>
<td>i.  ( \text{yn}^L \text{shi}^{LH} )</td>
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<td></td>
<td>ii.  ( \text{t}^\circ \text{ian}^L \text{xuei}^{LH} )</td>
<td>→</td>
<td>ii.  ( \text{t}^\circ \text{ian}^L \text{xuei}^{LH} )</td>
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<td>e.</td>
<td>i.  ( \text{y}^L \text{k}^h \text{uai}^{HL} )</td>
<td>→</td>
<td>i.  ( \text{y}^L \text{k}^h \text{uai}^{HL} )</td>
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<td></td>
<td>ii.  ( \text{tci}a^{H} \text{nian}^LH \text{xua}^LH \text{xuei}^H )</td>
<td>→</td>
<td>ii.  ( \text{tci}a^{H} \text{nian}^LH \text{xua}^LH \text{xuei}^H )</td>
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</table>

As we can see in (1a-c), the second tone undergoes a tonal change (LH → *ML) in final positions when the preceding tone is H, LH, HL, respectively. (1d) shows that the final LH does not change when preceded by L. The data in (1e) indicate that T2S does not apply when the LH is not in final positions.

The data in (1d) suggest that there exists some constraint prohibiting L-*ML sequence and thus forcing the final LH to stay unchanged. However, Some SM speakers, especially the elders, make the final LH fall, regardless of this constraint. In this kind of cases, the preceding L tone changes to LH after the final LH changes to *ML. Below are some examples.

(2) a. \( \text{pan}^L\text{la}^L \text{jaw}^H \text{tsa}^H\text{ja}^H \text{n} \) → \( \text{pan}^L\text{la}^L \text{jaw}^H \text{tsa}^H\text{ja}^H \) *ML

‘Originally (I) want (to do it) in this way.’

b. \( \text{ta}^H \text{hen}^L \text{nana}^L \text{shi}^H \text{hou}^H \) → \( \text{ta}^H \text{hen}^L \text{nana}^{*ML} \text{shi}^H \text{hou}^H \)

‘He is very hard to get along with.’

In (2a), the underlying L-LH sequence \( \text{pan}^L\text{la}^L \text{jaw}^H \) comes up as LH-*ML \( \text{pan}^L\text{la}^L \text{jaw}^H \text{tsa}^H\text{ja}^H \text{n} \). This process is reminiscent of the well-known Mandarin Tird Tone Sandhi (henceforth T3S). 3 Is it T3S that really plays a role here? If it is, the interaction

3 The Third Tone Sandhi is essentially formulated as: L ──→ LH / ___ L. However, it is not
between T2S and T3S will be worth exploring. (See later sections)

Several questions arise concerning the data above. First, what role does *ML play phonologically? Second, what is the nature of T2S, and what phonological processes are involved? Third, why is a final LH immune to T2S when it is preceded by a L tone, and how does T2S interact with other sandhi processes, for example, T3S? These questions will be explored from an Optimality Theory (henceforth OT, Prince and Smolensky 1993) perspective, which sees a grammar as a set of universal, violable constraints. To account for the tonal alternations resulting from T2S, pre-OT theories, or rule-based theories, cannot do without exceptions or extra conditions for a rule. For example, if a rule is formulated as a LH tone falls in final positions, we cannot explain why it does not fall when preceded by a L tone. All we can do is claim it as an exception or make it a specific condition attached to the rule. This is, however, not explanatorily adequate and not economic enough. Unlike rule-based theories, OT constraints evaluate input and output forms at the same time and there may be more than one constraint involved in a single phonological process. The reason why a LH tone does not fall in final positions before a L tone becomes palpable with the observation that the candidate “L-*ML” incurs a fatal violation while others do not. In this way all the relevant processes concerning T2S can be fully captured at the same time.

2. Relevant studies
2.1 Falling of LH in Taiwanese Mandarin

In the previous literature, the falling of LH is barely mentioned in Duanmu (2000), which points out that one of the major characteristics of Taiwanese Mandarin (henceforth TM) is the use of *ML at a phrase boundary for what is LH or H in Standard Chinese (henceforth SC, the dialect considered standard by people in Mainland China). His examples are given as follows:

<table>
<thead>
<tr>
<th>Phonetic sounds</th>
<th>Taiwanese Mandarin</th>
<th>Standard Mandarin</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. [tsou-la]</td>
<td>‘walk ASP (left)’</td>
<td>L-*ML</td>
</tr>
<tr>
<td>b. [xaix-aul-a]</td>
<td>‘still good ASP (not bad)’</td>
<td>LH-L-*ML</td>
</tr>
</tbody>
</table>

phonologically that simple. For more discussion, see Cheng (1973), Shih (1986) and Chung (1992).

4 Duanmu uses L, which is replaced with *ML to make it consistent here.
c. $[\text{khF}-\text{n}^{\text{L-HH}}\text{N}]$

‘maybe’ L-*ML L-LH

d. $[\text{thai}-\text{f}^{\text{HH}}\text{i}]$

‘too fat’ HL-*ML HL-LH

e. $[\text{ca-z}^{\text{HL}}\text{rn}]$

‘shrimp (without shell)’ H-*ML H-LH

There is, however, a difference between Duanmu’s descriptions and our data here. According to our collection, few, if any, TM speakers produce $L-L$ ($L-*ML$) sequence. Most of them abide by T3S and turn $L-L$ into $LH-L$. Thus, $[\text{khF}^{\text{L-LH}}-\text{nN}]$ ‘maybe’ is still $L-LH$ in TM. Moreover, Duanmu does not spend much space probing into the nature of this tonal alternation. Much room, therefore, has been left for this article.

