English words as triggers for Mandarin tone sandhi in bilingual speech

When bilingual speakers mix languages in their speech, two different phonologies come into contact in real time, which prompts the question of how potential incompatibilities between the two phonologies are (or are not) resolved. This study investigates one such potential incompatibility, namely how Mandarin-English bilinguals handle tone sandhi in Mandarin when the triggering environment is occupied by a word in English, a non-tonal language with syllable structures very different from that of Mandarin. A well-known tone sandhi on the negator word *bu* in Mandarin was selected for this purpose. The falling Tone 4 on *bu* in its canonical form changes to a rising Tone 2 when the following syllable also has Tone 4 (Chao, 1965; Duanmu, 2007). The current study looks at how this tone sandhi behaves when *bu* is followed by an English word in bilingual speech.

A production experiment was conducted for this study, where 17 Mandarin-English bilingual speakers (8F, 9M, aged 19-55) recorded Mandarin sentences containing English words with varying numbers of syllables, onset shapes, and stress positions after the word *bu*. Note that the embedded English words were produced like English, without any repairs to make them conform to Mandarin phonotactics (i.e. they are essentially word-level code-switches).

To see the relevant tonal context of the *bu* sandhi, pitch contours of the English syllable after *bu* were transcribed by the author, as summarized in Table 1. Since the English words are typically stressed in the constructions used in this experiment, monosyllables are expected to have a declarative falling H*L-L% pitch accent while stressed initial syllables in polysyllabic words should have a high H* pitch accent, which readily map to Mandarin T4 and T1 respectively based on acoustic similarity. Acoustic mappings of this kind, known as the *stress-to-tone* effect, have been found in previous studies on tone adaptation in Mandarin loanwords; in particular: 1) monosyllables tend to get T4 when adapted to Mandarin, and 2) stressed initial syllables tend to get T1 (Wu, 2006; Glewwe, 2021). Additionally, Shen (2019) found that the pitch on English words is amplified when they are embedded in Mandarin sentences compared to in unilingual English sentences as a result of tonal coarticulation, which makes it even more plausible for the embedded English words to be assigned tones in Mandarin sentences due to the stress-to-tone effect. These general patterns were consistent with what bilingual speakers produced on the English words in the current study.

	High = T1	Rising = T2	Low = T3	Falling = T4
Mono, non-complex onset (e.g. 'work')	7.7% (22)			92.3% (265)
Mono, complex onset (e.g. 'scan')	13.6% (20)		3.4% (5)	83.0% (122)
Poly, initial stress (e.g. 'native')	100% (97)			
Poly, non-initial stress (e.g. 'forget')	9.9% (7)		90.1% (64)	

Table 1: Transcription of pitch contours on the initial syllable of embedded English words

A falling pitch contour on the English syllable was indeed readily associated with the tone sandhi on *bu*, but it was nevertheless not the sole determinant for the realization of the sandhi: the shape of the English syllable onset also played a role. Figure 1 shows the f0 contour of the vowel in *bu* on a normalized time scale before four groups of English words separated along the dimensions of syllable count (monosyllabic vs. polysyllabic) and onset shape (noncomplex vs. complex). The dashed line on the right plot marks the right edge of the vowel, showing the f0 trajectory into the next syllable to account for tonal coarticulation (Xu, 1997). We see that *bu* only had a T2 before monosyllables with non-complex onsets and a T4 everywhere else.

What's particularly puzzling is that while monosyllables with non-complex onsets (and falling pitch) readily triggered the sandhi on *bu*, the sandhi was generally not produced when

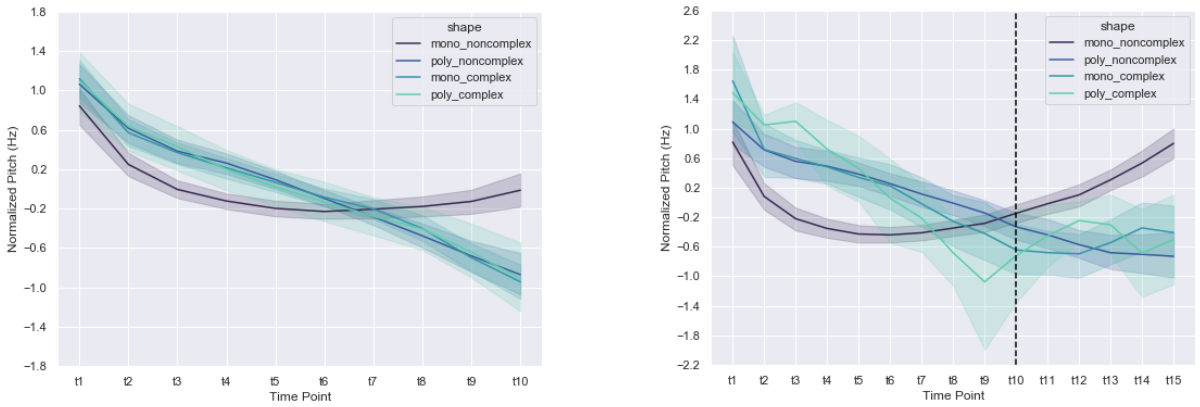

Figure 1: f0 contours on the vowel in *bu* before English words of various shapes; irregularities on the right plot are due to fewer available tokens with valid pitch measurements across all 15 timepoints

the English monosyllable has a consonant cluster in its onset, *even though the syllable still has a falling pitch contour* (thus mapping it to T4 per the stress-to-tone effect). This is unexpected if we assume the embedded English word is essentially the same as a loanword in Mandarin, which should trigger tone sandhi based on its tone alone. Yet, consonant clusters in the onset appeared to "block" native tone sandhi on the preceding *bu* despite the English syllable having a falling pitch contour. It is also worth noting that the blocking effect of English consonant clusters was only observed at the onset position, where the English word borders the recipient of the tone sandhi; clusters in the coda of the English syllable did not exhibit a similar effect.

The findings in this study raise questions about what exactly happens when the phonologies of two different languages come into contact in real time during the production of bilingual speech. On the one hand, a tone sandhi native to Mandarin phonology (which arguably has no representation in the English phonology) was consistently triggered by English words with certain characteristics in a Mandarin sentence, which can serve as evidence for the view that online adaptation took place and the English words are essentially loanwords with Mandarin tones assigned by the stress-to-tone effect. However, on the other hand, English consonant clusters on the edge of the code-switch blocked the sandhi on the preceding Mandarin syllable despite the English syllable having the pitch contour required by the tone sandhi. The latter observation suggests that even if adaptation had occurred, the adaptation was not complete. Since Mandarin phonotactics permits much less complexity in syllable structure compared to English, we might speculate that the presence of the phonotactically-incompatible consonant clusters at the point of code-switch removes an environment that can otherwise induce Mandarin tone sandhi across two languages. These observations could also be broadly related to facts about perception processing, in particular that lexical tone distinctions are generally less perceptually salient than segmental distinctions (Cutler and Chen, 1997), which has also been cited in loanword studies to explain the pattern where segmental faithfulness often takes precedence over tonal faithfulness in loan adaptation (Wu, 2006).

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