

Interaction of Cognitive and Linguistic Constraints in Communication: The Case of Informativity and the Actuation of Tonal Coarticulation in Taiwan Southern Min and Taiwan Mandarin

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Abstract

This study addresses how general cognitive constraints, specifically informativity, in communication interact with the linguistic constraint of tone inventory size in Taiwan Southern Min and Taiwan Mandarin in tonal coarticulation. Previous studies have identified the role of information-related measures in conditioning systematic variation in speech. However, the generalizability of informativity across languages remains an open question. In directly comparing two languages, Taiwan Southern Min and Taiwan Mandarin, this study demonstrates that the informativity of a lexical tone influences the varying actuation of tonal coarticulation in different tonal contexts. Crucially, such an informativity effect is conditioned by the language-specific structural features of tone inventory size. We demonstrate that while general cognitive constraints condition systematic variation in speech, they are also likely to interact with the different degrees of communicative pressure led by language-specific structural constraints.

Keywords: cognitive constraints; linguistic constraints; informativity; tonal coarticulation; Taiwan Southern Min; Taiwan Mandarin

Introduction

A growing number of studies have come to emphasize the role of cognitive constraints in communication and the conditioning of these constraints on linguistic distributions from high-level pragmatics and sentence formation to low-level speech production. In Khawaja, Chen, and Marcus (2012), it is found that cognitive load is positively correlated with the rate of plural pronoun usage. This is taken as a sign of the interlocutors seeking collaboration among each other as the task demand increases. Lombardi Vallauri and Masia (2013) likewise proposes that the Topic-Focus structure in syntax surfaces in compliance with working memory and overall bearable costs for the speaker and the listener. In addition to these, perhaps the most extensively investigated is the conditioning of speech production by information-theoretic constraints based on communicative pressures (Shannon, 1948).

In King (1967), it is already proposed that information-theoretic constraints, such as functional load, have great explanatory power in the diachronic course of sound change. Further support of the role of information-theoretic constraints in speech is provided in speech acquisition (Stokes & Surendran, 2005), the perceptual salience and articulatory complexity of speech sounds (Zhang et al., 2021), speech duration (Seyfarth, 2014; Kamierski, 2023), and systematic variation including lenition (Cohen Priva, 2017) and merger (Wedel, Kaplan, & Jackson, 2013).

Previous studies of these cognitive constraints on linguistic distributions, however, have been largely conducted without cross-linguistic comparisons, with few studies investigating the potential conditioning of linguistic constraints on cognitive constraints. Thus, it remains an open question whether the same cognitive constraint may induce different effects on the same linguistic distribution across different languages. In this study, we provide evidence from the effects of informativity on tonal coarticulation (TC). We show that while TC is conditioned by cognitive constraints, such conditioning interacts with language-specific constraints.

Specifically, two languages were compared: Taiwan Southern Min (TSM) and Taiwan Mandarin (TM), two Sino-Tibetan languages spoken in Taiwan. Both languages are tonal languages where TC has been attested. However, tone-specific and language-specific actuation of TC has also been found (e.g., Peng, 1997; H.-T. Huang, 2013; P.-H. Huang & Chiu, 2023). Since TC, like lenition and merger, is also systematic variation, it is likely that functional aspects may also play a role. The different actuation attested could thus be explained through an information-theoretic perspective.

On the other hand, the different structural constraints that exist across TM and TSM could further condition such informativity effects in the actuation of TC. TSM has a much larger tone inventory (seven lexical tones) than TM (four). Previous studies of TC (Brunelle, 2003; P.-H. Huang & Chiu, 2023) have found that language-specific structural constraints could induce different articulatory/perceptual mechanisms. It is thus likely that functional constraints may also react differently to TC across languages. Crucially, the larger tone inventory in TSM could induce a higher perceptual pressure (P.-H. Huang & Chiu, 2023). This could, in turn, make TSM speakers more sensitive to the communicative value of the lexical tones in a tonal context when faced with the variation brought by TC. On the flip side, the smaller tone inventory and subsequent mild communicative pressure in TM could render a less significant informativity effect in TC.

