A comparative study of violin and erhu emotional characteristics: Influence of playing techniques and instrument

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This study investigates the emotional characteristics of the violin and erhu in multiple musical excerpts. Participants assessed 52 musical excerpts played by both instruments using the Self-Assessment Manikin (SAM) scale. Pairwise comparisons explored the impact of playing techniques (Vibrato, Portamento, and Trill) and instrument on emotional perception. Fifty-eight participants evaluated four versions of 13 musical pieces. Significant agreement was found between the emotion categories and Valence-Arousal (VA) ratings. Ambiguity between calmness and sadness emerged, with VA tending to classify ambiguous excerpts as sad. Playing techniques enhanced the energetic qualities of both instruments. The violin consistently evoked more positive and energetic perceptions compared to the erhu, which were further enhanced when playing techniques such as vibrato were employed. Although erhu with playing techniques tended to be more negative, it still elicited greater energy and positivity than erhu without techniques.

Valence-Arousal means were used to determine the emotional qualities of the 13 musical pieces. A subsequent pairwise comparison involving 33 participants revealed that versions with playing techniques had stronger emotional impact than those without techniques. Furthermore, emotional impact was higher when the piece was originally composed for the instrument being played, which was manifest in higher Bradley-Terry-Luce (BTL) values.

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1.   INTRODUCTION

The study of musical emotion has long captivated researchers, who have sought to unravel the complex ways in which sound can evoke powerful feelings (Juslin, 2019). This field of study can be broadly divided into two main categories: *perceived* emotion (expressed by music) and *felt* emotion (experienced by the listener). Although there is no revealed significant differences between the two, Evans and Schubert's study suggests that the way music makes the listener feel is more important in determining enjoyment than noticing the emotion the music is trying to convey (Evans and Schubert, 2008).

While past research has found significant overlap between these two dimensions, the tools and methods used to measure them can vary considerably. Categorical models of musical emotion, for instance, aim to classify feelings into discrete labels like "happy," "sad," or "angry" (Ardakani and Arbabi, 2017). In contrast, valence-arousal (VA) models map emotions onto a two-dimensional space defined by positivity (valence) and intensity (arousal) (Russell and Fernandez-Dols, 1997). Some studies have even sought to combine these approaches, identifying four broad quadrants of emotional experience (Song *et al.*, 2016).

Researchers have delved into the structural features that shape emotional perception, such as tempo, mode, loudness, melody, rhythm, and timbre (Webster and Weir, 2005; Eitan, 2013; Hailstone *et al.*, 2009). Much work has been done correlating the timbral qualities of different musical instruments with various emotional characteristics (Wu *et al.*, 2014; Chau *et al.*, 2015). Others have zoomed in on the effects of pitch, dynamics (Chau *et al.*, 2017; Chan *et al.*, 2019b,a).

Beyond just investigating Western classical instruments, a growing trend in this field has been the comparative study of cross-cultural instrument pairings — namely, the iconic Chinese erhu and the Western violin. As both are bowed string instruments, they share fundamental similarities, yet exhibit key differences in tonality and playing techniques that may evoke distinct emotional responses (Beament and Beament, 2000; Samejima, 2023).
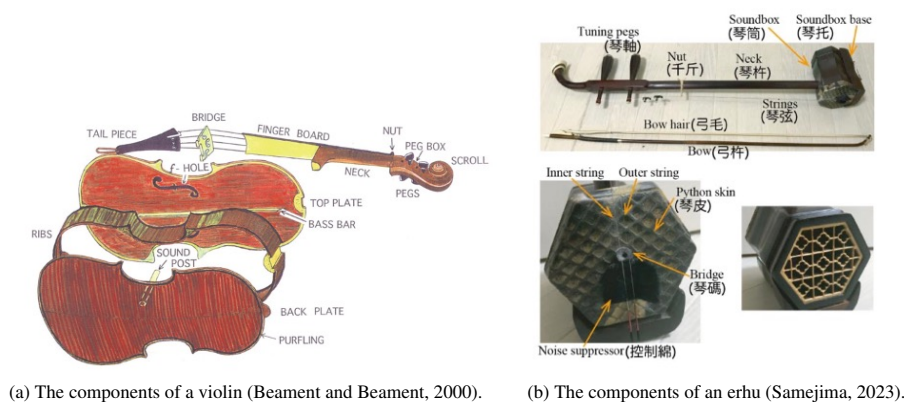

(a) The components of a violin (Beament and Beament, 2000).   (b) The components of an erhu (Samejima, 2023).

