Testing the applicability of third tone sandhi at the intonation boundary

The case of the monosyllabic topic

Chin-Ting Liu and Li-mei Chen
National Chin-Yi University of Technology |
National Cheng Kung University

The purpose of this study is to test the applicability of Tone Three Sandhi (T3S) when the critical syllable is a monosyllabic topic preceding a topic boundary. A recitation task from 37 native speakers of Taiwan Mandarin was employed. The results from human judgements indicated that the participants predominantly produced the critical syllables with Tone 3 (T3). Additionally, the fundamental frequency of the critical syllables demonstrated a falling contour, showing that T3S was not applied. Intonation break-ups and the prolongation of the critical syllables lent strong support to the view that the topic syllable was at an intonation/phonological phrase-final position. The findings can be elegantly accommodated by constraint-based analyses, which propose that T3S must be avoided when two T3 syllables are separated by an intonation/phonological phrase boundary. Issues relating to pauses, speech rates and word frequency effects are also discussed.

Keywords: Tone Three Sandhi (T3S), Tone Three Sandhi Avoidance (T3SA), intonation/phonological phrase boundary, Metrical Feet analysis, phonology-syntax interface, Mandarin Chinese

1. Introduction

This paper explores how Taiwan Mandarin speakers produce Tone Three (T3) syllables when the syllables are monosyllabic topic heads followed by another T3 subject such as the sentence in (1). The critical syllable in (1) is the topicalized monosyllabic word *chi* 'ruler', followed by a subject where the first syllable *Li* 'Li' is T3.

https://doi.org/10.1075/lali.00073.liu
Language and Linguistics 21:4 (2020), pp. 636–651. issn 1606-822x | e-issn 2309-5067 © ILAS

(1) **T3 topic followed by T3 subject**
雖然 尺，李明 用完 了，但是 還沒 收好。
suiran chi, Li Ming yong-wan le, danshi hai-mei shou-hao.
although ruler Li Ming use-finish SFP but not-yet put-away
'Although Li Ming finishes using the ruler, he doesn't put it away yet.'

In general, a T3 syllable becomes Tone 2 (T2) when it is followed by another T3 syllable in Standard Chinese, as shown in (2).[1]

(2) **Tone 3 Sandhi rule**
3 → 2 /__3

Although the Tone 3 Sandhi (T3S) phenomenon has been widely studied, few studies focused on T3S involving a topic structure. Additionally, those studies provide inconsistent intuitive surface tone judgements. For instance, Shih (1997: 102) asserts that when the T3S environment is applicable for a topic structure, T3S is optional, depending on the presence/absence of a pause. However, Yin (2003: 305) and Wee (2004: 70; 2008: 148) claim that T3S is not applicable for topic structures because the two adjacent T3 syllables are in different phonological phrase domains. As quantitative methods are of great help when intuitive judgements are inconsistent (Liu & Chen 2017 and the references therein), this study employs a production study providing quantitative results from both human judgements and acoustical analyses.

Since the seminal studies by Xu (1993; 1997; 1998), acoustical measurements have been widely used in studies pertaining to Mandarin tones (e.g. Wang et al. 2003; Zhang & Lai 2010; Chen 2011; Wong 2012; Cheng & Xu 2015; Li & Chen 2016, among many others). Acoustical analyses of tones allow us to generate time-normalized contours, which in turn enable us to make graphical comparisons. In the current study, if T3S is applied for the monosyllabic topic word, such as *chi* 'ruler' in (1), the fundamental frequency (f0) should demonstrate a rising contour. On the other hand, if T3S is not applicable, the f0 is expected to show a falling contour because the underlying T3 (the falling-rising tone) is pronounced as Half Third Tone in actual speech, where the falling part is maintained while the rising part is omitted (Chao 1968: 27; Chen 2000: 21).

Besides depicting the tone contours of the monosyllabic topic syllable, this study also includes duration measurements to explore several issues concerning T3S. First, if the presence/absence of a pause (i.e. the duration of the silence between

1. An alternative view is that the sandhi tone is a rising fundamental frequency (f0) contour and is only similar to T2. That is, the tone sandhi does not involve a categorical change of one tone (i.e. T3) to another (i.e. T2). Further discussions can be found in Yuan & Chen (2014) and the references therein.

a topic and a subject) will influence the (non-)application of T3S at the topic boundary (Shih 1997: 102), we expect that T3S should be avoided for monosyllabic topics without a detectable pause following them. Similarly, when a detectable pause is missing, T3S should take place. Next, the mean duration per syllable is measured to reflect the speech rate of each participant. If the relation between speech rates and surface T3S patterns is not rigid (Shih 1997: 85), various speech rates can be found in cases where T3S is or is not applied. Finally, Xu & Wang (2009) showed that, in Mandarin, syllable durations at phrase-final positions are the longest among syllables at phrase-initial, phrase-internal and phrase-final positions. Therefore, if the monosyllabic topic in (1) is at the intonation/phonological phrase-final position, the mean duration of the topic syllable is expected to be longer than the mean duration per syllable. In short, duration measurements such as pause duration, mean duration per syllable and topic syllable duration may inform us much about the nature of T3S.

