The Effect of Musicality on Cue Selection in Pitch Perception by English and Mandarin Speakers

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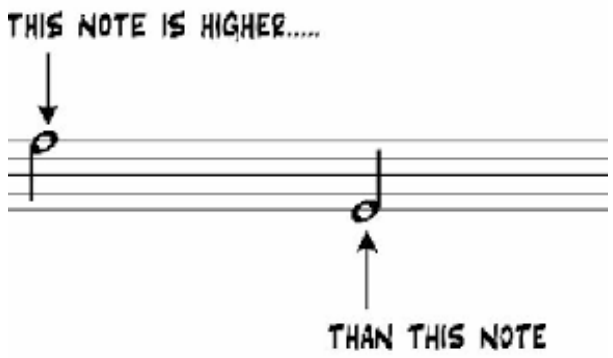
Music and speech share similar acoustic cues

- Pitch
- Rhythm
- Spectral shape



Tea = 𝅗𝅥 1 Beat

Coffee = ♫ ½ beat each

Coca cola = 𝅘𝅥𝅯𝅘𝅥𝅯𝅘𝅥𝅯𝅘𝅥𝅯 ¼ beat each

Lemonade = 𝅘𝅥𝅯𝅘𝅥𝅯𝅘𝅥𝅮 ¼ + ¼ + ½

Pineapple = 𝅘𝅥𝅮𝅘𝅥𝅯𝅘𝅥𝅯 ½ + ¼ + ¼

Musicality and language ability

- Musicality: aptitude for music
  - Innate (nature)
  - Learned (nurture)
- Good musicality -> better language abilities
  - Improved reading/verbal skills for L1 (Spychiger 1993; Douglas and Willatts 1994; Costa-Giomi 1999)
  - Better perception and production of L2 (Harrison 1979; Stevenson 1999; Pastuszek-Lipinska 2008)

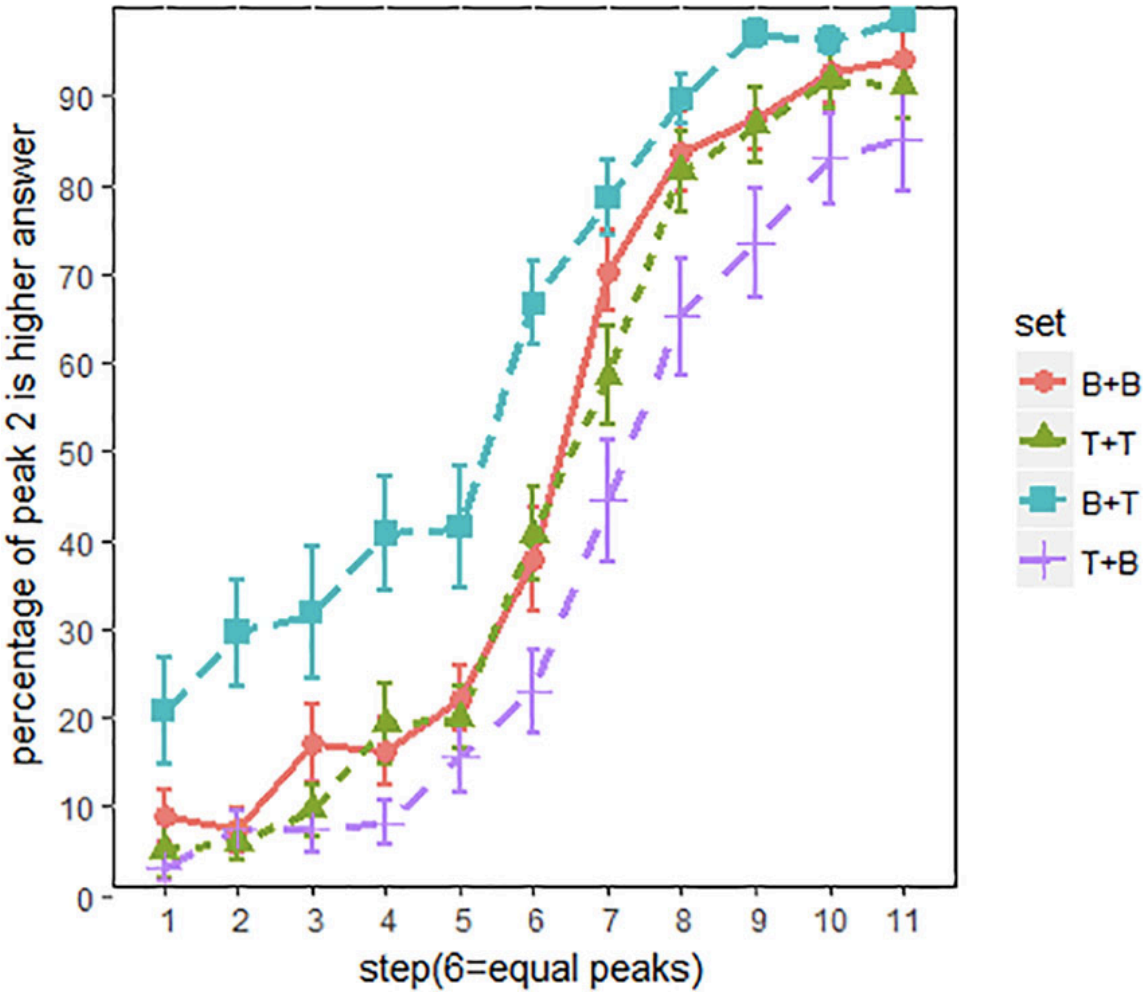
What about people with poor musicality?

