THE HONG KONG UNIVERSITY OF SCIENCE AND TECHNOLOGY
DEPARTMENT OF COMPUTER SCIENCE & ENGINEERING

The Emotional Characteristics of the Violin with Different Pitches, Dynamics, and Vibrato Levels

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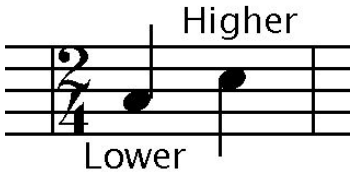
Pitch, Dynamics, and Vibrato

❑ *Music and Emotions*

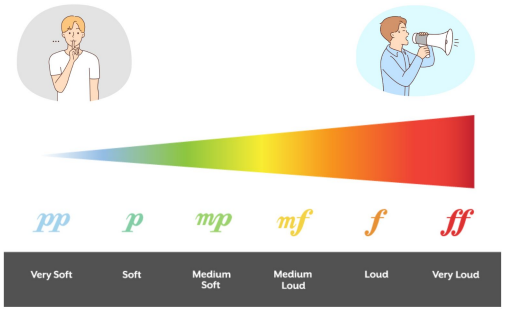
- Musical instruments evoke emotions

❑ *Musical Features with Emotions*

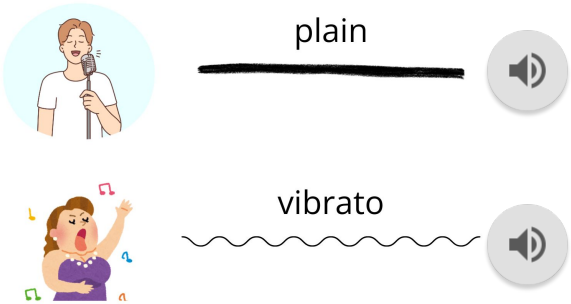
- **Pitch** *(height)*



- **Dynamics** *(loudness)*

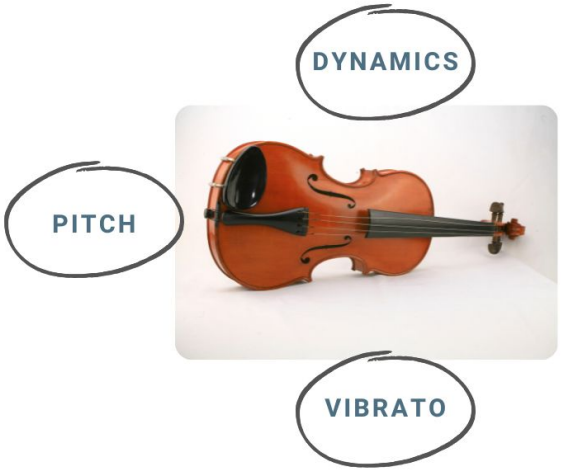


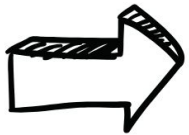
- **Vibrato** *(wobble)*



Motivation

- ***How** variations in **pitch**, **dynamics**, and **vibrato** shape the perceived **emotional** characteristics of **violin** sounds?*





Related Work

- ***Vibrato Performance Style (2013)***
  - Vibrato rate (speed) and extent (depth) of violin
  - No emotion studies

	Min	Mean	Max	SD
Vibrato Rate (Hz)	5.94	6.65	7.58	0.92
Vibrato Extent (semitones)	0.07	0.14	0.24	0.04

Average statistics for vibrato rates and extent for the six performances on the violin.
(Yang et al., 2013)

[1] L. Yang, E. Chew, S.-K. Rajab et al., “Vibrato performance style: A case study comparing erhu and violin,” 2013.

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  - Vibrato rate (speed) and extent (depth) of violin
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- ***Pitch and Dynamics with Strings (2016)***
  - Pitch (increased with happy, while decreased with sad)
  - Dynamics (louder with angry, while softer with calm)
  - No vibrato

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[2] S. J. Gilburt, C. Chau, and A. Horner, “The effects of pitch and dynamics on the emotional characteristics of bowed string instruments,” in Proc. Int. Comp. Music conf.(ICMC), 2016, pp. 405–410.

Related Work

- ***Vibrato Performance Style (2013)***
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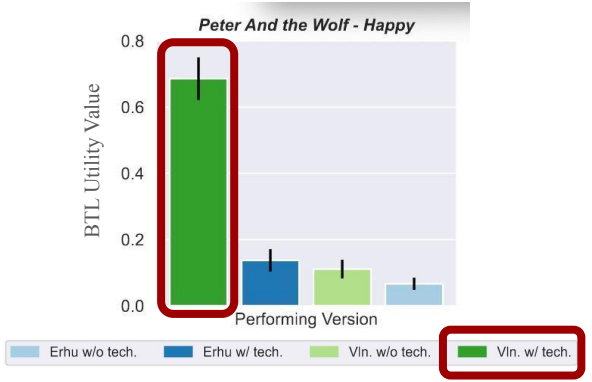
- ***Emotional Intensity w/ and w/o Vibrato (2024)***
  - With vibrato: more positive and energetic
  - No single-note/acoustic features



Bradley-Terry-Luce (BTL) utility value shows that the version of 'violin with vibrato' was preferred.
(Song et al., 2024)

[3] W. Song, Z. Zhou, Z. Huang, and A. B. Horner, "A comparative study of violin and erhu emotional characteristics: Influence of playing techniques and instrument," in 186th Meeting of the Acoustical Society of America and the Canadian Acoustical Association, Ottawa, Ontario, Canada, 2024, p. 035002.