Results from the current study can provide insights into several puzzling issues pertaining to T3S. First, results of the experiment are discussed based on analyses where the sandhi domains are constructed via interface constraints (e.g. Chen 2000; Wee 2004, 2008; Liang & Wee 2006) and via cyclic metrical foot structures (e.g. Duanmu 2000; 2007). The discussion enables us to understand the necessary ingredients of T3S analyses. Next, acoustical measurements provide insights into the relationship among the existence/absence of intonation break-ups and the (non-)application of T3S at the topic boundary. Finally, issues pertaining to word frequency effects and speech rates are discussed as well.

The organization of this study is as follows. Experimental methods and the results are described in § 2 and § 3, respectively. § 4 discusses relevant issues based on the experimental findings. § 5 concludes the paper and provides directions for future research.

2. Methods

2.1 Participants

Thirty-seven native speakers of Mandarin Chinese from a class at a university in the southern part of Taiwan joined this study. According to their self-report, none of them had any medical history of language-related disorders.

2.2 Design

The experiment employed a recitation task, in which participants read out sentences printed in a list. The complete list consisted of sixty sentences with 10 critical sentences containing a topic such as (1). For sentences involving a topic, the topic was always a T3 monosyllabic word which was followed by a name. The name was always a disyllabic word whose first syllable was another T3 syllable. Twenty sentences involving relative clauses were created for the purpose of the other study (Liu 2017). Thirty additional filler sentences were created and intermixed with other items to mask the real purpose of the experiment. The complete list of critical sentences is listed in Appendix. One thing to note here is that, due to the limited selection space for T3 syllables/words that could fit the context of the carrier sentences, we could not perfectly control the word frequency of the critical syllables/words. However, word frequency might not play a significant role in the current experiment. We shall return to this issue in § 4.3.

2.3 Procedure for data collection

Participants were invited to a quiet room individually. Each participant was able to read the list of sentences silently before the recording started. They could check the pronunciations of the words if they were not sure about the pronunciations. They were encouraged to recite those sentences as natural as possible. When the critical sentences were not correctly produced or overlapped with other noises, the participants were invited to re-produce those sentences after they finished reciting the whole list of sentences. Each participant spent around 8–15 minutes going through the whole process, depending on individual differences.

2.4 Equipment and software

All the utterances were recorded by the build-in microphone of the ASUS laptop X550L model. The software used to record and analyze the sounds was Praat (Boersma & Weenink 2018).

2.5 Human tone judgements

The tones of the critical syllables produced by the participants were judged by native speakers of Mandarin Chinese. One major coder and one additional coder were invited to judge the tones of the critical syllables to establish the reliability of the coding. The major coder judged all the critical sentences with topics produced by the participants and an additional coder judged 12.4% of the data (i.e.

46 items involving topics among a total of 370 items). According to Zhang & Lai (2010: 169), native speakers of Mandarin Chinese could easily detect the non-application of the sandhi processes; therefore, high inter-coder agreement should be observed. One thing to note here is that in natural speech and in contexts other than the environment specified in (2), the underlying T3 (the falling-rising tone) is pronounced as Half Third Tone, where the falling part is maintained while the rising part is omitted (Chao 1968: 27; Chen 2000: 21). Therefore, if the participants produced the critical syllables as Half Third Tone, the coders were instructed to identify them as T3.

2.6 Acoustic analyses

A custom-written script was used for f0 extraction and smoothing. The f0 values were extracted based on the vowel of the critical syllable, which was equally divided into 10 portions, giving rise to a total of eleven time-normalized points. To erase the potential effects from gender and inter-participant differences, the f0 values from each participant were normalized by using z scores (Chen 2011; Li & Chen 2016).