- One might expect disadvantages in language ability
  - E.g., Learning tones
- However, congenital amusics acquire tone languages
  - Have normal tone production (Nan et al 2011)
  - Show categorical perception of tones (Huang et al 2015)
- How do people with amusia acquire tones, if they are unable to process pitch?

Pitch in speech is multidimensional

- In addition to f0, **phonation cues** also play a role in pitch perception
- Co-variation between f0 and phonation cues:
  - Spectral tilt: more flat spectrum (tenser phonation) -> higher pitch (Kuang and Liberman, 2015, 2016a)
  - Jitter/periodicity: more irregularity (creakier phonation) -> lower pitch (Kuang and Liberman, 2016b)
  - Gender/vocal tract length information (Kuang and Liberman 2016c)
- People who struggle with f0 can use co-varying cues

Previous findings



Research Questions

- How does musicality affect cue selection in pitch perception?
  - Hypothesis: More musical -> Preference for f0 cues
  - Approach: Correlation between musicality and cue preference
- Is pitch perception strategy affected by language background?
  - Hypothesis: Tone language -> Enhanced pitch perception
  - Approach: Recruit tone (Mandarin) vs non-tone (English) speakers

Methods

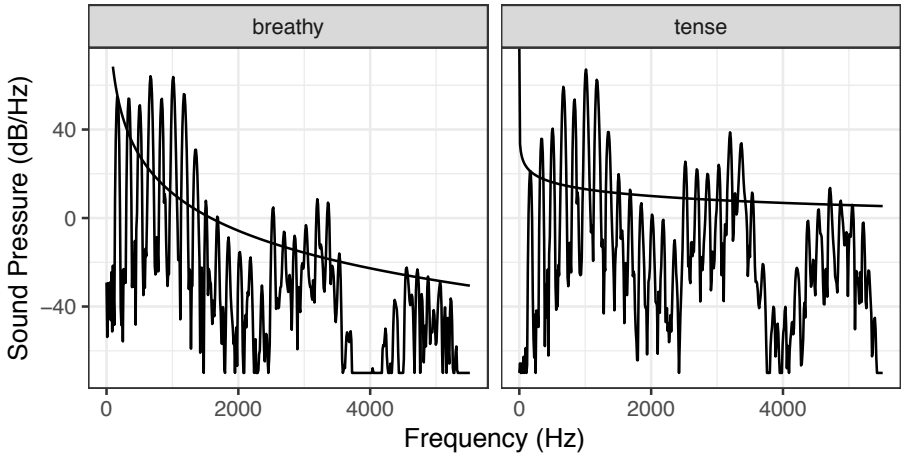
Overview

- Experiment 1: Pitch perception
- Experiment 2: Musicality
- Subjects: Two language groups
  - Non-tone: 71 English speakers (Age mean 19.74, sd 1.60, range 18-25)
  - Tone: 44 Mandarin speakers (Age mean 24.96, sd 6.93, range 18-50)

Experiment 1: Pitch Perception

Spectral manipulation of stimuli

- 4 spectral slope conditions
  - Breathy = natural spectrum
  - Tense = boosted 6 dB/Ocatve up

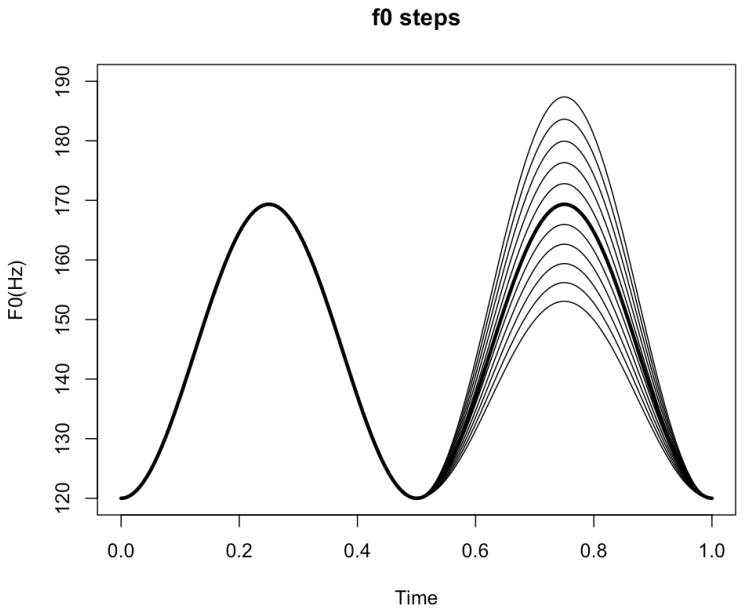


	Peak 1	Peak 2	Example
1.	Breathy	Breathy	
2.	Tense	Tense	
3.	Breathy	Tense	
4.	Tense	Breathy	

