

Cross-language effects on the perception of non-native tonal contrasts

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Cross-language lexical tone perception studies generally find that non-tone language speakers, compared to their native tone language counterparts, maintain different weightings of the perceptual dimension of tone, and thereby exhibit poorer performance in tone perception tasks. In comparison, it is less clear whether speakers of a tone language have an advantage over those of a non-tone language in the perception of tones from another language. On the one hand, tone language speakers' outperformance of non-tone language speakers in perception of an unfamiliar language's tones is evidence of the facilitatory effect of linguistic experience on tone perception (Liang & van Heuven, 2007; Qin & Mok, 2011; Wayland & Guion, 2004). On the other hand, no significant difference between performance of tone and non-tone language speakers has also been reported (Francis et al., 2008; Lee et al., 2006; So & Best, 2010). In addition to different complexities of tone inventories, different controls of speaker variability and speaker normalization effects in the aforementioned studies may have also rendered the cross-study results incomparable.

To provide unambiguous evidence for the effects of linguistic experience with lexical tones on the perception of non-native tonal contrasts, the present study examined the identification of three Cantonese level tones by Cantonese, Mandarin (one level tone) and English (no lexical tones) listener groups (15 participants per group). Since the contour tones are characterized by the interaction of F0 direction and height, the level tones (high, mid, low) were chosen because they contrast only in F0 height, which renders the cross-linguistic perception results easier to interpret. The stimuli, following Lee et al.'s (2011; 2014) experimental paradigm, were constructed and presented in ways that avoid listeners' familiarity with an individual speaker. The stimuli were: 1) produced by a large number of speakers; 2) specifically arranged in blocks that were balanced across gender and used each speaker no more than once; and 3) presented in isolation such that no external F0 information was available to listeners.

The identification accuracy was analyzed using a mixed-effects logistic regression model. The results showed that both the Cantonese and Mandarin groups had significantly higher overall identification accuracy than the English group. That is, experience with a tone language facilitated the perception of non-native tones. Identification accuracy varied across speaker gender and tone height (Table 1). While all groups had the highest accuracy when identifying acoustically more distinct tones (i.e., high tones produced by females and low tones produced by males), only the Cantonese group was able to identify all types of stimuli at an above chance level. The Mandarin group identified high tones produced by males at chance level, while the English group identified high tones produced by males and low tones produced by females at chance level. The reaction time data (log-transformed; only correct responses were included) were analyzed using a linear mixed-effects model. The results showed that all listener groups took longer to respond to mid-level tones than to the other tones. The post-hoc analysis that explored the significant tone height \times speaker gender interaction effect indicated that reaction time was shortest for high tones produced by female speakers and low tones produced by male speakers. That is, tones produced at the extremes of speakers' F0 range were easier to identify, which is consistent with the accuracy analysis. Group performance similarities and differences

are further discussed in terms of general auditory perception and whether (and how) tones are contrastive in their native languages.

Group	Speaker gender	Tone	Accuracy	t(14); p value	Reaction time
Hong Kong (Cantonese)	female	high	61.1 (15.2)	7.18 (p<.001)	1310 (475)
		mid	56.4 (12.2)	7.43 (p<.001)	1571 (759)
		low	54.7 (11.7)	7.21 (p<.001)	1495 (720)
	male	high	46.7 (19.7)	2.69 (p<.01)	1437 (628)
		mid	51.4 (9.8)	7.27 (p<.001)	1579 (750)
		low	61.9 (9.3)	12.06 (p<.001)	1413 (708)
Taiwan (Mandarin)	female	high	64.2 (15.3)	7.91 (p<.001)	1362 (816)
		mid	58.9 (16.6)	6.05 (p<.001)	1688 (1024)
		low	45.3 (20.7)	2.3 (p<.05)	1586 (1069)
	male	high	33.3 (23.1)	0.06 (p=.48)	1850 (2047)
		mid	46.7 (12.8)	4.13 (p<.001)	1709 (1036)
		low	69.7 (15.1)	9.44 (p<.001)	1271 (937)
US (English)	female	high	58.9 (10.7)	9.4 (p<.001)	1361 (945)
		mid	50.8 (10.7)	6.52 (p<.001)	1670 (1090)
		low	28.9 (8.1)	-1.97 (p=.97)	1637 (893)
	male	high	20.6 (12.6)	-3.81 (p=0.99)	1804 (1397)
		mid	40 (12.3)	2.21 (p<.05)	1874 (1612)
		low	65.8 (13.7)	9.25 (p<.001)	1480 (1067)

Table 1: Mean accuracy (in percent with SD) and reaction time (in ms with SD) of Cantonese level tone identification for the Cantonese, Mandarin and English listeners. Results from t-test evaluating whether the identification accuracy was above the chance level (33.3%) were also included.

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