Phonetic transparency as a factor in tone sandhi directionality: evidence from Laoling trisyllabic sequences

Previous studies have approached tone sandhi (TS) directionality in trisyllabic sequences with temporal sequence (Chen 2000), prosodically defined domain (Shih 1986; Wang & Lin 2017), evaluation of alternative derivational processes (Hsu 1994; Chen 2000, Wee 2010), correspondence between prosodically related outputs (Lin 2008), etc. Yet, the phonetic transparency of TS rules is rarely discussed. This study investigates the trisyllabic tone patterns in Laoling, a Mandarin dialect spoken in Laoling City, Shandong Province, and proposes TS directionality is influenced by the phonetic transparency of TS rules. Specifically, the default directionality is left to right except when phonetically arbitrary patterns are involved, in which case, TS directionality is conditioned by morphosyntactic structure and prosodic duration.

Monosyllabic, disyllabic, and trisyllabic data were collected from three native speakers of Laoling and analyzed via Praat 6.3.07 (Boersma & Weenink 2023). The extraction of average *f0* across speakers and time-normalization were conducted via *ProsodyPro 6.1.3 beta* (Xu 2013). The average *f0* values of monosyllables and disyllables were then transformed into Chao's 1-5 numerical values via Shi's (1986) formula to compare with Cao's (2007) transcription. All time-normalized *f0* contours were plotted via *Microsoft Excel* to observe TS.

Laoling has four lexical tones, as in (1), which shows the traditional tone categories, their corresponding tone values in this study and Cao's, and their pitch targets. As it is difficult to distinguish categorical TS and gradient tonal articulation (Zhang & Liu 2011), this study defines the tone sandhi in Laoling as any non-final tone change that makes the output *f0* contour deviate from the input *f0* contour (e.g., dipping→rising, falling→level). The disyllabic tone patterns are given in (2), where the shaded cells indicate there is no TS. Some sandhi tones are presented in numerical values (23, 14, 213), as they are gradient (not categorical) allotones.

(1) Lexical tones

Tone categories	T1	T2	T3	T4
This study	**13**	**53**	**45**	**51**
Cao (2007)	213	53	55	31
Pitch targets	LM	HM	H	L

Six TS rules are observed. T1, which has a dipping *f0* contour though unobservable from a numerical transcription, is simplified to a rising tone before T1. Before T4, the dipping contour of T1 remains while the *f0* offset is raised. Similarly, the *f0* offset of T2 and T4 are raised before T4. They surface respectively as H and 213. T3 changes into T2 before T1 and T3. (Examples are omitted to save space.)

(2) Disyllabic tone patterns

1st σ | 2nd σ	T1 (LM)	T2 (HM)	T3 (H)	T4 (L)
T1 (LM)	23.LM	LM.HM	LM.H	14.L
T2 (HM)	HM.LM	HM.HM	HM.H	H.L
T3 (H)	HM.LM	H.HM	HM.H	H.L
T4 (L)	L.LM	L.HM	L.H	213.L

In terms of phonetic transparency, all six TS rules are phonetically motivated except one rule (T3.T3→T2.T3). First, T1 is simplified into a rising tone before T1 as successive dipping tones are difficult to articulate. Second, the *f0* offset of the tone preceding T4 is raised (see Xu (1997) for possible accounts for the phenomenon). This low tone raising is also observed in other Mandarin dialects (Beijing: Xu (1997), Tianjin: Li & Chen 2016)) and Yorùbá (Connel & Ladd 1990). Third, tonal assimilation motivates T3 → T2 before T1. Though anticipatory assimilation is rarely discussed, it is also observed in Cantonese (Gu & Lee 2007: 1035) and Changting Hakka (Hsu 1994; Chen 2000: 152). The only phonetically arbitrary rule is T3→T2/__T3. Though one may attribute it to H tone dissimilation, regressive dissimilation triggered by H tone is rare (or perhaps unattested) cross-linguistically (Zhang & Liu 2011).

The trisyllabic patterns are classified into three types based on TS context. Simple TS context involves only one TS rule, as in (3), while complex sandhi context involves two. Complex sandhi context is further divided into conflicting and non-conflicting TS contexts. In conflicting TS context, as in (4), different TS directionality renders different outputs. Patterns with non-conflicting TS context are omitted as different directionality renders the same output.

Table (3) shows whether the rules apply when the disyllabic combinations are left-aligned (e.g., L.L.X, X=any tone that does not trigger TS) or right-aligned (e.g., X.L.L) in left-branching or right-branching structures. The results show that phonetically transparent rules apply whenever the conditions are met. First, non-final LMs are simplified into rising tones in trisyllabic sequences (LM.LM, LM.L). (Note that in disyllabic tone patterns, the non-final LM still preserves a certain degree of dipping before T4.) Second, anticipatory assimilation (HM.L) applies across the board. Third, low tone raising (L.L, HM.L) only occurs in the medial, not the initial, position, to counteract intonational declination (Xu 1997). The phonetically arbitrary rule (H.H) applies variably when the sequence is right-aligned. Its application and non-application may be sensitive to prosodic duration and morphosyntax. To maintain the Mandarin prosodic duration template (final σ > initial σ > medial σ), H → HM, which increases the tonal duration, is less preferred in the medial position. This implies that H.H tends to change when left-aligned but tends not to when right-aligned. Further, given that phonetically arbitrary rules are likely to be lexicalized patterns, right-aligned H.H sequences are more likely to undergo TS if they constitute a disyllabic morpheme. Hence, when H.H is right-aligned, TS tends to apply in right-branching structures but not in left-branching structures due to lexicalization.

(3) Trisyllabic sequences with simple tone sandhi context

		LM.LM	LM.L	H.LM	L.L	HM.L	H.H
L-aligned	[[σσ]σ]	✓	✓	✓	✗	✗	✓
	[σ[σσ]]	✓	✓	✓	✗	✗	✓
R-aligned	[[σσ]σ]	✓	✓	✓	✓	✓	✗ > ✓
	[σ[σσ]]	✓	✓	✓	✓	✓	✓

(✓ = TS applied; ✗ = TS not applied)

The patterns in (4a) show that TS applies from left to right regardless of the morphosyntactic structure and it does not backtrack to the disyllabic sequence that has already undergone TS, so derived context such as [H.H.L] in (4a) does not trigger TS. In (4b, c), TS operates differently from (4a) in that TS applies to disyllabic morphemes first, so TS applies from left to right in left-branching structures but from right to left in right-branching structures. The TS patterns in (4) show that TS applies from left to right except when H.H is involved, in which case, TS opts to apply to disyllabic morphemes.

(4) Trisyllabic sequences with complex, conflicting tone sandhi context

Input sequence		Morphosyntactic structure	Output sequence
a.	T3.T2.T4	[[σσ]σ]	L → R: H.H.L
	(H.HM.L)	[σ[σσ]]	L → R: H.H.L
			R → L: HM.H.L
b.	T3.T3.T1	[[σσ]σ]	L → R: HM.HM.LM
	(H.H.LM)	[σ[σσ]]	R → L: H.HM.LM
c.	T3.T3.T3	[[σσ]σ]	L → R: HM.HM.H
	(H.H.H)	[σ[σσ]]	R → L: H.HM.H

Despite that traditional tone categories may have different tone values in different Mandarin dialects (e.g., Tianjin vs. Laoling), there are overlapping sandhi patterns in not only disyllabic but also trisyllabic sequences. Moreover, the shared patterns are phonetically transparent. Even if TS were in fact a result of historical change, the existing TS rules could shed light on which rules are more likely to survive or become obsolete.