Experiment 1: Pitch Perception

f0 manipulation of stimuli

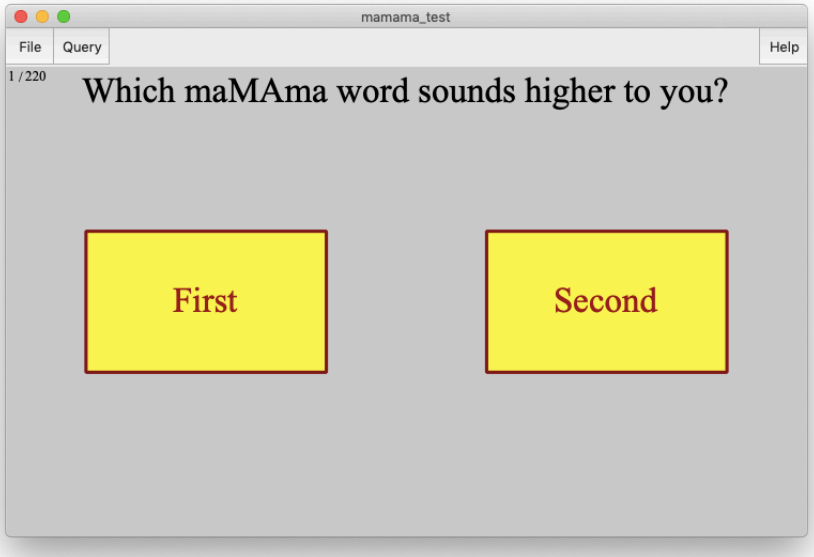
- First peak has constant peak f0
  - 169.34 Hz
- 11 f0 steps on the second peak
  - 0.5 semitones per step
  - equal as peak 1 at step 6



- 44 distinct stimuli in total after manipulations
  - 4 voice quality conditions × 11 f0 steps

Experiment 1: Pitch Perception

Task

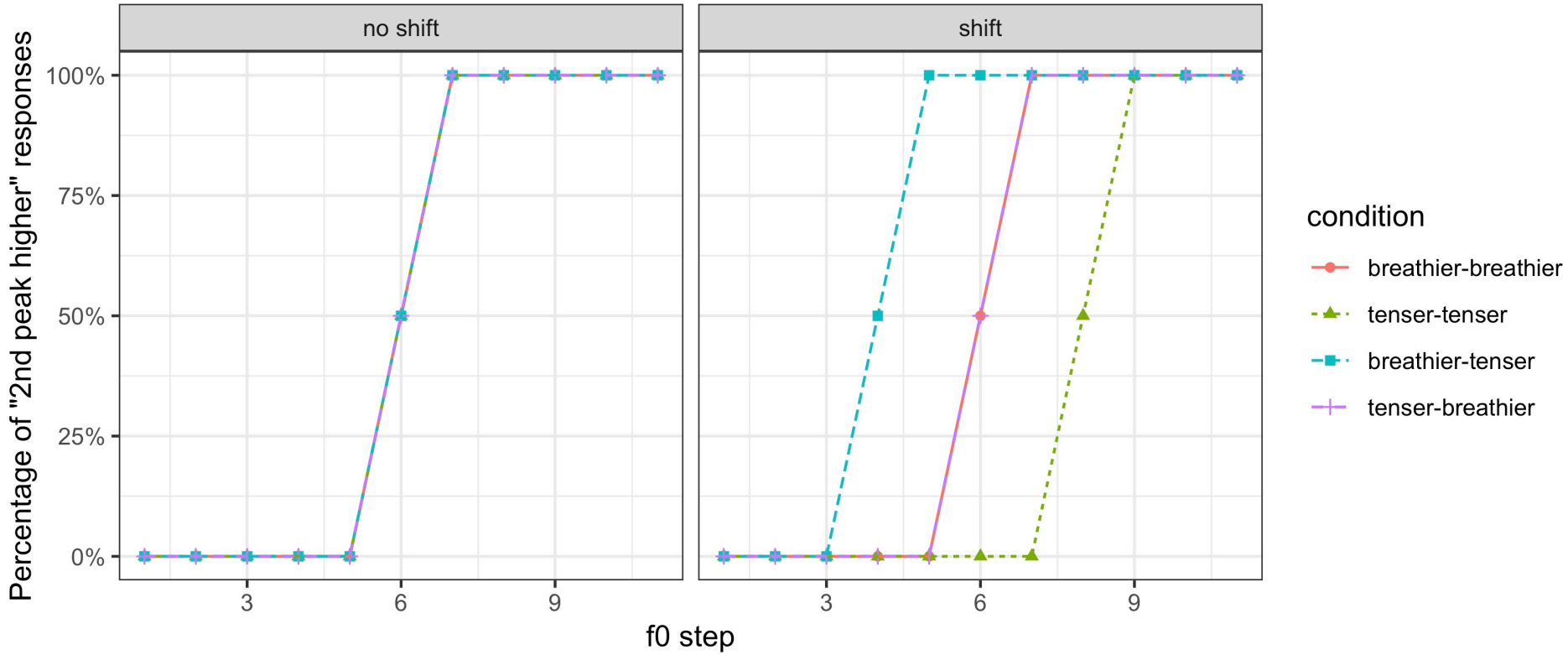


- Forced-choice classification
- Which “mamama” word sounds higher in pitch?
- 5 repetitions
- All stimuli randomized

Experiment 1: Pitch Perception

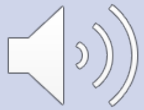
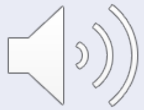
Predictions

Are listeners affected by spectral slope manipulations?



