Appendix A. The complete list of training items with di-tonal patterns associated with each item across the three learning conditions (rows with different tonal sequences are shaded).

Segment	Unit Group	Terminal Group	Control Group
pitʰu	H-L	H-L	H-L
pitʰa	H-LH	H-LH	H-LH
piku	L-LH	L-H	L-H
pika	L-HL	L-HL	L-HL
pinu	HL-H	HL-H	HL-H
pina	HL-L	HL-HL	HL-L
pimu	LH-H	LH-L	LH-L
pima	LH-HL	LH-LH	LH-LH
putʰi	H-LH	H-LH	H-H
putʰa	L-LH	L-H	L-LH
puki	L-HL	L-HL	LH-HL
puka	HL-H	HL-H	HL-HL
puni	HL-L	HL-HL	HL-LH
puna	LH-H	LH-LH	LH-H
pumi	LH-HL	LH-L	H-HL
puma	H-L	H-L	H-L
patʰi	L-LH	L-H	L-H
patʰu	L-HL	L-HL	L-HL
paki	HL-H	HL-H	HL-H
paku	HL-L	HL-HL	HL-L
pani	LH-H	LH-L	LH-L
panu	LH-HL	LH-LH	LH-LH
pami	H-L	H-L	H-H
pamu	H-LH	H-LH	L-LH
tʰipu	L-HL	L-HL	LH-HL
tʰipa	HL-H	HL-H	HL-HL
tʰiku	HL-L	HL-HL	HL-LH
tʰika	LH-H	LH-LH	LH-H
tʰinu	LH-HL	LH-L	H-HL
tʰina	H-L	H-L	H-L
tʰimu	H-LH	H-LH	HL-HL
tʰima	L-LH	L-H	L-HL
tʰupi	HL-H	HL-H	HL-H
tʰupa	HL-L	HL-HL	HL-L
tʰuki	LH-H	LH-L	LH-L
tʰuka	LH-HL	LH-LH	LH-LH
tʰuni	H-L	H-L	H-H

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tʰuna	H-LH	H-LH	L-LH
tʰumi	L-LH	L-H	L-H
tʰuma	L-HL	L-HL	LH-HL
tʰapi	HL-L	HL-HL	HL-LH
tʰapu	LH-H	LH-LH	LH-H
tʰaki	LH-HL	LH-L	H-HL
tʰaku	H-L	H-L	H-L
tʰani	H-LH	H-LH	H-LH
tʰanu	L-LH	L-H	L-HL
tʰami	L-HL	L-HL	HL-HL
tʰamu	HL-H	HL-H	HL-L
kipu	LH-H	LH-L	LH-L
kipa	LH-HL	LH-LH	LH-LH
kitʰu	H-L	H-L	H-H
kitʰa	H-LH	H-LH	H-LH
kinu	L-LH	L-H	L-LH
kina	L-HL	L-HL	LH-HL
kimu	HL-H	HL-H	HL-H
kima	HL-L	HL-HL	HL-LH
kupi	LH-HL	LH-L	LH-L
kupa	H-L	H-L	H-L
kutʰi	H-LH	H-LH	LH-H
kutʰa	L-LH	L-H	L-H
kuni	HL-H	HL-H	HL-L
kuna	L-HL	L-HL	H-HL
kumi	HL-L	HL-HL	HL-HL
kuma	LH-H	LH-LH	LH-LH
kapi	H-L	H-L	H-L
kapu	H-LH	H-LH	H-H
katʰi	L-LH	L-H	L-LH
katʰu	L-HL	L-HL	LH-HL
kani	HL-H	HL-H	HL-H
kanu	HL-L	HL-HL	HL-LH
kami	LH-H	LH-LH	LH-H
kamu	LH-HL	LH-L	L-HL
nipu	H-LH	H-LH	H-LH
nipa	L-LH	L-H	L-H
nitʰu	HL-H	HL-H	H-HL
nitʰa	LH-H	LH-L	HL-L
niku	HL-L	HL-HL	HL-HL