Experiment Settings

❑ *Test Materials*

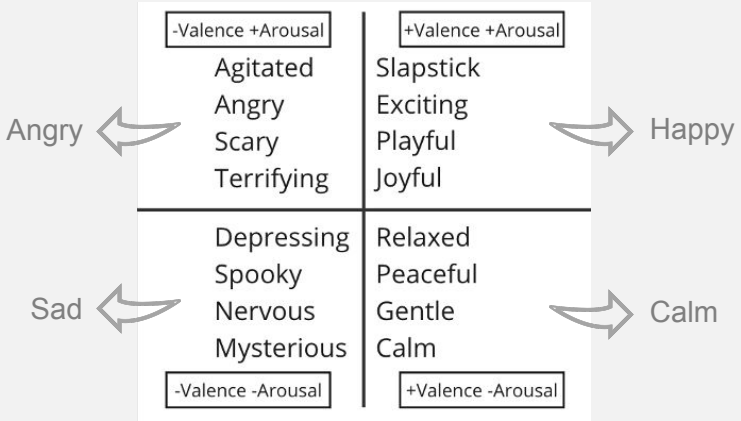
- ProSonus Sound Library
- Stimuli
  - Pitch: C4, C5, C6, C7
  - Dynamics: *forte (F)*, *piano (P)*
  - Vibrato: V0 (no), V3 (high)

Total: 16 samples

Pitch	Dynamics	Vibrato	Vibrato Rate (Hz)	Vibrato Depth (%)
C4	*Forte*	V3	6	9
C7	*Piano*	V3	6	8

❑ *Emotions*

- Perceived **Valence** (positivity)
- Perceived **Arousal** (intensity)
- Presence of **16 Emotions**



[4] Z. Huang, W. Song, X. Ma, and A. Horner, “The emotional characteristics of bass drums, snares, and disengaged snares with different strokes and dynamics,” The Journal of the Acoustical Society of America, vol. 154, pp. A288–A288, Oct. 2023.

Listening Test

✔ ***25 Participants***

Listen to the single note

Please listen to the following sound

9-point Valence-Arousal ratings

Binary 16 emotions

Please rate the positivity of the sound (e.g., "**happy**" is **positive** and "**sad**" is **negative**)

1 Very Sad	2	3 A little Sad	4	5 Neutral	6	7 A little Happy	8	9 Very Happy

Please rate the energy level of the sound (e.g., "**exciting**" is on a **higher** energy level, and "**relaxing**" is on a **lower** energy level)

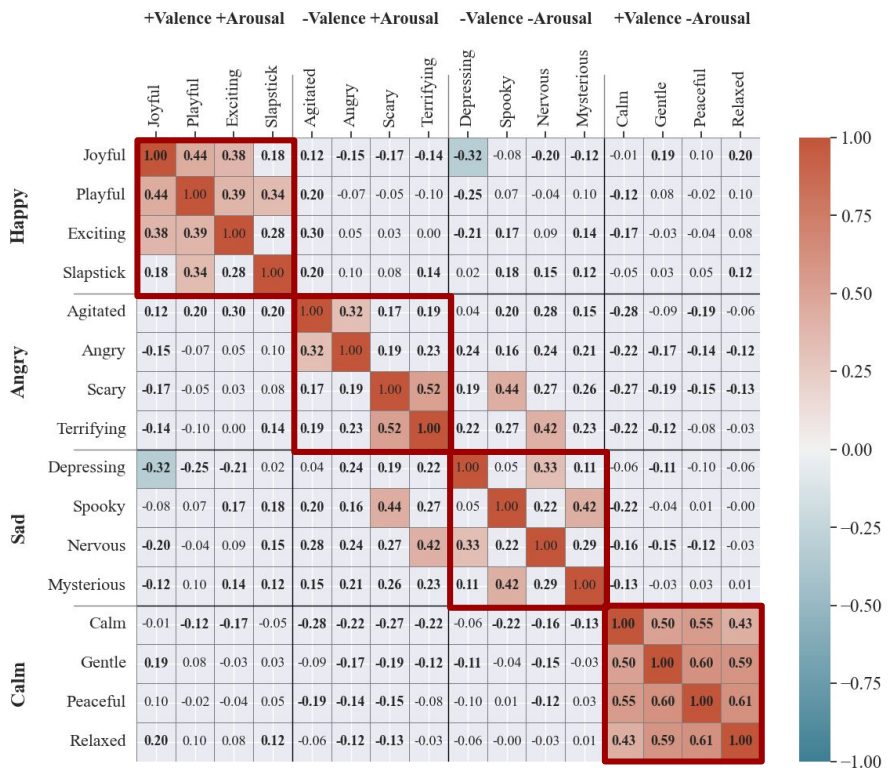
1 Very Relaxing	2	3 A little Relaxing	4	5 Neutral	6	7 A little Exciting	8	9 Very Exciting

Is the character of the sound...?

	No	Yes
agitated	○	○
joyful	○	○
depressing	○	○
calm	○	○

Correlation Analysis

- ***Emotions within the same quadrant did not always exhibit strong positive correlations***
  - **Calm** (=.54) > Happy (=.33) > Sad (=.27) > Angry (=.23)