Figure 1: Examples of erhu and violin constructions.

Previous studies have begun to unpack these nuances between these two instruments, offering intriguing insights. Yang's research, for example, compared the emotional impact of vibrato between the erhu and violin (Yang *et al.*, 2013), while Lee's work examined how the two instruments conveyed different emotions when performing the classic *Butterfly Lovers* piece (Lee, 2020; Lee *et al.*, 2021). Zhang et al's study, meanwhile, explored cultural differences in how the erhu and violin express quintessential Chinese musical elements (Zhang *et al.*, 2022). Wang's work compared several cross-culture instruments on different pieces with different emotions (Wang *et al.*, 2021). However, these existing studies have faced certain limitations. There are few studies that have compared the two instruments on instrument, playing techniques, and musical style that affect the emotional characteristics.

In this paper, our current study aims to address these gaps by taking a more holistic approach to uncovering the emotional characteristics that distinguish the erhu and violin. We propose three key hypotheses to explore how the instrument itself, the presence of playing techniques, and the cultural origins of the music all contribute to shaping the emotional responses they evoke.

To test these hypotheses (Section 2.1), we selected 13 musical pieces (7 Chinese, 6 Western) and created four distinct renditions of each: erhu with and without techniques, violin with and without techniques. Through two listening experiments, we sought to determine the felt emotions elicited by these various configurations using both categorical and VA models. The findings, detailed in the results and discussion sections, offer a fascinating glimpse into the power of instrumentation to evoke cross-cultural emotional responses.

As the world grows ever more connected, understanding these nuanced differences in musical expression will only become more crucial. By shedding light on how the erhu and violin can shape emotional experiences in unique ways, this study represents an important step forward in uncovering the complex interplay between culture, instrumentation, and the human experience of music.

2. METHODOLOGY

This section outlines the methodology employed in the study to investigate the emotional characteristics of cross-cultural instruments, specifically the erhu and violin, from Chinese and Western cultures.

A. HYPOTHESES

Before conducting the listening tests, three hypotheses were formulated to examine the generalizability previous findings on the emotional characteristics of the erhu and violin:

H 1 *The violin conveys more positive and energetic emotions, while the erhu is perceived as sadder.*

H 2 *Playing techniques have a stronger emotional impact than those without, for both instruments.*

H 3 *Emotional impact is correlated with the cultural origin of the musical composition (i.e. emotional impact was higher when the piece was originally composed for the instrument being played).*

B. MUSICAL STIMULI

To test these hypotheses, we selected 52 excerpts from 13 musical pieces based on Zhang et al.'s research (Zhang *et al.*, 2022), encompassing a range of keys, tempos, and time signatures. The excerpts were carefully curated, with 7 pieces in the Chinese style and 6 in the Western style. The details of each piece are in Table 1.

Each piece featured 4 excerpts: 2 instruments (erhu and violin) $\times$ 2 playing techniques (with and without). We ensured seamless audio quality by adding fade-in/out duration of 1 second to prevent distracting pops. All 4 excerpts for each piece were in the same key, tempo, and dynamics, with lengths ranging from 4 to 13 seconds ($6.26s$ on average).

C. EXPERIMENTS

Two listening tests were conducted to compare the emotional characteristics of the erhu and violin. Both tests were conducted online using the Qualtrics survey system. Participants were required to use high-quality wired headsets and provide video recordings for an honesty check.

Table 1: Selected Piece Details

Piece Name	Category	Playing Techniques
Three Treasures Buddha		Portamento, Vibrato
The Moon at the Fortified Pass		Portamento, DaYin, Martelé, Vibrato
Slow Sanliu Style		Mordent, Acciaccatura
Moonlight Night	Chinese	Portamento, Vibrato
Mei Hu (mei2 hu4) Lian Zou		Portamento, Vibrato
Despair in Illness		Portamento, Vibrato, Martelé
Parting at the Yang-Guan Gate		Portamento, Vibrato
Violin Concerto in A minor, RV 356, 2nd Mvt. Op3. No.6		Trill, Vibrato
Minuet in D Major, K334		Trill, Vibrato, Martelé
Peter And the Wolf		Martel
Scènes de la Csárda No.4 'Hejre Kati', Op.32	Western	Trill, Vibrato, Martelé
G.H.Fiocco's Allegro		Mordent
Fourth Pupil's Concerto 3rd Mvt.		Acciaccatura, Portamento, Martelé

