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Processing Linguistic and Musical Pitch by English-Speaking Musicians and Non-Musicians

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The perception of music and speech both involve processing complex acoustic stimuli. It remains unclear, however, whether the same or distinct mechanisms are implicated in music and speech perception. Previous research suggested that musical training may facilitate linguistic pitch perception. (Alexander, Wong, and Bradlow, 2005) Deutsch et al (2006) reported higher proportion of absolute pitch possessors in tone language (mandarin) speakers. This study explored the relationship between musical and linguistic pitch processing in four experiments. Two groups of participants were involved, musicians and non-musicians, all participants are native American English-speakers. The results show that despite limited exposure to the Mandarin tones, the musicians identified the intact Mandarin tones at 68% correct, outperforming non-musicians with 44% correct. The results also show that despite limited amount of pitch information in the stimuli, tone identification accuracy reached 54% for musicians and 36% for non-musicians in the silent-center condition; and 31% correct for musicians and 28% correct for non-musicians in the onset-only condition. While these results appear to suggest that musical training might facilitate linguistic pitch processing, no significant correlation was found in the identification accuracy between musical tones and Mandarin tones, weakening the argument that musical and linguistic pitch processing are closely associated.

0. Introduction

Pitch processing is involved in both spoken language comprehension and music perception. Given the functional role of pitch in linguistic and music contrasts, a legitimate question is whether the same processing mechanism is implicated in both linguistic and music pitch processing.

This study explored linguistic and musical pitch processing by examining Mandarin tone identification by 36 English-speaking musicians and 36 non-musicians, and musical note identification by the musicians.

We investigated how native English speakers with or without a musical background dealt with identifying acoustically modified Mandarin tones produced by multiple speakers. Since pitch processing is involved in both lexical tones and music, identification of lexical tones and musical notes both involve mapping pitch information

onto discrete linguistic or musical categories. If common processing mechanisms are involved, performance in musical and linguistic pitch processing should be correlated.

Our goal was to evaluate the nature of non-native lexical tone processing by incorporation common challenges to speech perception and to assess the tone of absolute pitch in the musicians' advantage in lexical tone processing commonly reported in the literature (Gottfried & Riester, 2000;Gottfried, Staby, & Ziemer, 2001; Alexander, Wong, & Bradlow, 2005; Wong, Skoe, Russo, Dees, & Kraus, 2007)

The present study aimed to explore the relationship between linguistic and musical pitch processing by addressing the following questions: (1) What is the role of musical background in the perceptual processing of intact and incomplete Mandarin tones? If musical pitch processing abilities could facilitate linguistic pitch processing, musicians would be expected to perform better than non-musicians in the Mandarin tone task. (2) What is the nature of the musicians' advantage in identifying Mandarin tones, if there is indeed an advantage?

1. Experiment 1: Mandarin tone identification

1.1 Materials

The Mandarin syllable *sa*, produced with all four tones by 16 female and 16 male native speakers, was selected to generate the stimuli for this experiment. The modified syllables included "silent-center" and "onset only" syllables, where the majority of the voiced portion of a syllable was attenuated to silence and devoid of F0 information. The silent-center syllables were generated by removing all but the first and final 15% of the voiced portion. The onset-only syllables were generated by removing all but the first 15% of the voiced portion. The fricative [s] was preserved in all intact and modified syllables.

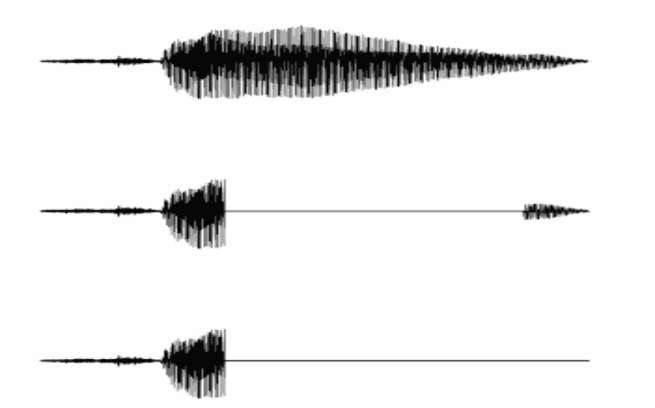

FIGURE 1
An example of the acoustic modifications: intact, silent-center, and onset-only syllables

