Flipping the switch: Tonal patterns in Mandarin-English code-switching

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Abstract

This paper investigates the phonological implications of bilingual code-switching (CS) between two languages with and without lexical tone, namely Mandarin and English. To this end, we examined the pitch extrema and range of Mandarin targets in two contexts—monolingual Mandarin sentences and English CS sentences—in order to determine whether pitch contour is affected in instances of CS. Previous literature on the phenomenon largely denies the existence of any cross-boundary phonological effects in Western languages; we aimed to discover whether this was equally true for tonal-intonational language pairs. Data was collected from ten subjects (eight female, two male) of heritage Mandarin-speaking backgrounds, each with varying degrees of bilingualism and language dominance. The experimental task consisted of reading aloud a set of twenty monolingual Mandarin sentences and twenty English CS sentences; the recorded audio was then processed in Praat, and the resulting data analyzed in R. We found that all subjects demonstrated the "base language effect"—the influence of the matrix language on the embedded element—to some extent, challenging the results of previous CS studies. Overall, this study aims to broaden the field of CS research to include non-Western languages, and thus further our understanding of this increasingly relevant phenomenon in a multilingual world.

1 Introduction

1.1 Overview of topic

Picture two international students in a Chinese high school, packing up their things at the end of the day. "Hurry up already," says one, "or the 阿姨 is gonna tell us to 回家." "别着急, I'm coming," says the other. To a monolingual listener, this exchange would be unintelligible. But to the participating bilingual speakers, the transfer of information is as perfect as if they had used only one language.

This is the phenomenon known as code-switching (CS), in which speakers of two languages or dialects switch rapidly between them inter- or intra-sententially in certain linguistic environments (namely, in the presence of other bilinguals). When talking about CS, linguists differentiate between the "matrix" (or "base") language—the main language of the utterance—and the "embedded" (or "guest") language—the language inserted into the utterance. For example, in the above anecdote, the first student's utterance has English as the matrix language, and Mandarin as the embedded.

For decades, CS has prompted investigation into what effect, if any, the matrix language has on the embedded element(s) of an utterance, whether in terms of phonetics, phonology, morphology, syntax, or semantics. This paper centers around the phonological implications of CS, and in particular, the effect on pitch contour of sentences involving CS between a tonal language and a non-tonal one.

1.2 Research questions

The broad question that forms the basis of this study is whether CS gives rise to any phonetic or phonological influences at all. By and large, previous literature suggests the contrary. However, the majority of existing CS studies only involve Western languages such as English, German, Spanish, or French; seldom do they consider tonal-intonational pairs like Mandarin and English. This scarcity is reason enough to revisit the potential existence of a unique "CS phonology" (Shen et al., 2020) between Mandarin and English.

The narrower question underlying this study deals specifically with surface forms, or the utterances actually produced by speakers. When two languages—one with phonemic tone, and one without—are code-switched by a bilingual speaker, what is the effect (if any) on the pitch contour of the resulting sentence?

1.3 Hypotheses

In view of these questions, there exist two potential hypotheses:

(1) The pitch contour of the matrix language will prevail over that of the embedded

language.

(2) The pitch of the embedded language will remain unaffected, essentially "ignoring" the pitch contour of the matrix language.

To understand the differing connotations of these two hypotheses, we can consider the following example:

(3) Have you been to 故宫 before?
'Have you been to the Forbidden City before?'

In (3) above, the Mandarin word "故宫" (gùgōng, 'the Forbidden City') is embedded into an English question. As we will see, yes/no questions in English typically follow a rising intonational contour throughout the utterance. However, with the introduction of a Mandarin word with a falling tone followed by a high, level tone—indicated respectively by the diacritics on 'gù' and 'gōng')—this may no longer be the case.

It should be noted that there exists a great number of systems, both within the International Phonetic Alphabet (IPA) and beyond it, for the notation of lexical tone. In the interests of simplicity and accessibility in this paper, we will follow the pinyin system of Chinese romanization, as exemplified in the CS sentence above.

Returning to the hypotheses, if Hypothesis (1) were true, the utterance in (3) would largely retain its rising intonation, effectively suppressing the tone of the CS element. This would indicate a cross-boundary effect of the matrix language onto the embedded language. By contrast, if Hypothesis (2) were true, the English question would no longer demonstrate its typical rising intonational pattern, as the Mandarin word would preserve its original tone and interrupt the contour. This latter case would suggest that CS happens completely and instantaneously, with no cross-boundary effects on either language involved; the majority of previous literature supports this hypothesis.

1.4 Summary of content

We will now enter into an overview of relevant background information, including pertinent definitions, relevant literature on CS, and introductions to Mandarin lexical tone and English intonational contour. Next, we will discuss the experimental design and methods involved in the data collection process. We will then examine the results of the experiment, undertake an analysis of the data, and determine which hypothesis is supported. Finally, we will conclude with an evaluation of the significance of this study, as well as potential next steps for future research.

2 Background

2.1 Overview of code-switching

2.1.1 Types of bilingualism

Earlier, we provided definitions for “code-switching,” the “matrix language,” and the “embedded language,” all of which are essential to an understanding of the phenomenon of CS. Equally important is the distinction between the two types of bilingualism—“simultaneous” versus “sequential” bilingualism. A simultaneous bilingual speaker acquires both languages within the same time frame in early childhood, typically due to the presence of two caregivers who use different languages. By contrast, a sequential bilingual speaker begins acquiring their second language only after the first has been partially, if not fully, acquired (Tabors, 2008).

Let’s consider an example. A child raised by two parents—one of whom uses English with the child, the other of whom uses Mandarin—would most likely achieve simultaneous bilingualism at home. A peer raised by Mandarin-speaking parents who only begins to acquire English upon entering kindergarten would probably develop into a sequential bilingual speaker.

Of course, a wide range of factors can affect language acquisition depending on the individual, including cognitive capacity, cognitive demand at a given time, as well as general aptitude for language-learning, social disposition, and psychological motivation. Nevertheless, language dominance—that is, the tendency of a bilingual speaker to use one language over the other—is typically proportional to the speaker’s degree of contact with that language in their linguistic environment (Tabors, 2008). Therefore, even if they speak the same languages, simultaneous and sequential bilinguals often differ in their language dominance. For this reason, the bilingual speakers who participated in this study were first analyzed for language dominance and level of proficiency.

2.1.2 Overview of relevant literature

The following survey of topical research presents the current general state of CS literature, and emphasizes the need for greater diversity in the language pairs addressed in CS studies.

While there does exist a body of CS-related literature, it largely denies any effect of the phenomenon on the phonetics or phonology of either language, matrix or embedded. One study that drew this conclusion was Grosjean and Miller (1994), which studied the effects of French-English CS on voice onset time (VOT). The central linguistic intuition in question was that of the "base language effect," first posited in Macnamara and Kushnir (1971). The phenomenon predicts that, in instances of CS, the matrix language (here called the "base language") causes the embedded language (here, the "guest language") to assimilate in some way, particularly right at the CS boundary (Macnamara & Kushnir, 1971). For example, under the base language effect, an English word inserted into a sentence of French might demonstrate a shorter VOT than it otherwise would in an English-only context, and thus better resemble a sound of French. However, the results of Grosjean and Miller (1994) ultimately refuted the effect; English targets exhibited roughly equal VOT duration in French- and English-matrix sentences. In other words, the data suggested that the switch between French and English was instantaneous and final (Grosjean & Miller, 1994). That said, it should be noted that the participants in Grosjean and Miller (1994) consisted solely of native French speakers who acquired English as adults; this may well have impacted the naturalness of their CS speech.

Nonetheless, a similar outcome arose in Muldner et al. (2019), which also investigated French-English CS, this time with regard to vowel phonetics. The particular parameters in question were the F1 and F2 formants, vocalic hyperarticulation, and pre-consonantal duration. The study shared the same intuition of Grosjean and Miller (1994)—as well as of this present paper—that the phonetics of the embedded language would undergo some influence from the matrix language so as to facilitate speaker production and listener comprehension. Yet ultimately, Muldner et al. (2019) found F1 and F2 to be unaffected and only saw evidence of hyperarticulation in vowel duration, overall refuting any significant phonetic or phonological impact on the embedded language in CS sentences. However, the study did note that the intonational contour of each embedded language shifted to better resemble that of its respective matrix language (Muldner et al., 2019). This last observation laid suitable groundwork for the investigation of pitch undertaken in this study.