i.   Experiment 1: Emotion Determination

Experiment 1 aimed to determine the main emotional category for each piece. Participants were asked to listen to each excerpt and then answer questions about the emotional characteristics using both a categorical emotion model and a continuous valence-arousal model. The categorical emotional labels were happy, sad, agitated, and calm, and the Self-Assessment Manikin (SAM) 9-point scale method was used to rate valence-arousal values (Bradley and Lang, 1994).

Participants received brief instructions on how to run the test on their computers, then provided basic information (age, gender, nationality, music background, and familiarity with the two instruments). Next, they completed 57 questions (5 warm-up and 52 excerpts), and all excerpts were randomized. The whole listening test took approximately 40 minutes to complete, and participants had the option to listen to each excerpt more than once.

ii.   Experiment 2: Emotion Intensity Comparison

Based on the results from Experiment 1, the second experiment compared the emotional intensity differences between the instruments and playing techniques across different pieces using pairwise comparison. For each piece, there were 6 pairs in total (2 instruments: erhu or violin) $\times$ 2 performance versions (with or without playing techniques). For each pair, participants were asked to listen to 2 excerpts and choose the one with stronger emotional intensity for that piece with the exact emotion.

Similar to Experiment 1, participants received brief instructions and provided basic information. Next, they completed 84 questions (1 piece for warming up and 13 pieces for testing, each piece with 6 pairs). The 13 piece orders were randomized, as were the pairs and the orders of the two excerpts within each pair. The whole listening test took approximately 40 minutes.

3.   RESULTS

We conducted an in-depth analysis to investigate how instruments and playing techniques influence the emotional responses of listeners to Chinese and Western classical music excerpts.

A.   EXPERIMENT 1: EMOTION DETERMINATION

i.   Participants

A total of 58 participants took part in the first experiment, including 40 males and 18 females, with an average age of 22.0 years ($std = 2.86$). Most participants were from China, with a small proportion from other countries. All participants were fluent in English and had no hearing issues.

Approximately half of the participants (33 out of 58) had musical training experience (1 to 14 years), mostly playing Western instruments. For the familiarity with the two instruments (erhu and violin), 37 participants indicated that they were familiar with both instruments, 17 were familiar only with the violin, 2 had never heard the two instruments, 1 could play the violin, and 1 reported playing both instruments.

ii.   Categorical Model

Participants were asked to choose one of four emotional labels (happy, sad, agitated, and calm) for each music excerpt, to indicate the emotions they felt. Figure 2 shows the percentage of each emotional label for the excerpts.

For the 7 Chinese-style pieces, 4 were perceived as sad, 2 as calm, and 1 as happy. There was often ambiguity between calmness and sadness, regardless of the instrument or playing techniques used. Additionally, the erhu with playing techniques was generally perceived as sounding sadder than the erhu without techniques.

For the 6 Western-style pieces, 3 were perceived as happy, 1 as agitated, 1 as sad, and 1 was ambiguous. In most cases, the violin with playing techniques was perceived as more energetic than the violin without techniques.

Overall, the violin consistently evoked more positive and energetic perceptions than the erhu, and these perceptions were further enhanced when playing techniques were employed.

iii.   Valence-Arousal (VA) Model

Participants were also asked to rate the valence (positivity) and arousal (energy) levels for each music excerpt. Figure 3 shows the VA values for the excerpts.

For the 7 Chinese-style pieces, most excerpts were classified as sad, with only 1 being happy. The four performances of the same piece were often distributed in the same quadrant of the VA space, indicating the main emotional characteristics of that piece.

For the 6 Western-style pieces, 3 were classified as happy, 1 as agitated, and 1 as sad. The four performances of the same piece were generally consistent in their main emotional characteristics, except for the piece *Hejre Kati*, which had four performances distributed across three quadrants.