2.2 Previous OT-based treatments to T3S

Since the interaction of T2S with T3S is one of our main concerns, we are going to review and discuss some OT-based approaches to T3S in this section.5

2.2.1 Lin’s (2001) analysis

In her thesis, Lin (2001) proposes three constraints for the nature of T3S, which are given in (4). The constraint ranking is listed in (5).

\begin{enumerate}
  \item The Tonal Constraints (Lin 2001)
  \begin{enumerate}
    \item $\ast LL$: Avoid adjacent low tones.
    \item $\text{IO-Ident}$: The tones in the output must be identical to those in the input.
    \item $\text{ParseR}$: Parse the tonal value of the rightmost tone of the outmost domain.
  \end{enumerate}
\end{enumerate}

\begin{enumerate}
  \item The ranking of these constraints
  \begin{enumerate}
    \item $\text{ParseR} \gg \ast LL \gg \text{IO-Ident}$
  \end{enumerate}
\end{enumerate}

By nature, (4a) is a constraint directly translated from the Mandarin tone sandhi rule that disallows two low tones to occur in an adjacent string and is motivated by OCP, which prohibits adjacent identical elements. $\text{IO-Ident}$ is a Faithfulness constraint demanding an output form to be exactly the same as its input. $\text{ParseR}$ is a constraint based on the claim that Mandarin, like Min and some Southern Wu dialects, has a right-dominant prosody that tends to maintain the identity of the right-most tone. With these three constraints, the selection of the optimal T3S output is shown in (6).

\footnote{For a detailed review and comments on pre-OT treatments to T3S, see Lo (2004).}
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In words, (6a) is the optimal output, which only violates the low-ranked \textit{IO-Ident}. As for the candidates in (6b,c), the second L is changed to LH (L \rightarrow LH), violating the undominated \textit{ParseR} and thus being ruled out. The candidate (6d) changes nothing, violating \textit{*LL}, in spite of its satisfying the low-ranked \textit{IO-Ident}.

Lin’s analysis adapts a general constraint \textit{IO-Ident} to show the conflict between the \textit{Markedness} constraint (\textit{*LL}) and this \textit{Faithfulness} constraint, which sticks to OT’s basic essence. Unfortunately, however, this analysis overlooks some generalizations.

First, it fails to explain why T3S can only turn L into LH but not into H or HL. The tableau in (7) shows the model would wrongly select “HL-L” and “H-L” as optimal.

Second, if the anti-two-adjacent-third-tone constraint is set to be \textit{*LL}, then why is there no tonal change in words like \textit{xaw}^{\text{L}} \textit{jang}^{\text{HL}} ‘ocean’ and \textit{fa}^{\text{HL}} \textit{y}^{\text{L}} ‘French (HL-L)’, where there are also \textit{L-L} sequences? This can be explained by stating that contour tones in Mandarin act as a whole. However, if it were incorporated into the concept of constraints, the analysis would be much more complete. (see later sections).

2.2.2 Wu (2002)

One chapter in Wu (2002) is devoted to the analysis of disyllabic reduplicated terms in Mandarin. There is a class of terms in Mandarin that utilize reduplication to show emphasis. When a monosyllabic term like “\textit{xaw}^{\text{L}} ‘good’” reduplicates, there are two possible surface structures. In one surface structure, T3S applies (\textit{xaw}^{\text{LH}} \textit{xaw}^{\text{L}}) while in the other T3S fails to apply. Instead, the second L tone changes to a neutral tone (\textit{xaw}^{\text{L}} \textit{xaw}^{\text{Neutral}}). In what follows, our attention will be placed on the former case. Some examples are provided in (8) below (The tone of a syllable is upper-marked. N stands for a neutral tone.).
Clearly, T3S applies here. To deal with this process, Wu proposes six relevant constraints, which are listed below in (9). Their ranking is shown in (10).

(9) The constraints for the reduplicated kinship forms (Wu 2002)

a. *LL: No adjacent Tone 3.

b. *σ: Every syllable bears a tone.

c. *T: Surface tone must not be the same as its underlying tone.

d. Ident-BR(T): A tone in the Red (reduplicant) must be the same with its correspondent in the Base.

e. Ident-IB(T): A tone in the Base must be the same with its correspondent in the input.

f. Ident-IR(T): A tone in the Red must be the same with its correspondent in the input.

(10) The Ranking of These Constraints

*σ >> *LL >> *T, Ident-IR(T) >> Ident-IB(T) >> Ident-BR(T)

The constraint *LL in (9a) prohibits two adjacent low tones, which is based on Lin (2001). In (9b), *σ requires that every surface syllable bear a tone. This constraint is based on the fact that Mandarin Chinese is a tone language, in which tones are phonemic. *T in (9c) is an “Anti-Faithfulness Constraint” (Alderete 1999), which requires tones to surface as changed tones. With these constraints defined, the formation of these reduplicated forms can be depicted in the following tableau (B stands for Base and R for Reduplicant).

(11)
The candidate (11a), in which there are two adjacent L tones, violates *LL and therefore is ruled out. (11b) violates *T and (11c) violates Ident-IR. These two are selected as optimal because (11d) and (11e) violate both *T and Ident-IR and thus are inferior to (11b) and (11c). The candidate (11f) is wiped out by the undominated *σ because the two syllables are toneless.

