1 Introduction

Tone processes in Chinese languages can be identified as phonological or phonetic. In the literature, this distinction is often made by referring to them as either tone sandhi (phonological) or tonal coarticulation (phonetic). However, while it is unchallenged that certain processes (e.g. Standard Mandarin Tone 3 Sandhi) belong to the phonological camp, some other tone processes that are considered phonetic may in fact display both properties of sandhi and coarticulation. The current paper investigates the mixed properties of Mandarin Tone 2 (T2) Coarticulation (Wu, 1985; Chen, 2000) observed in preliminary production data. I begin by discussing the properties of tonal processes that make them either phonological or phonetic (§2.1), why the coarticulation process of interest may display both types of properties (§2.2), as well as the remaining unresolved issues regarding this tonal process that has prompted this study (§2.3). I will then present the methods of the production study (§3), the results (§4), what it may reveal about the process (§5), and finally a summary of the findings (§6).

2 Background

2.1 Phonological vs. phonetic tonal processes

In attempt to distinguish tone sandhi from tonal coarticulation, Shen (1992) proposes three diagnostics. i) Tonal coarticulation can only be assimilatory whereas tone sandhi can be either assimilatory or dissimilatory. For example, Tone 4 in Standard Mandarin is realized as [35] rather than its canonical form [51] in non-final positions (Shih, 1987). The final pitch target is raised, partially assimilating with the onset of following tones (none of which begin at the bottom of the pitch range). An assimilatory process that is considered phonological is Mandarin Tone 2 Sandhi, in which a T2 [35] becomes [55] when it is preceded by a T1 [55] or T2 [35] and followed by any tone (Chen, 2000). The canonical example for a dissimilatory sandhi process is Mandarin T3 Sandhi, in which a T3 [214] becomes [35] before another T3 (Chen, 2000).
ii) Tonal coarticulation obeys only language-independent bio-mechanical constraints, while tone sandhi may be subject to language-specific morphological and phonological conditions. This is the idea that tonal coarticulation is a surface process that is sensitive only to post-lexical factors. For example, given a limited amount of time to realize multiple pitch targets, it is difficult to adjust vocal fold tension to be able to perfectly achieve all the targets, and therefore the speaker may approximate one or more of them. The observance of coarticulation should therefore be affected by factors such as speech rate and syllable duration (e.g. Gay, 1981). To the list of post-lexical effects, I would add the effects of word frequency, which is also known to affect phonetic processes (e.g. Bybee, 2002). Being post-lexical, tonal coarticulation should not be sensitive to morpheme identity, morphosyntactic boundaries, and higher level phonological contexts, which often condition tone sandhi processes. For example, in Mandarin, the ‘Yi-bu-qi-ba’ rule in Mandarin applies to a small set of morphemes (that do not necessarily bear the same underlying tone), turning them into rising [53] tones when following by the falling T4. Mandarin T3 Sandhi is representative of a phonologically conditioned process.

iii) Tonal coarticulation involves only allotonic variations, while tone sandhi may effect tonemic change. Here, Shen (1992) seems to be drawing a distinction between categorical vs. non-categorical change, where tonal coarticulation can only be non-categorical. Chen (2000) and Yang (2014) relate this last distinction to the perceptibility of change. That is, listeners should be able to perceive the difference between the base tone and a surface tone resulting from sandhi (e.g. Mandarin T3 Sandhi), whereas listeners are not able to perceive the subtle differences between base tones and coarticulated tones.

Given these diagnostics, it would seem that we should be able to categorize all tonal processes as either phonetic (i.e. coarticulatory) or phonological (i.e. sandhi). However, Chen (2000) cites counter-examples that seem to challenge this view. For example, Shih (1987) finds that T2 [35] and T4 [53] are realized higher before a T3 than when preceding other tones. The slightly raised pitch is a phonetic effect, however rather than bringing pitch targets closer (assimilation), it seems to be polarizing them (dissimilation), contra Shen’s (1992) first diagnostic. Also, Wu (1985) observed that a particular variation on the pitch contour of T2 is grammatically controlled. I will refer to this phenomenon as Tone 2 Coarticulation, the topic of the current study that I will discuss in detail in the following sections. Chen (2000:25) concludes that “It is not clear whether it is desirable or even possible to segregate tonal coarticulation from tone sandhi proper.”

### 2.2 Mandarin Tone 2 Coarticulation

For reference, Mandarin citation tones are given in tone numerals (Chao, 1930) in (1).