Overall, the playing techniques were nearly always more energetic than the versions without techniques for both the violin and erhu (24 out of 26 cases). Compared to the erhu, the violin was usually the most positive (9 out of 13 cases) and energetic (8 out of 13 cases). For the violin, playing with techniques was often both more positive and energetic than the violin without techniques (9 out of 13 cases), while the remaining 4 cases were either more positive or more energetic. For the erhu, the version with playing techniques was often both more energetic and more negative than the version without techniques (6 out of 13 cases), but it was also often both more energetic and more positive than the version without techniques (6 out of 13 cases).

iv.   Summary

The results from the two emotional models (categorical and VA) showed strong agreement between the emotion categories and the VA ratings. There was some ambiguity between calmness and sadness, with the
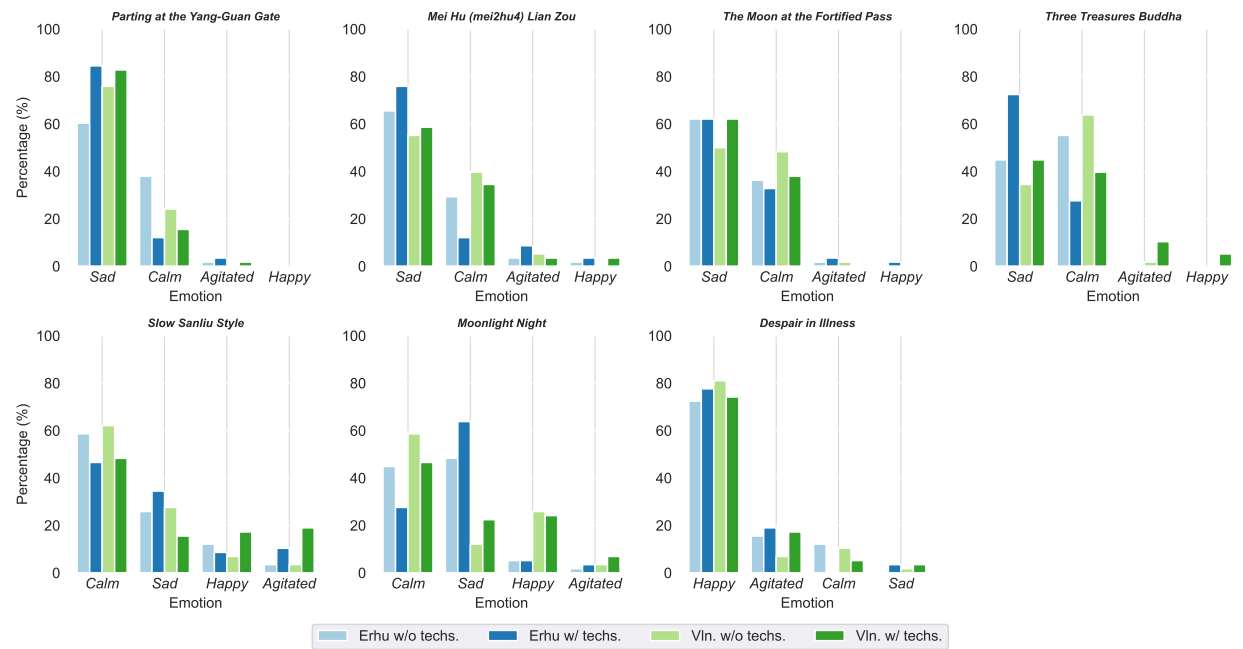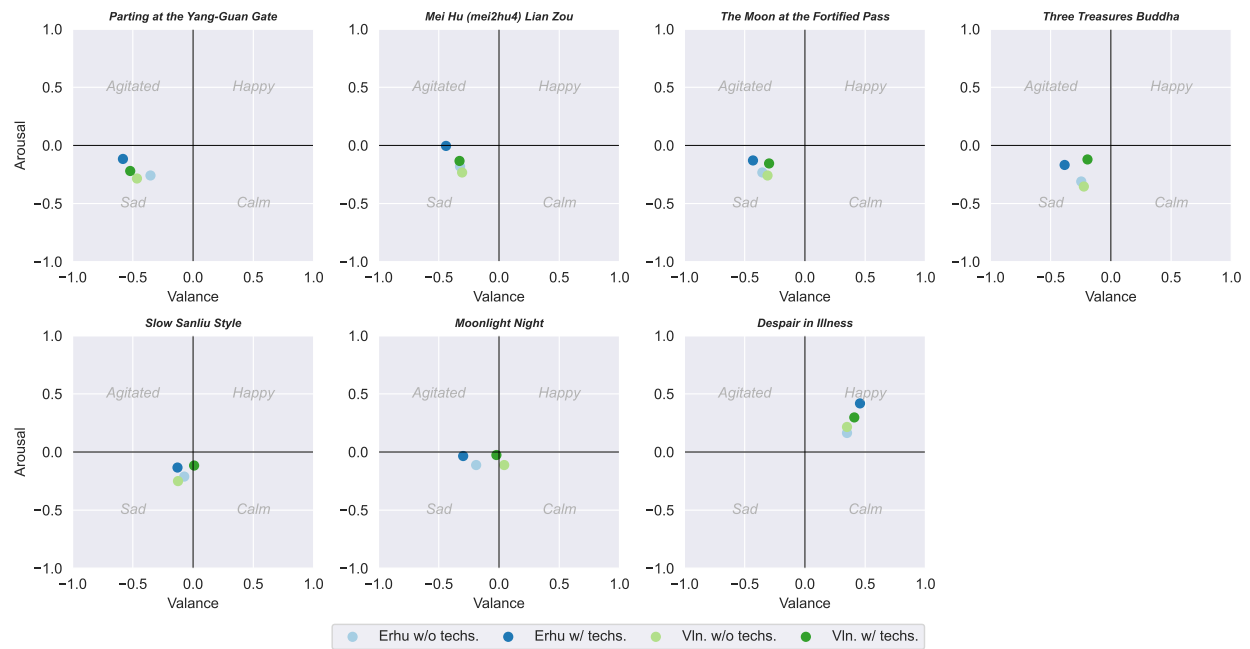
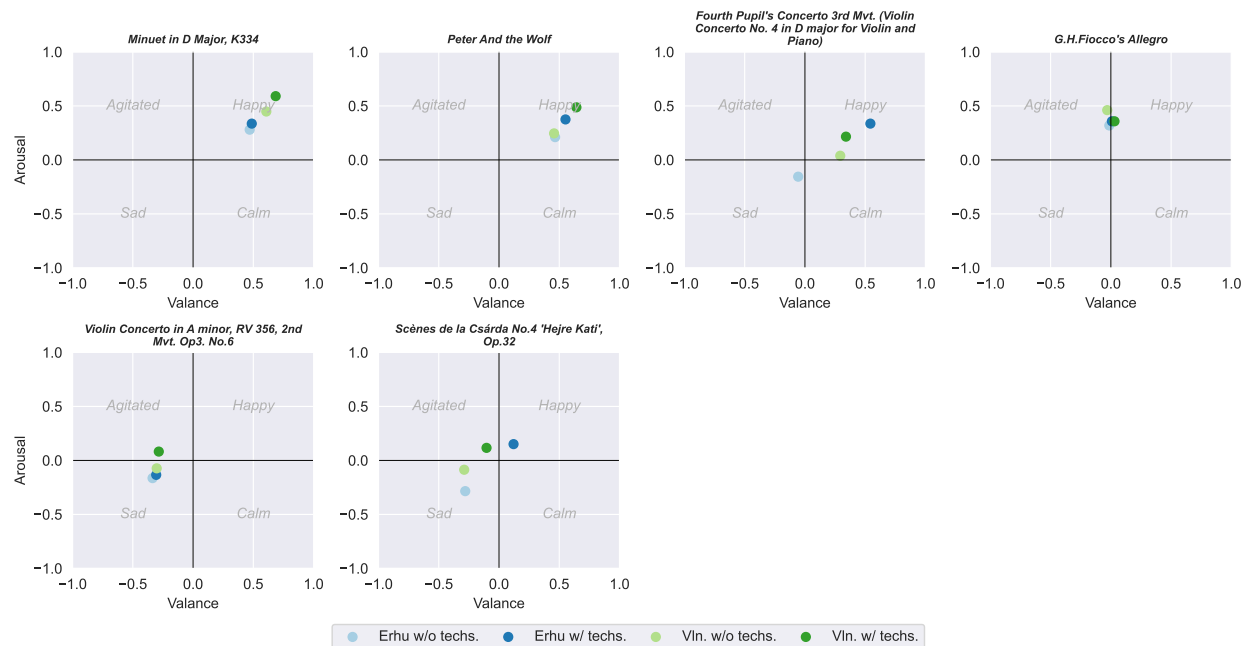*(a) Emotion percentage of Chinese style pieces.*
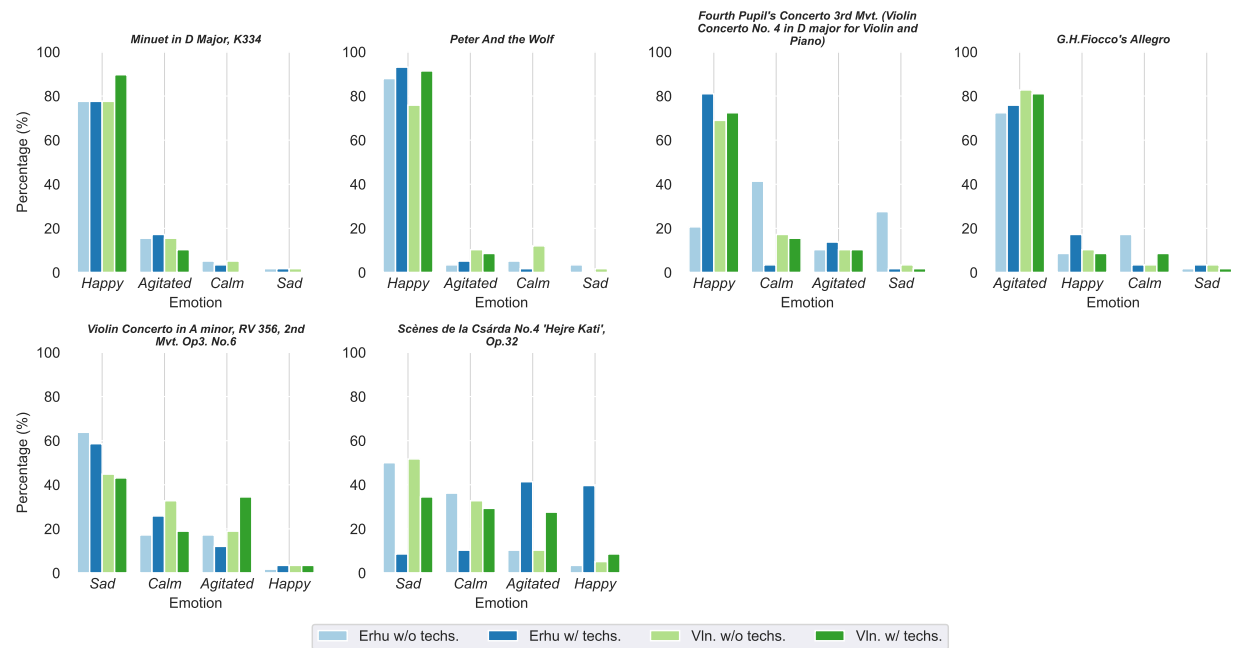
(b) Emotion percentage of Western style pieces.

