



## Contextual effect in second language perception and production of Mandarin tones

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### ABSTRACT

A robust contextual effect is well documented in native tone perception and production but less well studied in non-native speech. The current study examined English-speaking learners' Mandarin tone perception and production with varying preceding and following tones. Fifteen intermediate-level learners performed an Identification and a Reading task with disyllabic stimuli encompassing various tone combinations. The results revealed that the learners' accuracy rates and error patterns varied in the initial and final position as well as in different tonal environments. For example, the learners predominantly misidentified T3 as T4 in the initial position when the following tone was T1, but rarely made such an error in the final position. In the Reading task, on the other hand, the learners frequently misproduced T3 as T2 in the final position, but often misproduced T2 as T3 in the initial position, especially when the following tone was T1. The learners' overall accuracy and error rates in Identification correlated with those in Reading, indicating comparable tone perception and production abilities. However, there were some significant differences between perception and production with regard to T3. These findings suggest that the prosodic position and surrounding tones both have a significant effect on the learners' performance with L2 tones, and that the effect differs in perception and production.

### 1. Introduction

A major contributing factor for the high variability of speech sounds is the phonetic context. In production, the acoustic properties of the same phoneme often vary considerably when being adjacent to different sounds (e.g. effect of consonants on vowels: Hillenbrand et al., 2001; Strange et al., 2007; effect of vowels on consonants: Nearey and Rochet, 1994; effect of vowels on vowels: Alfonso and Baer, 1982; Beddor et al., 2002). On the other hand, listeners have been found to automatically normalize these variations according to the phonetic context in their perception (Fowler, 1981; Stevens and House, 1963; Steinlen, 2005; Steinlen and Bohn, 1999; Strange and Bohn, 1998). Since speech sounds rarely occur in isolation, phonetic context is crucial in accounting for the perception and production of the phonetic target.

Lexical tones are no exception to contextual variation. Several studies have demonstrated that the  $f_0$  contour of a tone produced by tonal language speakers often varies in different tonal contexts (Abramson, 1979; Gandour et al., 1994; Han and Kim, 1974; Peng, 1997; Shen, 1990; Shih, 1988; Xu, 1994, 1997). In addition, tonal language speakers' perception of the same pitch target may change categorically depending on the tonal environment (Fox and Qi, 1990; Leather, 1983; Lin and Wang, 1985; Moore and Jongman, 1997; Wong and Diehl,

2003). While it is clear that the surrounding tones significantly affect native speakers' perception and production of lexical tones, the contextual effect has been less systematically investigated in non-native speech. In view of this, the current study aims to examine English-speaking learners' perception and production of Mandarin tones with varying preceding and following tones. In the following sections we will give a brief description of the Mandarin tonal system, along with a review of the literature on native and non-native speakers' perception and production of Mandarin tones in different phonological contexts, and will then proceed to specify the rationale and research questions of the present study.

#### 1.1. Mandarin tones

Mandarin Chinese has four regular tones: T1 (high-level), T2 (high-rising), T3 (low-dipping), T4 (high-falling), plus a neutral tone, whose tonal value is determined by the preceding tone (Duanmu, 2007). The starting and ending pitch of the four tones in citation forms are typically denoted by Chao's (1930) tone letters as [55] (T1), [35] (T2), [214] (T3), and [51] (T4), with 1 representing the speaker's lowest pitch and 5 the highest pitch. Among them, T3 has the most allophonic variation. One example is the T3 sandhi rule that changes the underlying T3 to T2

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when it is followed by another T3 (Cheng, 1973). As a result, the surface forms of underlying T2T3 and T3T3 sequences are perceived as identical by native Mandarin listeners (Peng, 2000; Wang and Li, 1967). In addition to the sandhi rule, T3 is realized as a low-falling tone [21] in non-final positions and sometimes in the final position as well in casual speech (Chao, 1968; Duanmu, 2007; Shih, 1988).

### 1.2. Native perception and production of Mandarin tones in different phonological contexts

A number of studies have examined pitch variation of the four Mandarin tones due to coarticulation in native production. In disyllabic words, Shih (1988) observed both carry-over and anticipatory coarticulation, including T4 ending at a higher pitch in non-final than in final position, T2 ending at a lower pitch when followed by a high onset than by a low onset, and T2 starting lower when preceded by T3 than by other tones. She attributed all these variations to tone assimilation. Xu (1997) also examined Mandarin disyllables and revealed a more substantial carry-over than anticipatory effect. The carry-over effect he observed was largely assimilatory, with the onset of the pitch target becoming more similar to the offset of the preceding tone. As for the anticipatory effect, the only significant tendency was that the pitch peak of T2 and T4 was slightly higher when preceding T2 and T3 than preceding other tones, suggesting that the low onset of the second tone raised the pitch of the first tone. Xu thus concluded that the anticipatory effect was dissimilatory in nature albeit small in magnitude. In another study, Shen (1990) analyzed native speakers' production of Mandarin tri-syllabic words encompassing all the possible tone combinations. She found that T1 and T2 frequently raised the onset pitch of the following tone, and T4 raised the ending pitch of the preceding tone. Yet the low pitch onset of T2 and T3 had no effect on the offset of the preceding tone. Her data generally showed that tone coarticulation was a result of assimilation to adjacent high tones. In brief, even though these studies are not consistent in their findings and interpretations, they all demonstrate a clear effect of tonal context on the actual pitch contour of the four tones.