In this study, we put forth evidence from production experiments and show that informativity indeed predicts the actuation of TC. However, such an effect is present only in TSM, but not in TM. This suggests that while informativity plays a role in conditioning speech variation, it is also subject to language-specific structural constraints. We, therefore, demonstrate that a holistic account of cognitive conditioning

on language use must be coupled with the consideration of language-specific constraints.

In the next section, we first outline in greater detail the role of informativity and other information-theoretic constraints in speech production. We then argue for the need to integrate language-specific linguistic constraints when investigating information-theoretic effects. We then introduce the actuation problem of TC and the possibility of approaching this problem from an information-theoretic perspective. Finally, we propose potential language-specific differences between the two languages investigated in this study, TSM and TM.

Background

Information-theoretic Constraints in Speech Production and the Role of Linguistic Constraints

As mentioned previously, a large portion of the literature investigating the role of cognitive constraints in linguistic distributions focuses on how information-theoretic constraints condition speech production based on the view of communicative pressure (cf. Shannon, 1948).

The most basic measure, *frequency*, for example, has been found to correlate with word duration in Baker and Bradlow (2009). Likewise, the vowel-length contrast merger in Seoul Korean is also reported to be subject to the effect of frequency (Kang, Yoon, & Han, 2015).

Functional load, calculated as the number of minimal pairs (Martinet, 1952) or entropy difference (Hockett, 1967), also has been shown to play a role in speech production. This is the case of the vowel length in Thai (Maspong & Burroni, 2020) and children's consonant development in Cantonese, American English, and Dutch (Stokes & Surendran, 2005). It is also found that functional load, too, correlates with the frequency of merging, with segments with higher functional loads less likely to merge (Wedel, Jackson, & Kaplan, 2013).

More recently, *informativity*, measured as the amount of information an item carries across contexts, has also been found to be a good predictor of speech variation. The idea of information content was first proposed in Piantadosi, Tily, and Gibson's (2011) study of word length. The authors compared frequency to the information content of a word, calculated as the average probability of a word across contexts. The information content of a word was found to be a better predictor of word length than frequency. Such a positive correlation between information content and word length was argued to promote efficient communication under information theory.

Cohen Priva (2015) further proposed informativity as a similar metric for measuring the information content of speech segments across contexts, as in (1).

$$-\sum_{\text{context}} \Pr(\text{context}|\text{segment}) \log \Pr(\text{segment}|\text{context}) \quad (1)$$

Informativity was found to affect the rates of deletion and consonant duration in American English. Similarly, the actuation of lenition in Indonesian, English, and Spanish also strongly correlates with the amount of informativity of the target segment (Cohen Priva, 2017).

Language-specific discrepancies, however, have also been attested in studies where cross-language comparisons were made. In Stokes and Surendran (2005), for example, other than functional load, articulatory complexity and frequency were also used as predictors in children's consonant development. Different measures were found to have stronger or weaker influences in different languages. While a potential explanation was put forth based on linguistic differences in the number of consonants, the authors suggest that further investigation is needed. Likewise, while an informativity effect has been found in the conditioning of segment duration in the aforementioned studies, such an effect is absent in Polish (Koplenig, Kupietz, & Wolfer, 2022).

The attested linguistic differences thus indicate that the effects of cognitive constraints may not be universal, and may be constrained by language-specific factors. Indeed, this is the view of Kamierski (2023). In the study, the morphological richness in Polish and the subsequent lower sensitivity to contextual predictability is argued to be why the informativity effect on word duration was weaker in Polish than in English. In the current study, we support this view. Crucially, we provide evidence from the informativity effect in the actuation of TC in TSM and TM. We argue that while cognitive constraints play an important role in language use, this must be viewed together with consideration of linguistic factors.

In the remainder of this section, we outline the actuation problem of TC and the possibility of explaining this issue from an information-theoretic perspective. We then propose potential language-specific differences between TM and TSM.

The Actuation of Tonal Coarticulation among Languages and Different Tones

Tonal coarticulation (TC) denotes the contextual variation of the target tones together with preceding (*carryover*) and following (*anticipatory*) tones (cf. Chao, 1968). An example of carryover effects in TSM could be the lowering of the falling (51¹) tone after a preceding low (21) tone, making it potentially similar to a mid-level (33) or low (21) tone. Another example would be the raising of the TM rising (35) tone after a high (55) tone, which might make the raised rising tone surface closer to a high tone (55).