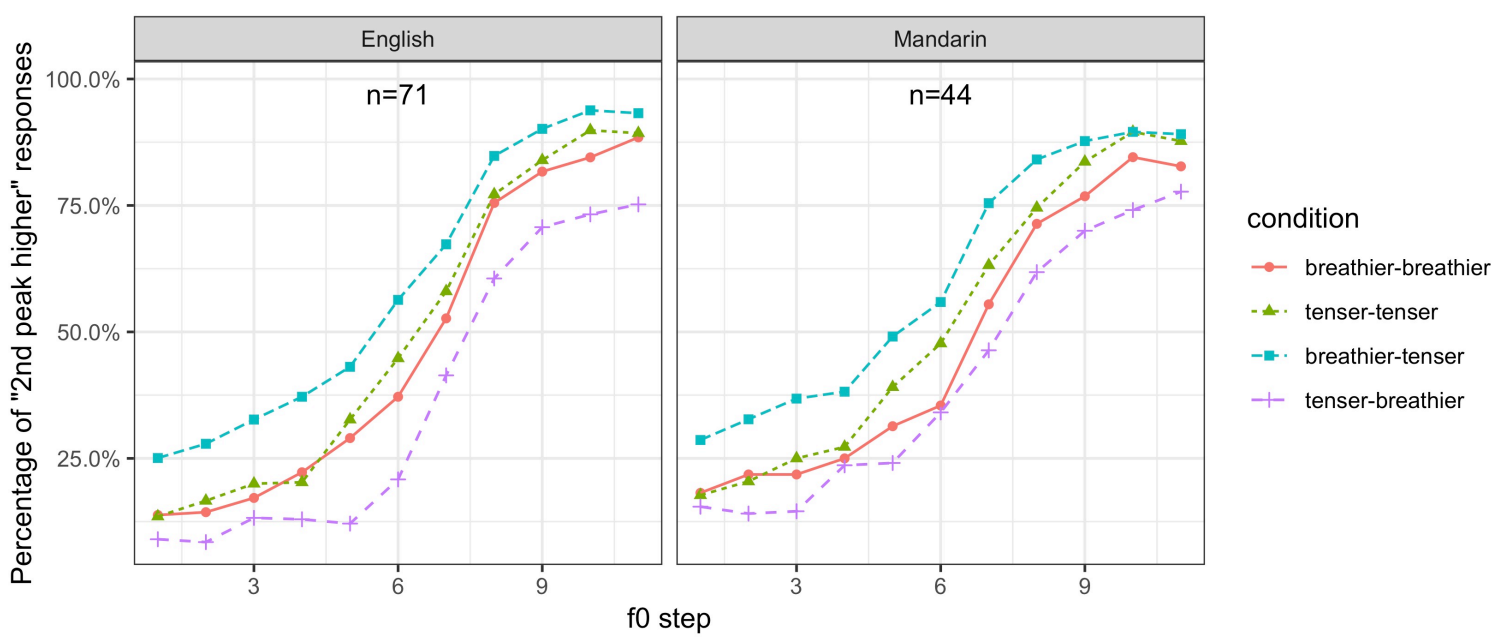
Experiment 2: Musicality

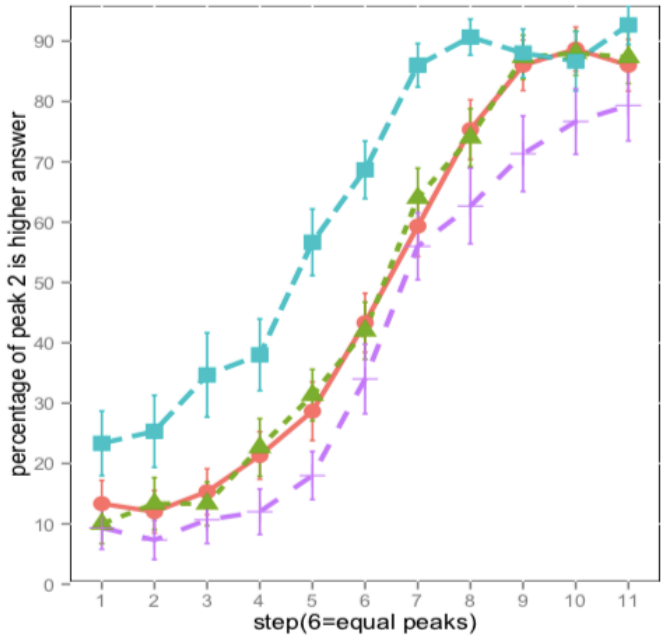
- The Montreal Battery of Evaluation of Musical Abilities (MBEMA) (Peretz et al. 2013)
- Musicality score: Percentage correct across all the tasks

Tasks	Stimuli	Number of stimuli
Melody comparison		20
Rhythm comparison		20
Memory		20

Results

Pitch Perception





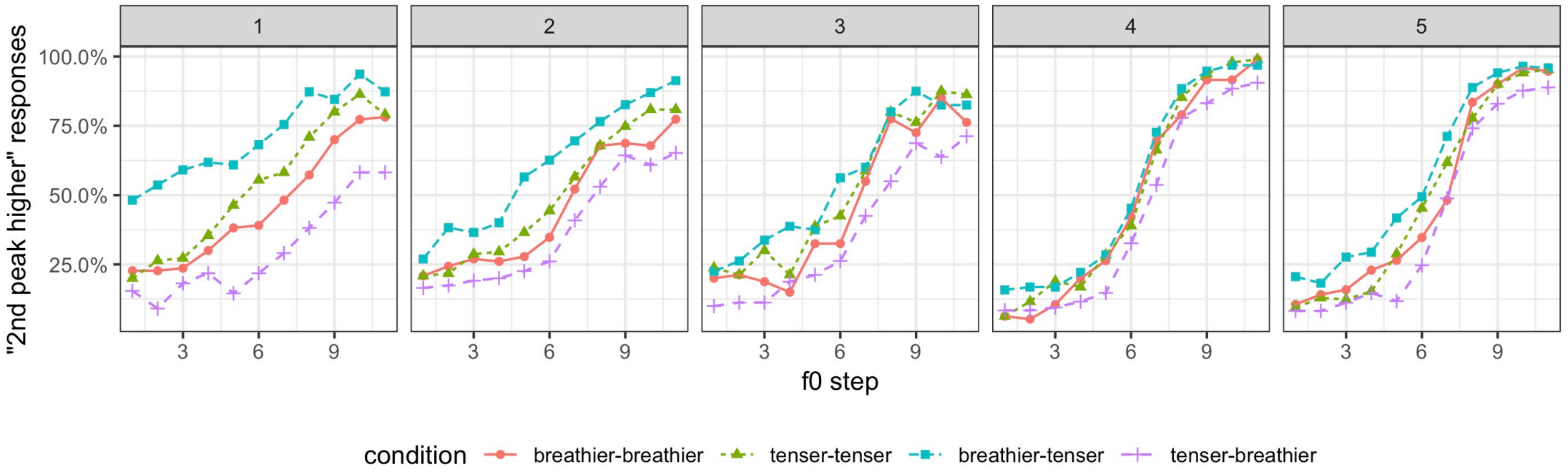
Replicated Kuang & Liberman (2018)