The majority of studies on Mandarin listeners' perception of tones observe a contextual effect, although the magnitude and nature of the effect differ between studies (Fox and Qi, 1990; Leather, 1983; Lin and Wang, 1985; Moore and Jongman, 1997). For example, Moore and Jongman (1997) found that native Mandarin speakers identified the same falling-rising pitch contour as T2 when the precursor phrase was spoken by a low-pitched speaker, and as T3 when the precursor phrase was spoken by a high-pitched speaker. In another study, Lin and Wang (1985) examined the perception of a level tone at 115 Hz followed by falling tones whose onsets ranged from 110 to 140 Hz. Their results showed that the higher onset the following tone had, the more likely it was for the target level tone to be identified as T2 as opposed to T1. The authors concluded that the perception of the target tone was normalized according to the pitch height of the surrounding tones. Fox and Qi (1990), on the other hand, only found a marginally significant effect of the precursor tone (T1 or T2) on the identification of a T1–T2 continuum. Specifically, their Mandarin speakers showed a slight tendency to label the target tone as T1 when the precursor was T1 and label it as T2 when the precursor was T2. In addition, their English-speaking participants demonstrated a similar tendency, leading the authors to suggest that the contextual effect was a product of auditory rather than linguistic processing.

These perception studies, while informative, are not easily comparable to the production studies due to the difference in the tonal stimuli (synthesized tone continuum vs. discrete tone categories). One study bridged this gap by employing the same type of stimuli in the production and perception tasks. Xu (1994) examined native Mandarin speakers' production and perception of T2 and T4 in the middle of tri-syllabic words. The preceding and following tones were varied to form compatible and conflicting tonal contexts, the former referring to tone

combinations in which the transition from one tone to another is smooth, while the latter referring to tone combinations in which the pitch difference at syllable boundary is large. The F<sub>0</sub> measurement of five native speakers' productions illustrated that the rising or falling pitch contour of the target tone was well preserved in compatible contexts, while that in conflicting contexts was flattened off or even changed into a slope in the opposite direction (e.g. rising contour became falling contour). The author also observed a stronger carry-over than anticipatory effect. As for the perception task, ten Mandarin listeners identified the middle tone of tri-syllabic non-words created by modifying the segmental cues of the native production. The results showed that the deviated pitch contours in the conflicting context were correctly identified by native listeners when presented in the original context. However, when they were presented in isolation or in a mismatched context, the listeners' accuracy significantly dropped. This study provided evidence consistent with the previous findings that the adjacent tones may substantially change the contour shape of the target tones in native production. Furthermore, it showed that native listeners had no difficulty recovering the tone identity when the contextual information was available, yet often failed to do so when the tonal context was removed or misplaced.

### 1.3. Non-native perception and production of lexical tones in different tonal contexts

Non-native speakers' perception and production of Mandarin tones have been investigated in a number of studies (Broselow et al., 1987; Chen, 1972, Chen, 1997; Hao, 2012; Kiriloff, 1969; Miracle, 1989; Shen, 1989; So and Best, 2010; Wang et al., 1999, 2003; White, 1981). However, relatively few studies have explored the effect of prosodic positions and tonal environments on non-native tone perception and production. Among them, Chen (1997) found that English-speaking L2 learners of Mandarin made different errors in perception and production. In the perception task, the learners' most common errors resulted from the mutual confusion between T2 and T3, and this was observed in both the initial and final position of disyllables. In the production task, on the other hand, the learners had most difficulty with T4, especially in the utterance-final position. They often misproduced T4 and sometimes T1 and T2 as mid- or low-level tones. This study illustrates that L2 learners' error patterns often differ in perception and production, and they are affected by the prosodic position. Examining a different L1 group, Ding (2012) compared German-speaking learners' identification and reading of Mandarin disyllabic words including all possible tone combinations. The learners' overall accuracy in perception and production was highly correlated, although their error patterns differed in the two tasks as well as in different prosodic positions. With regard to the perception task, the learners' most common errors were T1→T2 (T1 misidentified as T2), T2→T3, and T4→T3 in the initial position, while they made more T2→T3 and T3→T4 errors in the final position. As for their production, as evaluated by three native Mandarin listeners, they most often made T1→T3, T2→T1, T2→T3, T3→T2, and T4→T1 errors in the initial position. Whereas these similar error patterns were also observed in the final position, the most substantial difference was that T4 target was produced least accurately among the four tones and commonly heard as T1 and T3. This study similarly suggests that L2 learners' tone confusion patterns often vary in the initial and final position as well as in perception and production. However, neither Chen (1997) nor Ding (2012) took into consideration the effect of the preceding and following tones on the perception and production of target tones.

Different from the above two studies that focused on L2 learners, Bent (2005) examined Mandarin tone perception and production by English speakers who had no knowledge of Mandarin. The results revealed an effect of the surrounding tones on the confusion patterns. Specifically, she found that English speakers had more difficulty discriminating T2 and T3 in the tri-syllabic frame T1\_T4 (i.e. target tone

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