Wu’s analysis, too, gets some demerits. First, as Lin’s analysis, the constraint *LL is a little ad hoc. Second, the reason why it is the first L in the L-L pair to change, but not the second one, is left unanswered. While Lin (2001) makes use of the constraint ParseR to limit the change to the first L, there is no such a mechanism in Wu’s analysis. Third, under the constraints and their ranking in (10), candidates such as σB σR L and σB σR L can be wrongly selected as optimal, as shown in the tableau below.

<table>
<thead>
<tr>
<th>(12)</th>
<th>σL, RED</th>
<th>*σ</th>
<th>*LL</th>
<th>*T</th>
<th>Id-IR(T)</th>
<th>Id-IB(T)</th>
<th>Id-BR(T)</th>
</tr>
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<tbody>
<tr>
<td>a.</td>
<td>σB σR L</td>
<td>*</td>
<td>**</td>
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<td></td>
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<tr>
<td>b. σB HH σR L</td>
<td>*</td>
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<td>*</td>
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<tr>
<td>c. σB LH σR N</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>d. σB H σR L</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>e. σB HL σR L</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td></td>
<td></td>
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<tr>
<td>f. σB σR</td>
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</table>

The candidates (12d) and (12e) are as optimal as (12b) because they incur the same violations on the same constraints, the hence are (wrongly) selected. Fourth, there are some problems with the violation mark incurred by (11b) of *T. The candidate σB HH σR L incurs one violation mark of *T in (11). However, according to the definition of *T (Surface tone must not be the same as its underlying tone.), (11b) sweetly satisfies *T because the tone on the first syllable (LH) is not the same as its underlying tone (L) and the tone on the second syllable does not have a correspondent underlyingly (Reduplicants do not have inputs afterall.) and is not sensitive to *T. In consequence, (11b) does not violate *T and will be the only optimal form under this analysis.

The fifth problem resides in the theoretical assumption for Mandarin Reduplication. Throughout Wu’s analysis, the reduplicant is always by the right side of its base, that is, reduplicant behaves as a suffix. There is, however, another possibility. The reduplicant can work as a prefix and settled by the left side of its base. These two cases are equally possible because the two surface syllables have the same segments. The differences between the two are shown in (13) below.
For T3S, setting the reduplicant as a prefix may answer the question why the first L undergoes change but not the second one. Since the second L has a corresponding input and the first one (reduplicated one) does not, the first one is more likely to change, immune to any Faithfulness constraint. However, a successful analysis on this topic may not neglect such a point.

3. Our analysis

We are now ready for proposing our account for T2S within the framework of OT. We will first examine the nature of the changed LH. Then, we will provide the OT analyses of T2S, T3S, and the interaction between T2S and T3S.

3.1 The status of *ML

This section examines the nature of the changed *ML resulting from T2S. Evidence from phonetic analyses, listeners’ perception, and the interaction with T3S will be provided to shed more light on the nature of *ML.

3.1.1 It does fall!

It can easily be noticed that the LH produced by SM speakers truly falls in final positions, sometimes with a little rise at the end, just like L in Mandarin Chinese. With the advent of powerful tools for phonetic analysis such as Praat, we can get a more substantial picture of the *ML in phonetics. In (14) are two pitch graphs of LH in final positions. The SM speaker in (14a) is a twenty-four-year-old male and the NonSM speaker in (14b) is a twenty-five-year-old male.
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(14)  \text{yie}^{L} \text{you}^{L} \text{ren}^{LH} \text{tsu}^{LH} \text{‘(There is) also species of human.’} \\
     a. SM speaker:

\begin{figure}
\centering
\includegraphics[width=0.5\textwidth]{SMSpeaker.png}
\caption{Graph of SM speaker's pronunciation of (14).}
\end{figure}

b. NonSM speaker:

\begin{figure}
\centering
\includegraphics[width=0.5\textwidth]{NonSMSpeaker.png}
\caption{Graph of NonSM speaker's pronunciation of (14).}
\end{figure}

As shown in (14a), the LH on the final syllable \textit{tsu} apparently falls down dramatically at first and then rises a bit at the end. On the contrary, the LH on \textit{tsu} in (14b) rises smoothly to the end. The slight and gradual fall at the beginning is due to the rising of the preceding LH. This influence of the preceding rise is not unusual if we look at tones in Chao’s digits. Two adjacent LHs can be represented in Chao digits as 35-35. Reasonably, when one produces the first LH, which finishes at a high pitch 5, he/she must lower their pitch to or approximately to 3 in order to start the second LH. Therefore, this act of lowering may carry on to the beginning part of the producing process of the second LH, generating the slight falling in (14b). The beginning fall of the final LH in (14a), however, is quite different because of the following two reasons. First, the LH before the final LH in (14a) does not rise so high as that in (14b), which implies the change occurring to the final LH influences the preceding LH more or less, and thus reflects differences between the two final LHs. Second, the rise at the end of the final LH in (14b) rises higher than its beginning point, which makes it sound like a normal LH. On the other hand, the final rise of the final LH in (14a) does not rise so high. The ending point of the final rise is lower than the beginning point of the LH, which makes it sound, holistically, as a falling tone.
From the discussions above, there is no doubt that the final LH does fall. Hence, we have good reason to have the falling LH represented as *ML.

