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Recurring patterns in tone (chain) shift

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Abstract: This study investigates directional constraints on diachronic tone chain shifts and their applicability to non-chain shifts. Twenty-eight chain shift changes from 12 Sino-Tibetan, Kra-Dai, Austronesian, and Otomanguean languages were compared to a sample of 118 non-chain shifts (including merger) from 54 Asian tone languages. Significant overlap was found: the reported chain shift changes were also the most frequently occurring changes in non-chain shifts. Recurring patterns emerged in both chain shifts and non-chain shifts: (1) tonal alignment slides rightward, with effects on contour shape, f0 excursion and f0 onset height; and (2) falling tones become higher while rising tones lower. These crosslinguistic diachronic trends show parallels to tone variation in connected speech, which suggests that the direction of diachronic tone change is phonetically grounded, constrained by articulatory and cognitive biases in speech production and perception.

Keywords: sound change; tone; chain shift; constraints problem; phonetic bias

1 Introduction

Research on tonogenesis has yielded insights into the mechanisms of sound change (Gao and Kirby 2024; Hombert et al. 1979; Hyman 2013) and the historical tonology of specific language families (Baxter and Sagart 2014; Haudricourt 1954; Ratliff 2010). However, less attention has been given to how tonal systems continue to evolve after tonogenesis, particularly regarding changes in the phonetic realization of already existing tone categories (Henderson 1982) – a key characteristic of diachronic chain shift. Diachronic chain shift (henceforth chain shift) is defined as "a change in one sound caus[ing] a reactive change in another" (Gordon 2015: 174). While extensive research on vowel chain shifts has yielded principles that are attested across unrelated languages (e.g., Burns 2021; Chirkova and Gong 2014; Labov 1994), few studies have explored crosslinguistic constraints on tone chain shift (e.g., Pittayaporn 2018; Zhu 2018). This study addresses two questions: What, if any, constraints limit the direction of change in a tone chain shift? Do these constraints also apply to tone changes that are not part of a chain shift?

1.1 Two examples of tone chain shift: Misool Ma'ya and Bangkok Thai

To illustrate the concept of tone chain shift, we present an example from the Austronesian language Misool Ma'ya, reconstructed by Remijsen (2001a, 2001b) through comparison of tone surface forms and variation patterns across three dialects. Figure 1 compares the tonal systems of the Laganyan and Salawati dialects, which are considered conservative, to Misool, which is hypothesized to have undergone a change to the phonetic implementation of the Rise and Fall tonemes.

In Laganyan and Salawati, the Rise toneme's contour shape varies depending on its position in the utterance. In an utterance-final context, the rise occurs during the target syllable. However, in an utterance-medial context, the rise occurs during the following syllable (Remijsen 2001a). This spillover effect, known as peak delay, is a common prosodic phenomenon (Gussenhoven 2004; Kristoffersen 2021; Xu 2001). Consequently, Laganyan and

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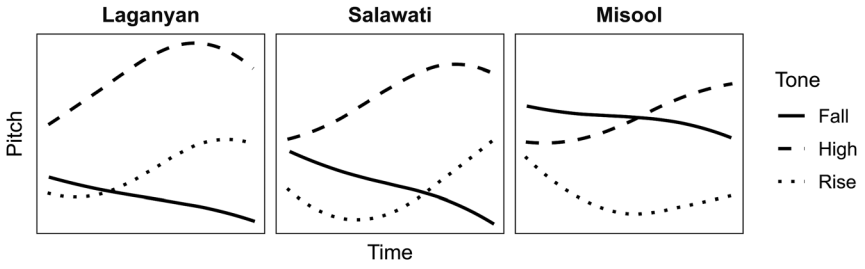

Figure 1: Tone chain shift in Misool Ma'ya, utterance-final position. Redrawn from Remijsen (2001a: 484).

Salawati exhibit two context-dependent variants for Rise: one with a rise during the syllable to which Rise is associated, and another with no rise during the associated syllable (occurring instead on the following syllable). The difference between the two variants is one of phonetic alignment, that is, the tone target's timing relative to the segmental string (Ladd 2008: 169).

In contrast with Laganyan and Salawati, in the Misool dialect Rise surfaces as low falling in both medial and final position (Figure 1, right panel). In medial position, no rise occurs during the associated syllable or the following syllable (Remijsen 2001a). Based on the cross-dialectal evidence, Remijsen proposes that Misool's no-rise realization was prosodically conditioned in the past, as found in Laganyan and Salawati, but has now generalized, leading to the change *Rise > [low falling]. This resulted in Rise's contour shape becoming similar to the archaic value of *Fall [low falling], still observable in Laganyan. Remijsen argues that the shift in Misool's Rise triggered a change in Fall, which became higher. Fall's upward movement in the pitch range prevented its merger with Rise, thereby maintaining the tonal contrast. This sequence of changes exemplifies a chain shift: the change of one toneme (Rise) precipitated a change in another (Fall), resulting in a rearrangement of the tonal system while preserving tonemic distinctions.