Cross-linguistically, carryover effects are generally found to be assimilatory and stronger, while anticipatory effects are dissimilatory and weaker (Chang & Hsieh, 2012). However, discrepancies across languages have also been attested (Peng, 1997; Wang, 2002; Brunelle, 2009; Chang & Hsieh, 2012; P.-H. Huang & Chiu, 2023). Likewise, tone-specific differences within a language exist, with different tones having differing degrees of TC (Shen, 1990; Wang, 2002; Chang & Hsieh, 2012; P.-H. Huang & Chiu, 2023). The linguistic and tonal discrepancies attested, thus, raise the question of whether TC is purely subject to language-invariant biomechanical needs (e.g., Shen, 1992; P.-H. Huang & Chiu, 2023)

¹Five-level tone marks.

or is conditioned by phonological constraints (e.g., Brunelle, 2009; Flemming, 2011).

Shen (1992) posits that TC is in nature driven by language-invariant biomechanism. Such a view is likewise put forth in Daniloff and Hammarberg (1973), Schouten and Pols (1979), and Fowler (1980). Production experiments conducted in P.-H. Huang and Chiu (2023) further support this stance. In P.-H. Huang and Chiu (2023), the influence of tone inventory sizes between TSM and TM was investigated. Despite the larger tone inventory in TSM and the subsequent higher possibility of perceptual confusion, comparable magnitudes of TC were attested in the two languages. Perception experiments, on the flip side, showed that speakers of TSM demonstrated a higher sensitivity for the tone boundaries. P.-H. Huang and Chiu (2023) therefore concludes that TC is likely invariable, and perceptual mechanisms are required to resolve the language-specific constraints.

Conversely, Flemming (2011) argues that coarticulation is inherently part of the phonological grammar, with different languages prioritizing either ease of articulation or ease of perception. It is proposed that the stronger magnitudes of carryover effects in TC attested across languages serve as an example of prioritizing perceptual ease first, since speakers delay TC on the more salient nucleus, resulting in stronger carryover effects. Such a view is further supported by language-specific empirical evidence in Brunelle (2009), where Northern Vietnamese, which uses both F0 and laryngealization for tonal contrast, was found to exhibit higher TC magnitudes than Southern Vietnamese, which only uses F0.

However, both accounts are challenged by the differently realized TC across languages and among different tones. Specifically, the phonetic account faces challenges from inconsistencies across languages. A sizable number of studies (Lin, 1989; Brunelle, 2009; Chang & Hsieh, 2012; Chen, Wiltshire, & Li, 2018; Wang, 2002; P.-H. Huang & Chiu, 2023) have already shown that both the directionality of carryover vs. anticipatory effects and the magnitude of TC may differ across languages.

A phonological account of TC may reconcile the language-specific discrepancies attested in these studies. Yet, the differently realized coarticulation on different tones within a language and across languages still poses challenges to both a phonological account and a phonetic account. In Chang and Hsieh (2012), it was found that different lexical tones in Malaysian Hokkien exhibit different degrees of coarticulation. Similar tone-specific discrepancies were likewise attested in both TSM and TM in P.-H. Huang and Chiu (2023). Furthermore, in P.-H. Huang and Chiu (2023), the same tone (e.g., high-level, falling, etc.) has been found to induce different magnitudes and even directionalities (assimilatory/dissimilatory) of coarticulatory effects between TSM and TM. Under a phonological account, it is unclear why the same biomechanical or linguistic constraint within a language should ever induce differing effects on different lexical tones. A phonetic account may explain such tone-specificity with

the different heights and contours a tone requires and the accordingly different biomechanical needs required. Yet, it is still difficult to say why the same tone would bear different magnitudes of coarticulation across different languages.

An Information-theoretic Perspective The discrepancies in the actuation of TC across languages and different tones are thus akin to the ones found in the systematic variation (i.e., segment duration, lenition, merger, etc.) mentioned previously. It is thus likely that the discrepancies attested in the literature of TC may also be correlated with the amount of information carried by a tone and its contextual predictability.