3.1.2 *ML perceived as L

The changed LH, which is denoted with *ML here, is also supported by the following dialogue.

(15) A: ni\(^L\)-mən\(^LH\) k\(^b\h\)-tɕia\(^H\)-xua\(^H\) xu\(^LH\)-tie\(^{*ML}\) tʂən\(^L\)-mə\(^N\) tɕiaŋ\(^L\)?
you – PL Hakka – language butterfly how speak
’How do you say “butterfly” in Hakka?’
B: a\(^N\)? ʂən\(^LH\)-mə\(^N\) ku\(^LH\)-tian\(^L\)?
Q what classic
’What? What classic?’

In (15) what speaker A wants to convey is [xu\(^LH\)-tie\(^LH\)] ‘butterfly,’ which is a disyllabic word with LH on both syllables. Speaker B, however, misunderstands it and perceives it as ku\(^LH\)-tian\(^L\) ‘classic.’ Apparently, this is due to the fact that speaker B perceives the second syllable of xu\(^LH\)-tie\(^LH\) as *ML (the changed LH), which is phonetically similar to the Mandarin L tone. Cases like (15) are quite common in our everyday conversations. Further data can be shown in (16). Note that those data are extracted from a dialogue. They are taken from one of the author’s personal experiences. “S” stands for the speaker and “L” for the listener.

(16) a. S: aɿ\(^HL\) cjaŋ\(^H\)-swej\(^{*ML}\)
love each other-follow
’title of a song (love following each other)’
L: aɿ\(^HL\) cjaŋ\(^H\)-swej\(^L\)
love fragrant-water
’love perfume’

b. S: pʰwo\(^HL\)-laŋ\(^HL\) tɕiaŋ\(^LH\)-ni\(^{*ML}\)
break-wave Johnny
’surfing Johnny’
L: pʰwo\(^HL\)-laŋ\(^HL\) tɕiaŋ\(^L\) ni\(^L\)
break-wave rob you
’surfing to rob you’

c. S: lju\(^LH\)-ɕiŋ\(^H\) xwa\(^H\)-yan\(^{*ML}\)
float-star flower-field
’title of a soap opera (the garden of shooting stars)’
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L:  iju\(^{\text{LH}}\)-cin\(^{\text{H}}\)  xwa\(^{\text{H}}\)  yan\(^{\text{L}}\)
float-star  flower  far
‘N/A’

d. S:  pwo\(^{\text{H}}\)-li\(^{\text{LH}}\)  cje\(^{*\text{ML}}\)
glass  shoe  ‘glass shoes’

L:  pwo\(^{\text{H}}\)-li\(^{\text{LH}}\)  cje\(^{\text{L}}\)
glass  blood  ‘N/A’

In (16a), the final LH syllable “swej” is perceived as a L syllable “ßwej,” whereby “following each other” becomes “perfume.” The final LH syllable “ni” becomes L in the listener’s perception. T3S is also at work here, leading “tcjañ\(^{\text{LH}}\)-ni\(^{*\text{ML}}\)” to “tcjañ\(^{\text{L}}\) ni\(^{\text{L}}\).” (16c) and (16d) are the instances in which the misunderstanding leads to meaningless expressions. It seems that the T2S incurs misunderstanding in communication.

The data discussed in this section present a picture in which *ML is usually realized as L in perception. In other words, people fail to differentiate *ML from L without being particularly specified.

3.1.3 T2S and T3S

As mentioned in the preceding section, on many occasions the changed LH [*ML] is realized as L. If this is the case, the next question is raised: Is there any psychological reality for the *ML? If *ML is psychologically supported, it naturally follows that it would trigger T3S, which means that the L tone will change to LH if it is followed by *ML. It implies that T3S can be reformulated as L → LH / ____ [L or *ML]. To test whether this is true, consider the data below:

(17) a.  ji\(^{\text{i}^\text{i}}\)-sαñ\(^{\text{HL}}\)  swo\(^{\text{L}}\)-jen\(^{\text{LH}}\)...
→  ji\(^{\text{i}^\text{i}}\)-sαñ\(^{\text{HL}}\)  swo\(^{\text{L}}\)-jen\(^{*\text{ML}}\)...
above  be  said
‘(What) has been mentioned above, …’

b.  tc\(^{\text{h}^\text{b}}\)-in\(^{\text{LH}}\)-tσαñ\(^{\text{HL}}\),  ni\(^{\text{L}}\)  laj\(^{\text{LH}}\)  la.
→  tc\(^{\text{h}^\text{b}}\)-in\(^{\text{LH}}\)-tσαñ\(^{\text{H}}\),  ni\(^{\text{LH}}\)  laj\(^{*\text{ML}}\)  la.
personal name  you  come  ASP
‘tc\(^{\text{h}^\text{b}}\)-in-tσαñ, you (have) come.’