Similar patterns of tonal change have been observed in the unrelated language of Bangkok Thai during the first half of the twentieth century. Figure 2 juxtaposes the Bangkok Thai tone system as described by Bradley (1911; dashed lines) with that reported by Abramson (1962; solid lines). Zhu et al. (2015), and Pittayaporn (2018) identify two key changes that appear to be a chain shift:

(1) The f0 onset of Falling rose to high, resulting in Falling's phonetic realization shifting from mid falling to high falling. This upward movement parallels the change observed in Misool Ma'ya's Fall.

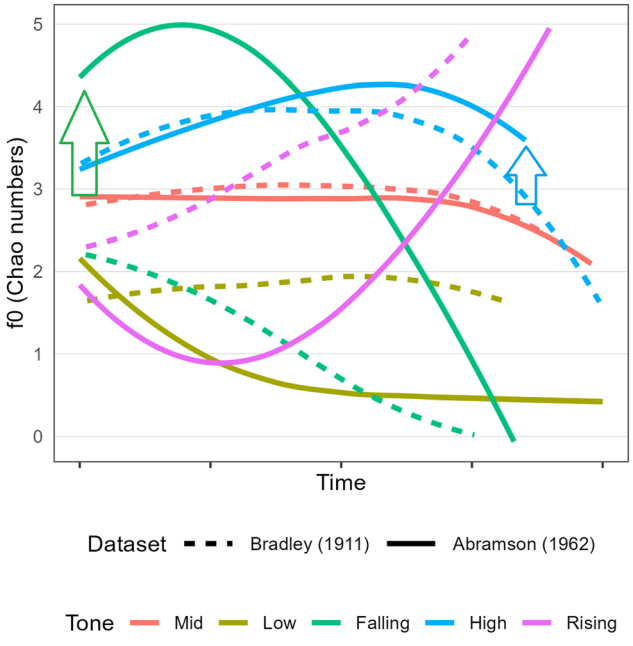

Figure 2: Tone chain shift in Bangkok Thai according to Pittayaporn (2018). Redrawn from Bradley (1911) and Abramson (1962) [https://doi.org/10.5281/zenodo.15137788].

(2) The f0 peak of the High tone shifted to later in the syllable, accompanied by a reduction in the f0 excursion of the fall. Pittayaporn suggests that the later peak alignment is grounded in peak delay – the same mechanism implicated in the change to Misool's Rise, albeit with different outcomes for contour shape in the two languages.

1.2 The present study: recurring patterns in tone chain shift?

The commonalities between the changes in Misool Ma'ya and Bangkok Thai motivate a broader investigation into crosslinguistic trends in tone chain shifts. Labov (1994: 117) posited that his principles of vowel chain shift "appear as powerful constraints on language change only in chain shifts," contrasting the limited set of patterns in chain shifts with the relatively unconstrained movement in "simple shifts," in which the phonetic realization of a phoneme changes without any apparent structural consequences (Labov 1994: 30). This assertion raises the question of whether patterns in tone chain shifts are restricted compared to non-chain shifts. Yang and Xu (2019), in their review of 54 studies on 45 Asian tone languages, identified 97 instances of tone change in apparent or real time. In their sample, certain tone changes occurred more frequently than others, suggesting that there are crosslinguistic constraints on the direction of tonal evolution. However, only four languages in their sample exhibited tone chain shifts and they did not differentiate between tone changes occurring within chain shifts and those occurring as simple shifts, splits, or mergers.

To address the constraints question, we conducted a crosslinguistic survey of tone chain shifts – the first such survey to our knowledge – employing an approach similar to that of Labov et al. (1972) in their study of vowel chain shifts. We then compared reported chain shift changes to non-chain shift changes.

To preview our results, we find a significant overlap between chain shift changes and non-chain shift changes, suggesting that both types are subject to similar constraints. Based on commonalities observed across multiple changes in unrelated languages, we identified two major trends in the direction of change applicable to both chain shifts and non-chain shifts: (1) tonal alignment shifts rightward and (2) falling tones become higher while rising tones become lower.

These trends likely result from a complex interaction of multiple underlying mechanisms. A comprehensive treatment of the phonetic underpinnings of tone change is beyond this study's scope, but in Section 3 we present parallels between synchronic tone variation and diachronic tone change that highlight the need for further research into their connection. The first trend appears to reflect the retiming of tonal gestures relative to the segmental string, rooted in the slight variations of tonal alignment that occur in connected speech (Pittayaporn 2018; Xu 2009). The second trend shows similarities to anticipatory tonal dissimilation (Burroni 2023; Hyman and Schuh 1974; Lee et al. 2021). The fact that these crosslinguistic trends parallel synchronic variation is unsurprising if the direction of tone change, like that of most sound change, is shaped by phonetic biases (Garrett and Johnson 2013).

In this paper, we focus our attention on diachronic changes in tone realization and their possible analogues in patterns of synchronic phonetic variation. There also exists a large body of literature on synchronic patterns of tonal alternation, much of which is focused on the description and analysis of tone sandhi, as documented for a diverse range of languages such as Southern Min (Sinitic; Barrie 2006; Wang 1967), Seenku (Mande; McPherson 2019), and A-Hmao (Hmong-Mien) and Jingpho (Tibeto-Burman; Mortensen 2002). Some types of tone sandhi, such as the syntagmatic tone spreading and tonal absorption processes common in Bantu languages, appear to result from the phonologization of low-level phonetic processes (Hyman 2025). On the other hand, the kinds of paradigmatic, replacive sandhi commonly found in languages of East and Southeast Asia often have a more opaque relationship with phonetic variation, possibly arising as a result of a series of diachronic changes (Chen 2000; Jie Zhang 2014; Lin 2019; Silverman 1997). A comparison of synchronic tonal alternations (including sandhi) with patterns of diachronic tone change would surely yield important insights into their similarities and differences, but such a comparison is beyond the scope of the current study.