Four duration measurements were computed by using the same script. The **topic boundary duration** was measured based on the silence between the offset of the topic syllable and the onset of the subject, indicated by the low intensity curves. The **clause boundary duration** was measured based on the silence between the offset of the independent clause and the onset of the dependent clause (i.e. between *le* 'SFP' and *danshi* 'but' in (1)), indicated by the low intensity curves, too. The **mean duration per syllable** was calculated as the following formula shows: (total sentence duration – topic boundary duration – clause boundary duration) / number of syllables in the sentence. Finally, the **mean duration of the topic syllable** was measured. The onset of the topic syllable was located at the closure or constriction of the onset consonant, which was marked by low intensity curves. The offset of the topic syllable was identical to the onset of the **topic boundary duration**.

All the labels were manually tagged in Praat. Two additional coders coded the data to establish the reliability of the coding. One major coder coded all the data and the other coder coded 27% of the data (i.e. data from 10 participants out of the 37 participants). Each participant's 11 time-normalized raw f0 values were used to check the inter-coder reliability.

3. Results

3.1 Inter-coder reliability

All the surface tones used for reliability check were agreed, showing that the judgements were objective.

A Pearson's correlation was computed to assess inter-rater reliability of raw f0 values. The results showed high agreement between two coders, $r(110) = .975$, $p = .000$, indicating that the results to be reported are reliable.

3.2 Tone preferences for critical syllables

The percentage of T2 and T3 for critical syllables involving topics produced by the participants are shown in Table 1.

Table 1. Percentage and number of tokens (in the parentheses) of T2 and T3 productions involving topics

	Topic (370)
Tone 2	0.27% (1)
Tone 3	99.73% (369)

The participants consistently produced a citation tone for the critical syllables involving topics, indicating that they tended to avoid applying T3S.

3.3 F0 contour

Figure 1 shows the mean z scores of the 11 time-normalized points.

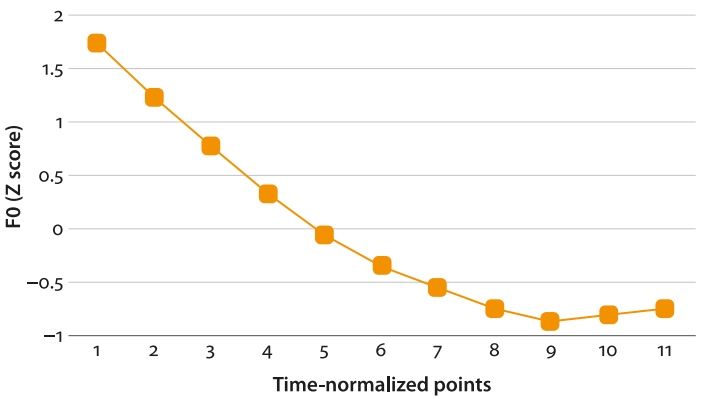

Figure 1. The f0 contour of the monosyllabic topic syllable

The f0 showed a falling contour, indicating that the participants produced the critical syllables as Half Third Tone. In other words, T3S was avoided at the topic boundary.

3.4 Duration measurements

Table 2 summarizes the mean length of the four duration measurements.

Table 2. Mean length of four duration measurements (Unit: second)

	Topic boundary	Clause boundary	Mean duration per syllable	Mean duration of topic syllable
Mean duration	0.124	0.185	0.237	0.378

A paired-samples t-test was performed to examine if there was a difference between the **topic boundary duration** and the **clause boundary duration.** The results indicated that the clause boundary duration (M= .185, SD= .132) was statistically longer than the topic boundary duration (M= .124, SD= .098), $t(36)$= -3.458, p= .001. That is, although the duration of a topic boundary was not as long as that of a clause boundary, T3S was still avoided. A closer look into the topic boundary duration revealed that, of all the analyzed instances, 27% of the topic boundary duration was zero, giving rise to the high standard deviation of the topic boundary duration. This also showed that T3S was avoided even when a noticeable pause was absent.

Another paired-samples t-test was performed to examine if there was a difference between the **mean duration per syllable** and the **mean duration of the topic syllable**. The results indicated that the **mean duration of the topic syllable** (M= .378, SD= .067) was statistically longer than the **mean duration per syllable** (M= .237, SD= .028), $t(36)$= -14.108, p= .000. The results indicated that the topic syllable, which was produced with longer duration, was at the intonation/phonological phrase-final position.

4. Discussion

The purpose of this study is to test the applicability of T3S when the critical syllable is a monosyllabic topic preceding a topic boundary. A production experiment coded by both human judgements and acoustical analyses revealed that the participants consistently avoided T3S when two T3 syllables were separated by a topic boundary. Duration measurements indicated that the participants produced the critical topic syllable with longer syllable duration and a pause generally appeared

after the topic syllable, showing that the topic syllable was at an intonation/phonological phrase-final position. Several related issues are discussed below.