Even more promising results appeared in Olson (2016), which examined the suprasegmental features of pitch and vowel duration in Spanish-English CS speech. The outcomes of the study did not directly support the base language effect hypothesis, but undeniably indicated some phonetic effect of CS. All CS utterances demonstrated increased pitch range and stressed vowel duration, posited to be hyperarticulation in response to diminished predictability. In other words, Olson (2016) surmised that speakers subconsciously hyperarticulate embedded CS phrases to avoid confusing their listener, especially in otherwise monolingual contexts (circumstances where CS might not be expected). This preventive speech style inherently dictates phonetic differences between CS and monolingual speech. Moreover, unlike Grosjean and Miller (1994) with its solely sequential bilingual participants, Olson (2016) controlled for the language dominance of each speaker; its results may therefore better represent the general CS behavior of bilingual speakers.

As is visible from the above overview of relevant studies, the majority of existing literature on CS focuses on pairs of Western languages, while phenomena such as Mandarin-English CS go comparatively underrepresented. It is for this reason that we should hesitate to automatically accept the commonly-posited non-existence of phonetic or phonological implications of CS, and that we are exploring a tonal-nontonal language pair as the subject of this study.

2.2 Overview of pitch

2.2.1 Mandarin lexical tone

Before we turn to the specifics of this study, there remains a crucial piece of background information requiring clarification: the difference between “tone” and “intonation.” As previously noted, Mandarin is a tonal language, meaning that pitch is a phonemic feature—that is to say, it can distinguish between two contrasting words. Mandarin is generally recognized as having five distinct tones: high level (“first tone”), high- or mid-rising (“second tone”), falling-rising (“third tone”), high-falling (“fourth tone”), and neutral, as given in the following minimal quintuplet from Xu (1997):

1. 妈 mā

   ‘mother’

2. 麻 má

   ‘hemp’

3. 马 mǎ

   ‘horse’

4. 骂 mà

‘scold’

5. 吗 ma

   interrogative particle

Crucially, every tone of Mandarin involves various other suprasegmental aspects in addition to pitch; for example, Mandarin speakers frequently produce the third tone with creaky voice (Coleman, n.d.). For the purposes of this study, only the second and fourth tones were relevant.

Xu (1997) found that, when produced as a monosyllabic token in isolation, each Mandarin tone exhibits a specific pitch contour and approximate duration. For example, the second tone typically demonstrates a relatively low fundamental frequency (f0) of around 110 Hz at its onset, falls slightly, then rises steadily through the end of the segment. The fourth tone follows, on average, the opposite trajectory: it has a high onset of roughly 140 Hz, rises slightly, then falls for the remainder of the tone. Similarly, Xu (1997) measured the average duration of the second tone in isolation at 273 ms, as opposed to 214 ms for the fourth tone. Though liable to differ from study to study, these general contours will be useful to keep in mind as we examine the pitch range and duration of Mandarin tones within different matrix languages.

For a study of Mandarin-English CS, it is equally necessary to consider how Mandarin tones behave intrasententially—that is to say, in context. Theoretically speaking, there are four possible forms a tone transition could take: mutual independence, two-way compromise, exclusive anticipation, or exclusive carryover (Xu, 1997). From an articulatory standpoint, however, mutual independence—in which neither tone is affected, and the switch is instantaneous—is not possible, given the anatomy of the glottis. That said, two-way compromise (in which both tones “meet in the middle” in terms of pitch), exclusive anticipation (in which the following tone assimilates towards the preceding one in pitch), and exclusive carryover (the opposite) are all possible (Xu, 1997).

The results of Xu (1997) indicated the clearest evidence for exclusive carryover: in disyllabic sequences, the f0 of the first syllable seemed to “spill over” substantially into the second, resulting in a smoother transition. This trend is of great interest to this study, given that the basic question underlying this research deals with the existence of cross-boundary effects between the matrix and embedded languages. If, in fact, Mandarin tones always demonstrate a carryover effect intrasententially, this impact would also be seen across the CS boundary in English-matrix sentences. A result of this kind would constitute strong evidence for Hypothesis (1).

2.2.2 English intonation

On the other end of the spectrum is English, an intonational language. Unlike Mandarin, in which pitch is phonemic and contributes to word meaning, pitch variation in English simply composes the intonational contour of a given utterance (Lee, 1997). This contour gives rise to what we often describe in layman's terms as "tone of voice"—whether the speaker sounds bored, excited, confident, nervous, etc. Intonational contour also informs whether we understand an utterance as a statement, question, or other. This study centered specifically around yes/no questions.

As with the annotation of Mandarin lexical tone, there are many different ways of representing intonational pitch in American English. In this paper, we will conform to the Tone and Break Indices (ToBI) annotation system, which breaks English pitch down into two possible types of tone (high, notated "H," or low, notated "L"), and analyzes intonational contour in terms of three "pitch loci" (pitch accent, phrase accent, and boundary tone) (Hedberg et al., 2014). High and low tones are self-explanatory; the three types of pitch loci are less so. A "pitch accent" (notated "H*" or "L*") refers to a tone associated with a stressed syllable, "boundary tones" (notated "H%" or "L%") designate the two tones that "bookend" the intonational contour, and a "phrase accent" (notated "H-" or "L-") denotes the pitch between the nearest pitch accent and a boundary tone. The specific frequencies and unique sequence of these pitch loci determine the perceived "melody" of a given phrase (Lee, 1997).

With regard to intonational contour in yes/no questions in American English, Hedberg et al. (2014) found that over 90% of these interrogatives display an overall rising contour. It should be noted that this percentage refers only to yes/no questions of the so-called "interrogative form"—that is to say, those with subject-auxiliary verb inversion. Additionally, there is general disagreement as to whether the primary contour of yes/no questions is low-rising or high-rising; Hedberg et al. (2014) hypothesized the former. Nevertheless, we can expect to see a rising contour of some type—which will be essential in determining whether the pitch of Mandarin targets is impacted in CS sentences. If the rise remains unaffected, Hypothesis (1) will be supported; if the intonational contour is disrupted by the target, Hypothesis (2) will prevail.

3 Methods

We will now discuss experimental methods for each of the four key stages of this study: participant recruitment, experimental design, data collection, and data analysis.

3.1 Participant recruitment

3.1.1 Survey design

As discussed in the previous section, bilingual speakers fall under different classifications based on the order in which they acquired their languages and the dominance with which they use them. Prior to beginning data collection, it was therefore necessary to evaluate the participants of the study, as their unique linguistic backgrounds could confound the overall pattern of results. For this purpose, a participant survey was generated using the Language History Questionnaire (LHQ3), the most recent version of a language proficiency diagnostic survey developed by Ping Li of the Brain, Language, and Computation Lab at the Hong Kong Polytechnic University (Li et al., 2020).

Using the LHQ3, each subject was assigned a randomized Participant ID. They then responded to questions related to their demographic data (age, gender, education level, handedness), countries of origin and residence, language proficiencies (native- and non-native) and modes of acquisition, self-rated language learning ability, and frequency of language use in different environments and social groups. Participants were also invited to supplement their responses with any other relevant information in a comment box at the end of the questionnaire (Li et al., 2020). See Appendix B for the full format of the questionnaire.

Potential participants were sourced from international student groups at Yale University (such as ACSSY, the Association of Chinese Students and Scholars at Yale) as well as from advanced-level heritage Mandarin courses in the East Asian Languages and Literatures Department. The specific objective of the study was not explicitly stated to prevent participants from subconsciously skewing the experimental results. Instead, they were simply informed that their completion of a brief survey and recording of several sentences would contribute to a study of Mandarin-English bilingualism. No compensation was provided to participant speakers, and the study received full IRB approval prior to the start of data collection.

3.1.2 Participant demographics

Ten subjects (eight female, two male) participated in this study. All were between the ages of eighteen and forty, had received at least a high school education, and originated from the US, American Samoa, Taiwan, or China. Four reported English as their L1 (mother tongue), while the remaining six reported Mandarin; all ten subjects reported either Mandarin or English as their L2 (second language), depending on their L1.

Based on respondents' self-reported competence in speaking, listening, reading, and writing, the LHQ3 questionnaire automatically generated a "proficiency score" between 0 (no proficiency) and 1.00 (native fluency) for each subject in each of their languages. Participants' L1 proficiency scores ranged between 0.75 and 1.00, with L2 proficiency scores falling between 0.57 and 1.00. As for their language dominance scores, five subjects were L1-dominant, three were L2-dominant, and two were relatively balanced bilinguals. These trends, along with individual subjects' demographic information, were useful in interpreting the data collected in this study.

3.2 Experimental design

3.2.1 Stimulus design

After participant recruitment, stimulus design constituted the majority of the work in devising this experiment. Many considerations came simultaneously into play in designing stimuli, including the naturalness and informality of the sentences, their meaning, the tone of the CS targets, target syllable count, sentential position, and even the sonority of the segments composing the targets. In consultation of all these variables, a total of forty sentences were generated, then pseudo-randomized into the five sets used in the experimental protocol.

