

Informativity and the actuation of tonal coarticulation in Taiwan Southern Min and Taiwan Mandarin

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Introduction & background The distribution of tonal coarticulation (TC) and its nature have long been studied and debated. Typologically, carryover effects are found to be assimilatory and stronger, and anticipatory effects dissimilatory and weaker (Chang & Hsieh, 2012). Discrepancies across languages, however, have also been attested (Peng, 1997; Wang, 2002; Brunelle, 2009; Huang, 2023). This raises the question of whether TC is subject to language-invariant biomechanical needs (e.g., Shen, 1992; Huang) or to some extent conditioned by phonological constraints (e.g., Brunelle). In Brunelle, Northern Vietnamese, which uses both F0 and laryngealization for tonal contrast, was found to exhibit higher TC magnitudes than Southern Vietnamese, where only F0 is used, supporting the phonological account. In our previous study (Huang, 2023) of Taiwan Southern Min (TSM) and Taiwan Mandarin (TM), on the other hand, comparable magnitudes of TC were found, despite the larger tone inventory in TSM and the subsequent higher possibility of perceptual confusion. In this study, we provide perspectives from information theory (Shannon, 1948) and show that while past studies of TC focus mainly on production and perception, functional-cognitive aspects are also involved. We thus suggest that the lack of production difference in Huang (2023) is likely due to neglect of these aspects. Specifically, a sizable number of studies (e.g., Stokes & Surendran, 2005; Seyfarth, 2014; Cohen Priva, 2017; Kamierski, 2023) have shown that information-theoretic constraints provide an explanation for systematic variation in speech. Crucially, Cohen Priva (2017) found that informativity outperforms other constraints in predicting the actuation of lenition across languages, with less informative targets more readily lenited. Since TC, like lenition and other kinds of systematic variation, involves the pull between articulatory costs and contrastive needs, it is likely to also be conditioned by the local informativity of the coarticulating tone pairs. In this study, we put forth evidence from TSM and TM and argue that informativity is at least partially responsible for the discrepancies in TC attested in the literature. In addition, we propose that such cognitive constraints interplay with linguistic constraints, such as tone inventory sizes.

Methodology The data in this study comes in two parts: 1) the F0 data of coarticulated tone pairs in TSM and TM and 2) the informativity of these tone pairs collected from a TSM corpus and a TM corpus. Linear mixed-effects models (LMMs) were then used for statistical analyses. F0 data Eleven TSM native speakers and fourteen TM native speakers (15 females; 20–27 y.o., mean=22.44) participated in the production experiment. In TM, all (4) tones were investigated. In TSM, checked tones were excluded due to the inherently shorter durations, leading to 5 chosen tones. For both languages, one disyllabic word was chosen for each tone pair. There were a total of 16 (4×4) TM and 25 (5×5) TSM tone pairs. There were 10 repetitions for each word. The participant was instructed to produce the stimuli in a relaxed manner. The audio was recorded at a sampling frequency of 4.41k Hz. Syllable boundaries were manually labeled in *Praat* (Boersma & Weenink, 2018), and F0 values were extracted using *Parselmouth* (Jadoul et al., 2018). Within each syllable, F0 values were sliced into 11 portions. The means of the last F0 portion in the preceding syllable and the first F0 portion in the following syllable were taken as their respective onset/offset. Informativity To estimate the informativity of each tone pair, one corpus was built for each language. The TSM corpus was taken from the TAT_MOE Corpus (Liao, 2022), with word boundaries and tones determined with the Tâi-lô orthography provided. Disyllabic words were chosen as the final corpus, comprising 306,001 words. The TM corpus was built with 21,668 posts on a Taiwan BBS forum PTT. The texts were first segmented with *CKIP segmenter* (Tsai & Chen, 2004). Disyllabic words were chosen as the final corpus, comprising 3,717,386 words. *pinyin* was used to label the tones of the words. Atonal characters were discarded. The informativity of the tone pairs was then calculated based on Cohen Priva’s (2017) formula with and without consideration of tone sandhi. We call these two types of informativity the *underlying* vs. *surface informativity*. Statistical analyses Two cross-language comparison models (underlying vs. surface informativity) were fitted. The target tone value was taken as the predicted value, and the context tone value and informativity and their interaction were taken as predictors, with participants and syllable onset/offset segment types as random effects. Four within-language models were also fitted to investigate the position (carryover vs. anticipatory) effects.