4.1 Theoretical consequences of T3S analyses

The current experimental results can be elegantly accommodated by analyses where T3S domains are constructed via interface constraints (e.g. Chen 2000; Wee 2004, 2008; Liang & Wee 2006). In fact, T3S analyses following the Optimality Theory (OT) framework (McCarthy & Prince 1993; Prince & Smolensky 2004[1993]) generally agree that T3S is avoided when the two consecutive T3 syllables are in different intonation/phonological phrase domains. For instance, Wee (2004; 2008) proposes that adjacent T3 syllables are avoided within the same phonological phrase. As a topic and a subject are in different phonological phrases, the application of T3S is not triggered. Similarly, Chen (2000) proposes that connected speech can be broken up into "Minimal Rhythmic Units" (MRUs), within which T3S applies obligatorily. MRUs are bounded by Intonation Phrases (IPs), which serve as the new reference for T3S application. That is, T3S is not applicable when two adjacent T3 syllables are separated by an IP boundary. The issue then turns to the inquiry if there is indeed an intonation/phonological boundary at the topic boundary. The current experimental results, along with previous syntactic analyses concerning Mandarin topics, confirm that topics constitute their independent intonation/phonological phrase. Syntactically, topics are the theme of a series of following sentences (Li & Thompson 1976) and they stand out as the most prominent topic to form a topic chain with the following sentences (See Tsao (1979) for an introduction on the *chaining function* of topics). Therefore, Rizzi (1997: 285) proposes that a topic is set off from the clause by "comma intonation". Phonetically, noticeable pauses are generally observed between a topic and a subject and the topic syllables are produced with longer duration, showing that an intonation/phonological boundary is formed at the topic boundary.

Non-OT-based T3S analyses are also available and one of the noticeable analyses was the Metrical Feet (MF) analysis proposed by Duanmu (2000; 2007) (c.f. Sun 2006; Wang 2011). However, the current findings cannot be accommodated by the MF analysis. According to Duanmu (2007), T3S domains are constructed via cyclic metrical foot structures, as shown in (3).

(3) **Rules of Metrical Footing**
   a. Build disyllabic feet left-to-right for polysyllabic words.
   b. Build feet cyclically based on phrasal stress.[2]
   c. Build disyllabic feet left-to-right for free words.
   d. T3S starts from each foot and then applies cyclically.

e. In a T3S domain, T3 must change before T3, but can optionally change before T2 that came from T3. (Duanmu 2007: 268 (39))

After the string of syllables are grouped in different foot structure domains, T3S applies based on the rules specified in (4).

(4) a. **Condition on T3S**
T3S is obligatory over two syllables that are adjacent.
T3S is optional over two syllables that are not adjacent.
b. **Definition**
Two syllables are adjacent if they belong to the same immediate syntactic constituent and they do not belong to separated full feet.
(A full foot contains two (or more) syllables.) (Duanmu 2007: 267 (36))

In fact, one may discover that the MF analysis encompasses most of the essential ingredients for T3S analyses in the literature (e.g. Shih 1986, 1997; Zhang 1988; Hsiao 1991; Zhang 1997; Chen 2000; Yip 2002; Lin 2007; Wang & Lin 2011). First, the construction of T3S domains requires a two-level process – a word-level and a phrase-level foot parsing. Second, binary footing is preferred. Next, T3S must apply when two adjacent T3 syllables are parsed in the same domain and T3S is optional when two adjacent T3 syllables are not within the same domain. Finally, the construction of T3S domains requires the left-to-right foot parsing. Despite the soundness of the analysis, one crucial difference between the MF analysis and other OT-based analyses (e.g. Chen 2000; Yin 2003; Wee 2004, 2008) is that the context where T3S avoidance (T3SA) takes place is absent in the MF analysis. As (4a) shows, the MF analysis only specifies when T3S must apply and when T3S can be optionally applied. Consequently, the MF analysis is less likely to accommodate the surface tone patterns in (1) where T3SA is expected for the monosyllabic topic syllable. In short, an effective T3S analysis must include conditions for T3SA and must take the effect of intonation/phonological phrase boundaries into account. Additionally, the construction of T3S and T3SA domains are sensitive to the phonology-syntax interface. Different types of syntactic boundaries may exert varying degrees of influences on the formation of prosodic foot structures and it is evident that the topic boundary is the one that exerts the stronger influence than other types of syntactic boundaries do.