2 Methodology

Gordon (2011) offers two empirical criteria to identify a chain shift, applicable regardless of one's stance on the causal relationship between changes: (1) the observed changes are interrelated, in the sense that the phonetic realization of one phoneme becomes more similar to that of another phoneme; and (2) the number of phonemic contrasts present in the system is preserved. We employed these criteria to identify tone chain shifts – for example, in Misool Ma'ya and Bangkok Thai – without making a particular claim about the nature of the link between changes.

We assembled a small but diverse sample of 12 chain shifts (see Supplementary Material). The limited dataset size reflects the scarcity of empirical research addressing tone chain shift from a diachronic perspective. The sample includes languages from the Austronesian, Kra-Dai, Otomanguean, and Sino-Tibetan language families. However, six of the 12 languages are Sinitic. This Sinitic bias may reflect the intense interest of Chinese linguistics in tone chain shift rather than a greater frequency of such shifts in Sinitic languages. We excluded tone dialect geography studies, such as Zhang and Zhu (2017), due to the absence of diachronic evidence, which is crucial for establishing direction of change.

Of the putative tone chain shifts, five were observed in real time (compared across time), two in apparent time (compared across generations), and five using micro-reconstruction. Micro-reconstruction applies the comparative method to closely related dialects, reconstructing change pathways at a shallow time-depth (Benn 2021). Synchronic variation that created the potential for a particular sound change may still be observable in some dialects, providing evidence for a particular change pathway, as in the Misool Ma'ya chain shift described by Remijsen (2001a).

As an empirical basis for comparing tone changes in different languages, we describe the changes reported in the survey in terms of three commonly measured acoustic parameters of tone (Hanssen et al. 2022; Karlin 2018; Tupper et al. 2020): (1) tonal alignment, (2) f0 contour excursion (i.e., the f0 difference between the beginning and end of a contour), and (3) f0 height (at rhyme onset or across the rhyme).

To compare chain shifts in our sample to non-chain shifts reported in the literature, we expand and update the dataset provided in Yang and Xu (2019). Chain shift changes in Bangkok Thai, Taiwan Mandarin, Jinhua Wu, and Jining Jin that were reported in Yang and Xu (2019) are placed in the chain shift dataset. Using the same selection criteria as Yang and Xu (2019), we add 16 recent studies to the non-chain shift dataset (Akharawatthanakun 2018, 2020; Brunelle and Kirby 2024; DiCanio et al. 2021; Ge et al. 2023; Jingwei Zhang 2019; Liang 2018; Phonyarit 2015; Qu 2020; Saeng-Ngam 2006; Teeranon 2010; Wongrukhave and Sudhinont 2022; Yang et al. 2022, 2024; Yi et al. 2024; Zhou 2020). The chain shift and non-chain shift datasets together comprise 146 instances of change in 66 languages and are available in the Supplementary Materials.

3 Results and discussion

3.1 Comparison of chain shifts and non-chain shifts

The comparison of tone chain shifts with non-chain shifts reveals significant similarities. Table 1 lists the changes reported in our chain shift survey alongside their frequency rank from Yang and Xu (2019) and the trend they reflect, discussed below. Notably, most of the chain shift changes rank among the ten most frequently reported changes in non-chain shifts.

Furthermore, the same types of changes that co-occurred in chain shifts were also found to occur independently as non-chain shifts. For example, in the tone chain shifts of Guienagati Zapotec (Benn 2021) and Jinhua Wu (Carroll 2010), the low falling tone moved toward the high falling tone, while the high falling tone moved toward high level. However, these changes have been documented in other languages without a chain shift occurring. In Lahu Na, the low falling tone is also becoming higher but there is no evidence of the high falling tone changing (Yang et al. 2022). Also, in Changsha Xiang, the *shang* high falling tone is changing to high level,

Table 1: Chain shift changes in our sample and their frequency rank in Yang and Xu's (2019) dataset of tone changes (including both chain shifts and non-chain shifts).

Change reported in the chain shift survey	Frequency rank in Yang and Xu (2019)	Trend
low rising > low fall-rise	#1	1a
high level > mid rising	#2	1c
high falling > high level	#3	1b
mid falling > high falling	#4	2
mid rising > low fall-rise	#5	2 & 1a
mid rising > delayed rise	#7 (low rising > delayed rise)	1a
low falling > mid falling	#8	1c & 2
low fall-rise > low falling	#10	1a & 1b
mid falling > high rise-fall	not in top 15, but similar to #4 mid falling > high falling	2 & 1a
high rise-fall > mid rising	not in top 15	1c & 1a

potentially creating acoustic space for the raising of the *yangqu* mid falling tone but there is no evidence of *yangqu* raising (Xiang and Shi 2007).