Specifically, Cohen Priva (2017) found that compared to informativity, functional load is less predictive of the actuation of lenition. The author postulates that it is likely due to the inherent difference between merger and lenition in communication. When a segment with a high functional load is merged, the high amount of collapsed distinction leads to immediate negative feedback from the interlocutor. On the flip side, lenition reduces the distinctiveness of a segment but still preserves certain information. Informativity, as a more fine-grained measure of the amount of information, thus serves as a better indicator in the case of lenition. When a tone is coarticulated, the variation caused is gradient. A coarticulated tone often surfaces in between the intended target and the potential lexical tone it may be confused with. TC, in this case, is a variation more similar to lenition. Both compromise the segments while preserving the information loaded on these segments to certain extents. We, therefore, use informativity as the information-based measure investigated in this study.

The Role of Language-specific Linguistic Constraints As argued previously, the effect of cognitive factors on speech production may not be universal, and may be subject to language-specific linguistic constraints. In Kamierski (2023), it is argued that morphological richness may be one of these constraints. In this study, we consider the communicative pressure that variation introduces. We postulate that the different sizes of tone inventory in TSM and TM may in turn condition the effect of informativity on the actuation of TC. Specifically, a larger number of lexical tones in a language would lead to a higher possibility of perceptual confusion (cf. P.-H. Huang & Chiu, 2023) and a larger communicative pressure. The different communicative pressures in the two languages are likely to cause different degrees of sensitivity to the informativity effect. Under this account, TSM would be more sensitive to the informativity of a lexical tone in a tonal context under TC than TM. This is because the same amount of variation on a lexical tone with the same amount of informativity would induce a higher cost for the interlocutor during communication in TSM.

In the next section, we first introduce the tone production data collection, the calculation of the informativity, and the statistical analyses used. We then demonstrate the results found in this study. Discussions are provided in the fifth section. The last section offers the concluding remarks.

Methodology

The data in this study comes in two parts: 1) the F0 measurement of coarticulated tone pairs produced by TSM and TM speakers 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 Measurement of Disyllabic Tone Pairs in Taiwan Southern Min and Taiwan Mandarin

Eleven TSM native speakers and fifteen TM native speakers (15 females; 20–27 y.o., mean=22.62) participated in the production experiment. The TSM speakers were also native speakers of TM. The speakers did not have any experience with other tonal languages. In TM, all (4) tones were investigated. In TSM, checked tones (T4 and T8) 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. To facilitate more faithful F0 measurement, words with voiceless segments or plosives were avoided. 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 first familiarized with the word lists, and then the stimuli were presented on slides one at a time on a MacBook Pro (13-inch, 2018). The Mandarin words were demonstrated in Traditional Chinese. The Southern Min words were demonstrated with the Chinese characters on the top and the Romanization (Tâi-lô) below them. The audio was recorded with a microphone (Audio-Technica Carcoid AT2035) connected to a portable audio interface (USBPre 2) and saved as WAV files with a sampling frequency of 4.41k Hz. The production was self-paced, with the participants instructed to read the words at a relaxed speed.

Syllable boundaries were then manually labeled in *Praat* (Boersma & Weenink, 2018), and F0 values were extracted using *Parselmouth* (Jadoul, Thompson, & de Boer, 2018). Within each syllable, F0 values were sliced into 11 portions. The means of the last portion in the preceding syllable and the first portion in the following syllable were taken as their respective onset/offset.

Calculation of Informativity from Taiwan Southern Min and Taiwan Mandarin Corpora