Finally, one additional note relating to intonation/phonological phrases is appropriate here. The MRU analysis, which is bound by intonation/phonological phrase boundaries, is criticized to be inconsistent with metrical feet (Duanmu 2007: 265). However, the role of intonation/phonological phrase boundaries has

2. Readers who are interested in Duanmu's stress assignment rules can refer to his work (Duanmu 1990; 2000; 2007: 129–157).

been recognized to be essential to speech analyses (e.g. Tseng 2010; Jeon & Nolan 2017; Kentner 2017). Therefore, T3S analyses, which construct the avoidance condition with a reference to the intonation/phonological phrase boundaries, should be acceptable.

4.2 Pauses, speech rates and T3S application

Two related issues proposed by Shih (1997) are appropriate here. First, the current findings do not support Shih's (1997: 102) view that T3S is optional for a topic syllable, depending on the presence/absence of a pause. According to the current results, although in average there was 0.124 second silence between the topic and the subject, no observable pauses were detected for 27% of the critical productions. That is, regardless of the presence or the absence of the pauses, T3SA must take place at the topic boundary.

Next, the current findings agree with Shih's (1997: 85) view that the relation between speech rates and surface tone patterns is not rigid. According to the experimental results, the participants with highest and lowest mean duration per syllable were 0.326 second and 0.189 second, respectively. However, regardless of the differences in speech rates, T3S was avoided, showing that the speech rates played an insignificant role in the case of T3SA. Instead, it was the formation of the intonation/phonological phrase boundary that contributed to the non-applications of T3S.

4.3 Word frequency effects on T3SA

As § 2.2 notes, due to the limited selection space for T3 syllables/words that could fit the context of the carrier sentences, the word frequency of the critical syllables/words could not be perfectly controlled. Nevertheless, the role of word frequency effects might be less significant for T3SA. Take the ten critical topic syllables/words for instance. The word frequency search results based on Sinica Corpus (http://elearning.ling.sinica.edu.tw/eng_teaching.html) indicated that the most frequently used lexeme is *shou* 'hand' (Rank: 384, Frequency: 1469) and the least frequently used lexeme is *san* 'umbrella' (Rank: 6693, Frequency: 71). In spite of the differences in word frequencies, the participants consistently produced those critical syllables/words as T3 in the recitation task, demonstrating that T3SA was less likely to be influenced by the word frequency effects.

5. Concluding remarks

In this paper, we tested the applicability of T3S in Taiwan Mandarin when the critical syllable is a monosyllabic topic preceding a topic boundary. Results from a recitation task demonstrated that the participants consistently avoided T3S. In addition, the monosyllabic topic syllables were produced with longer duration and pauses were generally observed after the topic syllables, showing that the topic syllable is at an intonation/phonological phrase-final position. We suggest that an effective T3S analysis must include conditions for T3SA and must take the effect of intonation/phonological phrase boundaries into account. Next, we show that the presence of T3SA does not necessarily require the presence of a noticeable pause after the topic syllable. Finally, we claim that speech rates and word frequency effects of the monosyllabic topic word play an insignificant role in T3SA. In spite of these findings, several issues deserve further attention and hence are the directions for future studies.

First, the participants in the current study speak Taiwan Mandarin as their native language and it is possible that Mandarin spoken by different speech communities in the world differs. Therefore, one might inquire if the current findings are limited to the speech community in Taiwan. However, if T3SA is a result triggered by intonation/phonological phrase boundaries, which are generally represented by a markedness constraint (c.f. Chen 2000; Wee 2004, 2008), we expect that this typological feature will persist in Mandarin spoken by different speech communities. That is, if a topic boundary always creates an intonation/phonological phrase boundary and if such a boundary serves as the new reference for T3S application (Chen 2000) or T3S never crosses different intonation/phonological phrase domains (Wee 2004; 2008), the T3SA phenomenon observed in this study must be applicable to other Mandarin speech communities, too.

Next, the critical topic words adopted in this study are always monosyllabic words. One inquiry following this design naturally is if changes in the syllable number of the topic words make a difference. That is, one may wonder whether T3SA will still be observed when the monosyllabic topics are changed into disyllabic words, trisyllabic words, or words with even more syllables. Our tentative response is that T3SA will still be observed even when the number of syllable increases for the topic words. Two reasons support our judgement. First, when Wee (2008) proposes that T3S is blocked by the topic boundary, one of the exemplar sentences used is a trisyllabic topic word (cf. Wee 2008: 148 (30b)). We agree with Wee's (2008) judgement that T3S is still blocked in this case. Second, as we mentioned above, if a topic boundary always creates an intonation/phonological phrase boundary and if T3S is blocked by the boundary, we suspect that changes in

the syllable number of the topic words might influence the creation of the boundary and hence might not exert significant influence on the non-application of T3S.