c.  tc\(^{\text{h}^\text{b}}\)-jen\(^{\text{LH}}\)-nαñ\(^{\text{LH}}\),  sι\(^{\text{HL}}\)  xαn\(^{\text{L}}\)  tc\(^{\text{h}^\text{b}}\)-jan\(^{\text{LH}}\)  xαn\(^{\text{L}}\)  tc\(^{\text{h}^\text{b}}\)-jan\(^{\text{LH}}\)  tc\(^{\text{h}^\text{b}}\)-jan\(^{\text{LH}}\)  to.
→  tc\(^{\text{h}^\text{b}}\)-jen\(^{\text{LH}}\)-nαñ\(^{*\text{ML}}\),  sι\(^{\text{HL}}\)  xαn\(^{\text{L}}\)  tc\(^{\text{h}^\text{b}}\)-jan\(^{\text{LH}}\)  xαn\(^{\text{L}}\)  tc\(^{\text{h}^\text{b}}\)-jan\(^{\text{LH}}\)  tc\(^{\text{h}^\text{b}}\)-jan\(^{\text{LH}}\)  to.
hidden-power, is very powerful very powerful very powerful Adj-suf.
‘Potential, is very very powerful.’
In (17a), underlying “swo\(^{\text{L}}\)-jen\(^{\text{LH}}\)” becomes “swo\(^{\text{LH}}\)-jen\(^{\text{ML}}\)” in surface. This can hardly be accounted for if we do not assume that the L-LH sequence becomes L-*ML, due to T2S, and then the L-*ML sequence becomes LH-*ML under T3S. The two stage derivations in phonology are also observed in (17b) and (17c), where “ni\(^{\text{L}}\) laj\(^{\text{LH}}\)” becomes “ni\(^{\text{LH}}\) laj\(^{\text{ML}}\)” (17b), and “te\(^{\text{h}}\)jen\(^{\text{LH}}\) -nøŋ\(^{\text{LH}}\)” and the final “xøn\(^{\text{L}}\) tc\(^{\text{h}}\)jaŋ\(^{\text{LH}}\)” become “tc\(^{\text{h}}\)jen\(^{\text{LH}}\)-nøŋ\(^{\text{ML}}\)” and “xøn\(^{\text{LH}}\) tc\(^{\text{h}}\)jaŋ\(^{\text{ML}}\)” respectively (17c). Note that the aspect marker “lø” (17c) and the suffix “tø” (17c) have no tone of their own and hence they are treated as a final position for the preceding element. That the changed LH (*ML) triggers T3S provides powerful evidence for the psychological reality of *ML.

In a nutshell, we conclude that the changed LH, phonetically realized as *ML, plays a role on a par with L for SM speakers in Taiwan.

### 3.2 The nature of T2S: an OT perspective

In this section, we are going to approach the nature of T2S in the light of OT. In the form of rules, T2S may be captured as a final LH falling down when not preceded by L. This sandhi process is illustrated in (18). The dot denotes a syllable boundary and the symbol \(.]_o\) indicates a final position.

(18) Falling of LH in Final Positions

<table>
<thead>
<tr>
<th>Input</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>H.LH (.]_o)</td>
<td>H.L (.]_o)</td>
</tr>
<tr>
<td>LH.LH (.]_o)</td>
<td>LH.L (.]_o)</td>
</tr>
<tr>
<td>HL.LH (.]_o)</td>
<td>HL.L (.]_o)</td>
</tr>
</tbody>
</table>

Here, we assume that the falling of LH is a neutralization, or weakening process. For the weakening to apply to a full extent, what one needs to do is to format a constraint allowing only the elements which involve fewest efforts from the articulators. In terms of tone, this element will be “no tone at all”. This constraint for can be formatted as \(*T \]_o\).\(^6\) However, this is not the case with T2S, in which L occurs in the final position. The simplest resolution might replace \(*T \]_o\) with \(L \]_o\), which allows only L to occur at the syllable boundary. This, however, is much like the spirit of rule-based account in ruling out other tones without further interpretation. On the other hand, it also predicts that Mandarin has only L-toned monosyllabic words, which is not the case. Therefore, we must find some other way out.

In Yip (2002), it is proposed that a constraint like \(*T\) is a tonal markedness

---

\(^6\) This kind of constraints is referred to as “context-sensitive markedness constraints” in Kager (1999).
constraint that prohibits any surface association of tones. This proposal is quite different from \(*T\) in Lin (2001) and Wu (2002), where it is treated as an anti-faithfulness constraint, requiring a tone to surface as its sandhi form. According to Yip 2002, \(*T\) is a cover constraint for all the other tonal markedness constraints, including \(*H\), \(*L\), \(*Rising\), and so on. When there is no need to consider these constraints, it is convenient to use the cover constraint. When they are active and play an important role, they can be decomposed and have different rankings depending on different languages.

Here we follow Yip by assuming that \(*T\) is a cover constraint, incorporating constraints such as \(*H\), \(*L\), and \(*Rising\). In this way we can limit the tone subject to T2S to LH by the following constraint:

\[
(19) \quad *\text{Rising} \succ\text{FaithTone} \succ *T
\]

No rising tones are allowed in final positions

This tonal markedness constraint forces the final LH to change; however, this change violates the faithfulness cover constraint, \(\text{FaithTone}\). As a result, \(*\text{Rising}\) must out-rank \(\text{FaithTone}\). Moreover, that other tones do not undergo any change in final positions implies that \(\text{FaithTone}\) is ranked higher than any other tonal constraints referring to final positions (\(*H\), \(*L\), \(*\text{Falling}\),…). For convenience, we still use the cover constraint \(*T\) for them. We now have the ranking \(*\text{Rising}\) \(\succ\) \(\text{FaithTone} \succ *T\). However, this is not the end of the story. One important question remains to be answered: Why does T2S change a final LH to *ML (or L), rather than to any of the other tones?