Musicality

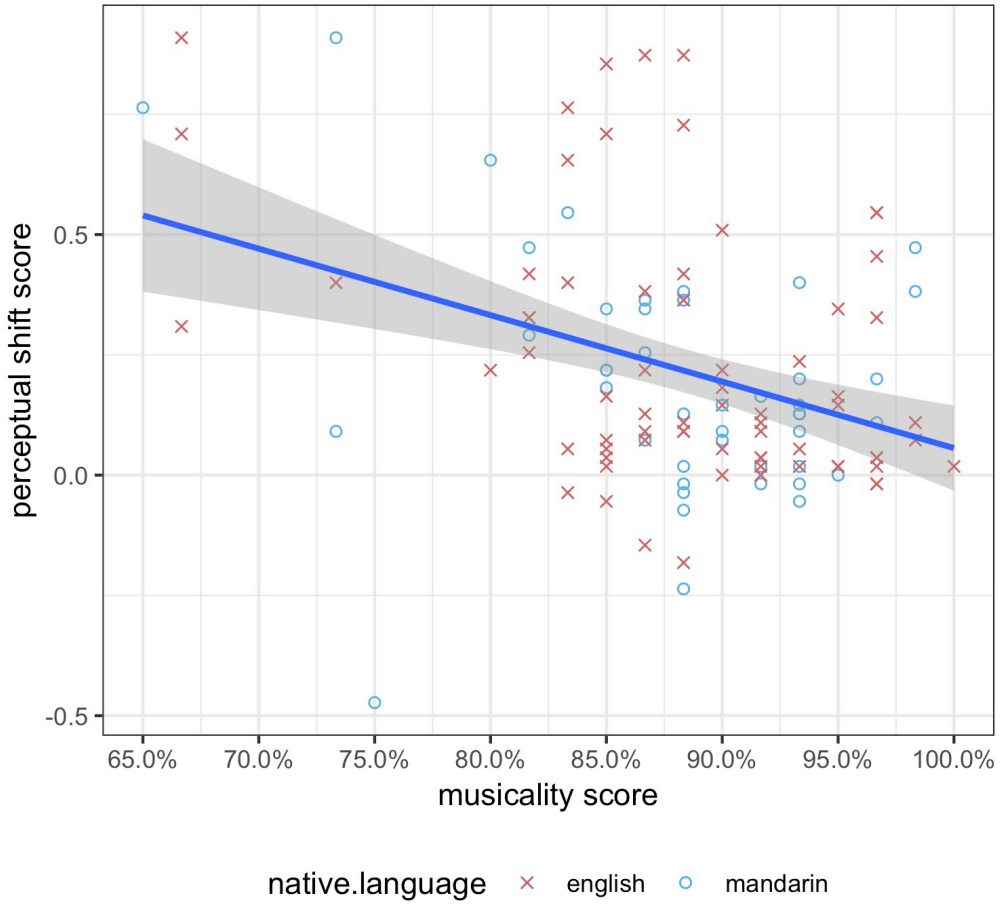
Language	N	melody	rhythm	memory	total
English	70	0.881	0.892	0.881	2.654
Mandarin	44	0.868	0.880	0.895	2.643

T-test on total scores between language groups (p = 0.784)
No significant difference in language, consistent with