Finally, the carrier sentence of the critical items always starts with *suiran* 'although'. Therefore, the monosyllabic topic word always follows the T2 syllable *ran* 'then' in *suiran* 'although'. It is possible that the monosyllabic T3 topic avoids becoming T2 (or a rising tone) in order to avoid formulating a consecutive of two adjacent T2 syllables formed by *ran* 'then' and the sandhi tone (i.e. *chi* 'ruler' in (1)). We also tentatively claim that this possibility is unlikely for the following reasons. First, to the best of our knowledge, none of the studies in Mandarin Chinese report that adjacent T2 syllables are avoided. Second, according to the current results, the source for T3SA comes from the intonation/phonological phrase boundary followed by the topic words and therefore the contribution from the syllables preceding the topic words might be small.

In sum, future studies testing the applicability of tone sandhi at the topic boundary among different Mandarin speech communities will inform us much about the nature of T3S. Moreover, the effects contributed by the changes in the syllable number of the topic words and the tone patterns of the materials preceding the T3 topic deserve more attention.

Acknowledgements

The data reported in this paper are based on Chapter 3 of the first author's doctoral dissertation; however the framework of the current paper, the addition of acoustical analyses, the interpretation of the findings, and the directions of the discussion are distinct from the dissertation. For the kind advice, invaluable suggestions and highly constructive comments, which led to the above mentioned changes, we thank the anonymous reviewers and the editor of *Language & Linguistics*. Remaining inadequacies are our own.

Abbreviations

GUO	experiential aspect marker
IPs	Intonation Phrases
MF	Metrical Feet
MRUs	Minimal Rhythmic Units
OT	Optimality Theory
SFP	sentence-final particle
T2	Tone 2
T3	Tone 3
T3S	Tone Three Sandhi
T3SA	Tone Three Sandhi Avoidance

Appendix. Critical sentences with a monosyllabic topic word (with critical syllables in bold)

1. 雖然 **狗**，李四 餵過 了，但是 還沒 洗。
   *suiran **gou**, Li Si wei-guo le, danshi hai-mei xi.*
   although dog Li Si feed-finish SFP but not-yet wash
   'Although Lisi finished feeding the dog, he hasn't washed it yet.'

2. 雖然 **馬**，小王 餵過 了，但是 還沒 騎過。
   *suiran **ma**, Xiao Wang wei-guo le, danshi hai-mei qi-guo.*
   although horse Xiao Wang feed-finish SFP but not-yet ride-GUO
   'Although Xiao Wang finished feeding the horse, he hasn't ridden it yet.'

3. 雖然 **傘**， 老劉 用完 了，但是 還沒 收。
   *suiran **san**, Lao Liu yong-wan le, danshi hai-mei shou.*
   although umbrella Lao Liu use-finish SFP but not-yet close
   'Although Lao Liu finished using the umbrella, he hasn't closed it yet.'

4. 雖然 **米**，李易 洗完 了，但是 還沒 煮。
   *suiran **mi**, Li Yi xi-wan le, danshi hai-mei zhu.*
   although rice Li Yi wash-finish SFP but not-yet cook
   'Although Li Yi finished washing the rice, he hasn't cooked it yet.'

5. 雖然 **手**，老張 洗完 了，但是 還沒 擦乾。
   *suiran **shou**, Lao Zhang xi-wan le, danshi hai-mei ca-gan.*
   although hand Lao Zhang wash-finish SFP but not-yet dry
   'Although Lao Zhang finished washing his hands, he hasn't dried them yet.'

6. 雖然 **碗**，老謝 洗完 了，但是 還沒 烘乾。
   *suiran **wan**, Lao Xie xi-wan le, danshi hai-mei hong-gan.*
   although bowl Lao Xie wash-finish SFP but not-yet dry
   'Although Lao Xie finished washing bowls, he hasn't dried them yet.'

7. 雖然 **臉**，李白 洗完 了，但是 還沒 擦乾。
   *suiran **lian**, Li Bai xi-wan le, danshi hai-mei ca-gan.*
   although face Li Bai wash-finish SFP but not-yet dry
   'Although Li Bai finished washing face, he hasn't dried it yet.'

8. 雖然 **筆**，小明 買完 了，但是 還沒 拿來 寫過。
   *suiran **bi**, Xiao Ming mai-wan le, danshi hai-mei na-lai xie-guo.*
   although pen Xiao Ming buy-finish SFP but not-yet use write-GUO
   'Although Xiao Ming finished buying the pen, he hasn't used to write yet.'