To estimate the informativity of each tone pair, one corpus was built for each of the two languages. The TSM corpus was taken from the textual portion of the TAT_MOE Corpus (Liao, 2022). The word boundaries and the segments and tones within a word were determined directly with the Tâi-lô orthography system provided in the corpus. Disyllabic words were chosen as the final corpus, with words containing atonal characters discarded, comprising 306,001 words. The TM corpus was built with 21,668 posts and their comments on a Taiwan BBS forum, PTT. The texts were first preprocessed, with only Chinese characters preserved. Spaces and punctuations were taken as sentence segmentation markers. *CKIP segmenter* (Tsai & Chen, 2004) was then used to perform

word segmentation of each sentence. Disyllabic words were then chosen as the final corpus, comprising 3,717,386 words. *pypinyin* was then used to label the tones and segments of the words. Words with atonal characters were also discarded. The informativity of the tone pairs was then calculated based on Cohen Priva's (2015) formula in (1). Since tone sandhi exists in both TSM and TM, the informativity of a tone pair in the two languages would vary when the probability (frequency in the corpus) is calculated before or after tone sandhi is applied. Informativity was therefore calculated both with and without tone sandhi considered.

Linear Mixed-effects Models

Eight LMMs ($\alpha = .05$) were modeled for the two languages and the two positions (carryover vs. anticipatory), with and without tone sandhi. The target tone value was taken as the predicted value. The context tone value, informativity, and their interaction were taken as predictors. Participants and syllable onset/offset segment types (vowels, liquids, nasals, or obstruents) were taken as random effects.

Results

The visualizations of the fitted target tone values in the eight models are shown in Figures 1 and 2. The x-axis is the onset/offset of the context tone. The y-axis is the predicted offset/onset of the target tone. The darkness of the fitted spline indicates how informative the target tone is under the tonal context.

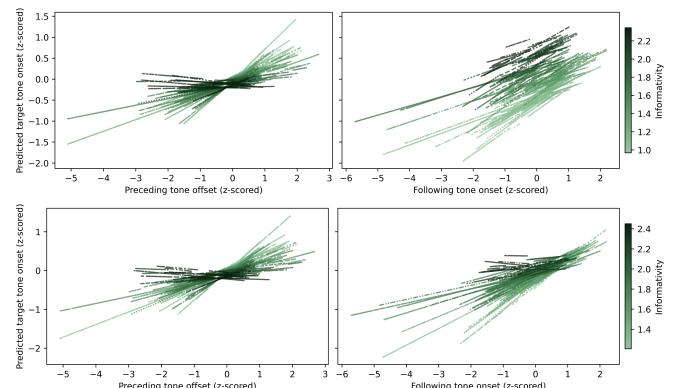
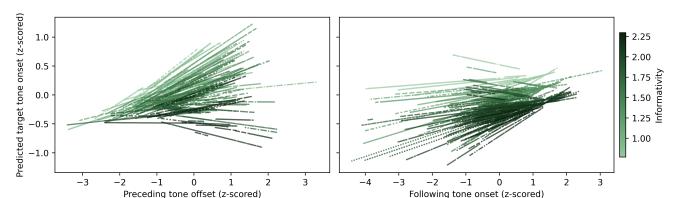


Figure 1: Fitted target tone values in carryover (left)/anticipatory (right) positions in TSM with (top) and without (bottom) tone sandhi.



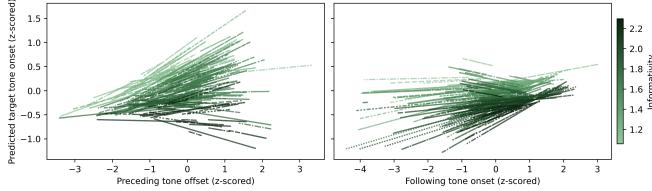


Figure 2: Fitted target tone values in carryover (left)/anticipatory (right) positions in TM with (top) and without (bottom) tone sandhi.

In general, positive correlations between the context tone and the target tone can be observed, suggesting assimilatory coarticulation in the two languages. Informativity, on the flip side, seems to interact with such a correlation, with the less informative pairs (lighter-colored) having stronger correlations (steeper splines), especially in TSM. In this section, we outline these findings in detail.

Coarticulatory Effects of Context Tones on Target Tones

Taiwan Southern Min A general positive effect of the context tone onset/offset on the predicted target tone offset/onset could be observed in TSM. Such an effect was significant in both the carryover position and anticipatory position with and without tone sandhi (all p 's < .001). This suggests that in TSM, both carryover and anticipatory effects are present and assimilatory. This distribution attested in TSM largely echoes the one found in previous studies of TSM (Wang, 2002; P.-H. Huang & Chiu, 2023).