Musicality and Pitch Perception by quantiles

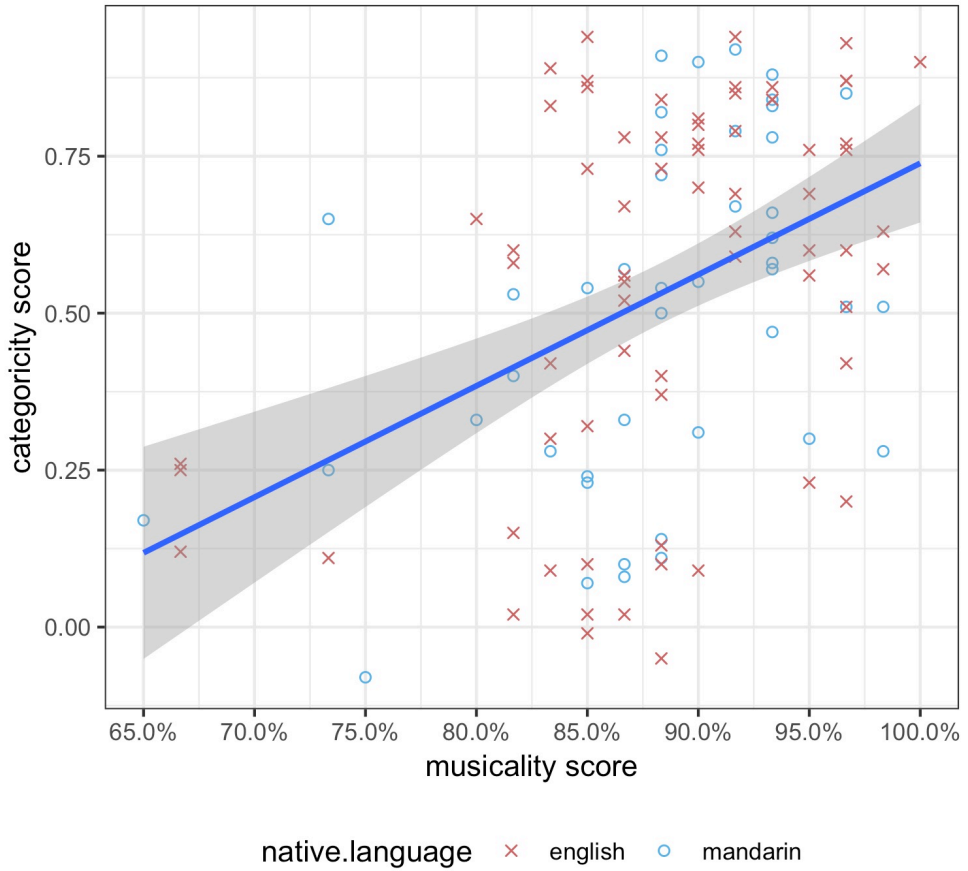


Musicality and Perceptual Shift



r = -0.3695 (t = -4.2091, df = 112, p-value < 0.001)

Musicality and f0 categoricity in perception



r = 0.4314 (t = 5.0616, df = 112, p-value < 0.001)

Discussion

Musicality and pitch perception

- Musicality is a significant predictor of pitch processing strategies
- Better musicality -> enhanced sensitivity to f0
  - More categorical perception along the f0 dimension
  - Less affected by spectral slope differences
- Implications: people who are less sensitive to f0 can rely on spectral cues in pitch perception
  - Amusic people might acquire tonal contrasts through cues co-varying with f0
  - Needs to be validated through studies with amusic population

Language background and pitch perception

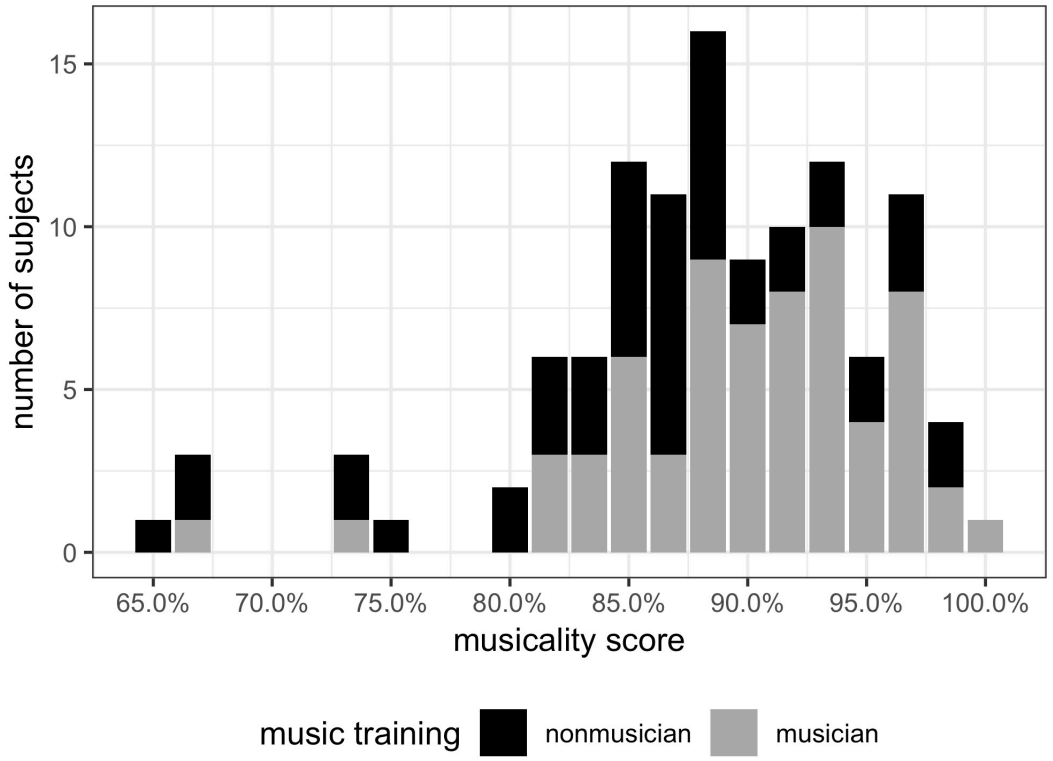
- language experience has little effect on
  - musicality scores
  - general pitch perception (Ngo et al., 2016; Zheng and Samuel, 2018)
- English and Mandarin speakers have similar strategies in pitch perception
  - Higher musicality scores -> more likely to rely on f0 in pitch perception
  - Lower musicality scores -> more likely to rely on spectral slope cue
- Maybe with multiple level tones will show language effects
  - E.g., Cantonese?

Thank you!