(1) Mandarin Citation Tones

<table>
<thead>
<tr>
<th>Tone 1</th>
<th>55</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tone 2</td>
<td>35</td>
</tr>
<tr>
<td>Tone 3</td>
<td>214</td>
</tr>
<tr>
<td>Tone 4</td>
<td>51</td>
</tr>
</tbody>
</table>
Mandarin Tone 2 coarticulation occurs in a trisyllabic tone sequence in which T2 [35] on the second syllable is realized as falling [53] when the previous tone ends in a high pitch target and the following tone begins with a low or mid tone target (Wu, 1985). The process is schematized in (2) below.

(2) Mandarin T2 Coarticulation

\[ [MH] \rightarrow [HM] / H \_ \_ \{L,M\} \]

An example of a tonal sequence that meets this phonetic context is given in (3).

(3) \([T1.T2]T3\)

\[/H.MH.L/ \rightarrow [H.HM].L\]

The example in (3) shows a tone sequence in which a rising tone (T2) is preceded by a high tone (T1) and followed by a low tone (T3). Crucially T1 has a high final pitch target and T3 has a low initial pitch target, thus between these two pitch targets, the rising tone becomes falling to interpolate between these two pitch points.

What is interesting about this process is that, in the literature, it is described as displaying both phonetic and phonological properties, thus posing a problem for the view that tonal processes either sandhi or coarticulation.

The properties of T2 coarticulation that make it resemble a low-level phonetic process are the following. i) It is assimilatory. The claim is that at the surface, the initial pitch target has assimilated completely with the last pitch target of the previous tone, and the final pitch target has assimilated completely with the first pitch target of the following tone. This results in a reversal in pitch trajectory. ii) The process affects tones are a surface phonology level. Thus, it is observed whether the second syllable bears and underlying rising tone (T2) or whether it bears a rising tone that is the output of T3 Sandhi (i.e underlyingly T3). An example involving T3 on the second syllable is given in (4).

(4) \([T3.T3]T3\)

\[/LH.LH.LH/ \rightarrow [MH.MH.L] \rightarrow [MH.HM.L]\]

In this example, the underlying tone of each syllable is T3. The first two tones in the sequence undergo T3 sandhi to become realized as rising tones [MH]. Since the middle tone is now [MH] occurring between H and L pitch targets, T2 coarticulation is observed. iii) Lastly, though it completely changes the contour of the tone, the process is only detectable instrumentally. Native listeners are unable to perceive the falling pitch in this context (Chen 2000).³

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¹Here I have replaced Chao’s (1930) tone numerals with H(igh), M(id) and L(ow) notation for simplicity.
²T3 is often realized as this low allotone in this context.
³I am unaware of any studies that test specifically whether listeners still perceive a T2 in this context if contextual factors (e.g. lexical effects) are removed. Supposedly the resulting tone contour resembles that of T4 in utterance medial context. It would be interesting to see if listeners can also access a lexical entry
The main evidence for T2 coarticulation having phonological properties is its sensitivity to morphosyntactic structure. That is, Wu (1985) claims that it occurs only in left-branching structure (i.e. $\sigma[\sigma\sigma]$) but is blocked in right-branching structure (i.e. $\sigma[\sigma\sigma]$). What is puzzling in Wu's (1985) descriptions is that the process is observed in only 4 of 7 tone sequences where the phonetic context for coarticulation is met. These are /T1.T2.T3/, /T2.T2.T2/, /T2.T2.T3/, and /T3.T3.T3/. It is not observed in the tone sequences /T1.T2.T2/, /T1.T3.T3/, and /T2.T3.T3/. The distinction here seems to be arbitrary and it would be difficult to form any generalizations. Regarding this, Wu does not provide any explanation.

2.3 Issues and Current Research Questions

As one can probably see from the discussion above, there are many issues surrounding the exact nature of Mandarin T2 coarticulation. One source of confusion is the exact way in which morphosyntactic structure affects the application of the coarticulation process. For example, in Mandarin T3 Sandhi, the process applies to inner constituents first, then expands outward if the context for application continues to be met (Chen, 2000). This results in the difference outlined in (5).

\[(5)\]

a. Left-branching:

\[
\]

b. Right-branching

\[
T3[T3.T3] \rightarrow T3[T2.T3]
\]

In the left-branching structure, T3 Sandhi applies first to the two left-most syllables in the brackets, thus the first tone undergoes the sandhi. Expanding the sandhi domain outside the brackets, the context for sandhi (T3.T3) is again met for the second and third tones, thus the second tone becomes T2 also. In the right-branching structure, T3 sandhi first applies to the second and third tones, thus the second tone must change first. When the domain is then expanded, the context for sandhi is no longer met. In the case of Mandarin T3 Sandhi, the process is truly sensitive to morphosyntactic structure since the structure is governing the domains of sandhi application reminiscent of what is observed in other cyclic phonological processes.