Among the many variables mentioned, maximal naturalness and simplicity were of foremost importance; if participants were to find any of the provided sentences stilted or overcomplicated, it would be impossible to elicit data accurately representing their natural speech. To address the issue, CS targets were limited to fairly common nouns (with a few exceptions), all ending in the typically neutral-tone noun suffix 子 ('zi'). The sentence frames themselves were equally simple, consisting of only two English frames and their Mandarin equivalents:

1. Have you seen ___ before?

2. Do you have ___ at home?

3. 你看过 ___ 吗?

4. 你在家里有 ___ 吗?

The design process of these sentences frames equally prioritized plain, informal language. For example, the Mandarin frames contain only the second-person pronoun 你 ('nǐ') rather than its formal counterpart 您 ('nín')), in the hopes of eliciting relaxed and casual speech.

As for the targets' tone, the initial plan was to divide them among the four tones of Mandarin. However, given that the study aimed to examine target duration and pitch range in English- versus Mandarin-matrix sentences, the first tone—which tends to be long—and the third tone—which many speakers produce with creaky voice—had to be eliminated. Consequently, all experimental materials contained only second- and fourth-tone targets, with twenty of each. The targets were also restricted to two syllables (including the 'zi' suffix), placed at the nuclear pitch accent of the sentence, and composed entirely of sonorants —the class of sounds including vowels, glides, nasals, and approximants.

The sheer volume of considerations involved in stimulus design greatly complicated the process, but ultimately yielded a set of sentences optimized to deliver clear, informative results. See Appendix A for a full list of experimental materials.

3.2.2 Experimental protocol

The experimental protocol of this study was extremely straight-forward. Each subject was asked to read aloud a set of forty sentences, composed equally of ten sentences from each of four groups: English matrix with a rising-tone Mandarin target (Group A), Mandarin matrix with a rising target (Group B), English matrix with a falling target (Group C), and Mandarin matrix with a falling target (Group D). As mentioned above, these sentences were pseudo-randomized into five sets using an online shuffler. In order to accommodate subjects of all educational and linguistic backgrounds, four sets presented Mandarin materials in simplified characters, while the fifth did so in traditional. All five sets also provided pinyin of the Mandarin materials and English translations of the target nouns.

So as to promote a maximally natural speech style, subjects were encouraged to imagine they were speaking with an equally bilingual foreigner and introducing them to basic items from the speaker's country. To reinforce the scenario, five slideshows of visual aids were provided, each corresponding to a sentence set; each slide depicted two people discussing the target noun in question. These visuals were also intended to aid English-dominant subjects, especially in the few sentences involving less common targets (e.g., yàozi, 'sparrowhawk').

Subjects read each sentence aloud only once. Before recording began, they were instructed that, in the event of a pronunciation error or other incident, they should restart the interrupted sentence from the beginning, then resume as normal. They were also invited to flag any sentences that they judged unacceptable or "too unnatural" by on their linguistic intuitions and provide feedback on them.

3.2.3 Challenges

As discussed above, stimulus design posed the greatest challenge in the experimental design process. The sheer number of variables at play significantly limited the field of potential target nouns. Furthermore, as an English-dominant, sequential bilingual, I myself lacked the same intuitions that a native speaker born and raised speaking Mandarin might have. It was for this reason that speaker feedback on stimulus sentences was so strongly encouraged.

An additional obstacle was, predictably, the difficulty of conducting in-person data collection during a pandemic. Due to a surge of the virus in early 2022 as well as university policy on in-person activities, the first recording session could not take place until mid-February. As a result, the data collection process was limited to under two weeks, restricting the number of subjects that could be involved.

Participants were also more difficult to source and recruit than usual due to the pandemic. All recruitment efforts took place over email and social media, and it was often challenging to attract speakers willing to take part in an in-person recording session. In addition, several subjects who confirmed months in advance then delayed their return to campus to avoid the surge, further delaying data collection. Under normal circumstances, these issues would have been avoided.

3.2.4 Areas of improvement

Over the course of this study, there emerged several sources of error in the experimental design that could have confounded the results of the research. When reproducing this or a similar study, one should keep in mind these areas of improvement.

First, the experimental design of this study failed to account for the range of dialectal variation among its ten bilingual subjects. For example, one subject exclusively produces the voiced alveolar affricate in words like “子” (zi, the common noun suffix) as postalveolar; another regularly changed the lateral approximant in words like “家里” (jiālǐ, ‘at home’) to a tap. Though none of this consonantal variation should have significantly impacted the results of the study, it would have been a relevant consideration when designing experimental materials.

Related to the issue of speaker variation, many US-born subjects struggled to read some of the Mandarin characters in the provided materials—especially in the case of rare words like the aforementioned “鹞子” (yàozi, ‘sparrowhawk’). Although plain pinyin was provided for all Mandarin materials, the majority of these romanizations did not include tone diacritics or English glosses—these were limited to the targets of CS sentences. The intent behind this decision was to prevent subjects from reading the tone diacritics and thus overthinking their own tone production in the monolingual Mandarin sentences. However, as a result, several subjects were forced to guess the tone of less familiar targets and produced them incorrectly (e.g. yáozi or yāozi), requiring the associated trials to be discarded.

Finally, there were several opportunities for improvement raised by subjects themselves, given that three accepted the invitation to provide feedback on the experiment based on their intuitions as heritage speakers. For example, one recommended that the Mandarin sentence frame “你在家里有 ___ 吗? ” (‘Do you have ___ at home?’) would feel more natural without the preposition “在” (zài, ‘at’). Another noted that some of the target nouns (such as 梨子 (lízi, ‘pear’)) hardly ever take a noun suffix in spoken Mandarin, and are far more likely to be monosyllabic (e.g., 梨). Finally, one subject suggested that English articles be added before Mandarin targets in CS sentences. All three recommendations could be valuable developments in a future iteration of this study.

3.3 Experimental procedures

3.3.1 Technology and facilities

All data collection sessions were conducted in the sound booth in Dow Hall, home to the Linguistics Department at Yale University. Audio was recorded directly into Praat using a Blue Yeti USB microphone. The sound files were then processed in Praat (Boersma & Weenink, 2022), and the resulting data was analyzed in R (R Core Team, 2020).

3.3.2 Data collection procedures

Data collection sessions for this study involved three primary tasks: survey completion, participant orientation, and stimulus recording. As noted, all recruitment took place remotely, and potential subjects were encouraged to reach out individually if interested in the study. Upon doing so, they were assigned a Participant ID and directed to complete the LHQ3 background questionnaire, then invited to schedule a recording session at their convenience.

At each recording session, the subject was read an introductory statement explaining the study protocol and the associated time demands, followed by an IRB-approved verbal consent script. They were then situated in the recording booth and provided with a sentence set and its corresponding visual aids. After a brief sound check, they were recorded reading all forty sentences aloud in one take, and were then free to ask any questions and depart. Each subject also received a follow-up message thanking them for their participation and providing the contact information for the Yale Human Subjects Committee.

A short note on COVID-19 safety precautions: while subjects recorded the sentences unmasked, they removed their masks only once alone in the sound booth and replaced them immediately when finished. All other elements of data collection were conducted with appropriate masking and social distancing. All subjects were fully vaccinated in compliance with university requirements.

3.4 Data analysis procedures

Once all recording sessions were complete, the resulting audio files were processed in Praat. Each file was first cleaned to eliminate excess silence and speaker errors; a script was then run to generate a Textgrid for the file with boundaries at areas of low intensity (effectively separating utterances from pauses). Another script read labels for all forty trials into the Textgrid of each sound file, marking each trial with a unique label of the form 'SubjectID_ItemID'; the next saved each trial as a separate sound file, yielding four hundred in total. The final steps of data processing included demarcating and annotating the target word of each sound file, then running a last script to generate a text file containing the duration and pitch mean, range, and extrema of each of the four hundred targets. The first three scripts were sourced from Mietta Lennes' Praat toolkit (Lennes, 2017); the final two steps of data analysis used scripts written by Jason Shaw (Shaw, 2021).