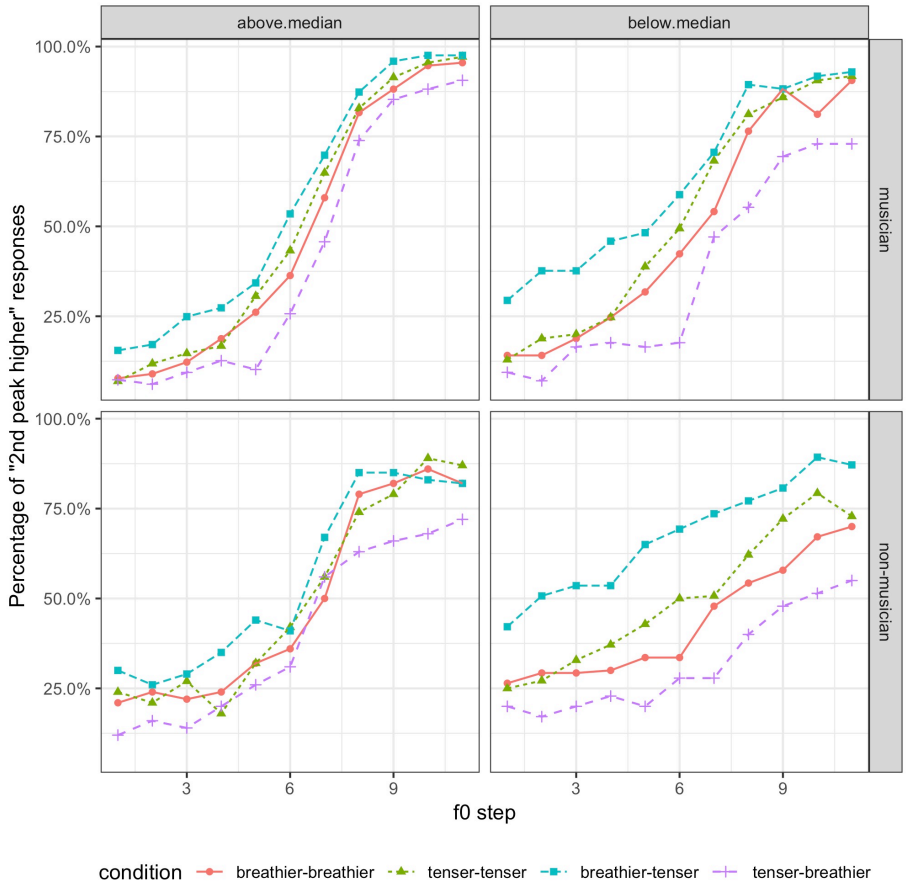
- Main effects of spectral slope for every pair of conditions for English and Mandarin speakers. Means of regression coefficients are followed by 95% highest posterior density intervals in square brackets and p-values.

		BB	TT	BT
English	**TT**	0.11 [0.03, 0.18], p = 0.006		
	BT	0.53 [0.44, 0.62], p < 0.001	0.69 [0.46, 0.89], p < 0.001	
	TB	-0.47 [-0.56, -0.38], p < 0.001	-0.97 [-1.20, -0.64], p < 0.001	-1.12 [-1.28, -0.97], p < 0.001
		BB	**TT**	**BT**
Mandarin	**TT**	0.22 [0.11, 0.34], p < 0.001		
	BT	0.62 [0.49, 0.74], p < 0.001	0.54 [0.37, 0.74], p < 0.001	
	TB	-0.29 [-0.41, -0.18], p < 0.001	-0.71 [-0.94, -0.52], p < 0.001	-1.69 [-2.24, -1.15], p < 0.001

Musicianship vs. musicality



Musicianship vs. musicality



Perceptual shift

- shift_score~musicality*language

	Estimate	Std. Error	t value	Pr(>t)
(Intercept)	1.5439	0.3694	4.18	0.0001 ***
musicality.score	-0.4938	0.1387	-3.56	0.0006 ***
native.language	-0.2630	0.6035	-0.44	0.6639
musicality.score:native.language	0.0819	0.2273	0.36	0.7194

Categoricity

- categoricity_score~musicality*language

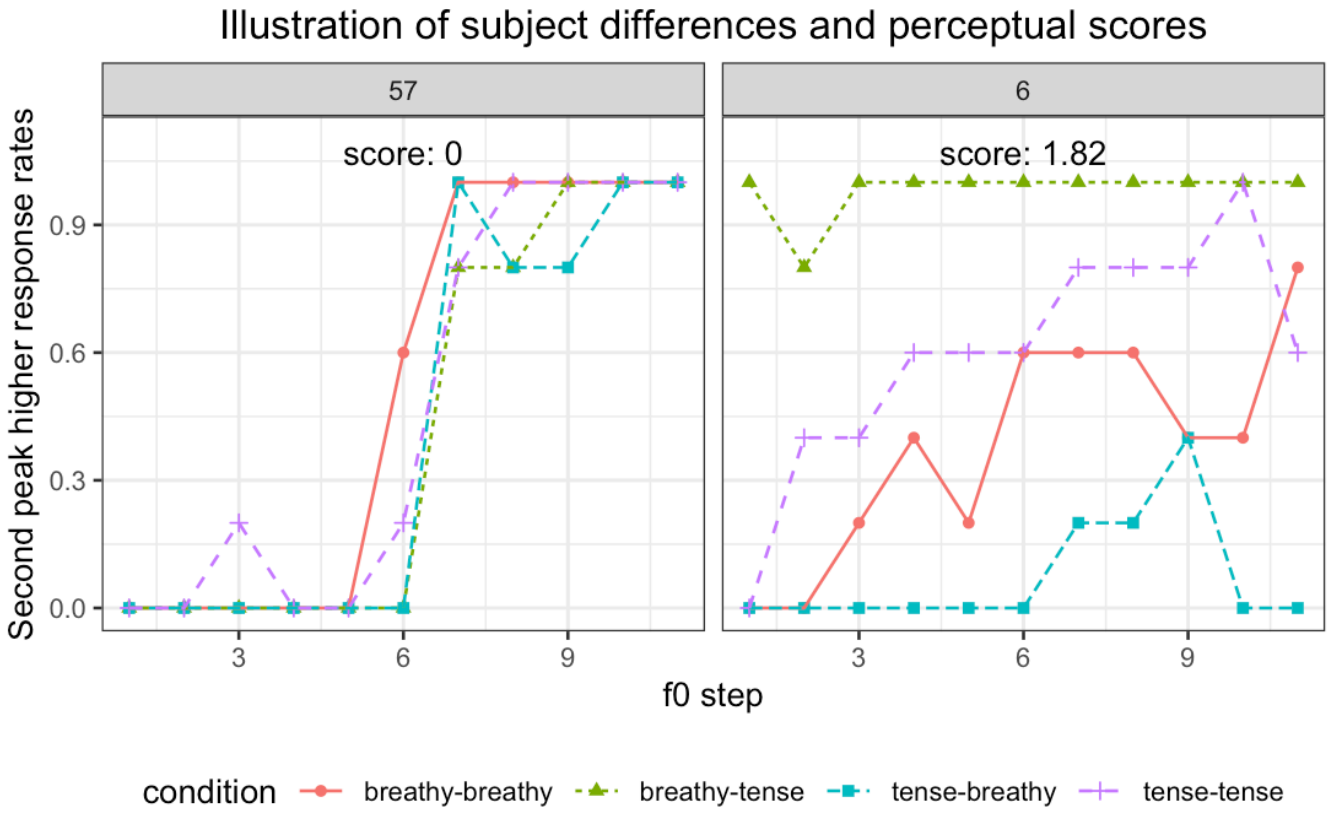
	Estimate	Std. Error	t value	Pr(>t)
(Intercept)	-1.0154	0.3948	-2.57	0.0114 *
musicality.score	0.5904	0.1483	3.98	0.0001 ***
native.language	-0.0294	0.6449	-0.05	0.9638
musicality.score:native.language	-0.0059	0.2428	-0.02	0.9805