1.2. Procedure

The participants were directed to four keys on the keyboard labeled with "→", "↘", "↗", and "↴", representing the high-level (Tone 1), high-falling (Tone 4), low-rising (Tone 2), and low-dipping (Tone 3) tones, respectively. They were asked to respond after each syllable by pressing one of four labeled keys.

1.3. Data analysis

Response accuracy and reaction time were automatically recorded. Reaction time was measured from stimulus offset to avoid the potential confound of intrinsic duration differences among the four tones. Only correct responses were included in the reaction time analysis. For each syllable type, response data were evaluated to examine the effects of tone and musical background.

1.4. Results

Musicians without prior Mandarin experience were able to identify Mandarin tones with 68% accuracy for intact syllables and 54% accuracy for silent-center syllables. The musicians were more accurate than the non-musicians in tone identification from all three types of syllables. For reaction time, the accuracy difference between the musicians and the non-musicians became less as the amount of acoustic input was reduced.

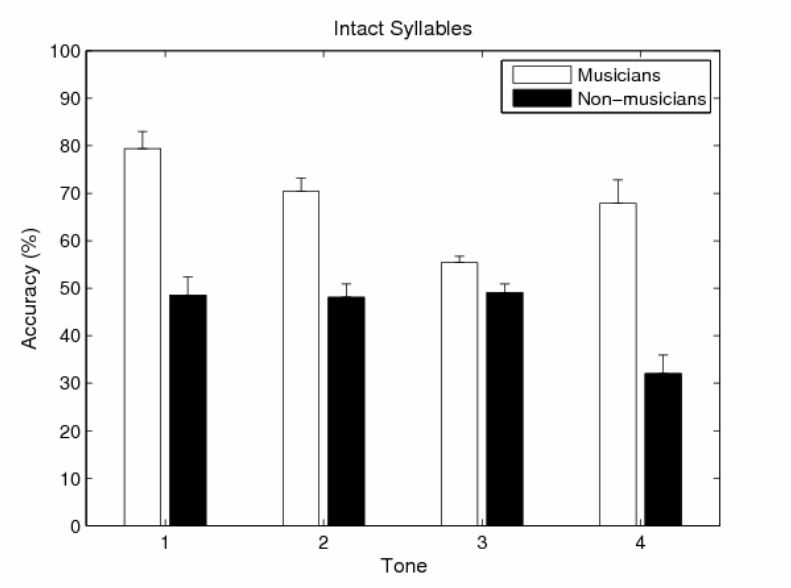

FIGURE 2
The accuracy of tone identification for intact syllables as a function of musical background and tone.