We also observed that the same directions of change reported for chain shift changes were also reported for changes leading to merger. Wuxi Wu T4, once low rise-fall, is now pronounced as low rising by younger speakers; while this change follows a trend seen in chain shifts, the T4 change appears headed toward merger with T2/T6 (Jingwei Zhang 2014). In the Duyun lect (also Sinitic), T4ab mid falling raised to high falling, following a pattern observed in chain shifts but in this case leading to merger with T2b high falling (Li 2010). These findings suggest that the mechanisms driving tonal changes may be similar across different types of tonal evolution, including chain shifts, simple shifts, and mergers.

Across the total sample, most of the changes share similarities with at least one change in an unrelated language. We synthesized the commonalities into four patterns, centered on three key parameters: tonal alignment, f0 excursion, and f0 height. We grouped the first three patterns together under one general principle of rightward sliding of tonal alignment. It is important to note that these trends are not exhaustive but rather represent a step toward developing a crosslinguistic typology of tonal change. While these trends do not predict the occurrence of future changes, they suggest that if a change does occur, it is likely to follow one of the following pathways:

(1) Tonal alignment slides rightward.
   a. F0 targets slide rightward within their associated domain.
   b. In contour tones, this movement can result in a decrease in f0 excursion.
   c. Low f0 onsets are raised to mid; high f0 onsets are lowered to mid.
(2) Falling tones become higher; rising tones become lower.

Table 1 presents our categorization of the reported chain shift changes according to these major trends. In the following sections, we provide examples of each trend and highlight parallel processes of synchronic variation.

3.2 Trend 1: tonal alignment slides rightward

The timing of tone gestures relative to the segmental string is a key parameter for both tone production and perception (Ladd 2008; Yip 2002). Autosegmental phonology emphasizes a tone's semi-independence from its segmental host while recognizing that they necessarily overlap in time (Goldsmith 1976; Hyman 2011). Tonal alignment is a highly salient cue in tone perception (Gjersøe and Remijsen 2024; Zsiga and Nitisaroj 2007) and speakers have been shown to employ adaptive strategies to maintain tonal alignment and contour shape, such as increasing their f0 rate of change with faster speech rates (Burroni and Kirby 2023; Flemming and Cho 2017).

However, tonal alignment is also subject to biomechanical constraints on the speed of f0 movement. Making any change to f0 requires a certain minimum amount of time (Xu 2009), and rises typically take longer to execute than falls (Silverman 1997; Xu and Sun 2002). As a result, while tonal alignment is perceptually salient, it also exhibits variability shaped by these constraints. The interplay of salience and variability creates conditions that can potentially lead to change over time.

A consequence of the biomechanical constraints on f0 movement speed is peak delay. In connected speech, f0 peaks (which typically involve an f0 movement that rises toward the peak) may be realized with a delayed alignment and may even displace onto the following syllable (Yip 2002: 8). Peak delay is more likely to take place when the preceding tone ends at an f0 level that is opposite from the target – for example, high may be delayed after low (Xu 2001) – or when an initial mid or low target is required to be reached before moving toward a peak, as in mid or low rising contours (Hao et al. 2017).

Peak delay affects not only the timing of the peak but also subsequent f0 movements. For example, Figure 3 depicts the Bangkok Thai Falling tone on the syllable *mii* followed by a Rising tone on the syllable *maa* (Burroni 2023: 72). The peak of Falling is delayed past the mid-syllable point of *mii*, and therefore the initiation of the fall is also delayed. The fall spills over onto the following syllable *maa*, which results in a delay of the Rising tone's initial low target, a target that must be reached before the rise movement can begin. With Rising's low target delayed, the rise associated with the syllable *maa* does not start until the onset of the following syllable. The cascading effects of peak delay may thus affect the timing of f0 targets (discussed in Section 3.2.1), f0 movement in tonal offsets (Section 3.2.2), and the f0 height of tonal onsets (Section 3.2.3).

3.2.1 Trend 1a: f0 targets slide rightward within their associated domain

Trend 1a describes the tendency for f0 landmarks such as f0 peaks and valleys to shift, over time, to a later alignment within an associated domain, termed "peak sliding" in Pittayaporn (2018). For example, the f0 valley of Rise can be described as shifting to the end of the syllable in Misool Ma'ya (Figure 1) and the f0 peak of High acquires a later alignment in Bangkok Thai (Figure 2).

Similar patterns are observed in other languages. Figure 4 (left panel) illustrates generational differences in the Iu Mien B1 tone: speakers born between 1950 and 1960 produce this tone as high rise-fall but speakers born between 1970 and 1980 show a later peak and a shorter fall (Yang et al. 2024). Figure 4 (right panel) compares Beijing Mandarin's Tone 3 (*shang*) in the early twentieth century versus the late twentieth century: the timing of the rise shifted from syllable onset to mid-syllable (Yang 2023).

Contour shape is also affected by shifts in alignment (Barnes et al. 2012). Complex rise-fall contours tend to evolve from convex ("domey") to concave ("scoopy"), as exemplified in the Iu Mien B1 tone. Similarly, simple rises tend to become scoopier, as seen in Beijing Mandarin's Tone 3.