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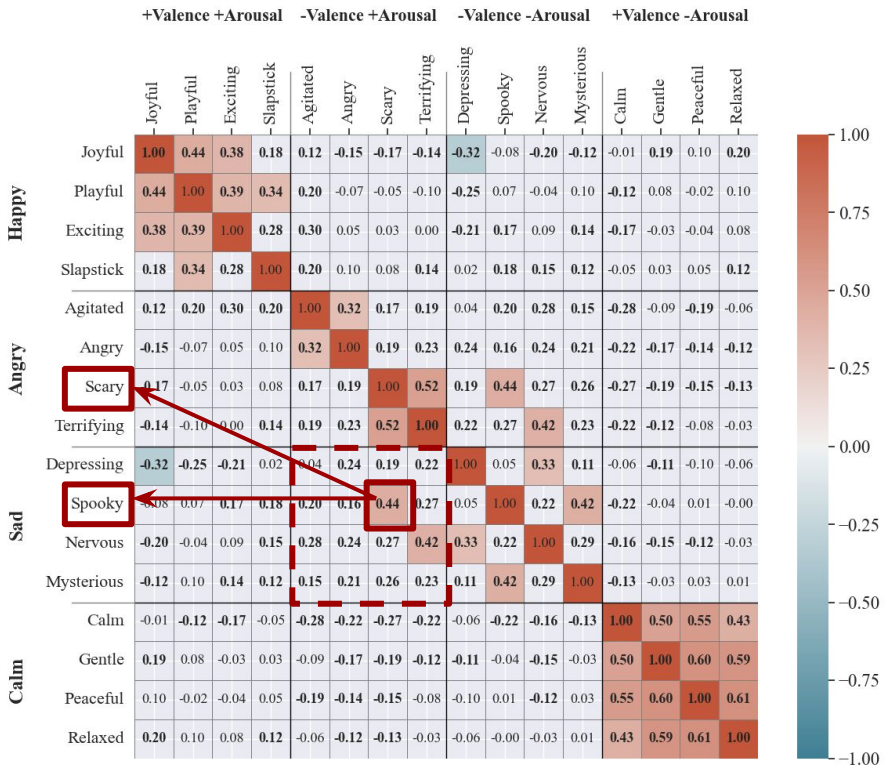
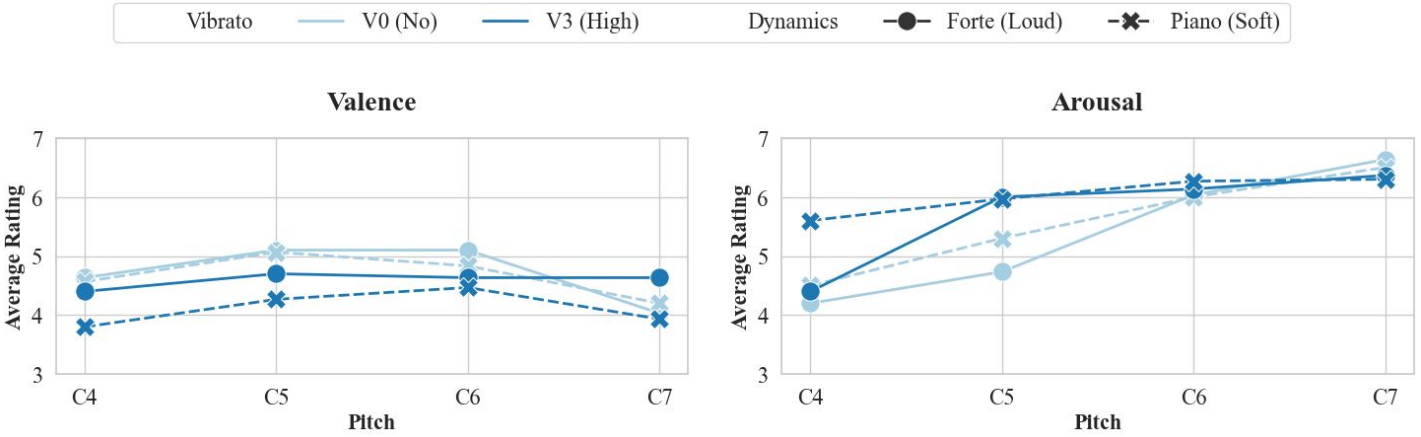
- ***Correlation between the Angry and Sad categories***



Basic Trends on Pitch, Dynamics, and Vibrato



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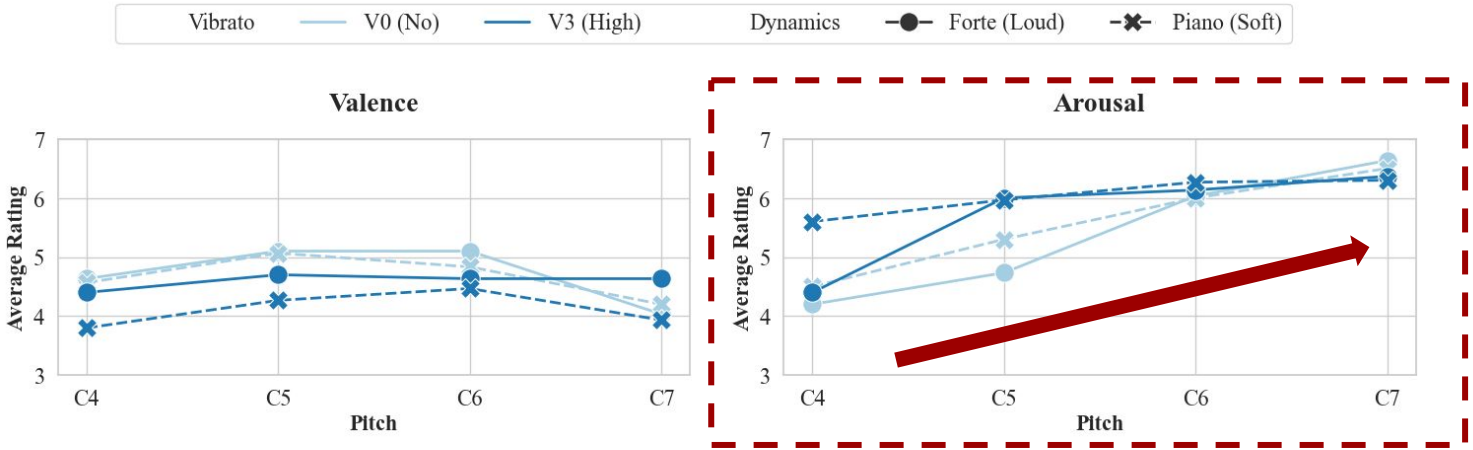
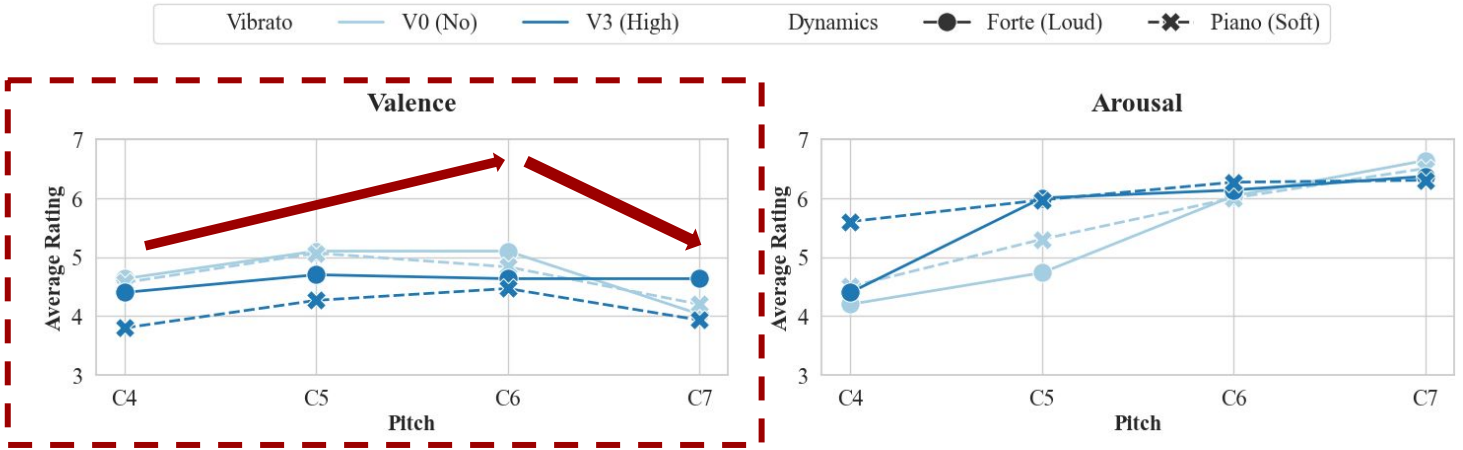