nika	L-HL	L-HL	LH-L
nimu	LH-HL	LH-LH	LH-LH
nima	H-L	H-L	H-L
nupi	L-LH	L-H	L-LH
nupa	L-HL	L-HL	L-H
nutʰi	HL-H	HL-H	HL-H
nutʰa	HL-L	HL-HL	HL-LH
nuki	LH-H	LH-LH	LH-H
nuka	LH-HL	LH-L	L-HL
numi	H-L	H-L	H-H
numa	H-LH	H-LH	H-LH
napi	L-HL	L-HL	LH-HL
napu	HL-H	HL-H	H-HL
natʰi	HL-L	HL-HL	HL-HL
natʰu	LH-H	LH-L	LH-HL
naki	LH-HL	LH-LH	LH-LH
naku	H-L	H-L	H-L
nami	H-LH	H-LH	H-HL
namu	L-LH	L-H	L-H
mipu	HL-H	HL-H	HL-H
mipa	HL-L	HL-HL	HL-L
mitʰu	LH-H	LH-L	LH-L
mitʰa	LH-HL	LH-LH	LH-H
miku	H-L	H-L	H-L
mika	H-LH	H-LH	H-LH
minu	L-LH	L-H	L-LH
mina	LH-H	LH-L	LH-L
mupi	HL-L	HL-HL	HL-LH
mupa	L-HL	L-HL	HL-L
mutʰi	LH-HL	LH-LH	LH-LH
mutʰa	H-L	H-L	H-H
muki	H-LH	H-LH	H-LH
muka	L-LH	L-H	L-LH
muni	HL-H	HL-H	HL-HL
muna	L-HL	L-HL	L-HL
mapi	LH-H	LH-LH	LH-H
mapu	H-L	H-L	H-H
matʰi	LH-HL	LH-L	L-HL
matʰu	H-LH	H-LH	H-HL
maki	L-LH	L-H	L-H

maku	L-HL	L-HL	LH-HL
mani	HL-H	HL-H	HL-H
manu	HL-L	HL-HL	HL-LH

Appendix B. The full list of Exp I test items; shaded cells represent the items used in practice trials.

Segment	Tones	Segment	Tones	Segment	Tones
fifu	H-H	susa	H-HL	lali	LH-LH
fisu	H-H	lifu	HL-LH	lixu	L-LH
fisa	H-L	lifa	LH-H	lixa	HL-H
filu	H-HL	lisu	LH-L	luxi	HL-L
fila	H-LH	lisa	LH-HL	luxa	HL-HL
fusi	L-H	lufi	H-LH	laxi	HL-LH
fusa	L-HL	lufa	H-H	laxu	LH-H
fuli	L-LH	lusi	H-HL	xifu	LH-L
fula	HL-H	lusa	H-LH	xifa	LH-HL
fasi	HL-L	lafi	L-H	xisu	H-H
fasu	HL-HL	lafu	L-HL	xisa	LH-LH
fali	HL-LH	lasi	L-LH	xilu	H-L
falu	LH-H	lasu	HL-H	xila	L-H
sifu	LH-L	fixu	HL-L	xufi	H-HL
sifa	LH-HL	fixa	HL-HL	xufa	L-HL
silu	LH-LH	fuxi	HL-LH	xusi	L-LH
sila	H-L	fuxa	LH-H	xusa	HL-H
sufi	H-HL	faxi	LH-L	xuli	HL-LH
sufa	H-LH	faxu	LH-HL	xula	HL-L
suli	L-H	sixu	LH-LH	xafi	HL-HL
sula	L-HL	sixa	H-L	xafu	LH-H
safi	L-LH	suxi	H-H	xasi	LH-L
safu	HL-H	suxa	H-LH	xasu	LH-LH
sali	HL-L	saxi	L-H	xali	LH-HL
salu	HL-HL	saxu	L-HL	xalu	H-L

Appendix C. The full procedure for recording, editing, and validating auditory stimuli