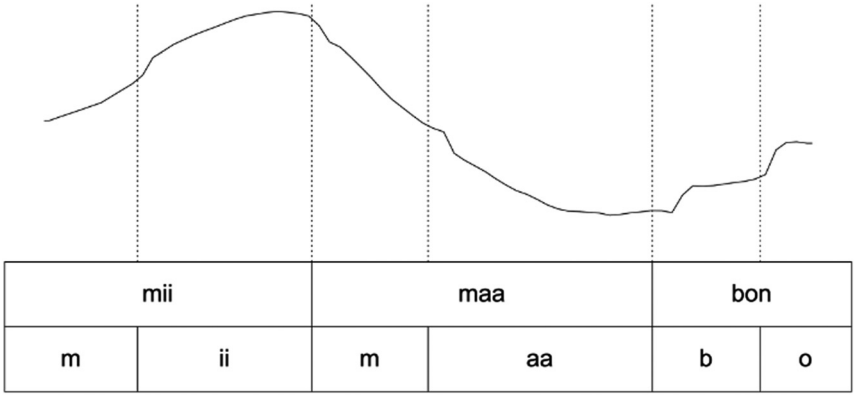

Figure 3: Spillover and peak delay in Bangkok Thai. The Falling tone of syllable *mii* spills over onto the following syllable *maa* (Rising tone), which delays the peak of the Rising tone until the following syllable *bon* (Mid tone). Adapted from Burroni (2023: 72) with permission.

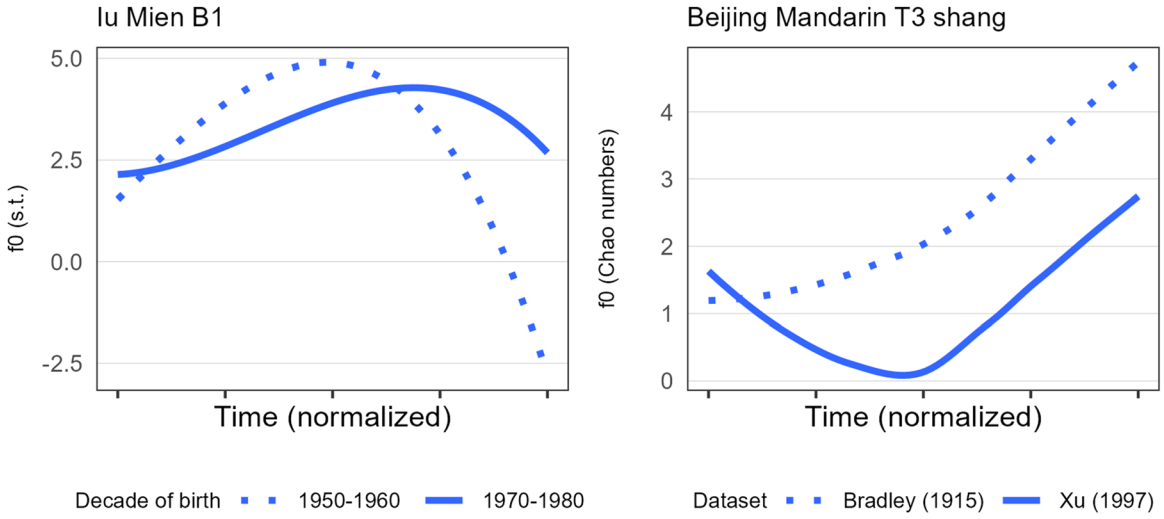

Figure 4: Rightward sliding of tonal targets. Left panel: Iu Mien speakers born 1950–1960 produce tone B1 as high rise-fall, but speakers born 1970–1980 have a much later alignment. Redrawn from Yang et al. (2024). Right panel: Beijing Mandarin Tone 3 in the early twentieth century was pronounced as low rising, but in the late twentieth century as low fall-rise. Redrawn from Yang (2023).

3.2.2 Trend 1b: rightward-shifted f0 movements reduce in excursion

Trend 1b describes the tendency for f0 movements that have been rightward-shifted to reduce in excursion within their associated domain, termed "contour reduction" by Pittayaporn (2018). A downstream effect of peak delay is that f0 movements that follow peaks also get delayed. When f0 movements are delayed, the time available for their realization during the associated domain decreases, which can lead to reduced f0 excursion during that window (DiCanio et al. 2021). Over time, the reduced variant may generalize across contexts, leading to contour reduction.

For example, Bangkok Thai Falling shows a reduction in fall excursion during the last half of the twentieth century (Figure 5, left panel). Comparison of the citation tone in Abramson (1962) and Burroni (2023) suggests that the fall initiates at a later alignment and no longer falls as far as it once did, a change noted by Henderson