- ✔ **Higher** pitches evoke a **stronger** sense of arousal
- ✔ **Strong** vibrato may enhance arousal

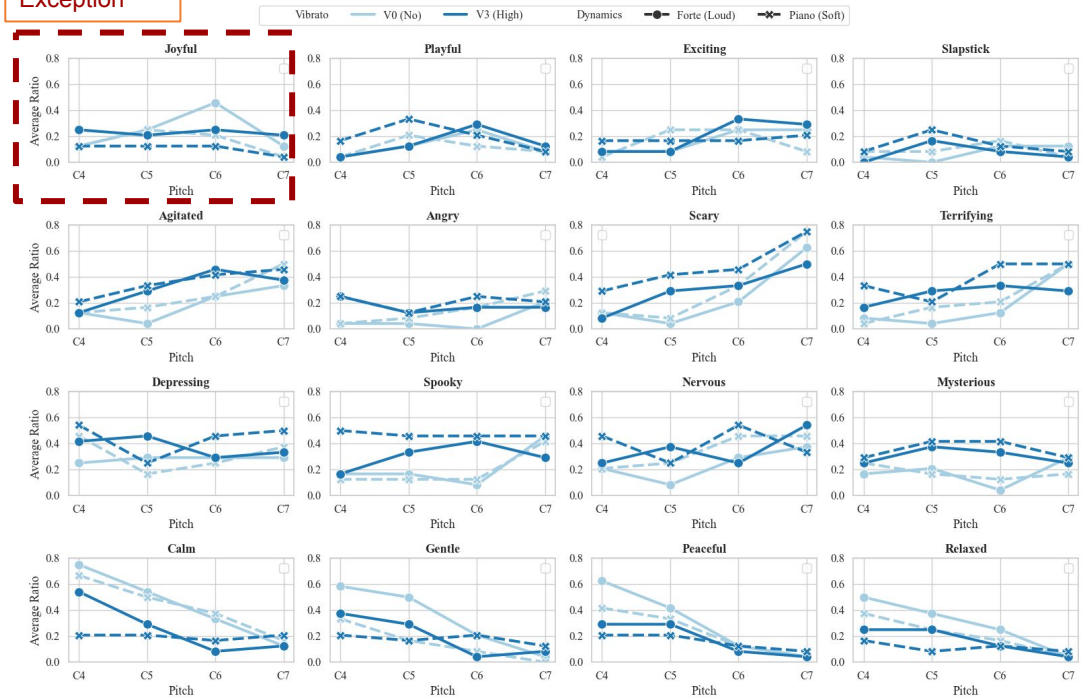
Basic Trends on Pitch, Dynamics, and Vibrato



- ✔ Valence generally highest in the middle range
- ✔ Strong vibrato may decrease valence
- ✔ Loud dynamics resulted in higher valence

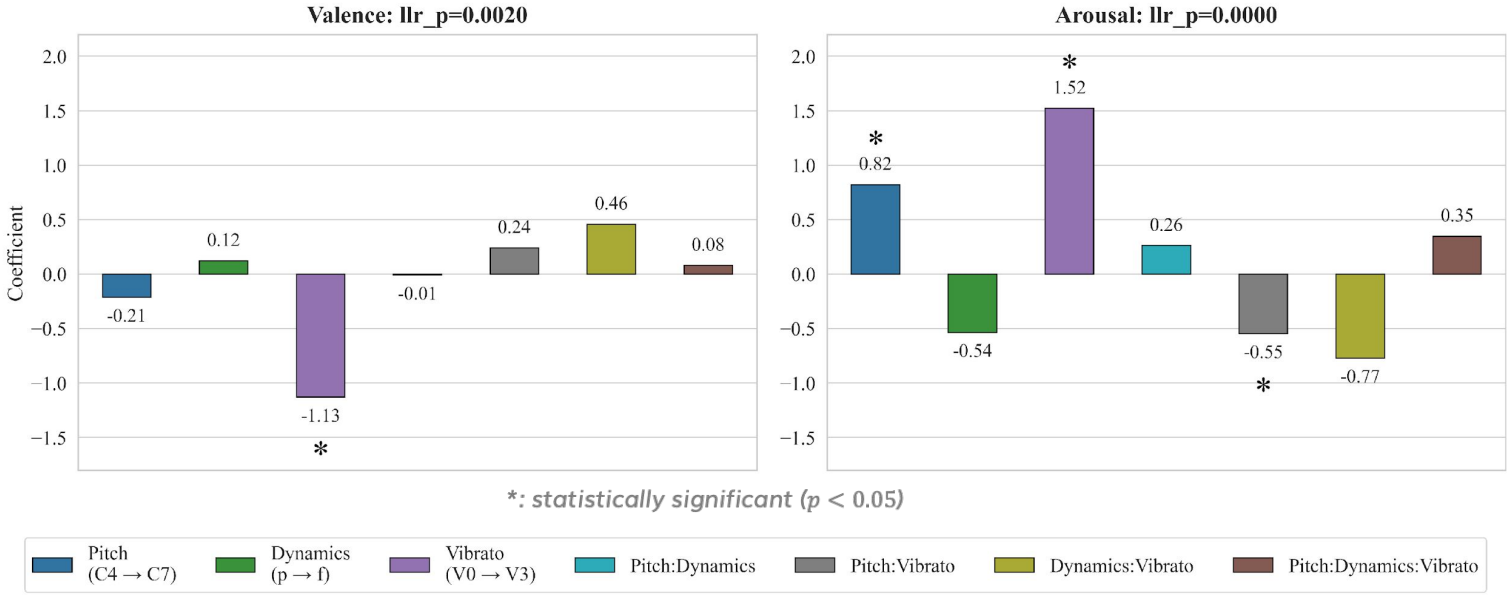
Basic Trends on Pitch, Dynamics, and Vibrato