The resulting measurements were then Z-scored and cleaned in Excel, with any mistaken trials and outliers eliminated. A total of 52 trials, or 13% of the data, were ultimately excluded for the following reasons:

- Speaker error: 19 trials (4.75% of all data)
- Praat error (pitch range ≤ 0): 12 trials (3%)
- Pitch range or maximum Z-score ≥ 2.5: 14 trials (3.5%)
- Pitch minimum Z-score ≥ 2.5: 7 trials (1.75%)

The ensuing analysis was based on the remaining 348 trials, or 87% of the original measurements. The data was loaded into R as a data frame, and the dependent measures of maximum pitch, pitch range, and minimum pitch were examined using the package ggplot2 (Wickham, 2016), yielding the figures presented in the next section. Using the package lme4 (Bates et al., 2015), linear mixed-effects (LME) models were then fitted to the data to test the reliability of the patterns that emerged, and analysis of variance (ANOVA) tests were run to calculate the statistical reliability of these predictions (Winter, 2013).

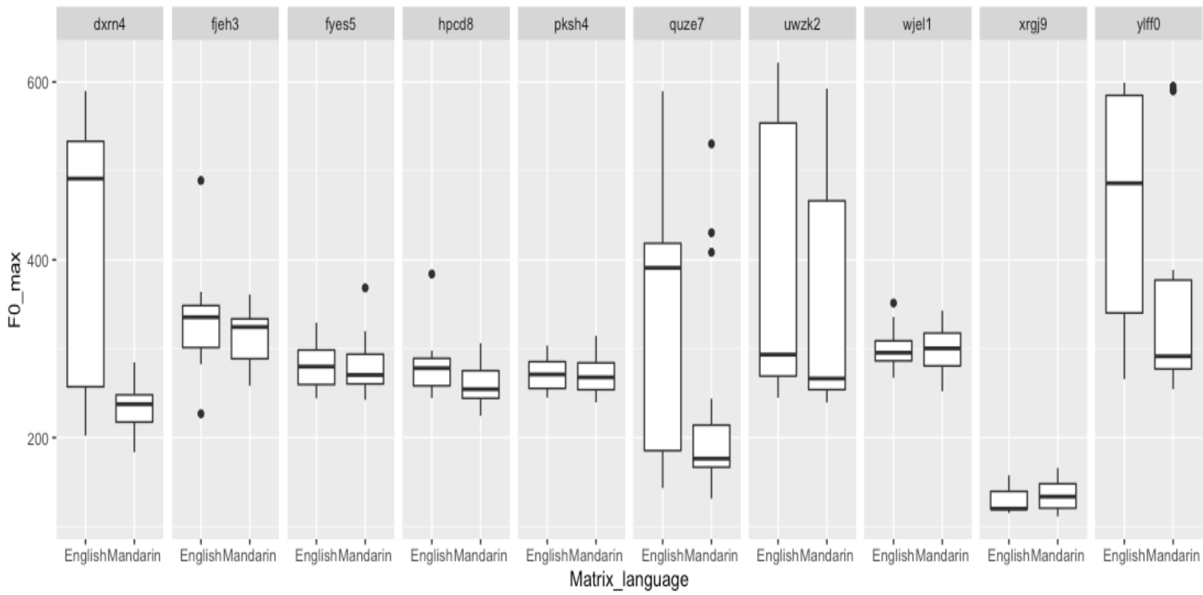
4 Results

Having thoroughly covered the underlying questions and intuitions, requisite background information, and experimental methods of this study, we are now prepared to examine the data and draw generalizations based on the patterns that appear.

4.1 Maximum pitch

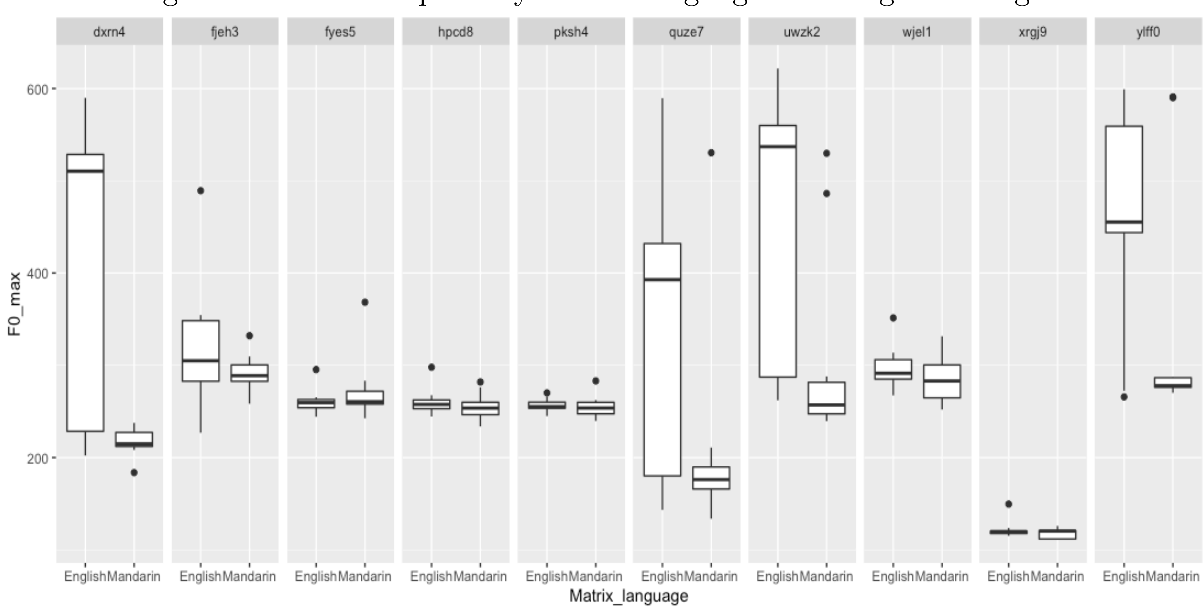
Let's begin with the dependent measure of maximum pitch. Figure 1 below plots the maximum pitch of Mandarin targets by matrix language for each of the ten bilingual subjects.

Figure 1: Maximum pitch by matrix language for targets of all tones.



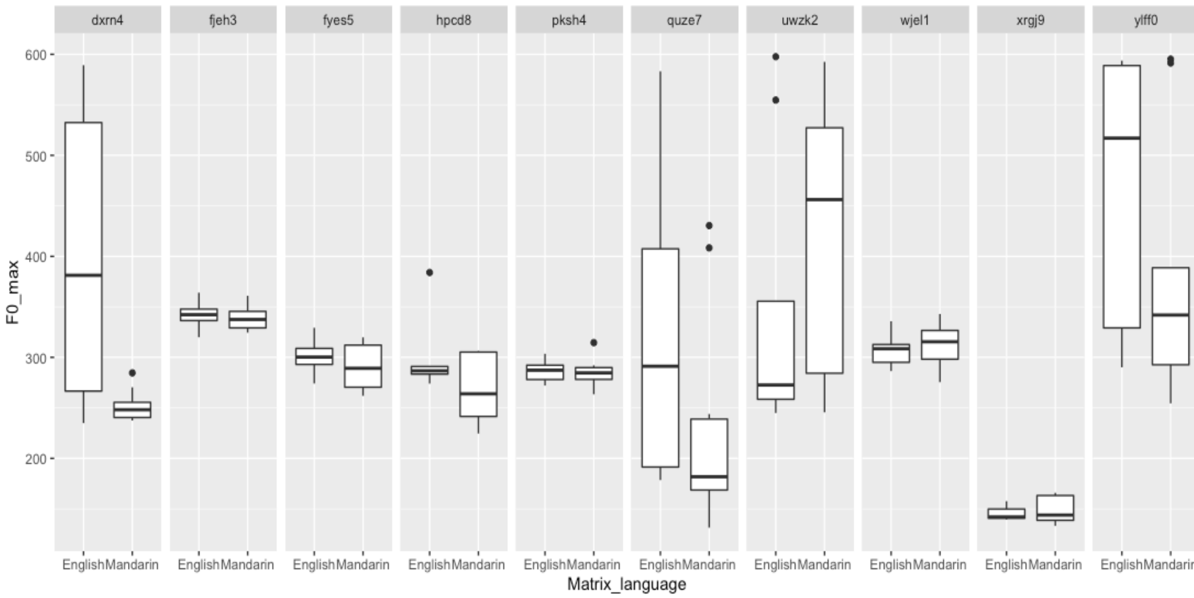
Collapsing across targets of both rising and falling tones, all but two subjects (wjel1 and xrgj9) clearly demonstrate greater maximum pitch measurements in English-matrix sentences—that is to say, CS contexts—than in monolingual Mandarin. Now to distinguish between targets of different tones: Figure 2 indicates maximum pitch by matrix language for rising-tone targets, while Figure 3 does so for those with falling tone.

Figure 2: Maximum pitch by matrix language for rising-tone targets.



Though some subjects' measurements fall very close across the two matrix languages, the overall pattern shows that all but one subject (xrgj9) demonstrate greater maximum pitch for rising-tone targets in English, as compared to in Mandarin.