Taiwan Mandarin Similar to TSM, a general positive effect of the context tone onset/offset on the predicted target tone offset/onset was also observed in TM. However, unlike TSM, such an effect was only attested in the carryover position, both with (p < .01) and without (p = .013) tone sandhi. Anticipatory effects, on the other hand, were not observed (p = .18 with and p = .19 without tone sandhi). This finding is inconsistent with the one found in P.-H. Huang and Chiu (2023), where anticipatory effects were found. It is potentially due to the inclusion of informativity, which may explain parts of the variation that could not be explained in P.-H. Huang and Chiu's (2023) models.

The Interaction of Informativity and the Coarticulatory Effects

Aside from the distribution of coarticulatory effects, the major question in this study is whether informativity is correlated with the actuation (i.e., magnitude) of these effects, and whether such an informativity effect is conditioned by the linguistic constraint, tone inventory size, in the two languages. The interaction between the context tones and the informativity of the tone pairs on the target tones was, therefore, also included in the LMM models. The remainder of this section outlines the findings found.

Taiwan Southern Min As can be seen in Figure 1, in TSM, an interaction between informativity and the coarticulatory effects is rather apparent, with the darker (higher informativity) splines being generally less steep (lower coarticulation). This suggests that more informative tone pairs are subject to less coarticulation. Indeed, LMM results showed that in both the carryover and anticipatory positions, informativity was negatively correlated with the effect of context tones on target tones, be it with or without tone sandhi (all p 's < .001).

Taiwan Mandarin While the direct observation of Figure 2 seems to suggest a mild effect of informativity on TC in TM, LMM results showed no effects of informativity in both positions, with (carryover: p = .43; anticipatory: p = .39) and without (carryover: p = .54; anticipatory: p = .89) tone sandhi. This suggests that, as predicted, while informativity is involved in TC in TSM, such effects seem absent in TM.

Discussions

In the previous section, TC was found in both languages. Specifically, an informativity effect has been found to correlate with the magnitude of TC in TSM. This supports our hypothesis that the actuation problem of TC can be explained through information-theoretic perspectives. More importantly, as predicted, the interaction with language-specific linguistic constraints was present: such an informativity effect was only found in TSM but not in TM. In this section, we discuss these two issues.

Informativity and the Actuation of Tonal Coarticulation

A major purpose of this study is to investigate the role informativity plays in the actuation of TC. As discussed previously, a major conundrum of previous accounts of TC has been how to reconcile at the same time the differently realized TC across languages and specific lexical tones.

The two prominent accounts, i.e., the phonetic account and the phonological account, both encounter difficulties explaining this actuation problem. This study, therefore, seeks to provide perspectives from information theory and communicative pressure. Previous studies of speech variation, such as merger and lenition, have shown that due to the different amounts of information that an item carries, the communicative pressure a speaker may encounter when producing that item also differs. As such, a more informative item tends to display a stronger resistance to variation, as the information loss of collapsing the contrast on this item will be higher than for a less informative item, therefore inducing a higher cost in the communication between the speaker and the interlocutor.

In this study, we adapt one of the information-theoretic measures proposed in previous studies, informativity, and explore the relationship between informativity and TC in TSM and TM. Linear-mixed effects models indicated a negative correlation between informativity and the coarticulatory effects exerted on the target tones by their neighboring tones in TSM. Yet, such a correlation was not attested in TM.

Taken together, this suggests that TSM speakers avoid having too strong TC when producing a more informative tone pair. Less informative pairs, on the flip side, are allowed to undergo stronger coarticulatory effects. Such a finding helps explain the idiosyncrasies found across lexical tones within a language and across languages. Within a language, the distribution of lexical tones is often uneven. For example, in the TAT_MOE TSM corpus, the most frequent tone is the mid-level tone, followed by the rising and high tones. Likewise, in the TM corpus built in this study, the falling tone is 1.7 times more frequent than the second most frequent high tone, with the rising and low tones slightly less frequent.