Another way in which morphosyntactic structure can affect process application is if the morphosyntactic boundaries correspond to some kind of prosodic break. That is, certain processes will apply across boundaries between relatively small prosodic domains but are blocked at larger prosodic domains (e.g. Nespor & Vogel, 1982). If this is the case, then morphosyntactic structure may not tell us anything at all regarding whether a process is phonetic or phonological, since both types of processes are sensitive to prosodic breaks of varying levels. In the case of tonal coarticulations, it could be that pitch perturbations are affected by very low level prosodic boundaries (i.e. small breaks can trigger a ‘resetting’ of with underlying T4 of comparable frequency.
laryngeal configuration for producing f0). In this sense, the examples given in Wu (1985) are especially problematic because while left-branching structures were usually noun-compounds (e.g. \textit{xi1.yang2.jing3} ‘ocean scenery’), right-branching structures tended to be verb and complement (e.g. \textit{he1.leng2.shui3} ‘drink cold water’). The prosodic break between verb complement in right-branching structures were likely greater than the break between the constituents of a nominal phrase, thus confounding the evidence.

Also, as discussed in Section 2.2, it is unclear why the process should apply to some tonal contexts but not others given that the phonetic contexts for application are met. Finally, as with most descriptions of tonal processes, Wu (1985) treats the process as consistently occurring in the contexts he specifies. However, this process is likely subject to some degree of variation both in terms of consistency of application and in terms of the shape of the resulting pitch curve.

Given the many issues surrounding the nature of Mandarin T2 coarticulation, the current study investigates the following questions: 1) How consistently does T2 coarticulation apply in contexts where it is licit? If it is a phonetic process, we may expect more variability compared to a relatively consistent phonological process. 2) Is the process affected factors such as frequency, speech rate, and syllable length? If it is phonetic, we may expect it to apply more often in words with higher frequency, at a faster speech rate, and on shorter syllables. 3) Is the process conditioned by morphosyntactic boundaries within left- and right-branching nominal phrases\textsuperscript{5}? phonological context? 4) With this preliminary evidence, is it possible to identify this process as either phonetic or phonological?

### 3 Methods

A production experiment was conducted to try to tease apart the various factors that may affect the application of Mandarin T2 coarticulation.

#### 3.1 Participants

Three UCLA undergraduate students were recruited for this study, 2 males and 1 female. All participants were native speakers of Standard Mandarin and had lived abroad for 6 years or less.

#### 3.2 Materials

The list of target words were controlled for the variables listed in (6).

(6) Independent Variables

\textsuperscript{4}I use Pinyin orthography with numbers indicating the tone.

\textsuperscript{5}Although comparing only nominal phrases improves the strength of the argument, it does not remove the confound of prosodic effects. See Section 4 for discussion.
Morphosyntactic structure (x2) \( \sigma[\sigma\sigma] \) vs. \([\sigma\sigma]\sigma\)

Tone sequence (x7) T1.T2.T2
T1.T2.T3
T1.T3.T3
T2.T2.T2
T2.T2.T3
T2.T3.T3
T3.T3.T3

Speech rate (x2) slow vs. fast

Word Frequency (x2) high and low frequency evenly distributed within each condition

Rhyme length (x2) V vs. (G)VN, where G = glide

Word frequency was obtained by doing searches on the Baidu.com search engine\(^6\). This creates 112 different types, with two representative noun phrases per type, generating 224 tokens. Filler words were added with a target-filler ratio of 14:11 (400 tokens overall). These tokens were randomized and separated into 200-token blocks.