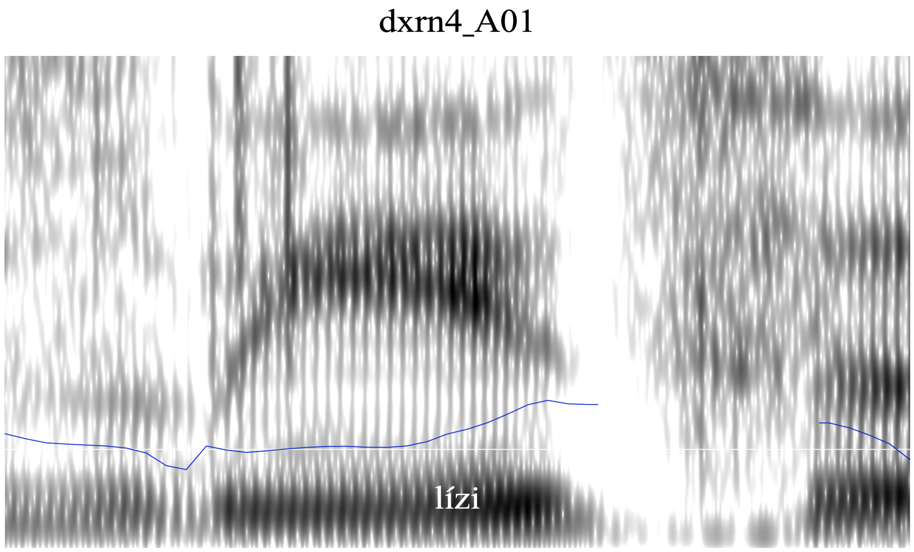
Figure 3: Maximum pitch by matrix language for falling-tone targets.



As for falling-tone targets, the results are less conclusive: seven subjects in Figure 3 indicate higher maximum pitch in English-matrix sentences, while the remaining three (dxrn4, quze7, and ylff0) have higher pitch in Mandarin contexts.

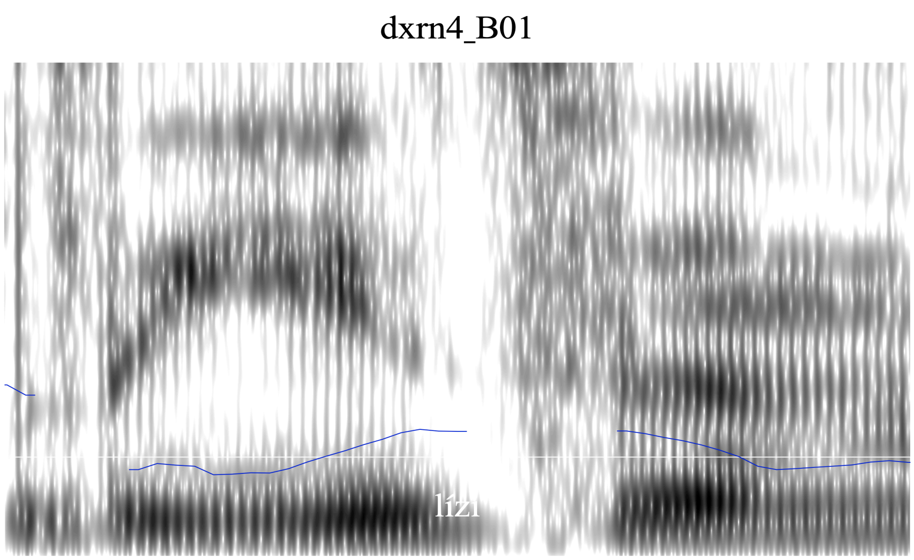
Nonetheless, we can see a general pattern emerging. In most cases, subjects demonstrate higher maximum f0 measurements in CS sentences than in Mandarin-matrix ones. To better understand what this looks like, let's examine the following minimal pair of spectrograms, which share the same speaker (dxrn4), target (lízi, 'pear'), and target tone (rising), differing only by matrix language:

Figure 4: Spectrogram with pitch contour for token /lízi/ within an English matrix.



In the above spectrogram, we can see that the token's pitch contour (drawn in blue) rises throughout the first vowel—[i] being distinguishable by its low F1 and high F2 formants—and reaches its peak near the end of the vowel.

Figure 5: Spectrogram with pitch contour for token /lízi/ within a Mandarin matrix.



In Figure 5, we see the same rise throughout the vowel, but the highest pitch value does not equal that of its English-matrix counterpart: the pitch contour of Figure 4 reaches its peak at approximately 200 Hz, while here the maximum f0 is about 20 Hz lower. In general, most subjects adhere to this pattern, producing a higher maximum pitch for targets in CS contexts.

But just how reliable is this generalization? To better understand the influence of matrix language on target pitch, we conducted a linear mixed-effects analysis of the data, constructing four nested LME models of increasing complexity for each dependent measure of the study.

The so-called "null" model (Winter, 2013) for maximum pitch (called "f0max1") had a fixed effect for target tone and random intercepts for subject and item. The next ("f0max2") added by-subject random slopes for the effect of matrix language, while the third ("f0max3") further included a fixed effect for matrix language. The most complex model ("f0max4") was identical to the previous, except that it contained an interaction term between the fixed effects of tone and matrix language.

An ANOVA test comparing the nested models found that f0max4, the model with the interaction term between tone and matrix language, provided the best fit to the data, as illustrated in the following table.

Table 1: ANOVA of four LME models for maximum f0.

	npar	AIC	BIC	logLik	deviance	Chisq	Df	Pr(>Chisq)
f0max1	5	4196	4216	-2093	4186	NA	NA	NA
f0max2	7	4161	4188	-2073	4147	39.6265	2	2.4843E-09
f0max3	8	4158	4188	-2071	4142	4.9601	1	0.0259
f0max4	9	4156	4191	-2069	4138	3.5895	1	0.0581

Sure enough, the interaction model demonstrates lower values for AIC and residual deviance than any of its alternatives.

Table 2: Coefficients for model f0max4.

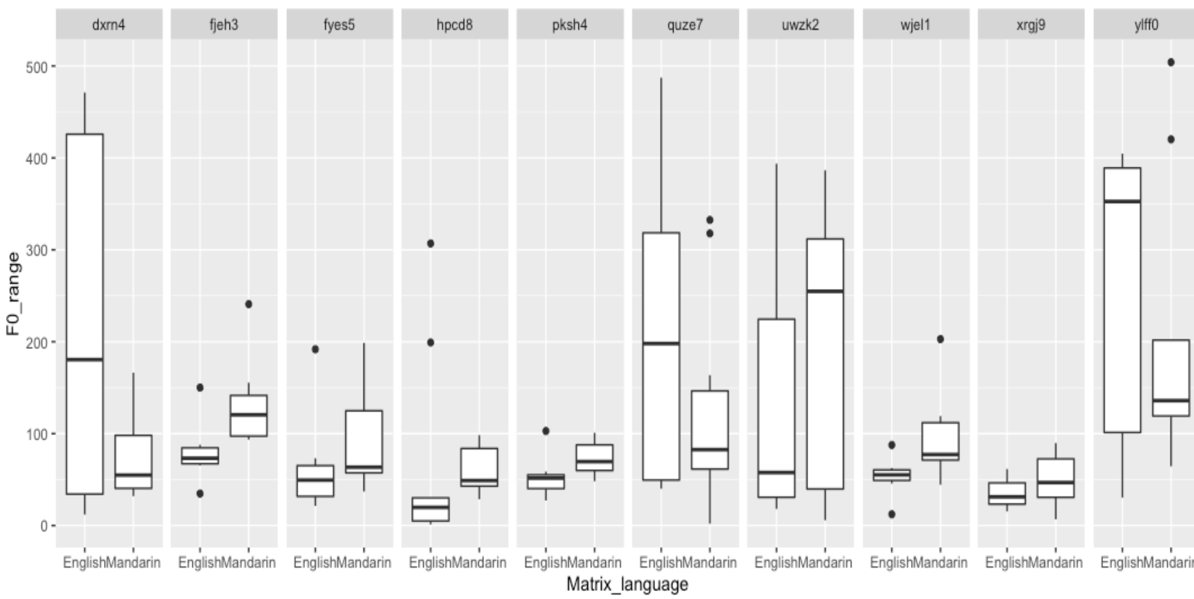
	Estimate	Std. Error	df	t value	Pr(>|t|)
(Intercept)	387.0236	41.3912	23.9575	9.3503	1.8249E-09
MatrixMandarin	-33.2140	20.1013	17.5719	-1.6523	0.1162
Tonerising	7.4660	44.9796	17.3153	0.1659	0.8700
MatrixMandarin:Tonerising	-33.8671	19.1907	306.1618	-1.7647	0.0786

As the above coefficients table indicates, the interaction of rising tone and Mandarin as matrix language demonstrates a p-value of 0.0786; in other words, this interaction term explains more variation than either fixed effect on its own.