Results General positive effects of context tone values on target tone values were found in both the underlying and surface informativity models (both p ’s < 0.001), suggesting assimilatory TC effects. Crucially, informativity was found to be inversely correlated with the degree of TC (underlying: p < 0.001; surface: p = 0.001). Linguistic differences were also attested: informativity effects are stronger in TSM (underlying: p < 0.001; surface: p = 0.002). Within-language models and follow-up models revealed that carryover effects are stronger in TSM (all p ’s < 0.001), while in TM, there is no position difference. Lastly, while informativity effects were found in both positions in TSM for both underlying and surface informativity (carryover: both p ’s < 0.001; anticipatory: p < 0.001; p = .003), they were only found in carryover positions in TM (both p ’s < 0.001). Illustrations are shown in Figures 1 and 2.

Discussion The inverse correlation between informativity and the magnitude of TC in the two languages shows that TC is conditioned by functional constraints other than purely phonetic-phonological factors. Speakers in both languages, in general, avoid strong TC on more informative pairs and allow less informative ones to bear on more coarticulation. However, linguistic differences were also found: informativity effects are stronger in TSM, while TM speakers are less sensitive to informativity. In Cohen Priva (2017), it is proposed that the informativity of an element indirectly entails the cost a language pays to maintain its faithfulness. Likewise, in Huang (2023), TSM has been seen to have comparable magnitudes of TC as TM despite the larger size of tone inventory, which is taken to be evidence that biomechanical needs constrain TC. We argue in this study, however, that, together, the results suggest that while the global articulatory costs that TSM and TM speakers pay are comparable, a more fine-grained local allocation of such costs is also at work. In TSM, with the larger tone inventory and the subsequent higher perceptual pressure, speakers strategically allocate costs based on how informative a tone pair is. On the flip side, in TM, perceptual confusion is less probable, and a fine-grained allocation of costs is of less importance.

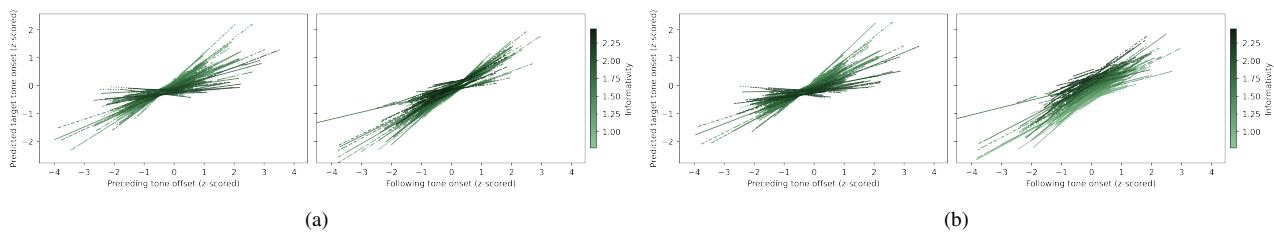


Figure 1: Fitted target tone values in carryover (left)/anticipatory (right) positions in TSM under the effects of underlying (a) and surface (b) informativity. The more informative tone pairs (darker lines) generally have smaller slopes (less TC).

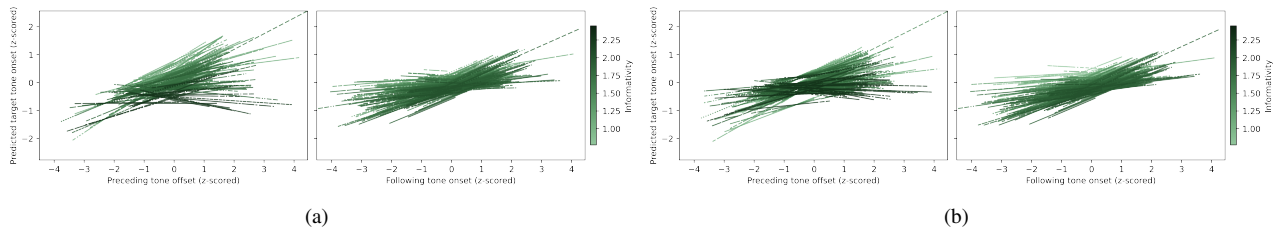


Figure 2: Fitted target tone values in carryover (left)/anticipatory (right) positions in TM under the effects of underlying (a) and surface (b) informativity. The more informative tone pairs (darker lines) generally have smaller slopes (less TC), though this is less pronounced in anticipatory positions.

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