Vibrato Exception



	❑ *Vibrato*	❑ *Pitch*
Happy	Higher	↗↘
Angry	Higher	→
Sad	Higher	Mixed
Calm	Lower	→

Ordinal Logistic Regression on Valence-Arousal



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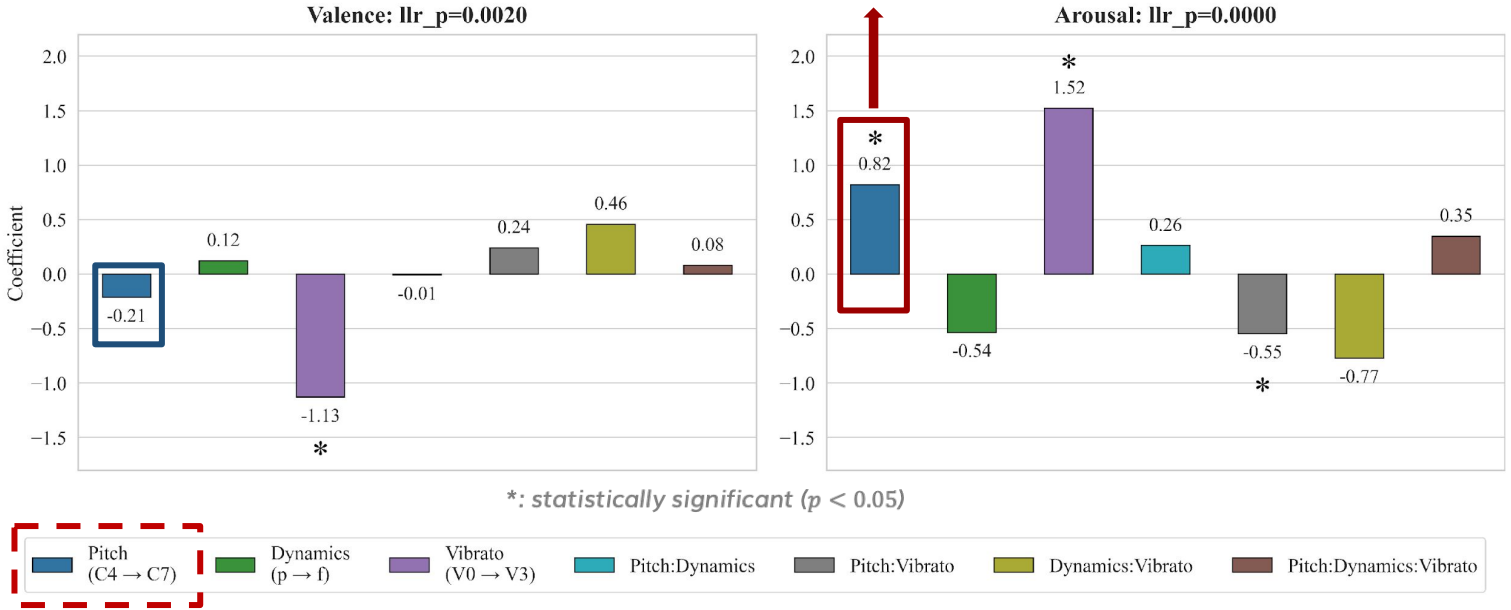