4.2 Pitch range

Moving on from maximum f0, what is the role of matrix language with regard to pitch range? If matrix language does impact target pitch range, it will likely appear most clearly in targets with falling tone. Figure 6 below therefore plots pitch range of falling-tone targets by matrix language.

Figure 6: Pitch range by matrix language for falling-tone targets.



Similar to Figure 3, Figure 6 shows variation across subjects: seven subjects demonstrate wider pitch range in Mandarin than in English, while the other three (fjeh3, quze7, and ylff0) are the opposite. To address some of this ambiguity, we performed the same LME analysis for the parameter of f0 range, conducting an ANOVA test of four nested models: one null model with a fixed effect for tone and random intercepts for subject and item, one with additional by-subject random slopes for matrix language, one with the added fixed effect of matrix language, and one with an interaction term between the two fixed effects.

Table 3: ANOVA of four LME models for f0 range.

	npar	AIC	BIC	logLik	deviance	Chisq	Df	Pr(>Chisq)
f0range1	5	4600	4620	-2295	4590	NA	NA	NA
f0range2	7	4586	4613	-2286	4572	18.3680	2	0.0001
f0range3	8	4585	4616	-2284	4569	3.0717	1	0.0796
f0range4	9	4585	4620	-2283	4567	1.7027	1	0.1919

Here, the second model f0range2, with a fixed effect for tone and by-subject random slopes for the effect of matrix language, was determined to be the best model by the metric of p-value.

Table 4: Coefficients for model f0range2.

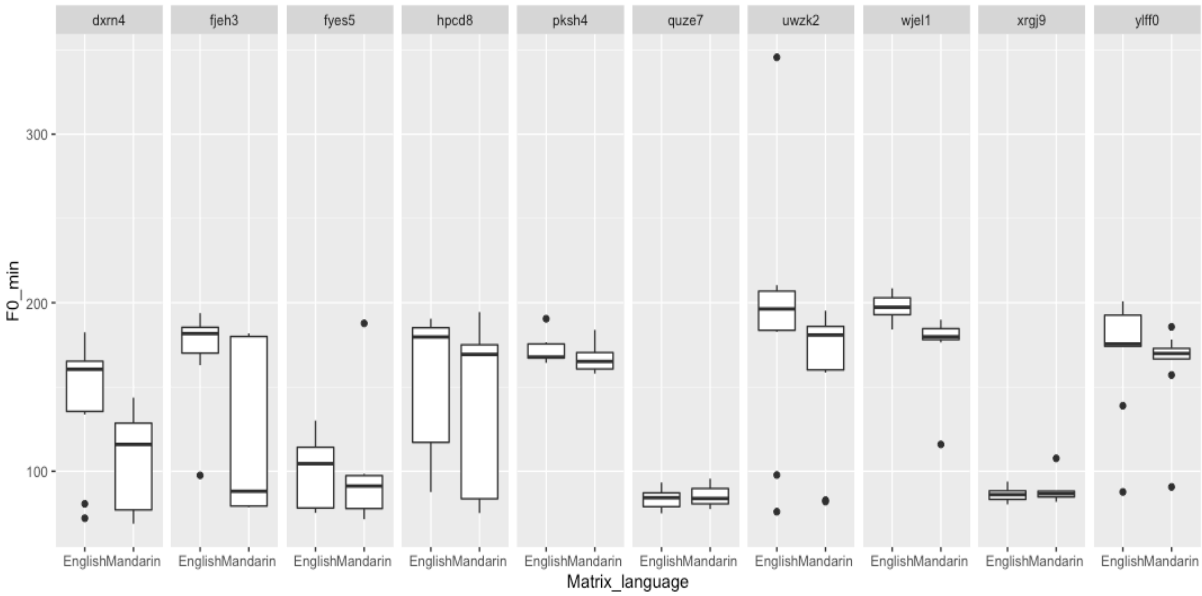
	Estimate	Std. Error	df	t value	Pr(>|t|)
(Intercept)	169.5728	37.0175	17.0074	4.5808	0.0002
Tonerising	38.7485	49.0868	16.0298	0.7893	0.4414

Indeed, according to the above table, rising tone increases target pitch range by approximately 38 Hz (p=0.4414), whereas for matrix language, there is a by-subject random effect on pitch.

4.3 Minimum pitch

Finally, we can look at the dependent measure of minimum pitch, which yields particularly useful implications for targets with rising tone. Figure 7 plots minimum pitch for rising-tone targets by matrix language.

Figure 7: Minimum pitch by matrix language for rising-tone targets.



In this figure, another clear generalization emerges: with the exception of one subject (xrgj9) with near-identical results between English and Mandarin, all subjects have a higher minimum f0 in CS contexts than monolingual ones. To determine the effect of matrix language on target minimum pitch, we repeated the same LME analysis and ANOVA test of nested models as for the previous two dependent measures:

Table 5: ANOVA of four LME models for minimum f0.

	npar	AIC	BIC	logLik	deviance	Chisq	Df	Pr(>Chisq)
f0min1	5	3963	3983	-1976	3953	NA	NA	NA
f0min2	7	3961	3988	-1973	3947	6.1543	2	0.0460
f0min3	8	3954	3986	-1969	3938	8.5650	1	0.0034
f0min4	9	3956	3992	-1969	3938	0.0818	1	0.7748

This time, the best model was f0min3, with fixed effects for both tone and matrix language. This model provided the best fit to the data, demonstrating the lowest AIC and p-value and the highest chi-squared value of any alternative.

Table 6: Coefficients for model f0min3.

	Estimate	Std. Error	df	t value	Pr(>|t|)
(Intercept)	202.7494	13.7867	11.5283	14.7060	7.9822E-09
MatrixMandarin	-18.0514	5.3569	33.8111	-3.3697	0.0018
Tonerising	-54.8962	6.2270	16.8932	-8.8158	9.9876E-08

According to this model, the minimum pitch of targets in Mandarin-matrix sentences are about 18 Hz lower-pitched than in CS contexts (p=0.0018), whereas rising tone decreases minimum f0 by roughly 55 Hz (p=9.9876E-08). The data therefore indicates a main effect of both target tone and matrix language on target minimum pitch.

5 Discussion

5.1 Interpretation of results

Before we enter into a discussion of these results, let's first revisit the two hypotheses underlying this study:

(1) The pitch contour of the matrix language will prevail over that of the embedded language.

(2) The pitch of the embedded language will remain unaffected, essentially "ignoring" the pitch contour of the matrix language.

As previously discussed, the concept ultimately in question here is the "base language effect," a term coined by Macnamara and Kushnir (1971) to describe the (albeit contested) phenomenon of the influence of the matrix language on the embedded language in CS utterances. In other words, Hypothesis (1) supports the existence of this effect, while Hypothesis (2) refutes it. By and large, the results of this study are consistent with Hypothesis (1), and in turn, with the base language effect.

A significant piece of evidence for this finding is the effect of English on maximum pitch in Mandarin targets. Recall Figure 2, in which all but one subject demonstrated a greater maximum f0 for rising-tone targets in CS contexts than in monolingual Mandarin ones. The base language effect is easy to satisfy: the fact that the switch in matrix language from English to Mandarin generates any impact at all on the target supports the phenomenon.

And sure enough, as the first LME analysis revealed, the prediction that matrix language influences target f0 is statistically reliable. The model that provided the best fit to the data was not the null model, with a fixed effect only for tone and no consideration of matrix language; it was f0max4, the model that included an interaction term between target tone and matrix language, as well as by-subject random slopes for the effect of matrix language. In other words, the best model for the data acknowledges that individual subjects have different baseline frequencies by matrix language, but that they still each demonstrate an effect of matrix language—in conjunction with target tone—on target maximum pitch. Similarly, we see the same success with the random-slopes model for the dependent measure of f0 range.

One might argue that, by-subject variation aside, different languages have different baselines for pitch overall: perhaps English speech is inherently higher-pitched than Mandarin. Yet if, as Grosjean and Miller (1994) claims, "pronouncing a code switch is no different from pronouncing another word within the same base language," one would still expect an embedded Mandarin target to rise instantaneously to the pitch of English speech. As Figure 2 demonstrates, this is not the case; this argument therefore does not hold up, and Hypothesis (1) is still supported.