### 3.3 Procedure

Participants were presented with words one by one via PowerPoint and asked to read the words from the screen as if saying them naturally in conversation. A metronome beat was played through headphones simultaneously to control for speech rate, 50 beats per minute for the slow condition and 90 beats per minute for the fast condition. Participants were asked to say the word on one beat and click for the next slide on the following beat. This was effective in controlling for this variable as participants were generally very consistent with the metronome. Participants repeated each token twice. The experiment lasted approximately 45 minutes per participant, including the initial orientation and explanation as well as breaks during the experiment. The produced tokens were recorded using a head-mounted microphone using PCquerier in the UCLA Phonetics Lab sound booth.

### 3.4 Analysis

A total of 1344 target tokens were collected, from which 14 were discarded due to mispronunciation of the intended tone (e.g. T1 read as T4). Remaining tokens were labelled as ‘0’ if no T2 coarticulation was observed and ‘1’ if T2 coarticulation was observed. All variables were coded as factors except for Word Frequency which was kept as a continuous variable. Tone Sequence was broken up into three separate factors (Tone on Syllable 1, Tone on Syllable 2, and Tone on Syllable 3). The data were analyzed using a mixed-effects logistic regression model, implemented in R using the lme4 package.

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\(^6\)Official Chinese word frequency databases were also consulted, but they were found to be inadequate for providing collocation frequency for trisyllables that approximated daily use.
4 Results & Discussion

The pitch contour on the second syllable of trisyllabic words can be categorized as three types of realizations: i) rising (no T2 coarticulation), ii) falling (T2 coarticulation), and iii) falling followed by rising. Pitch curves of three tokens representing each type of realization are given in (7).

(7) Example Pitch Contours

a. ‘police station’ /T1.T2.T2/

b. ‘glass bottle’ /T1.T2.T2/

c. ‘obsertatory’ /T1.T2.T2/
All of these examples have left-branching structure ([σσ]) and the same underlying tones (/T1.T2.T2/), and were produced by a single participant in the slow speech condition. Example (7-a) shows that the tone on the second syllable can be realized as the canonical rising contour. Example (7-b) shows that the tone on the same syllable can be realized with a falling contour. Example (7-c) shows that the tone on the second syllable can be realized with both a falling contour and a rising contour. This was the most frequent case. The criterion for coding the occurrence of T2 coarticulation was if the proportion of falling pitch was greater than the proportion of rising pitch on the tone-bearing portion of the syllable. (See Section 5.2 for discussion of possible issues with coding criterion.)

Overall, 507 out of 1330 tokens were produced with T2 coarticulation on the second syllable. A mixed-effects logistic regression model was used to evaluate which variables were better predictors of the probability of the occurrence of T2 coarticulation. The fixed effects included in the final logistic regression model were Speech Rate, Morphosyntactic Structure, Frequency, Rhyme Length, Tone on Syllable 1, Tone on Syllable 2, Tone on Syllable 3, Participant, as well as interactions between Participant and Tone on Syllable 1, and Morphosyntactic Structure and Tone on Syllable 1. Participant was also included as a random intercept\(^7\). The fixed effects for the final model are given in (8).