Quantifying Perceptual Shift:

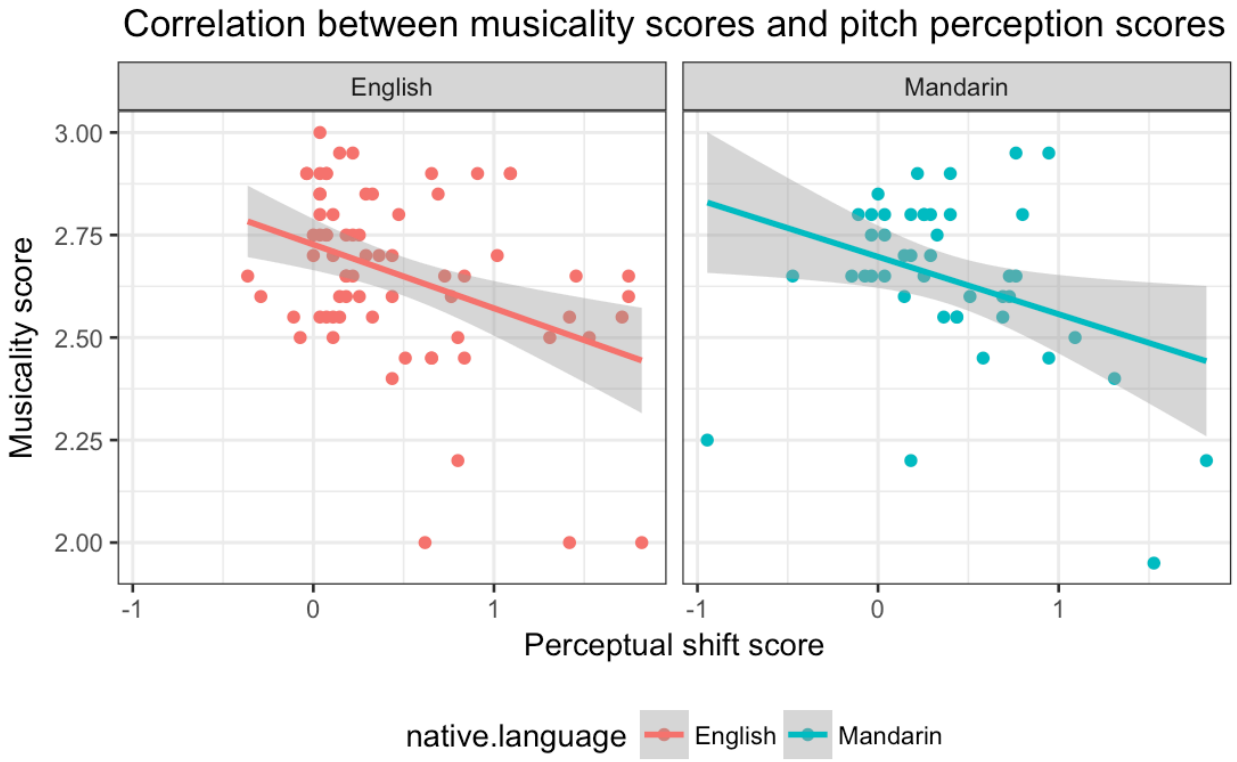
F0 dominant vs. spectral dominant

Shift = $(\overline{BT} - \overline{BB}) + (\overline{BT} - \overline{TT}) + (\overline{BB} - \overline{TB}) + (\overline{TT} - \overline{TB})$

Higher score = more shift



Perceptual Shift and Musicality



English: r = -0.392 (t = -3.51, df = 68, p = 0.00079)
Mandarin: r = -0.340 (t = -2.34, df = 42, p = 0.024)