5.2 Alternative explanation

An alternative explanation for these results could be that they are due to hyperarticulation, not the base language effect. It seems logical enough that, in order to signal the change in language and stave off listener confusion, speakers would hyperarticulate a CS target—in fact, we have already seen this occur in Olson (2016). We noted earlier that an influence of matrix language on f0 range would most clearly manifest in Mandarin targets with falling tone; this is because, from an intuitive standpoint, hyperarticulation of falling-tone targets would result in a higher-pitch onset, and therefore a wider f0 range across the target in CS sentences. By contrast, under the base language effect, we would expect to a narrower f0 range for falling-tone targets in CS contexts. Sure enough, as we see in Figure 6, 70% of subjects show a wider pitch range in Mandarin-matrix contexts, indicating that their range decreases in CS sentences.

As for the remaining three subjects (dxrn4, quze7, and ylff0), it is important to remember that the base language effect and hyperarticulation are not mutually exclusive, and can occur within the same speaker. Given the wider target f0 range in English demonstrated by these subjects, they are perhaps the "hyperarticulators" of the group, but as Figures 1 and 2 demonstrate, their results are still consistent with the base language effect. So although hyperarticulation does seem to occur in their CS speech, it cannot explain away the clear impact of the matrix language on the embedded.

For rising-tone targets, however, hyperarticulation is less clearly identifiable. While a wider f0 range in CS contexts could signal hyperarticulation, it could also indicate an assimilatory influence of the rising intonation of the English yes/no question frame—in short, the base language effect. It is for this reason that minimum pitch is the most useful dependent measure for singling out the base language effect for targets with rising tone. Intuitively speaking, hyperarticulation of rising-tone targets would correspond to a lower-pitch onset. By contrast, if minimum f0 were higher in CS contexts than in monolingual ones, this would confirm an effect of the English sentence's rising intonational contour on the target. Indeed, as Figure 7 shows, all but one subject demonstrate a higher minimum pitch in English than in Mandarin, and LME analysis indicates a main effect of matrix language on target minimum pitch.

To summarize, though some subjects show signs of hyperarticulation in their CS speech, the overall trends in the data are still consistent with the base language effect. This is further evidence in support of Hypothesis (1).

6 Conclusion

6.1 Significance of research

At the end of the day, what does it matter whether target pitch is affected in Mandarin-English CS sentences? Ultimately, the significance of this research lies not only in its linguistic implications—which are fascinating in their own right—but also in its efforts to broaden the scope of research into the phenomenon of CS.

As formerly discussed, CS research is already somewhat scarce, particularly with regard to its phonetic and phonological effects. This subset of research is small even for mutually similar language pairs, let alone for tonal-nontonal pairings. Yet its relative scarcity—presumably stemming from a historical lack of access to a wide range of bilingual speakers—becomes increasingly outdated as international contact becomes more and more accessible worldwide. In such a globalized, hyper-connected world, there is every reason to consider CS a matter of utmost relevance to the field of linguistics.

Furthermore, this study may have implications that extend beyond strictly CS contexts and into other domains of linguistics. For example, Tang and Shaw (2021), which investigated the relationship between word predictability and lexical prominence (duration, pitch, and intensity) in Mandarin, noted the following: "Words that are typically produced in prominent environments will come to take on the phonetic characteristics of prominent environments, even when produced in lexicalally weak positions." Along the same lines, it seems plausible that frequently code-switched words (often words for food or cultural artifacts) might over time begin to demonstrate CS phonology even in monolingual contexts. The phenomenon of CS may therefore have repercussions for language change.

And even on an interpersonal level, one cannot overstate the significance of CS. From a sociolinguistic standpoint, there is no doubt that language attitudes include CS speech within their purview. Bilingual speakers are therefore liable to discrimination—whether latent or explicit—much like speakers of marginalized dialects. Nor do the parallels between bilingualism and marginalized dialects end there: the degree of societal acceptance bilinguals receive also depends on the perceived prestige of their languages and usage habits. This subfield of research is therefore meaningful not only to linguistics, but also in other areas of academia.

6.2 Next steps

Looking towards the future, there are several potential avenues to extend the research undertaken in this study. Beyond simply improving upon and repeating the same experiment, a logical next step would be a follow-up study involving an almost identical CS task, but with the languages reversed—that is to say, with English targets embedded in Mandarin-matrix sentences as the experimental condition. Comparing the results of both studies would allow for exploration of directionality and predominance: does it matter which language (tonal or nontonal) is the matrix and which is the embedded? Does one type of language have an outsize effect on the other? If so, why might that be? Investigation of these questions, among others, would be a fascinating continuation along the lines of this study.

Another possible extension might better address hyperarticulation, an alternative explanation we considered for the base language effect. By seeking out additional phonetic cues of hyperarticulation rather than focusing solely on target pitch, a study of this kind would shed light on the question of whether some bilingual speakers are more prone to hyperarticulation in CS contexts than others.

Finally, a topic of interest adjacent (if not directly relevant) to this study is whether Mandarin speakers "store" information about lexical tone on a phonological or semantic level. For example, if bilingual participants were asked to choose among four different recordings of a given monolingual English sentence, each assigning a different phonemic tone to a target noun, would they automatically judge the target variant with the same tone as the corresponding Mandarin translation to be the best? If so, this would suggest that Mandarin speakers store tone on a conceptual level, associating it with word meaning regardless of language. Though this type of perceptual study has no direct relation to CS, it would continue to build upon a body of research investigating multilingual language use, thus furthering the overarching objective of this study.

References

Bates, D., Maechler, M., Bolker, B., & Walker, S. (2015). Fitting Linear Mixed-Effects Models Using lme4.

Boersma, P., & Weenink, D. (2022). Praat: Doing Phonetics by Computer.

Coleman, J. (n.d.). Prosody 1 - Pitch, tone and intonation.

Grosjean, F., & Miller, J. L. (1994). Going in and out of languages: An example of bilingual flexibility: *Psychological Science*, *5*(4), 201–206.

Hedberg, N., Sosa, J. M., & Görgülü, E. (2014). The meaning of intonation in yes-no questions in American English: A corpus study. *Corpus Linguistics and Lingustic Theory*.

Lee, S.-D. (1997). English Intonation: Intonational Contour and Intonational Phrase. *Journal of Language Sciences*, *4*, 231–250.

Lennes, M. (2017). SpeCT - Speech Corpus Toolkit for Praat (v1.0.0). First release on GitHub.

Li, P., Zhang, F., Yu, A., & Zhao, X. (2020). Language History Questionnaire (LHQ3): An enhanced tool for assessing multilingual experience. *Bilingualism: Language and Cognition*, *23*(5), 938–944.

Macnamara, J., & Kushnir, S. L. (1971). Linguistic independence of bilinguals: The input switch. *Journal of Verbal Learning and Verbal Behavior*, *10*(5), 490–487.

Muldner, K., Hoiting, L., Sanger, L., Blumenfeld, L., & Toivonen, I. (2019). The phonetics of code-switched vowels. *International Journal of Bilingualism*, *23*(1), 37–52.

Olson, D. J. (2016). The impact of code-switching, language context, and language dominance on suprasegmental phonetics: Evidence for the role of predictability. *International Journal of Bilingualism*, *20*(4), 453–472.

R Core Team. (2020). R: A Language and Environment for Statistical Computing.

Shaw, J. A. (2021). Praat scripts: Label_files_and_save.praat and get_pitch_measurements.praat.

Shen, A., Gahl, S., & Johnson, K. (2020). Didn't hear that coming: Effects of withholding phonetic cues to code-switching. *23*(5), 1020–1031.

Tabors, P. O. (2008). *One child, two languages: A guide for early childhood educators of children learning English as a second language* (Second). Paul H. Brookes Pub. Co.

Tang, K., & Shaw, J. A. (2021). Prosody leaks into the memories of words. *Cognition*, *210*.

Wickham, H. (2016). Ggplot2: Elegant Graphics for Data Analysis.

Winter, B. (2013). Linear models and linear mixed effects models in R with linguistic applications. *arXiv*.

Xu, Y. (1997). Contextual tonal variations in Mandarin. *Journal of Phonetics*, *25*(1), 61–83.