When we recorded the auditory stimuli, the native speaker naturally read aloud each training and test item once to an Audio-Technica® MB 3k microphone directly input to a desktop computer. The speech signals were recorded in Praat (Boersma & Weenink, 2019) at a sampling rate of 22,050 Hz, which were later stored as a WAV file. We then proceeded to take necessary steps to reduce inter-stimulus phonetic variations. First, we extracted and averaged the f0 contours of each tone by vowel type and syllable position (see Figure C1 for average f0 contours by syllable position). We then calculated the mean length of each onset consonant type by syllable position and that of each vowel type by syllable position and tone type (see Table C1 for the descriptive statistics). The raw recordings were then resynthesized with the average phonetic profiles in Praat to unify consonant/vowel length as well as f0 contour by tone type, vowel type, and syllable position. Since the average f0 height of the high-level tone was generally higher in the first syllable than in the second syllable (Figure C1), we resynthesized the second H in tokens with a H-H sequence with the average f0 contour of an H produced with the same vowel in the first syllable to better approximate the f0 plateau in H-H sequences in Standard/Taiwan Mandarin (e.g., Xu 1997; Huang 2017). Finally, we trimmed the silent portions in each WAV file and normalized the volume of all stimuli in Praat by setting the amplitude peak to 0.99. To validate the robustness of the phonetic cues for tonal sequences in the resynthesized auditory stimuli, two research assistants speaking Taiwan Mandarin as their L1 were recruited to transcribe tones of the three sets of training items and the same set of test items without being told the goals of this study in advance. A high consistency rate ($\geq 95\%$) was found in their transcriptions of target tonal sequences for both training and test items.
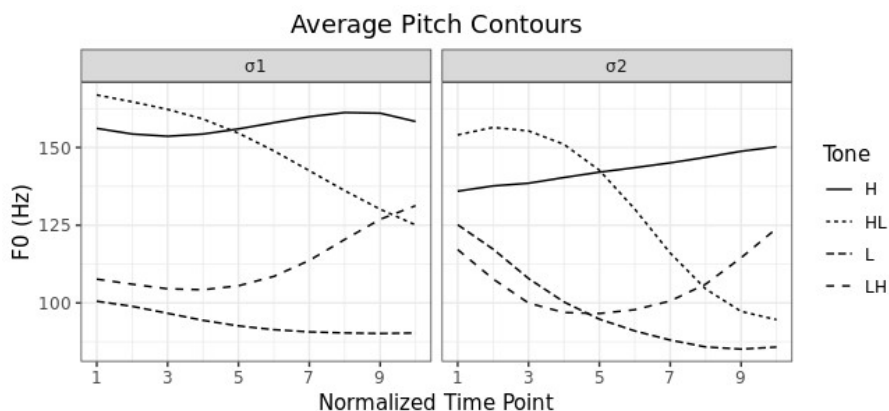

Figure C1: Time-normalized average f0 contours by syllable position used to replace original variable f0 contours in auditory stimuli.

References

Boersma, Paul & Weenick, David. 2019. Praat: doing phonetics by computer. Retrieved from http://www.fon.hum.uva.nl/praat/

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

Table C1: Mean segment length (ms) of consonants and vowels by syllable position and tone type for controlling inter-stimulus variations.

	σ1				σ2			
[f]	154.3				102			
[k]	31.1				97			
[l]	47.7				49.1			
[m]	50.6				78.5			
[n]	55.7				75.3			
[p]	12.9				91.8			
[s]	187.3				122			
[tʰ]	82.9				117.4			
[x]	86				77.1			
	H	LH	L	HL	H	LH	L	HL
[i]	175.9	180.1	166.4	174.5	321.5	322.5	255.8	270.9
[u]	167.6	185	173.6	168.2	307.3	341.8	241.6	268.8
[a]	187.5	203.6	188.7	195.6	343.7	365.6	276	293.4

Appendix D. The full list of Exp II test items (shaded cells represent practice items)

Inclusion		Exclusion	
Segment	Orthography	Segment	Orthography
lilu	ㄌ一? ㄌㄨ?	lilu	ㄌ一? ㄌㄨ?
sasu	ㄙㄚ? ㄙㄨ?	sasu	ㄙㄚ? ㄙㄨ?
sali	ㄙㄚ?ㄌ一?	sali	ㄙㄚ?ㄌ一?
sula	ㄙㄨ?ㄌㄚ?	sula	ㄙㄨ?ㄌㄚ?
lixa	ㄌ一?ㄏㄚ?	lixa	ㄌ一?ㄏㄚ?
lufa	ㄌㄨ?ㄈㄚ?	lufa	ㄌㄨ?ㄈㄚ?
xafu	ㄏㄚ?ㄈㄨ?	xafu	ㄏㄚ?ㄈㄨ?
xusa	ㄏㄨ?ㄙㄚ?	xusa	ㄏㄨ? ㄙㄚ?
lasu	ㄌㄚ?ㄙㄨ?	lasu	ㄌㄚ? ㄙㄨ?
fuli	ㄈㄨ?ㄌ一?	fuli	ㄈㄨ?ㄌ一?
lasu	ㄌㄚ?ㄙㄨ?	lasu	ㄌㄚ? ㄙㄨ?
lufa	ㄌㄨ?ㄈㄚ?	lufa	ㄌㄨ?ㄈㄚ?
lisu	ㄌ一?ㄙㄨ?	lisu	ㄌ一? ㄙㄨ?
sufa	ㄙㄨ?ㄈㄚ?	sufa	ㄙㄨ?ㄈㄚ?
saxu	ㄙㄚ?ㄏㄨ?	saxu	ㄙㄚ?ㄏㄨ?
fuxa	ㄈㄨ?ㄏㄚ?	fuxa	ㄈㄨ?ㄏㄚ?
salu	ㄙㄚ?ㄌㄨ?	salu	ㄙㄚ?ㄌㄨ?
laxu	ㄌㄚ?ㄏㄨ?	laxu	ㄌㄚ?ㄏㄨ?