By reasoning, H and HL are allowed to occur in final positions, for neither of them violates \(*\text{Rising}\). Note that under the ranking \(*\text{Rising}\) \(\succ\) \(\text{FaithTone} \succ *T\), the failure of generating H and HL in final positions comes very naturally (blocked by \(*H\) and \(*\text{Falling}\)). However, it also prevents L from being generated in final positions (by \(*L\)). For this problem, Yip (2002) provides another inspiration. It is proposed that within a syllable, the first (or only) tone is the head tone and the second one, the non-head. For example, in the contour tone LH, L is the head tone and H is the non-head. It is the non-head tone that is prone to change. With this background, we have the following constraint:

\[
(20) \quad \text{FaithNuclearTone}
\]

The head tone of a syllable must be identical with its correspondent in the input.

Given that \(\text{FaithNuclearTone}\) is undominated, the LH can only change to *ML, or phonetically, L (LH → L). The ranking is presented in (21) and the tableau for the falling of the LH in final positions is shown in (22).
(21) The Ranking for the Falling of LH in Final Positions
   \[ \text{Faith nuclear Tone, *Rising } \]_# \Rightarrow \text{Faith Tone} \Rightarrow *T \]_# \Rightarrow *T \]

(22) Tableau for the Falling of LH in Final Positions

<table>
<thead>
<tr>
<th>H.LH ]_#</th>
<th>FaithNucTone</th>
<th>*Rising ]_#</th>
<th>FaithTone</th>
<th>*T ]_#</th>
<th>*T</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. H.LH ]_#</td>
<td>*!</td>
<td></td>
<td></td>
<td>***</td>
<td></td>
</tr>
<tr>
<td>b. H.L ]_#</td>
<td></td>
<td>*(Max-T)</td>
<td></td>
<td>**</td>
<td></td>
</tr>
<tr>
<td>c. H.H ]_#</td>
<td>*!</td>
<td>*(Max-T)</td>
<td>*(*H ]_#)</td>
<td>**</td>
<td></td>
</tr>
<tr>
<td>d. H.HL ]_#</td>
<td>*!</td>
<td>*(Linearity)</td>
<td>*(Falling ]_#)</td>
<td>***</td>
<td></td>
</tr>
</tbody>
</table>

The most faithful candidate (22a), in which the final LH remains unchanged, incurs a fatal violation of \*Rising ]_#, so it is ruled out in spite of its satisfying FaithTone. Candidates (22b), (22c), and (22d) satisfy \*Rising ]_#, but (22c), and (22d) violate FaithNuclearTone. This makes (22b) the most harmonic candidate and thus it is selected as the optimal output.

The constraints and ranking in (21) are anything but the final version for T2S. A full account must include a final L-LH string, where the final LH stays unchanged. We will explore this in the next section.

3.3 Interactions between T2S and T3S

In the previous sections, the interaction between T2S and T3S has been identified. When preceded by L, the final LH stays intact. When the final LH changes, it triggers T3S. In what follows, we first provide our OT-based analysis for T3S. Then we will look into the interaction between T2S and T3S.

3.3.1 Our OT analysis for T3S

Simply put, T3S requires the L to change into LH when followed by another L. This has been an intriguing topic in the literature (Cheng 1973, Shih 1986, Lin 2001, Wu 2002). However, they are inadequate in one way or another, as reviewed in Section 2.

The prohibition on the two successive L tones reflects that there is an \(OCP\) constraint banning two adjacent low tones. Note that \(OCP\) is also a cover constraint which can further be decomposed into constraints like \(OCP(H)\), \(OCP(L)\), and \(OCP(LH)\). The constraint at work here is \(OCP(L)\), which is shown in (23).

(23) \(OCP(L)\)

No adjacent low tones are allowed.
The constraint (23) works in conjunction with other OCP constraints staying in the general OCP cover constraint: \( \text{OCP(General)} \) (Yip 2002). A rough picture of T3S can be captured by this ranking: \( \text{OCP(L)} >> \text{FaithTone} >> \text{OCP(General)} >> *T \), as is illustrated below.

(24) The Tableau for the General T3S Pattern

<table>
<thead>
<tr>
<th></th>
<th>OCP(L)</th>
<th>FaithTone</th>
<th>OCP(General)</th>
<th>*T</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. L.L</td>
<td>!</td>
<td></td>
<td></td>
<td>**</td>
</tr>
<tr>
<td>b. LH.L</td>
<td>*(Dep-T)</td>
<td></td>
<td></td>
<td>***</td>
</tr>
</tbody>
</table>

In (24), the candidate (24a) is ruled out because it incurs a fatal violation on \( \text{OCP(L)} \). Consequently, (24b) is selected as optimal. These constraints and their ranking seem to be able to account for T3S successfully. However, interested readers may ask the following questions: Why is it always the first L that changes? Why should L change to LH but not other tones?

In Lin (2001), the constraint \( \text{ParsR} \) (see Section 2) is adopted to account for why it is always the first L that changes. \( \text{ParsR} \) works under the assumption that Mandarin Chinese is right-dominant in prosody. However, the headedness of the prosody of Mandarin Chinese is still a controversial issue. Shih (1986) and Chen (1996) argue that Mandarin feet are right-headed, while Duanmu (1994, 1996) argues that they are left-headed. In the following discussion, we will follow the former proposal that Mandarin feet are right-headed.