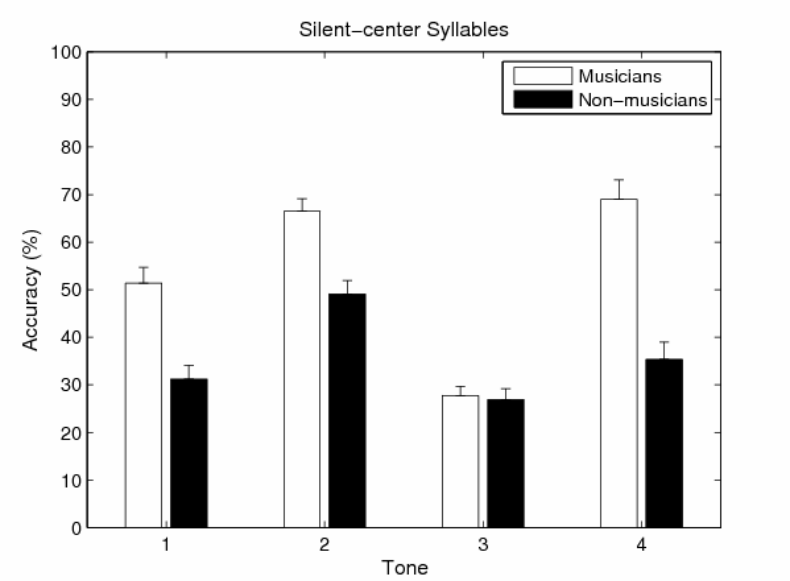

FIGURE 3
The accuracy of tone identification for silent-center syllable as a function of musical background and tone.

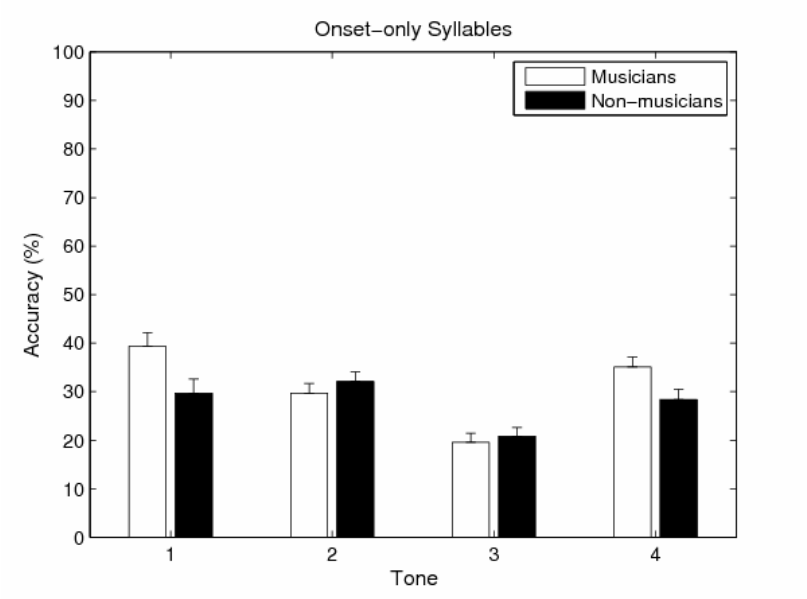

FIGURE 4
The accuracy of tone identification for onset-only syllables as a function of musical background and tone.

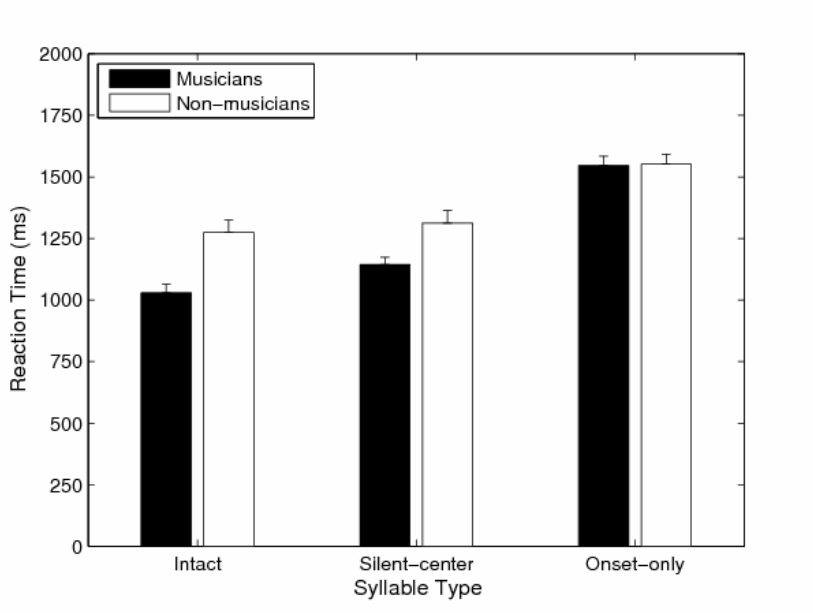

FIGURE 5
The reaction time of tone identification as a function of musical background and tone.