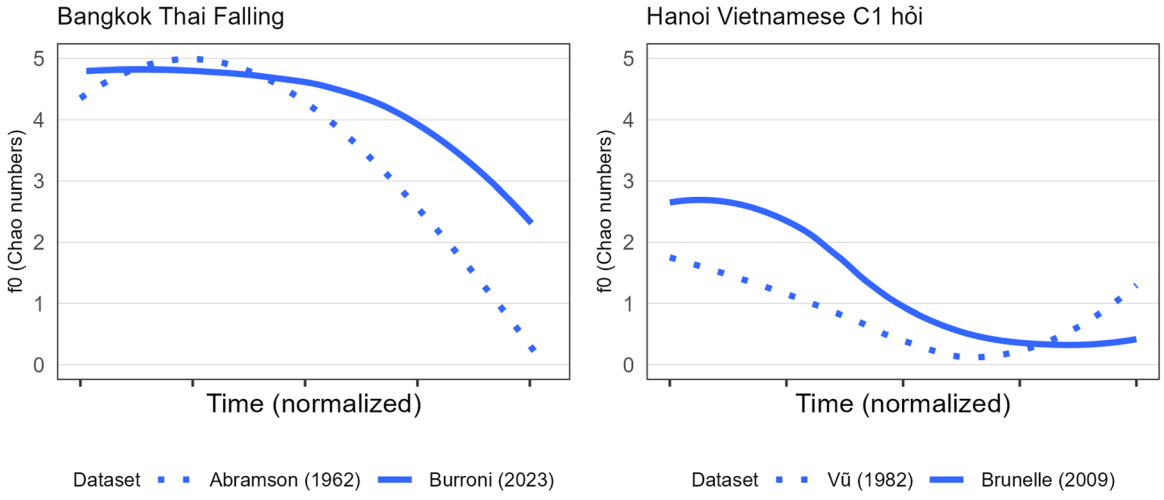

Figure 5: Contour reduction of rightward-shifted f0 movements. Left panel: Bangkok Thai Falling in 1962 vs. 2023. Redrawn from Abramson (1962) and Burroni (2023). Right panel: Hanoi Vietnamese C1 *hỏi* tone in 1982 vs. 2009. Redrawn from Vũ (1982) and Brunelle and Kirby (2024).

(1982). A similar phenomenon is observed in Hanoi Vietnamese (Figure 5, right panel), where the C1 *hỏi* tone, historically low fall-rise, is now typically produced without a final rise (Brunelle 2009; Brunelle and Kirby 2024).

Yang and Xu (2019) attributed contour reduction to truncation – the premature termination of the f0 movement under time pressure. However, Burroni and Kirby's (2023) study of Bangkok Thai found that faster speech rates lead to truncation only in specific tonal contexts. More commonly, delayed f0 movements in Thai tend to spill over onto the following syllable (Burroni 2023; Rose 2014), as illustrated in Figure 3.

Although spillover and truncation differ synchronically, both can lead to contour reduction diachronically. If the delayed target spills over onto a following tone domain with a similar target, the delayed target may not be perceptually recoverable, potentially resulting in tonal absorption (Hyman and Schuh 1974). For example, the change LH.H → L.H has been observed in languages such as Luba (Hyman 2007), Hanoi Vietnamese (Brunelle et al. 2016), and Beijing Mandarin (Hsieh 2011).

Even when the following target differs or lacks tonal specification, spillover may still result in contour reduction over time, because spillover creates potential ambiguity about which domain the target belongs to. If listeners fail to attribute the f0 target to the domain it is associated to – a parsing error (Garrett and Johnson 2013) – then that target may not be maintained in the lexical representation of the toneme. In Misool Ma'ya, for example, the no-rise variant of Rise, which was formerly restricted to nonfinal utterance position, seems to have generalized to all positions (Remijsen 2001a).

3.2.3 Trend 1c: low f0 onsets are raised to mid, and high f0 onsets are lowered to mid

In Trend 1c, low onsets become higher, and high onsets become lower, reflecting the effect of the preceding prosodic environment on low versus high f0 onsets. Low onset raising is seen in Lahu Na's low level tone T11 (Figure 6, left panel), with younger speakers producing higher f0 onsets than their older counterparts (Yang et al. 2022). Conversely, Liang and Meng (2011) report high onset lowering in Chongqing Mandarin's T1 *yinping* tone among the younger generation (Figure 6, right panel).

Spillover, discussed in Section 3.2.2, affects the f0 onset of the following syllable, as can be seen in Figure 3. Even when spillover does not occur, carryover assimilation may occur; for example, the onset of a high tone may be lower after a low tone. Like spillover, carryover effects result from the biomechanical constraints on how quickly f0 can change: the vocal folds cannot instantly adjust their vibration rate, requiring a transition period

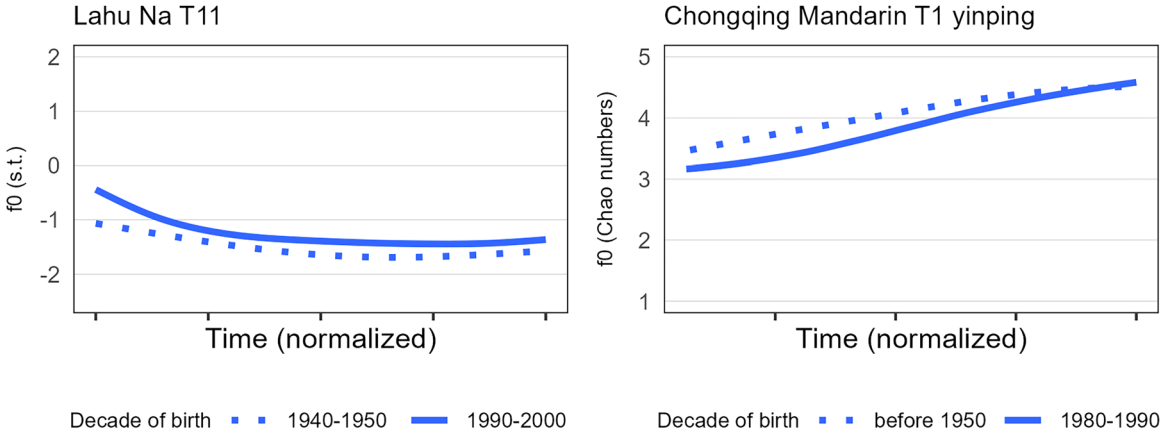

Figure 6: Low onset raising and high onset lowering. Left panel: Older Lahu Na speakers produce T11 as low level, but younger speakers produce it as low falling. Redrawn from Yang et al. (2022). Right panel: Older Chongqing Mandarin speakers produce T1 *yinping* as high rising but young speakers show a lower f0 onset. Redrawn from L. Liang and Meng (2011).