9. 雖然 尺，李明 用完 了，但是 還沒 收好。
suiran ***chi,*** *Li Ming yong-wan le, danshi hai-mei shou-hao.*
although ruler Li Ming use-finish SFP but not-yet put away
'Although Li Ming finished using the ruler, he hasn't put it away yet.'

10. 雖然 **紙**，老陳 買完 了，但是 還沒 用過。
suiran ***zhi,*** *Lao Chen mai-wan le, danshi hai-mei young-guo.*
although paper Lao Chen buy-finish SFP but not-yet use-GUO
'Although Lao Chen finished buying the paper, he hasn't used it yet.'

References

Boersma, Paul & Weenink, David. 2018. *Praat: Doing phonetics by computer* (computer program, version 6.0.42). (http://www.praat.org/) (Accessed 2018-08-15.)

Chao, Yuen Ren. 1968. *A grammar of spoken Chinese*. Berkeley: University of California Press.

Chen, Matthew Y. 2000. *Tone sandhi: Patterns across Chinese dialects*. Cambridge: Cambridge University Press. https://doi.org/10.1017/CBO9780511486364

Chen, Yiya. 2011. How does phonology guide phonetics in segment–*f*0 interaction? *Journal of Phonetics* 39(4). 612–625. https://doi.org/10.1016/j.wocn.2011.04.001

Cheng, Chierh & Xu, Yi. 2015. Mechanism of disyllabic tonal reduction in Taiwan Mandarin. *Language and Speech* 58(3). 281–314. https://doi.org/10.1177/0023830914543286

Duanmu, San. 1990. *A formal study of syllable, tone, stress and domain in Chinese languages*. Cambridge: MIT. (Doctoral dissertation.)

Duanmu, San. 2000. *The phonology of standard Chinese*. Oxford: Oxford University Press.

Duanmu, San. 2007. *The phonology of standard Chinese*. 2nd edn. Oxford: Oxford University Press.

Hsiao, Yuchau E. 1991. *Syntax, rhythm and tone: A triangular relationship*. San Diego: University of California at San Diego. (Doctoral dissertation.)

Jeon, Hae-Sung & Nolan, Francis. 2017. Prosodic marking of narrow focus in Seoul Korean. *Laboratory Phonology: Journal of the Association for Laboratory Phonology* 8(1). 1–30. (Article 2.) https://doi.org/10.5334/labphon.48

Kentner, Gerrit. 2017. Rhythmic parsing. *The Linguistic Review* 34(1). 123–155. https://doi.org/10.1515/tlr-2016-0005

Li, Qian & Chen, Yiya. 2016. An acoustic study of contextual tonal variation in Tianjin Mandarin. *Journal of Phonetics* 54. 123–150. https://doi.org/10.1016/j.wocn.2015.10.002

Li, Charles N. & Thompson, Sandra A. 1976. Subject and topic: A new typology of language. In Li, Charles N. (ed.), *Subject and topic*, 457–489. New York: Academic Press.

Liang, Yuan & Wee, Lian-Hee. 2006. Beijinghua de lianshang biandiao [Third tone sandhi in Beijing Mandarin]. *Zhongguo Yuwen* [Studies of the Chinese Language] 2006(2). 151–163.

Lin, Yen-Hwei. 2007. *The sounds of Chinese*. Cambridge: Cambridge University Press.

Liu, Chin-Ting Jimbo. 2017. *Empirical evidence of tone three sandhi acquisition in Mandarin Chinese*. Tainan: National Cheng Kung University. (Doctoral dissertation.)

Liu, Chin-Ting Jimbo & Chen, Li-mei. 2017. Processing conjunctive entailment of disjunction. *Language and Linguistics* 18(2). 269–295.

McCarthy, John J. & Prince, Alan. 1993. *Prosodic morphology I: Constraint interaction and satisfaction* (Linguistics Department Faculty Publication Series 14). Amherst: University of Massachusetts at Amherst.

Prince, Alan & Smolensky, Paul. 2004[1993]. *Optimality theory: Constraint interaction in generative grammar*. Oxford: Blackwell. (Originally circulated in 1993 as a technical report by the Rutgers University Center for Cognitive Science.) https://doi.org/10.1002/9780470759400

Rizzi, Luigi. 1997. The fine structure of the left periphery. In Haegeman, Liliane (ed.), *Elements of grammar: Handbook in generative syntax* (Kluwer International Handbooks of Linguistics 1), 281–337. Dordrecht: Springer. https://doi.org/10.1007/978-94-011-5420-8_7

Shih, Chilin. 1986. *The prosodic domain of tone sandhi in Chinese*. San Diego: University of California at San Diego. (Doctoral dissertation.)