(8) Summary of fixed effects

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Estimate</th>
<th>Standard Error</th>
<th>Wald z</th>
<th>p-value</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Intercept)</td>
<td>0.07</td>
<td>0.22</td>
<td>0.33</td>
<td>0.74</td>
<td>---</td>
</tr>
<tr>
<td>Speech Rate</td>
<td>-0.45</td>
<td>0.12</td>
<td>-3.72</td>
<td>&lt;0.001 ***</td>
<td></td>
</tr>
<tr>
<td>Morphosyntactic Structure</td>
<td>0.09</td>
<td>0.18</td>
<td>0.51</td>
<td>0.61</td>
<td>---</td>
</tr>
<tr>
<td>Frequency</td>
<td>-0.00</td>
<td>0.00</td>
<td>-0.58</td>
<td>0.56</td>
<td>---</td>
</tr>
<tr>
<td>Rhyme Length</td>
<td>0.55</td>
<td>0.12</td>
<td>4.51</td>
<td>&lt;0.001 ***</td>
<td></td>
</tr>
<tr>
<td>Syll 1 (T2~T1)</td>
<td>-0.43</td>
<td>0.25</td>
<td>-1.68</td>
<td>0.09</td>
<td>.</td>
</tr>
<tr>
<td>Syll 1 (T3~T1)</td>
<td>-3.71</td>
<td>0.81</td>
<td>-4.56</td>
<td>&lt;0.001 ***</td>
<td></td>
</tr>
<tr>
<td>Syll 2 (T3~T2)</td>
<td>0.21</td>
<td>0.15</td>
<td>1.35</td>
<td>0.18</td>
<td>---</td>
</tr>
<tr>
<td>Syll 3 (T3~T2)</td>
<td>-0.73</td>
<td>0.15</td>
<td>-4.72</td>
<td>&lt;0.001 ***</td>
<td></td>
</tr>
<tr>
<td>Participant (2~1)</td>
<td>-0.06</td>
<td>0.21</td>
<td>-0.29</td>
<td>0.77</td>
<td>---</td>
</tr>
<tr>
<td>Participant (3~1)</td>
<td>0.71</td>
<td>0.22</td>
<td>3.29</td>
<td>0.001 **</td>
<td></td>
</tr>
<tr>
<td>Syll 1 (T2<del>T1) × Part (2</del>1)</td>
<td>0.11</td>
<td>0.31</td>
<td>0.34</td>
<td>0.73</td>
<td>---</td>
</tr>
<tr>
<td>Syll 1 (T3<del>T1) × Part (2</del>1)</td>
<td>0.72</td>
<td>0.54</td>
<td>1.32</td>
<td>0.19</td>
<td>---</td>
</tr>
<tr>
<td>Syll 1 (T2<del>T1) × Part (3</del>1)</td>
<td>-0.77</td>
<td>0.31</td>
<td>-2.49</td>
<td>0.013 *</td>
<td></td>
</tr>
<tr>
<td>Syll 1 (T3<del>T1) × Part (3</del>1)</td>
<td>-0.95</td>
<td>0.58</td>
<td>-1.65</td>
<td>0.10</td>
<td>.</td>
</tr>
<tr>
<td>Syll 1 (T2~T1) × Structure</td>
<td>0.04</td>
<td>0.25</td>
<td>0.18</td>
<td>0.86</td>
<td>---</td>
</tr>
<tr>
<td>Syll 1 (T3~T1) × Structure</td>
<td>3.25</td>
<td>0.77</td>
<td>4.20</td>
<td>&lt;0.001 ***</td>
<td></td>
</tr>
</tbody>
</table>

\(^7\)Given the small number of participants, this did not need to be included as a random intercept, but since there were no other random variables, Participant was included as a random intercept since the model requires at least one random intercept.
Overall, Participant 3 produced significantly more instances of T2 coarticulation than Participants 1 and 2, $z(1312)=3.29$, $p=.001$. T2 coarticulation was more likely during slow speech than fast speech, $z(1312)=−3.72$, $p<.001$. The main fixed effect of Rhyme Length was also significant, $z(1312)=4.51$, $p<.001$, with coarticulation being more likely in longer rhymes. T2 coarticulation was less likely when the tone on the first syllable was T3 than when it was T1 or T2, $z(1312)=−4.56$, $p<.001$. It was more likely when the tone on the third syllable was T3 than when it was T2, $z(1312)=−4.72$. There was a significant interaction between Tone on Syllable 1 and Participant, $z(1312)=−0.77$, $p=.013$. The probability of T2 coarticulation occurring was greater when Syllable 1 was T1, but this effect was only observed for Participant 3. There was also a significant interaction between Tone on Syllable 1 and Morphosyntactic Structure, $z(1312)=4.20$, $p<.001$. The probability of T2 coarticulation occurring was greater for left-branching structure than for right-branching structure but only when the tone on the first syllable was T3. There were no significant main effects of Morphosyntactic Structure, $z(1312)=0.51$, $p=.61$, Frequency, $z(1312)=−0.58$, $p=.56$, or Tone on Syllable 2, $z(1312)=1.35$, $p=.18$.

5 Discussion

The interaction between Morphosyntactic Structure and Tone on Syllable 1 was expected. In particular, the probabilistic difference observed only when the first syllable is T3 reflects the difference in Mandarin T3 application across trisyllabic words with different morphosyntactic structure. That is, the output of Mandarin T3 sandhi for a /T3.T3.T3/ sequence should be [T2.T2]T3 or T3[T2.T3]. Only the first output has the phonetic context for T2 coarticulation, thus we should naturally only observe coarticulation for words with left-branching structure. This also explains why overall, proportionately few tokens with T2 coarticulation are observed when the first syllable bears a T3 compared to the other two tones.