between different f0 levels. While this transition is only a low-level effect of prosodic environment, such prosodic effects may conceivably "leak" into the lexical representation of tone categories, leading to change over time (Shaw and Tang 2021; Tang and Shaw 2021).

In congruent environments, where the target onset and preceding offset are similar (e.g., a high onset after a high offset), carryover effects do not create variants different from the canonical form and the onset remains unchanged. However, in conflicting environments, where the preceding tonal offset differs from the target (e.g., a high onset following a low offset), carryover effects introduce the potential for tonal change. The conflicting environment results in a variant different from the canonical form, whereas congruent environments have little or no perceptible effect. Therefore, the effect of the conflicting environment drives the direction of change. In conflicting environments, low onsets will be higher, and high onsets will be lower, and thus Trend 1c follows that direction.

3.3 Trend 2: falling tones become higher and rising tones become lower

In Trend 2, falling tones move into the upper pitch range while rising tones move into the lower pitch range, similar to what Pittayaporn (2018) terms "contour maximization." Trend 2 results in mid falling > high falling, as in Misool Ma'ya Fall (Figure 1) and Bangkok Thai Falling (Figure 2). Trend 2 is also evident in Yilu, a Western Lalo lect ("W-Yilu" in Figure 7, left panel): tone *L(ow) is reconstructed as low falling, as is still found in the Central Lalo lect of Leba, but it is pronounced as mid falling in the Eastern Lalo lect of Diaocao and as high falling in Yilu (Yang 2022). Trend 2 also results in mid rising > low rising, as is seen in the lowering of Hanoi Vietnamese B1 *sắc* (Brunelle and Kirby 2024) in Figure 7 (right panel).

If the initial f0 target changes, but the final f0 target does not change, f0 contour excursion will increase, as in the case of Bangkok Thai Falling in the first half of the twentieth century (Figure 2). However, the initial and final target may change together – for example, Lalo's L tone becomes higher overall, while Hanoi Vietnamese B1 *sắc* becomes lower overall – without increased excursion.

Trend 1c and Trend 2 overlap in their effect on low falling and high rising tones, with both trends resulting in low falling > mid falling and high rising > mid rising. However, the two trends are distinct in that Trend 1c affects level and contour tones with a high or low onset, but is not predicted to affect a mid onset, while Trend 2 applies to all contour tones, even those with a mid onset. Trend 2 may also combine with Trend 1 in the formation of complex contour tones, as can be seen in the development of the fall-rise contour of Beijing Mandarin Tone 3 (Figure 4), which involves both rightward sliding (Trend 1) and lowering (Trend 2).

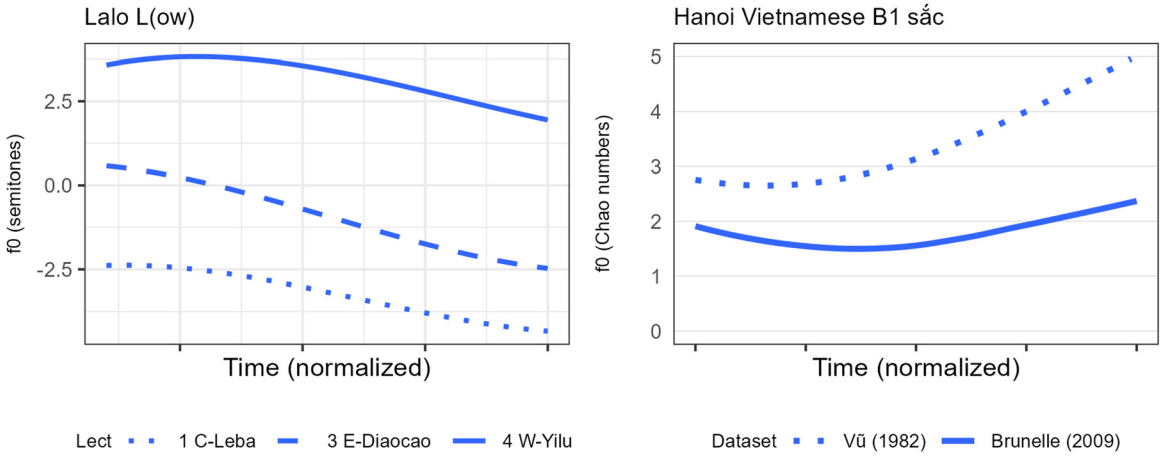

Figure 7: Falling tones become higher and rising tones lower. Left panel: Lalo *Low falling tone is now realized as high falling in the Western Lalo lect of Yilu. Redrawn from Yang (2022). Right panel: Hanoi Vietnamese B1 *sắc* in 1982 versus. 2009. Redrawn from Vũ (1982) and Brunelle and Kirby (2024).