Figure 2: Percentage of single emotional label selection on categorical model (4 labels: happy, sad, agitated, calm).

(a) VA values of Chinese style pieces.

(b) VA values of Western style pieces.

Figure 3: Normalized Valence-Arousal ratings by instruments and playing techniques for each piece.

VA model tending to classify ambiguous excerpts as sad.

Based on the VA model results, the main emotional characteristics of each piece were determined and used in the next experiment, as summarized in Table 2.

Table 2: Main emotional label for each piece by VA model.

Piece Name	Category	Emotion
Parting at the Yang-Guan Gate		Sad
Mei Hu Lian Zou		Sad
The Moon at the Fortified Pass		Sad
Three Treasures Buddha	Chinese	Sad
Slow Sanliu Style		Sad
Moonlight Night		Sad
Despair in Illness		Happy
Minuet in D Major, K334		Happy
Peter And the Wolf		Happy
Fourth Pupil's Concerto 3rd Mvt.	Western	Happy
G.H.Fiocco's Allegro		Agitated
Violin Concerto in A minor, RV 356, 2nd Mvt. Op3. No.6		Sad
Scènes de la Csárda No.4 'Hejre Kati', Op.32		Sad

B. EXPERIMENT 2: EMOTION INTENSITY COMPARISON

i. Participants

A total of 33 participants took part in the second experiment, including 21 males and 12 females, with an average age of 21.0 years ($std = 0.90$). Most participants were from China, with a small proportion from other countries.