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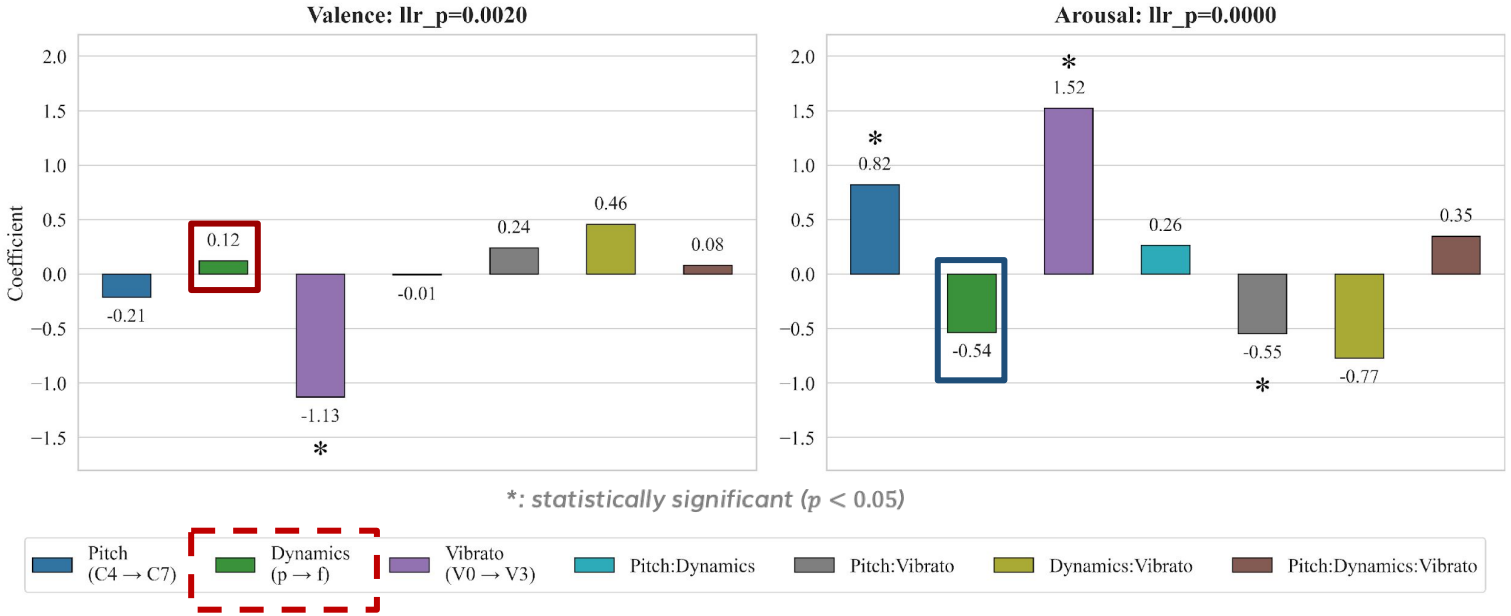