Shih, Chilin. 1997. Mandarin third tone sandhi and prosodic structure. In Wang, Jialing & Smith, Norval (eds.), *Studies in Chinese phonology* (Linguistic Models 20), 81–124. Berlin: De Gruyter Mouton. https://doi.org/10.1515/9783110822014.81

Sun, Chaofen. 2006. *Chinese: A linguistic introduction*. Cambridge: Cambridge University Press. https://doi.org/10.1017/CBO9780511755019

Tsao, Feng-Fu. 1979. *A functional study of topic in Chinese: The first step towards discourse analysis*. Taipei: Student Book.

Tseng, Chiu-yu. 2010. Yupian de jipingouzu yu yuliuyunlu tixian [An F0 analysis of discourse construction and global information in realized narrative prosody]. *Language and Linguistics* 11(2). 183–218.

Wang, Chiung-Yao. 2011. *Children's acquisition of tone 3 sandhi in Mandarin*. East Lansing: Michigan State University. (Doctoral dissertation.)

Wang, Chiung-Yao & Lin, Yen-Hwei. 2011. Variation in tone 3 sandhi in Mandarin: The case of prepositions and pronouns. In Jing-Schmidt, Zhuo (ed.), *Proceedings of the 23rd North American Conference on Chinese Linguistics (23rd NACCL)*, vol. 1, 138–155. Eugene: University of Oregon.

Wang, Yue & Jongman, Allard & Sereno, Joan A. 2003. Acoustic and perceptual evaluation of Mandarin tone productions before and after perceptual training. *The Journal of the Acoustical Society of America* 113(2). 1033–1043. https://doi.org/10.1121/1.1531176

Wee, Lian-Hee. 2004. *Inter-tier Correspondence Theory*. Rutgers: The State University of New Jersey. (Doctoral dissertation.)

Wee, Lian-Hee. 2008. Opacity from constituency. *Language and Linguistics* 9(1). 127–160.

Wong, Puisan. 2012. Acoustic characteristics of three-year-olds' correct and incorrect monosyllabic Mandarin lexical tone productions. *Journal of Phonetics* 40(1). 141–151. https://doi.org/10.1016/j.wocn.2011.10.005

Xu, Yi. 1993. *Contextual tonal variation in Mandarin Chinese*. Storrs: The University of Connecticut. (Doctoral dissertation.)

Xu, Yi. 1997. Contextual tonal variations in Mandarin. *Journal of Phonetics* 25(1). 61–83. https://doi.org/10.1006/jpho.1996.0034

Xu, Yi. 1998. Consistency of tone-syllable alignment across different syllable structures and speaking rates. *Phonetica* 55(4). 179–203. https://doi.org/10.1159/000028432

Xu, Yi & Wang, Maolin. 2009. Organizing syllables into groups—Evidence from F_0 and duration patterns in Mandarin. *Journal of Phonetics* 37(4). 502–520. https://doi.org/10.1016/j.wocn.2009.08.003

Yin, Hui. 2003. The blocking of tone sandhi in Mandarin Chinese. In Burelle, Sophie & Somesfalean, Stanca (eds.), *Proceedings of the 2003 Annual Conference of the Canadian Linguistic Association*, 296–307. Quebec: University of Quebec.

Yip, Moira. 2002. *Tone*. Cambridge: Cambridge University Press. https://doi.org/10.1017/CBO9781139164559

Yuan, Jiahong & Chen, Yiya. 2014. 3rd tone sandhi in standard Chinese: A corpus approach. *Journal of Chinese Linguistics* 42(1). 218–236.

Zhang, Jie & Lai, Yuwen. 2010. Testing the role of phonetic knowledge in Mandarin tone sandhi. *Phonology* 27(1). 153–201. https://doi.org/10.1017/S0952675710000060

Zhang, Ning. 1997. The avoidance of the third tone sandhi in Mandarin Chinese. *Journal of East Asian Linguistics* 6(4). 293–338. https://doi.org/10.1023/A:1008232121848

Zhang, Zheng-sheng. 1988. *Tone and tone sandhi in Chinese*. Columbus: The Ohio State University. (Doctoral dissertation.)

Authors' addresses

Chin-Ting Liu (corresponding author)
Department of Applied English
National Chin-Yi University of Technology
No. 57, Sec. 2, Zhongshan Rd.
Taiping Dist., Taichung 41170
Taiwan

ctjimboliu@gmail.com

Publication history

Date received: 1 April 2018
Date accepted: 10 September 2018