The interaction between Tone on Syllable 1 and Participant revealed that Participant 3 patterned differently from Participants 1 and 2, producing T2 significantly more when the tone on the first syllable was T1 vs T2. This is likely due to the fact that the tone sequences /T2.T2.T2/ and /T2.T2.T3/ are contexts for both Mandarin T2 Sandhi (see §2.1) and T2 coarticulation. Participant 3 had a stronger preference for T2 Sandhi in these contexts compared to Participants 1 and 2.

5.1 Phonological vs. Phonetic evidence

The most striking results pertain to the factors of Speech Rate, Rhyme Length, and Morphosyntactic structure. I will discuss these in turn.

It was predicted that, if T2 coarticulation was truly phonetic, then it should be more probable given faster speech rate. In faster speech, there is less time to produce all the pitch targets, thus bio-mechanical constraints dictate that speakers should prefer to coarticulate the second syllable and produce T2 with a [HM] contour. However, the results were signifi-
cant in the opposite direction (i.e. T2 coarticulation was more probable at a slower speech rate). The situation for the Rhyme factor is parallel. It was predicted that T2 coarticulation should be more probable when the tone bearing portion of the target syllable was shorter, since durationally shorter segments should force speakers to approximate their pitch targets more. Again, the opposite was true (i.e. speakers were more likely to produce T2 coarticulation given longer syllables).

Recall that generally when there was some kind of coarticulation on the second syllable, the preferred pitch shape was falling and rising rather than falling alone. This can be interpreted as the result of competing constraints. We can imagine that it is marked to jump from two different pitch targets or to transition quickly from one to the other since this is physiologically constrained by how quickly a speaker can adjust the tension on their vocal chords. From this perspective, it is better to prolong the transition from the final H on the first syllable to the initial M of the second syllable. However, at the same time speakers also want to be faithful to the rising contour of the citation tone. To satisfy both constraints, speakers will prefer to produce a gradual falling contour between the H and M pitch targets, and then produce a rise. This is naturally easier to achieve in slower speech in longer syllables. Importantly, these results, which are opposite to what was predicted, can still be explained phonetically.

The observed patterns for pitch contours produced in this study also suggest that true T2 coarticulation (HM) does not result from assimilation of the type discussed in Shen (1992). That is, the two pitch targets of the falling contour are not the result of complete assimilation of initial M to the preceding H target and final H to the following M target. Rather, it is an interpolation between the preceding H target and the initial M target. The difference between the two analyses is schematized below in (9).

(9) Assimilation vs. Interpolation (Image by Joshua Lai)

The figure on the left shows varying degrees of assimilation on the initial and final pitch targets of a syllable. The figure on the right shows the interpolation analysis in which the falling contour is a transition between a H target and a persisting M target. Under this analysis, the varying degrees of rise following the fall in many of the tokens should be modelled as weakening/deletion of the final H tone target on the second syllable. If the preference for longer transition outweighs the preference to be faithful in a certain context, then the falling tone results. If the preference to be faithful outweighs the preferences for longer transition time, the resulting tone should closely approximate the contour of the citation tone.
Also a surprising result was that there was no significant difference in the likelihood of T2 coarticulation between the two morphosyntactic structures. This is contrary to Wu’s claim that morphosyntactic structure was a sure determiner for whether the process applied or not. Although as discussed in Section 2.3, morphosyntax may not help us to determine whether the process is phonetic or phonological, these results seem to suggest that it is not a factor at all.

5.2 Methodological Issues

At the outset of this study, the expectation for tone contour realization was either rising [MH] or falling [HM] and therefore coding of the tokens was binary. However, it is quite obvious from the variation on pitch contours observed that they would be better modelled by a continuous variable. For example, if the tokens where T2 Sandhi occurred were discarded, the remaining tokens could be given a measure of when the pitch minimum occurred proportionate to the duration of the syllable. This would be able to capture rising, falling, and falling-rising variants.

6 Conclusion

This production study aimed to determine the exact nature of Mandarin T2 coarticulation by examining the effect of phonetic and phonological factors in predicting the likelihood of process application. The factor that would have provided the strongest motivation (according to past descriptions) was shown to be insignificant. Other phonological factors such as tonal context were mediated by conflict with tone processes other than the one of interest. Although the factors of Speech Rate and Rhyme Length were significant in the opposite direction than what was hypothesized, they could still be explained phonetically and thus gave support to the phonetic analysis of T2 coarticulation. The results of this study also prompted a re-analysis of the exact process in which the surface pitch contour is derived, which contrary to previous claims is the result of interpolation rather than assimilation.
References