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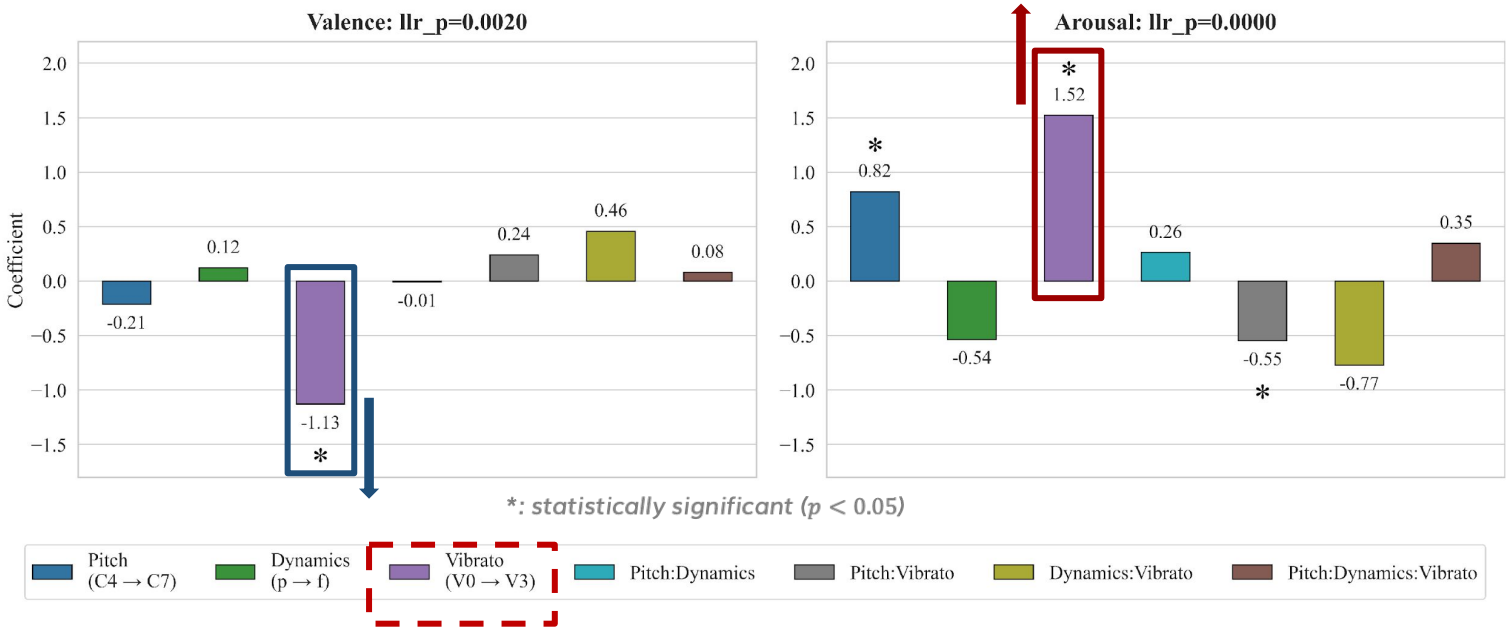
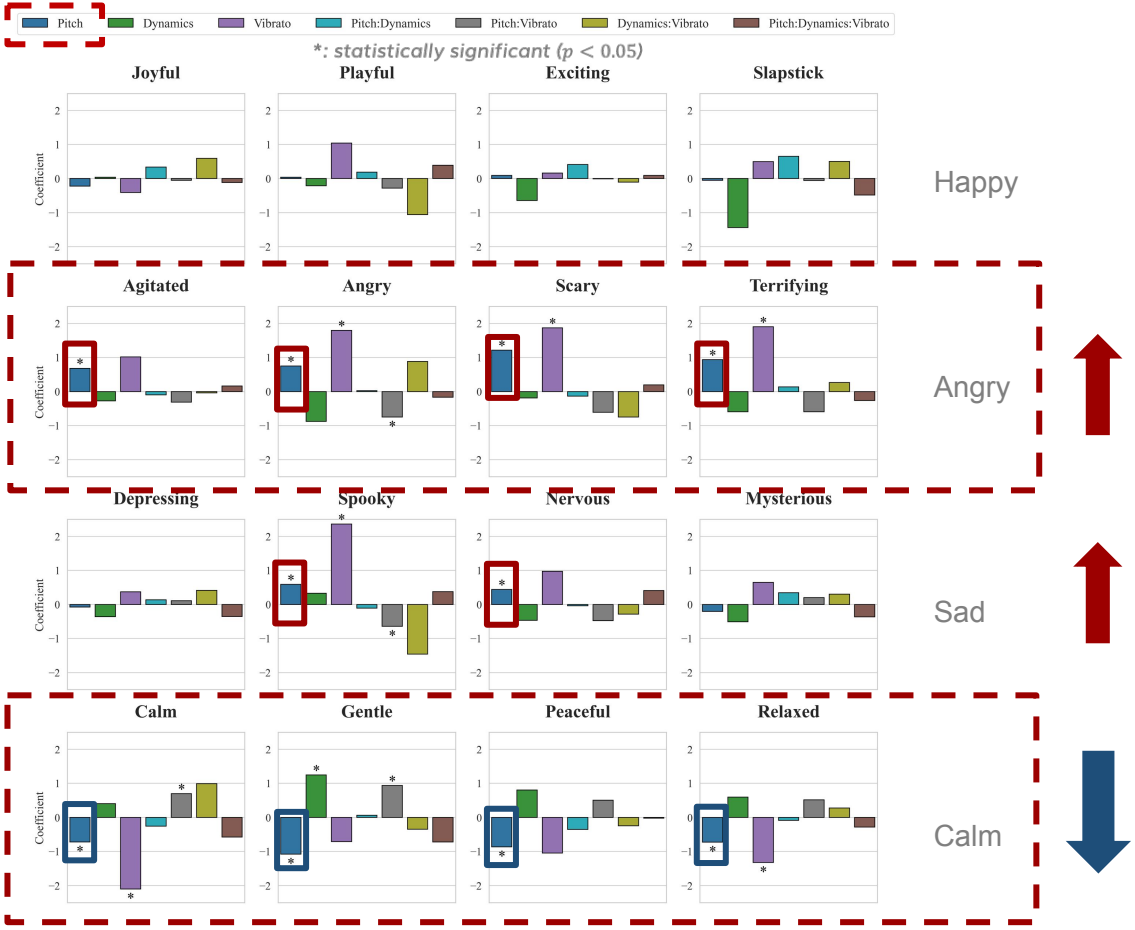
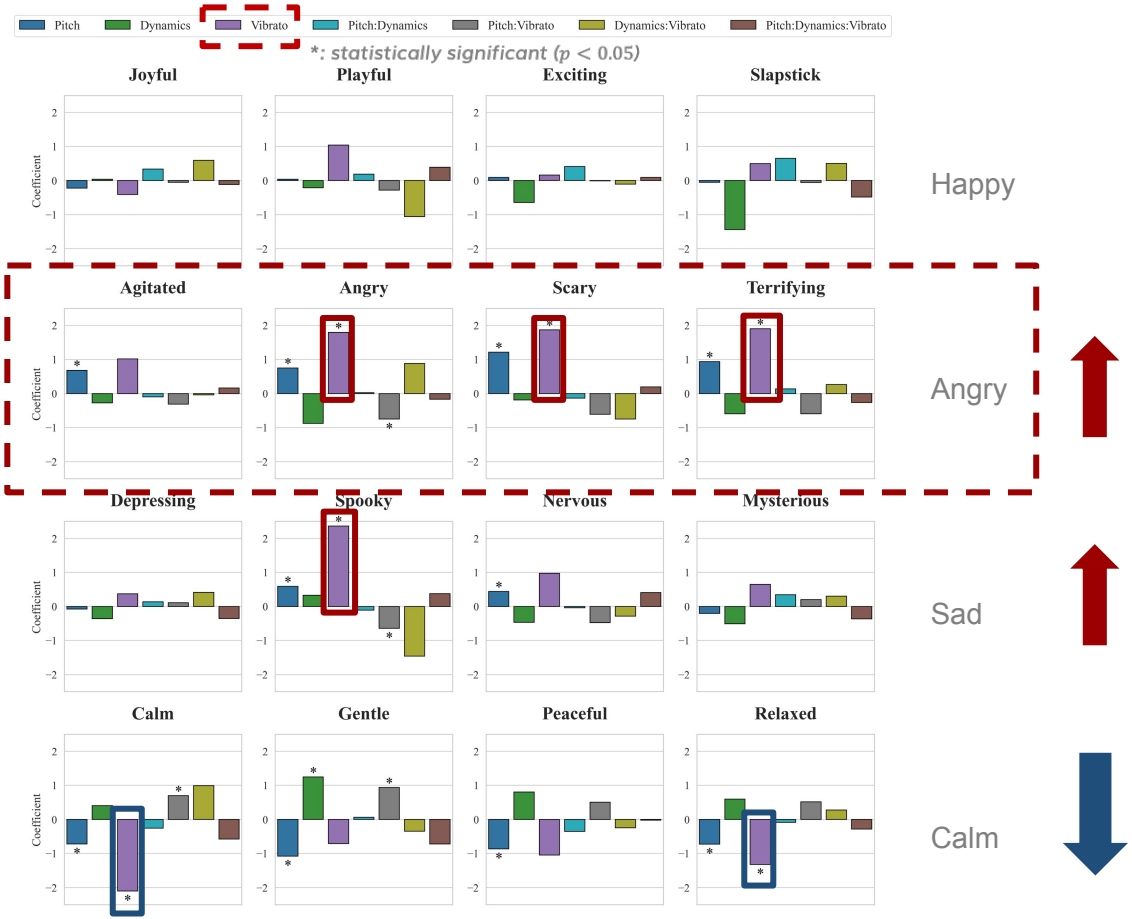