According to Yip (1999), there is a cross-linguistic tendency for prosodic heads to retain their properties in output and non-headed elements tend to change. It naturally follows that we have a cover constraint for the faithfulness in head positions:

(25) \( \text{HeadFaithTone} \)

A tone in head position must be identical with its correspondent in the input.

This constraint prohibits any change on the head tone. In T3S, \( \text{HeadFaithTone} \) is ranked topmost, ensured by the fact that only the left L is subject to change.

As for the next question why L should change to LH but not other tones, the constraint \( \text{FaithNuclearTone} \) comes into play. Since the nuclear of L is L in itself, a L tone can change only to LH (LH) in order to preserve its nuclear tone.

In terms of ranking, \( \text{FaithNuclearTone} \) is ranked on a par with \( \text{HeadFaithTone} \), both of which are undominated. So we have the following ranking: \( \text{FaithNuclearTone}, \text{HeadFaithTone}, \text{OCP(L)} >> \text{FaithTone} >> \text{OCP(General)} >> *T \). The general T3S
pattern thus comes into light, as shown below in (26).\(^7\)

(26)  The Tableau for T3S (final version)

<table>
<thead>
<tr>
<th>L.L</th>
<th>FaithNucT</th>
<th>HeadFaithT</th>
<th>OCP(L)</th>
<th>FaithTone</th>
<th>OCP(General)</th>
<th>*T</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. H.L</td>
<td>*!</td>
<td></td>
<td>*(Ident(T))</td>
<td>**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. L.H.L</td>
<td>*(Dep-T)</td>
<td>*!</td>
<td></td>
<td></td>
<td></td>
<td>**</td>
</tr>
<tr>
<td>c. L.L</td>
<td></td>
<td>*!</td>
<td></td>
<td></td>
<td></td>
<td>***</td>
</tr>
<tr>
<td>d. HL.L</td>
<td>*!</td>
<td></td>
<td>*(Dep-T)</td>
<td></td>
<td></td>
<td>***</td>
</tr>
<tr>
<td>e. L.LH</td>
<td></td>
<td>*!</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Both the candidates (26a) and (26d) are ruled out at the beginning since they violate the undominated FaithNuclearTone. The candidate (26e) violates HeadFaithTone because there is change on the head. Thus, (26d) is chosen as optimal.

In this way, our OT account has overcome the difficulties encountered in the literature. Now we are ready for the analysis of the interaction between T2S and T3S.

3.3.2 T2S interacting with T3S

We first look at the case in which the final LH does not fall when preceded by a L tone. Presumably, this results from the fact that OCP(L) outranks *Rising \(|\_\_\_\|\). With this in mind, we will get the ranking in (27) if we combine the constraint rankings in (22) and (26).

(27)  FaithNuclearTone, HeadFaithTone, OCP(L) >> *Rising \(|\_\_\_\| >> FaithTone >> OCP(General), *T \_\_\_ >> *T

However, this ranking cannot prevent the candidate L.H.L \(_\_\_\| to become optimal. This is illustrated in the tableau in (28) (The undominated FaithNuclearTone and HeadFaithTone are omitted here).

---

\(^7\) Actually, this tableau leaves one question unanswered: Does an input like (26d) with two adjacent Ls (HL.L) violate OCP(L) and triggers T3S? This problem can be taken good care of by separating OCP constraints into two general constraints: OCP(Whole Tone) and OCP(Constituent Tone) (Yip 2002). In this way, the OCP constraint for T3S is actually OCP(Whole L). See Lo (2004:58-61) for more detailed discussions.
(28)

<table>
<thead>
<tr>
<th>L.LH ]ₜ</th>
<th>OCP(L)</th>
<th>*Rising ]ₜ</th>
<th>FaithTone</th>
<th>OCP(General)</th>
<th>*T ]ₜ</th>
<th>*T</th>
</tr>
</thead>
<tbody>
<tr>
<td>☞ a. L.LH ]ₜ</td>
<td>*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>***</td>
</tr>
<tr>
<td>☞ c. LH.L ]ₜ</td>
<td>*(Dep-T,Max-T)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>***</td>
</tr>
</tbody>
</table>

In (28), the candidate (28c), which represents the result of T3S, passes through both \( OCP(L) \) and \( \text{*Rising } ]ₜ \) and is wrongly selected as the optional. To cope with this, we assume that the faithfulness constraint \( \text{Dep-T} \), previously hidden under the cover constraint \( \text{FaithTone} \), now plays a crucial part here. \( \text{Dep-T} \) prohibits any epenthetic tone without an input correspondent. (29c) violates \( \text{Dep-T} \) because of the epenthetic \( \text{H} \). Therefore, \( \text{Dep-T} \) is ranked between \( OCP(L) \) and \( \text{*Rising } ]ₜ \). Now we have the final version of our T2S. The constraints and ranking are indicated in (29) and the tableau in (30) (The undominated \( \text{FaithNuclearTone} \) and \( \text{HeadFaithTone} \) are omitted here).