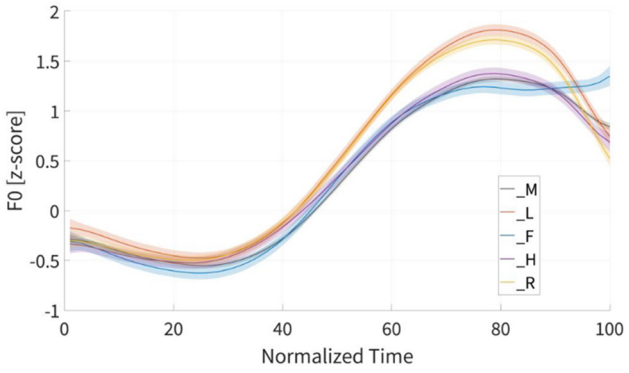

Figure 8: Anticipatory dissimilation effects on Bangkok Thai's Falling tone: a generalized additive mixed-effects model fit of Falling tone in different following tonal contexts (a Mid tone precedes the Falling tone). Note the higher f0 trajectories when Falling precedes tones with low onsets, Low (_L) and Rising (_R). Reproduced with permission from Burroni (2023: 210).

The two trends reflect different mechanisms in speech production. While Trend 1 appears related to the biomechanical constraint on the speed of f0 change, Trend 2 parallels the effects of anticipatory dissimilation, a type of tonal coarticulation where a tone becomes more distinct from a dissimilar following tone (Xu 1997). For example, Burroni (2023) found that the f0 trajectory of the Bangkok Thai Falling was higher when followed by a tone with low onset, as seen in Figure 8. This effect, known as pre-low raising, has also been documented in languages such as Mandarin (Xu 1997), Japanese (Lee et al. 2017), and Yoruba (Laniran and Clements 2003). Note that Burroni (2023) also found evidence for pre-high lowering of Rising before a tone with a high onset.

According to Tilsen's (2013, 2016, 2019) model of speech production, articulatory gestures that are dissimilar, including tones, can interact with each other during the planning phase. The interaction can lead to a target taking on a more extreme articulatory realization away from the upcoming dissimilar tone. For example, an initial f0 target in a mid falling tone [ML] may become higher before the L target, resulting in a high falling realization [HL], which parallels the mid falling > high falling change of Bangkok Thai Falling (Figure 2). Because falling and rising tones have two dissimilar targets in sequence, they are more likely to undergo this type of change than level tones.

4 Conclusions

Based on tone changes found in 12 cases of putative tonal chain shifts and in a larger dataset of non-chain shift changes in 54 languages, we identified two main trends of tone change: (1) tonal alignment shifts rightward, and (2) falling tones become higher while rising tones lower. The same trends appear in both datasets, regardless of the impact of the change on the system of tonal contrasts (i.e., whether contrast-preserving or not). This finding suggests that similar constraints apply to both chain and non-chain shifts, in contrast with Labov's (1994: 30) comment on the unconstrained movement in non-chain shifts. A further step would be to examine whether the same relative frequency of each trend holds across the different types of change.[1] However, such a test would require a larger chain shift dataset than is currently available.

There are intriguing similarities between changes in diphthongs and the contour tone changes that follow Trends 1 and 2. Both diphthongs and contour tones are dynamic trajectories that may be shaped by durational constraints (Jie Zhang 2002; Petersen 2018) and cognitive planning mechanisms (Tilsen 2013). For both, there are attested cases of reduction and dissimilation. For example, the monophthongization of /aj/ in the southern United States involves "glide weakening" (Thomas 2003), parallel to the reduction of the fall seen in Bangkok Thai Falling (following Trend 1b). An interesting possibility is that the glide weakening, similar to Trend 1b, may be due to rightward sliding of the timing of the offglide, resulting in a reduced durational window for its movement.

Also, the shift of *ij > aj in the English Vowel Shift follows Labov's (1994) Principle IIa "nuclei of upgliding diphthongs fall." Intriguingly, this dissimilation parallels Trend 2, as seen in Bangkok Thai Rising's lowering of the

1 Thanks to an anonymous reviewer for this suggestion.

initial target of mid rising to become low fall-rise (Figure 2). Further research comparing diachronic trends of diphthongs and contour tones may yield new insights into the role of articulatory time pressure and cognitive planning mechanisms in shaping the diachronic pathways of dynamic trajectories.

We hypothesize that the trends in tone change we have identified are crosslinguistically active, as they show parallels to patterns of synchronic variation known to be rooted in phonetic biases. Parallels between synchronic tone variation and diachronic tone change should be explored further to more fully understand the phonetic grounding of Trends 1 and 2. Furthermore, these trends likely interact with the typological properties of a language's tone system in complex ways that warrant additional study using a broader sample. Tone languages vary considerably in terms of their tonal density – how sparsely or densely tones are specified in the lexicon (Gussenhoven 2004: 35). While the proposed trends characterize common pathways in languages with relatively high tonal density, their applicability to tone systems with lower tonal density, such as privative or pitch-accent systems, remains an open question.

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