The uneven distribution of lexical tones in a language suggests an uneven distribution of information carried by these lexical tones. When a tone occurs frequently, it is less surprising when it occurs. Conversely, if a tone rarely happens, when it does happen, the event is highly surprising and denotes much higher information from an information-theoretic perspective. Not being able to clearly deliver a less frequent event would thus cause a higher loss of information.

In Cohen Priva (2015), informativity is conceived based on this idea, with the additional consideration of the conditioned probability of the occurrence of a segment in different contexts. This provides an even more sensitive measure than frequency, as the same segment may have higher or lower probabilities of occurrence in different contexts.

In this study, the finding that TSM speakers avoid tone pairs with higher informativity is, therefore, unsurprising. During speech production, the speaker and the interlocutor collaborate to facilitate communication. While coarticulation increases the ease of articulation, it also leads to unintended variation. This compromises the ease of perception on the interlocutor's end. A successful speaker, as such, must strive for ease of articulation while maintaining a good amount of contrast that is also agreeable to their interlocutor. It is then only natural that different context tones incur different levels of TC on the target tones, depending on how informative the target tones are in the given contexts, hence the different actuation of TC attested in the literature.

Interaction of Cognitive and Linguistic Constraints

A crucial issue in this study is whether the effects cognitive constraints have on linguistic distributions interact with linguistic constraints. Indeed, while an informativity effect in TC was attested in TSM, it was not the case in TM.

As argued previously, while past studies of cognitive constraints have been largely conducted within languages, cross-linguistic studies suggest that linguistic discrepancies exist in how sensitive different languages are to different cognitive constraints. The cross-linguistic difference between TSM and TM, thus, strongly supports the view that in different languages, the same cognitive constraint may exert different degrees of effects. The strong informativity effect in TC in TSM indicates that its speakers may be faced with more acute communicative pressures than TM, and, as such, need to attend to the informativity of a tone in a certain context. Indeed,

potentially higher communicative pressures led by linguistic constraints have often been identified in previous studies. In Brunelle (2009), it is noted that Southern Vietnamese, which only uses F0 as the cue for tones, may incur a higher pressure to avoid variation than its Northern counterpart, where laryngealization is served as an extra cue for tone distinction. In P.-H. Huang and Chiu (2023), it is also suggested that the larger tone inventory in TSM could lead to a higher probability of perceptual confusion.

The presence of an informativity effect in TC in TSM and its absence in TM are hence likely due to a difference in communicative pressure in tone production between the two languages led by a difference in the language-specific constraint, i.e., the more crowded tone space in TSM and the less crowded tone space in TM.

Under this view, a more crowded tone space in TSM induces a higher possibility for speakers to cause perceptual confusion, as there are more potential lexical tones with which the interlocutor may confuse the intended tone. While the overall magnitudes of TC may be comparable in TSM and TM, as suggested in P.-H. Huang and Chiu (2023), speakers of TSM strategically allocate the articulatory effort that they are willing to pay on different tones in different contexts. When a tone is more informative in a certain context, the speaker is willing to reduce the amount of coarticulation for the sake of the integrity of the information being conveyed. Conversely, when a tone is less informative in a context, the speaker pays less effort in resisting variation. On the account that the overall coarticulation is still comparable between the two languages, it is likely that TSM speakers allocate the articulatory cost locally, and compensate for the cost they pay on more informative pairs by conserving more energy on less informative ones. TM speakers, on the other hand, are likely less attentive to informativity due to the generally low communicative pressure stemming from a small tone inventory.

Conclusion

This study investigates the effects of informativity in the actuation of tonal coarticulation and the interaction of these effects with the linguistic constraint of tone inventory size in Taiwan Southern Min and Taiwan Mandarin. While a biological or phonological account may not satisfactorily explain the tone-specific actuation of tonal coarticulation, we provide a novel perspective from information theory. It is shown that in Taiwan Southern Min, the realization of tonal coarticulation is dependent on how informative a target tone is in a tonal context. In addition, we also provide evidence that such an informativity effect interacts with language-specific constraints. Taiwan Mandarin, with its smaller tone inventory, has lower communicative pressure, and is therefore not sensitive to informativity.

The findings in this study underscore the importance of considering linguistic factors when investigating the effects of cognitive constraints on linguistic distributions across languages.

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