2. Experiment 2: Music note identification by musicias

2.1. Materials

In this experiment, the 36 musicians who participated in the Mandarin tone experiment were asked to listen to synthesized musical tones of three timbres (piano, pure tone, and viola) and to identify the notes in the absence of a reference pitch. Thirty-six notes that spanned a three-octave range from C3 (131 Hz) to B5 (988 Hz). The 36 notes were ordered such that any two consecutive notes were separated by more than an octave and were 500 ms long. Their task was to notate the notes that they had heard on the staff paper immediately after each note was played, and to apply accidental signatures if applicable.

2.2. Results

The ANOVA revealed no significant timbre effect. The values of the correlation between these two sets of variables were generally low, ranging from -.014 to .329.

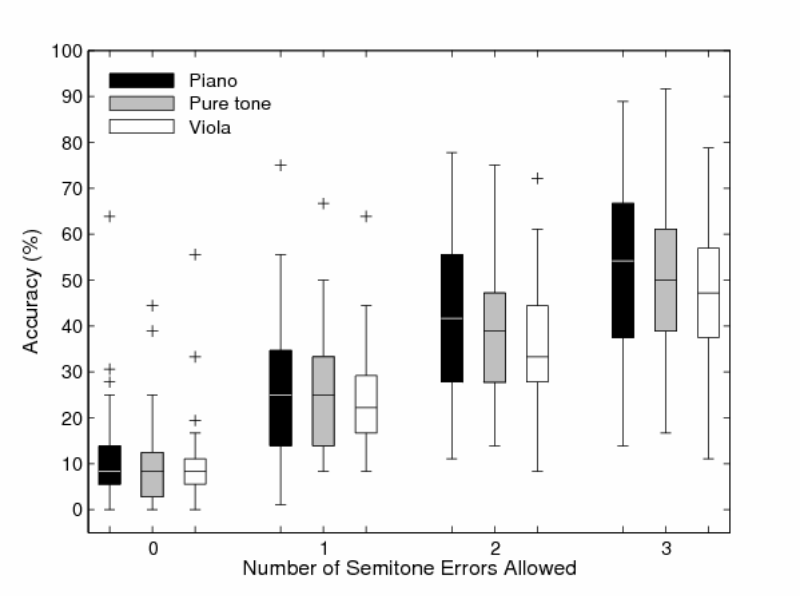

FIGURE 6
The accuracy of musical note identification arranged by timber and the number of semitone errors allowed.

3. Discussion

The Mandarin tone experiment showed that the musicians were able to identify multi-speaker intact and silent-center Mandarin tones with accuracy exceeding chance.

Furthermore, the acoustic modifications revealed tone specific effects of reduction; namely, Tone 2 and Tone 4 were minimally compromised even when the majority of the syllable center was absent. It has been shown that silent-center Mandarin tones could be identified quite accurately by native and non-native listeners despite missing substantial F0 information, indicating that listeners are capable of reconstructing lexical tones based on limited acoustic input (Gottfried & Suiter, 1997; Lee, Tao, & Bond, 2006, 2008).

In the musical pitch task given to the musicians, accuracy of musical note identification was generally low even when errors up to three semitones were allowed. The correlation between the Mandarin tone and musical note identification performance was weak.

By simulating common challenges to speech perception with degraded stimuli and speaker variability, the present study showed that the benefit of musical experience varied depending on the amount of acoustic input. Specifically, even though the musicians were faster and more accurate in identifying intact Mandarin tones, the reaction time advantage disappeared for silent-center syllables. The advantage of musical training in learning to identify non-native lexical tones depends on the amount of acoustic input. It would be of interest to investigate if other types of degraded signal (e.g., noise) would exert a similar effect. Future work could further explore the basis of the advantage.

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