(29) The Constraints and Ranking for T2S

\( \text{FaithNuclearTone, HeadFaithTone, OCP(L)} \gg \text{Dep-T} \gg \text{*Rising } ]ₜ \gg \text{FaithTone} \gg \text{OCP(General), } \text{*T } ]ₜ \gg \text{*T} \)

(30) The Tableau for the Final LH Preceded by Tone 3

<table>
<thead>
<tr>
<th>L.LH ]ₜ</th>
<th>OCP(L)</th>
<th>Dep-T</th>
<th>*Rising ]ₜ</th>
<th>FaithTone</th>
<th>OCP(General)</th>
<th>*T ]ₜ</th>
<th>*T</th>
</tr>
</thead>
<tbody>
<tr>
<td>☞ a. L.LH ]ₜ</td>
<td></td>
<td></td>
<td>*</td>
<td></td>
<td></td>
<td></td>
<td>***</td>
</tr>
<tr>
<td>☞ c. LH.L ]ₜ</td>
<td></td>
<td></td>
<td>*!</td>
<td></td>
<td>*(Max-T)</td>
<td></td>
<td>***</td>
</tr>
</tbody>
</table>

Note that drawing \( \text{Dep-T} \) out of \( \text{FaithTone} \) doesn’t influence our treatment to T2S above. Providing HL.LH ]ₜ as input, we still have HL.L ]ₜ as the optimal output, as shown in (31).

(31)

<table>
<thead>
<tr>
<th>HL.LH ]ₜ</th>
<th>FNucT</th>
<th>OCP(L)</th>
<th>Dep-T</th>
<th>*Rising ]ₜ</th>
<th>FaithTone</th>
<th>OCP(General)</th>
<th>*T ]ₜ</th>
<th>*T</th>
</tr>
</thead>
<tbody>
<tr>
<td>☞ a. HL.LH ]ₜ</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>***</td>
</tr>
<tr>
<td>☞ b. HL.L ]ₜ</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>*(Max-T)</td>
<td></td>
<td></td>
<td>***</td>
</tr>
<tr>
<td>c. HL.H ]ₜ</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>*(Max-T)</td>
<td></td>
<td>*(H ]ₜ)</td>
<td>***</td>
</tr>
<tr>
<td>d. HL.HL ]ₜ</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>*(Linearity)</td>
<td>*</td>
<td>*(Falling ]ₜ)</td>
<td>****</td>
</tr>
</tbody>
</table>

For the case in which T2S does apply and trigger T3S, the constraint \( \text{*Rising } ]ₜ \) is
ranked above both OCP(L) and Dep-T. This ranking is in need to save the violation of *Rising ]# when T2S activates. Then to avoid violating OCP(L), the lower-ranked Dep-T is violated. Since *Rising ]# and OCP(L) are never violated in this case, we assume that they are both undominated. Putting Dep-T back to its cover constraint FaithTone, we get the ranking in (32) below and the tableau is provided in (33) (The undominated FaithNuclearTone and HeadFaithTone are omitted here).

(32) The Constraints and Ranking for T2S Triggering T3S

FaithNuclearTone, HeadFaithTone, *Rising ]#, OCP(L) >> FaithTone >> OCP(General), *T ]# >> *T

(33) The Tableau for T2S Triggering T3S

<table>
<thead>
<tr>
<th>Constraint</th>
<th>*Rising ]#</th>
<th>OCP(Wh,L)</th>
<th>FaithTone</th>
<th>OCP(Gen)</th>
<th>*T ]#</th>
<th>*T</th>
</tr>
</thead>
<tbody>
<tr>
<td>L.LH ]#</td>
<td>*!</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>***</td>
</tr>
<tr>
<td>L.L ]#</td>
<td></td>
<td>*!</td>
<td>*(Max-T)</td>
<td>*(L ]#)</td>
<td>**</td>
<td></td>
</tr>
<tr>
<td>c. LH.L ]#</td>
<td></td>
<td></td>
<td>**(Dep-T, Max-T)</td>
<td>*(L ]#)</td>
<td>***</td>
<td></td>
</tr>
</tbody>
</table>

Note that (33c) incurs two violation marks on FaithTone now (Max-T and Dep-T) since Dep-T is set under the cover constraint. This shift of rankings between or among constraints, however, raises a theoretical problem. Is there any possibility that in one language more than one ranking exist? The answer is positive. Some researchers like Itô and Mester (1995), Garrett (1996), and Feliu (2001), to name just a few, propose that differences in a single language result from different rankings, too. Therefore, the differences dwelling in the interaction between T2S and T3S is raised from the different rankings.

3.4 Concluding remarks and further issues

In this paper, we first point out the specific behavior of the LH tone in Mandarin Chinese, which has never been fully explored in the literature. Briefly speaking, the LH tone will become a falling tone, which is denoted as *ML here, in final positions. Furthermore, it is indicated that tone sandhi patterns in Taiwan Mandarin can be well-captured in the framework of OT. The OT analysis gives proper and effective accounts not only for the nature of T2S and T3S, but also for the interaction between these two sandhi phenomena. In addition, this paper provides empirical support for the theories proposed in Yip (1999, 2002) that constraints like *T and OCP behave like an integrated unit on some occasions, while on others they can be further decomposed into more smaller constraints.

However, there is still room for further studies concerning T2S. When a sandhi
The phenomenon is not limited to certain specific context, the sandhi pattern depends largely on the prosodic structure of the language. T3S, for example, applies according to the foot structure of the expression. Similarly, when T2S is not confined to final positions, the prosodic structure, especially the foot structure of the expression it applies to, might influence its application. Therefore, different prosodic structures will induce different sandhi patterns. However, in tone languages like Chinese, the structure of foot has always been controversial. Given that a fully successful account for issues related to tone sandhi, whether it is put under OT or rule based framework, lies heavily upon the foot structure, there seems to be a long way to go for the prosodic exploration in the future.

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