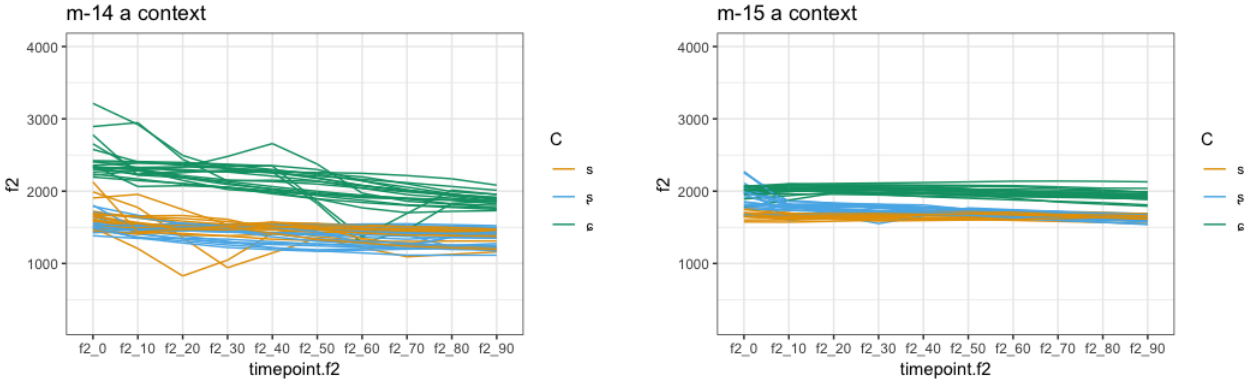
Coarticulation with alveopalatal sibilants in Mandarin and Polish: Phonetics or phonology?

Introduction: Previous work has shown that vowels following alveopalatal sibilants typically exhibit raised second formant (F2) values (Stevens, 2004 in Mandarin; Bukmaier & Harrington, 2016 in Polish, among others). This paper re-examines the palatalizing coarticulatory effects of the alveopalatal sibilant in Mandarin and Polish. While previous studies have focused on differences in F2 transitions or values at vowel onset, we find that the raised F2 values following alveopalatal sibilants persist through the entire duration of the vowel. This raises the question of whether this is a phonetic coarticulation effect or a phonological assimilation effect. We review the diagnostics for such a distinction and provide evidence from speech rate which suggests that the raised F2 effect should be analyzed as phonological. Implications for perception and sound change are also discussed.

Methods: Data was obtained from 11 native Mandarin speakers during a laboratory speech production task. The stimuli were mono- and bisyllabic words with word-initial alveopalatal, retroflex, and alveolar sibilants followed by vowels [a u] placed in a carrier phrase. These data are compared with Polish data which come from a separate study of 3 native Polish speakers where the stimuli were words and non-words of 1-4 syllables with word-initial alveopalatal, retroflex, and alveolar sibilants followed by vowels [ɛ a ɔ] placed in a carrier phrase.

Results: F2 trajectories for [a] for two representative Mandarin speakers are shown in Figure 1, which show F2 values of /a/ following three different sibilants with raw trajectories over raw time. As expected, we found consistent differences in onset F2 following the alveopalatal sibilant relative to the other sibilants. Somewhat less expected, we found that these differences persisted throughout the entire duration of the vowel. The speakers showed variation in mean F2 values and amount of within-category variance, but the raised F2 effect was consistent across speakers and vowel contexts. These results were compared with data from Polish, which showed a similar pattern in all vowels that were elicited. Vowels following the alveopalatal sibilant exhibited raised F2 values throughout the vowel duration.

Figure 1: F2 trajectories in Mandarin /a/: two representative speakers



Discussion: The results here show that the influence of the alveopalatal sibilant on the following vowel is not merely in the transitions to the vowel; vowels following the sibilant have a higher F2 throughout the vowel duration. Given this, it could be the case that this is a phonological effect and speakers are selecting a raised F2 allophone for vowels following alveopalatal sibilants. Several diagnostics proposed in the literature would seem to indicate that this effect should

be analyzed as phonological assimilation. Keating (1990) suggests that processes affecting the whole segment should be viewed as phonological while processes affecting part of the segment should be viewed as phonetic. Under that view, this effect would be considered phonological. There are also several proposals which focus on the gradience of phonetic effects compared to categorical phonological effects (see Cohn, 2007, for a review). The raised F2 effect in Mandarin and Polish does not appear to be particularly gradient or variable. There is consistency in the pattern of raised F2 across tokens, speakers, vowels contexts, and speech rates.

Solé (2007) proposes that phonetic or "mechanical" effects should have temporal extensions which are independent of speech rate. Therefore, if raised F2 were a purely mechanical effect, we would see raised F2 for a fixed period of time across all speech rates. We performed a speech rate analysis using a linear mixed effects regression model predicting F2 at vowel offset. Neither vowel duration nor carrier phrase duration (as a metric of speech rate) were significant predictors of F2 at vowel offset. However, preceding sibilant was a significant predictor. We see that the duration of raised F2 is not fixed; F2 is raised throughout the entire vowel regardless of vowel duration or speech rate.

It could be argued that the consistency of raised F2 across two unrelated languages suggests the effect is not phonological, but instead arises from universal articulatory constraints (though language-specific phonetic patterns have certainly been documented). However, we do have evidence from other languages where the palatalizing coarticulatory effect only raises F2 for a portion of the vowel duration following the sibilant (see Kochetov (2017) on Russian pataltalized postalveolar sibilants). This suggests that the raising of F2 for the entire following vowel is a more active and potentially phonological effect in Mandarin and Polish.

Previous work on perception has found that Polish speakers were only able to correctly identify sibilants when the appropriate following vowel transitions were present Nowak (2006). Our results suggest the potential for a stronger perceptual effect—Mandarin and Polish speakers may be able to identify the preceding fricative from only hearing the following vowel, or even only the offset of the following vowel. Further perception work will need to be done to determine exactly how listeners use the vocalic information for sibilant identification.

Conclusion: We have presented data from Mandarin and Polish where vowels following alveopalatal sibilants exhibit raised F2 throughout the entire vowel duration. We use previously proposed diagnostics in the literature to analyze this as a phonological assimilation effect, rather than a phonetic coarticulatory effect. This is because the raising affects the whole segment, it is consistent across tokens and speakers, and it is not temporally independent (as would be expected from a purely mechanical effect). Further work will need to be done to determine the effects of raised F2 on perception and processing in these and other languages.

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