Appendix A

Group A: English matrix, rising-tone target

A01: Do you have 梨子 at home? (梨子 = lízi = pear)
A02: Do you have 蚊子 at home? (蚊子 = wénzi = mosquitoes)
A03: Do you have 鱼子 at home? (鱼子 = yúzi = roe)
A04: Do you have 梅子 at home? (梅子 = méizi = plums)
A05: Do you have 莲子 at home? (莲子 = liánzi = lotus seeds)
A06: Have you seen 圆子 before? (圆子 = yuánzi = glutinous rice dumplings)
A07: Have you seen 骡子 before? (骡子 = luózi = mules)
A08: Have you seen 男子 before? (男子 = nánzi = men)
A09: Have you seen 轮子 before? (轮子 = lúnzi = wheels)
A10: Have you seen 笼子 before? (笼子 = lóngzi = woven cages)

Group B: Mandarin matrix, rising-tone target

B01: 你在家里有梨子吗? *Ni zai jia li you lizi ma?*
B02: 你在家里有蚊子吗? *Ni zai jia li you wenzi ma?*
B03: 你在家里有鱼子吗? *Ni zai jia li you yuzi ma?*
B04: 你在家里有梅子吗? *Ni zai jia li you meizi ma?*
B05: 你在家里有莲子吗? *Ni zai jia li you lianzi ma?*
B06: 你看过圆子吗? *Ni kan guo yuanzi ma?*
B07: 你看过骡子吗? *Ni kan guo luozi ma?*
B08: 你看过男子吗? *Ni kan guo nanzi ma?*
B09: 你看过轮子吗? *Ni kan guo lunzi ma?*
B10: 你看过笼子吗? *Ni kan guo longzi ma?*

Group C: English matrix, falling-tone target

C01: Do you have 栗子 at home? (栗子 = lìzi = chestnuts)
C02: Do you have 辣子 at home? (辣子 = làzi = sweet chili peppers)
C03: Do you have 麦子 at home? (麦子 = màizi = wheat)
C04: Do you have 妹子 at home? (妹子 = mèizi = younger sister)
C05: Do you have 袜子 at home? (袜子 = wàzi = socks)
C06: Have you seen 院子 before? (院子 = yuànzi = courtyard)
C07: Have you seen 鹞子 before? (鹞子 = yàozi = sparrowhawk)
C08: Have you seen 帽子 before? (帽子 = màozi = hats)
C09: Have you seen 燕子 before? (燕子 = yànzi = swallow (type of bird))
C10: Have you seen 叶子 before? (叶子 = yèzi = leaves)

Group D: Mandarin matrix, falling-tone target

D01: 你在家里有栗子吗? *Ni zai jia li you lizi ma?*
D02: 你在家里有辣子吗? *Ni zai jia li you lazi ma?*
D03: 你在家里有麦子吗? *Ni zai jia li you maizi ma?*
D04: 你在家里有妹子吗? *Ni zai jia li you meizi ma?*
D05: 你在家里有袜子吗? *Ni zai jia li you wazi ma?*
D06: 你看过院子吗? *Ni kan guo yuanzi ma?*
D07: 你看过鹞子吗? *Ni kan guo yaozi ma?*
D08: 你看过帽子吗? *Ni kan guo maozi ma?*
D09: 你看过燕子吗? *Ni kan guo yanzi ma?*
D10: 你看过叶子吗? *Ni kan guo yezi ma?*

Appendix B

Language History Questionnaire 3

1.Participant ID number

2.Age

3.Gender

Selec

4.Education

Selec

5.Parents' Education

Father: Selec

Mother: Selec

6.Handedness

Selec

7. Indicate your native language(s) and any other languages you have studied or learned, the age at which you started using each language in terms of listening, speaking, reading, and writing, and the total number of years you have spent using each language.

Language	Listening	Speaking	Reading	Writing	Years of use*
Sel					
Sel					
Sel					
Sel					

*Notes For "Years of use", you may have learned a language, stopped using it, and then started using it again. Please give the total number of years.

8. Country of origin

Select an opti

9. Country of residence

Select an opti

10. If you have lived or traveled in countries other than your country of residence for three months or more, then indicate the name of the country, your length of stay (in Months), the language you used, and the frequency of your use of the language for each country.

Country	Length of stay (in Months)*	Language	Frequency of use
Select an opt ▾		Select an opti ▾	Select an opti ▾
Select an opt ▾		Select an opti ▾	Select an opti ▾
Select an opt ▾		Select an opti ▾	Select an opti ▾
Select an opt ▾		Select an opti ▾	Select an opti ▾

* You may have been to the country on multiple occasions, each for a different length of time. Add all the trips together

11. Indicate the way you learned or acquired your non-native language(s). Check one or more boxes that apply.

Non-native Language	Immersion*	Classroom instruction	Self-learning
Select an opt ▾	☐	☐	☐
Select an opt ▾	☐	☐	☐
Select an opt ▾	☐	☐	☐
Select an opt ▾	☐	☐	☐

* e.g., Immigrating to another country where the dominant language is different from your native language so you learn this language through immersion in the language environment.

12. Indicate the age at which you started using each of the languages you have studied or learned in the following environments (Including native language).

Language	At home	With friends	At school	At work	Languag softwar
Sele ▾					
Sele ▾					
Sele ▾					
Sele ▾					

13. Indicate the language used by your teachers for instruction at each

educational level. If the instructional language switched during any educational level, then also indicate the "Switched to" language. If you had a bilingual education at any educational level, then simply check the box under "Both Languages".

Environment	Language	(Switched to)	Both Language
Elementary school	Select an opti ▾	Select an opti ▾	☐
Middle school	Select an opti ▾	Select an opti ▾	☐
High school	Select an opti ▾	Select an opti ▾	☐
College (Bachelor)	Select an opti ▾	Select an opti ▾	☐
Graduate school (Master)	Select an opti ▾	Select an opti ▾	☐
Graduate school (Doctor)	Select an opti ▾	Select an opti ▾	☐

14. Rate your current ability in terms of listening, speaking, reading, and writing in each of the languages you have studied or learned (including the native language). ⓘ

Language	Listening	Speaking	Reading	Writing
Sel ▾ ⓘ	Selec ▾	Selec ▾	Selec ▾	Selec ▾
Sel ▾ ⓘ	Selec ▾	Selec ▾	Selec ▾	Selec ▾
Sel ▾ ⓘ	Selec ▾	Selec ▾	Selec ▾	Selec ▾
Sel ▾ ⓘ	Selec ▾	Selec ▾	Selec ▾	Selec ▾

15. Rate the strength of your foreign accent for each of the languages you have studied or learned. ⓘ

Language	Accent
Select an ▾ ⓘ	Select an opti ▾
Select an ▾ ⓘ	Select an opti ▾
Select an ▾ ⓘ	Select an opti ▾
ⓘ	Select an opti ▾

Select an ▾

16. Estimate how many hours per day you spend speaking with the following groups of people in each of the languages you have studied or learned (including the native language).

Language	Family members	Friends*	Classmates	Others (co-workers**, roommates, etc.)
Sel ▾				
Sel ▾				
Sel ▾				
Sel ▾				

Note *Include significant others in this category if you did not include them as family members (e.g., married partners)

**Include anyone in the work environment in this category (e.g., if you are a teacher, include students as co-workers).

17. If you use mixed language in daily life, please indicate the languages that you mix and estimate the frequency of mixing in normal conversation with the following groups of people.

	Language 1	Language 2	Frequency of mixing
Family members	Select an opti ▾	Select an opti ▾	Select an opti ▾
Friends	Select an opti ▾	Select an opti ▾	Select an opti ▾
Classmates	Select an opti ▾	Select an opti ▾	Select an opti ▾
Others (co-workers, roommates, etc.)	Select an opti ▾	Select an opti ▾	Select an opti ▾

* Include significant others in this category if you did not include them as family members (e.g., married partners)

** Include anyone in the work environment in this category (e.g., if you are a teacher, include students as co-workers).

18. In which language do you communicate best or feel most comfortable in terms of listening, speaking, reading, and writing in each of the following environments? You may be selecting the same language for all or some of

the fields below.

	Listening	Speaking	Reading	Writing
At Home	Selec	Selec	Selec	Selec
At school	Selec	Selec	Selec	Selec
At work	Selec	Selec	Selec	Selec
With friends	Selec	Selec	Selec	Selec

19. How often do you use each of the languages you have studied or learned for the following activities? (including the native language)

Language	Thinking	Talking to yourself	Expressing emotion*	Dreaming	Arithmeti
Sele	Select	Select	Select	Select	Select
Sele	Select	Select	Select	Select	Select
Sele	Select	Select	Select	Select	Select
Sele	Select	Select	Select	Select	Select

Note*This includes shouting, cursing, showing affection, etc.

**This includes counting, calculating tips, etc.

***This includes telephone numbers, ID numbers, etc.

20. What percentage of your friends speaks each of the languages you have studied or learned? (including the native language)

Language	Percentage	
Select an		%
Select an		%
Select an		%
		%

Select an ▾

21. Use the comment box below to provide any other information about your language background or usage.

22. Do you also speak/use any dialects of the languages you know? Please indicate the name(s) of the dialect and the degree you use them.

Submit