Logistic Regression on 16 Emotions



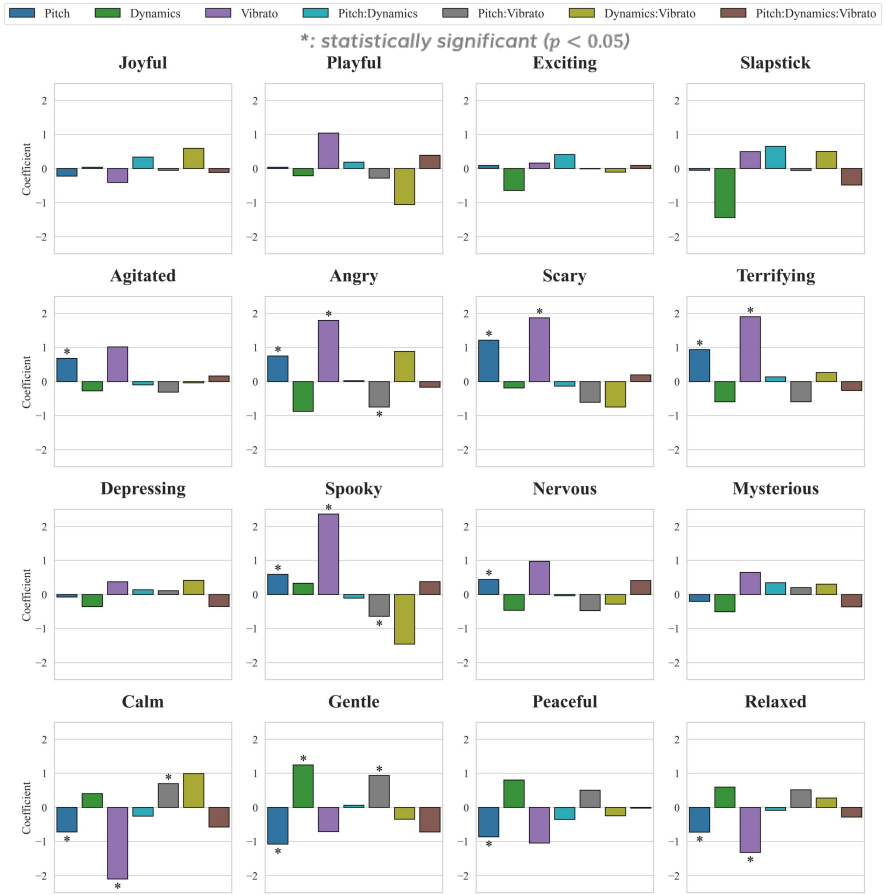
- ✔ **Pitch: most significant**
  - Angry (+), Calm (-)

Logistic Regression on 16 Emotions



- ✔ **Pitch: most significant**
  - Angry (+), Calm (-)
- ✔ **Vibrato: strongest**
  - Angry (+)

Logistic Regression on 16 Emotions



Happy

Angry

Sad

Calm

- ✔ **Pitch: most significant**
  - Angry (+), Calm (-)
- ✔ **Vibrato: strongest**
  - Angry (+)
- ✔ **Pitch > Vibrato > Dynamics**

Discussion

❑ ***How Pitch, Dynamics, and Vibrato Shape Emotions in Violin Music***

✔ 🥇 **Pitch** (widespread effect)

✔ 🥈 **Vibrato** (strongest influence on emotion)

✔ 🥉 **Dynamics** (minor effect)

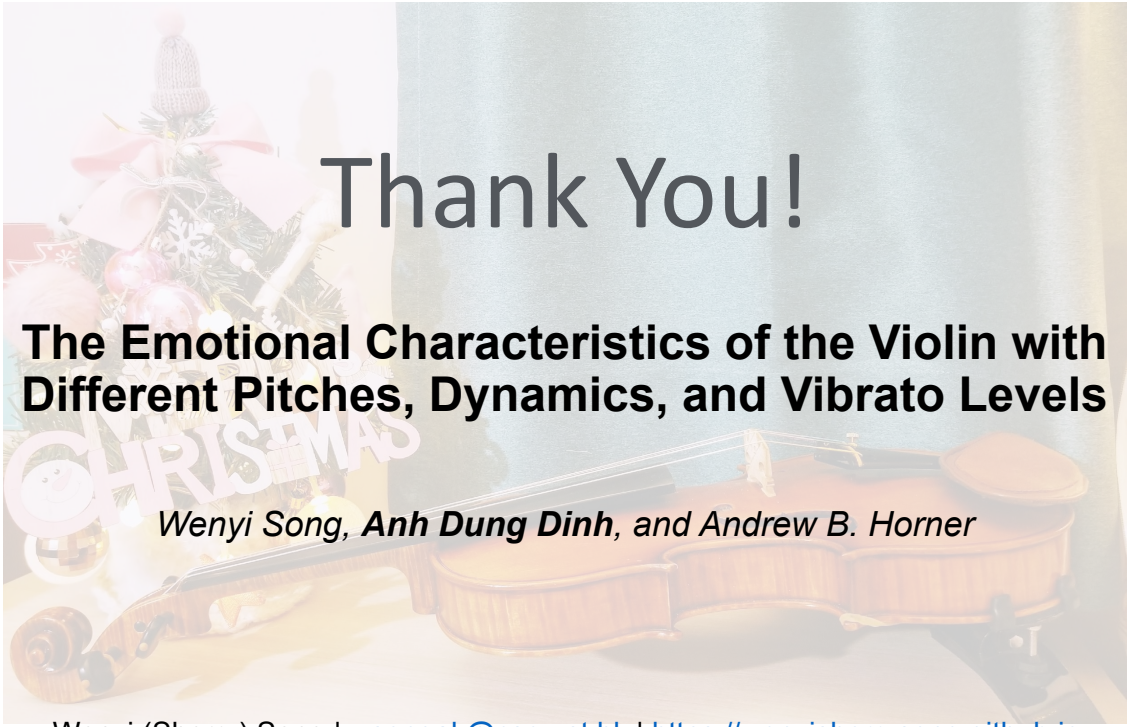
❑ ***Limitation and Future Work***

✔ Small number of participants

✔ 16 emotional labels for the violin?

✔ Vibrato levels

✔ Erhu study



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