About half of the participants (17/33) had musical training experience, mostly playing Western instruments. Similar to Experiment 1, 23 out of 33 participants indicated that they were familiar with both instruments, 8 were familiar only with the violin, 1 had never heard the two instruments, and 1 could play the violin.

ii. Bradley-Terry-Luce (BTL) Results

We used the Bradley-Terry-Luce (BTL) model to analyze the pairwise comparisons of emotional intensity between the instruments and playing techniques for each piece (Bradley, 1984; Firth and Turner, 2012). This model calculates utility values (u-values) for all four performing versions of each piece, where a value of $1.0/4 = 0.25$ would indicate that all versions were judged equally preferred.

Table 3 shows the model test and model fit statistics for each piece, indicating a good fit of the BTL model. The small Akaike Information Criterion (AIC) and Pearson χ^2 values, as well as χ^2 p-values greater than 0.05, suggest that the BTL model adequately describes the observed data.

Figure 4 presents the BTL utility values with 95% confidence intervals (CI) and parameter estimated p-values for each piece. The u-values demonstrate differences in preference selection for the four performing versions of each piece. The parameter estimated p-values and Effect p-values (shown in Table 3) indicate statistically significant differences between the four performing versions for each piece.

For the 7 Chinese-style pieces, 6 out of 7 pieces showed that the erhu with playing techniques (i.e., vibrato) was preferred, meaning this version had stronger emotional intensity than the other three versions.

Table 3: Bradley-Terry-Luce (BTL) model tests and model fit statistics details for each piece.

Piece Name	Category	Effect P Value	AIC	Pearson χ^2 Value	Pearson χ^2 P Value
Parting at the Yang-Guan Gate		**0.0003**	30.086	0.943	0.815
Mei Hu Lian Zou		**1.99e-05**	31.306	2.362	0.500
The Moon at the Fortified Pass		**0.0020**	30.134	0.833	0.839
Three Treasures Buddha	Chinese	**0.0001**	31.342	2.321	0.510
Slow Sanliu Style		0.0571	30.068	0.532	0.911
Moonlight Night		**< 2e-16**	33.623	10.010	0.016
Despair in Illness		**0.0153**	33.413	4.028	0.253
Minuet in D Major, K334		**< 2e-16**	28.555	2.950	0.394
Peter And the Wolf		**1.28e-14**	27.444	0.240	0.971
Fourth Pupil's Concerto 3rd Mvt.		**< 2e-16**	31.088	7.704	0.069
G.H.Fiocco's Allegro	Western	**< 2e-16**	29.913	3.055	0.391
Violin Concerto in A minor, RV 356, 2nd Mvt. Op3. No.6		**0.0099**	29.839	0.423	0.936
Scènes de la Csárda No.4 'Hejre Kati', Op.32		**< 2e-16**	27.820	2.295	0.501

* Values bolded indicate statistical significance at the $p < 0.05$ level.

* Model is rejected if χ^2 p-value is less than 0.05.

* Akaike Information Criterion (AIC): AIC < 200, good fitness; AIC < 100, very good fitness.

All pieces had statistically significant differences. For the sad pieces, 5 out of 6 showed that the erhu with playing techniques was preferred, while 1 piece had the violin with playing techniques as the preferred version.

For the 6 Western-style pieces, the violin with playing techniques was preferred for most pieces (4 out of 6). Exceptions were *Hejre Kati*, where the erhu and violin without techniques were preferred, and *Fourth Pupil's Concerto*, where the erhu with playing techniques was preferred, but the utility value was very close to the version of the violin with playing techniques. For the 3 pieces with a happy emotion, 2 of them had the violin with playing techniques as the happier version compared to the other three versions.

Overall, the instruments with playing techniques had a more significant emotional impact than the versions without techniques. In 10 out of 13 excerpts, playing techniques significantly increased the emotional impact in at least one of the instruments. Additionally, the instrument the piece was originally written for had more emotional impact in 11 out of 13 excerpts.

4. DISCUSSION

### A. DETERMINING EMOTIONAL CHARACTERISTICS USING TWO MODELS

In the first experiment, we used two emotional models - categorical and valence-arousal (VA) - to determine the emotional characteristics of the music excerpts.

The key findings include:

- There was significant agreement between the emotional categories (happy, sad, agitated, calm) and the VA ratings.

- There was some ambiguity between calmness and sadness, with the VA model tending to classify ambiguous excerpts as sad.

- The use of playing techniques enhanced the energetic qualities of both the erhu and violin instruments.
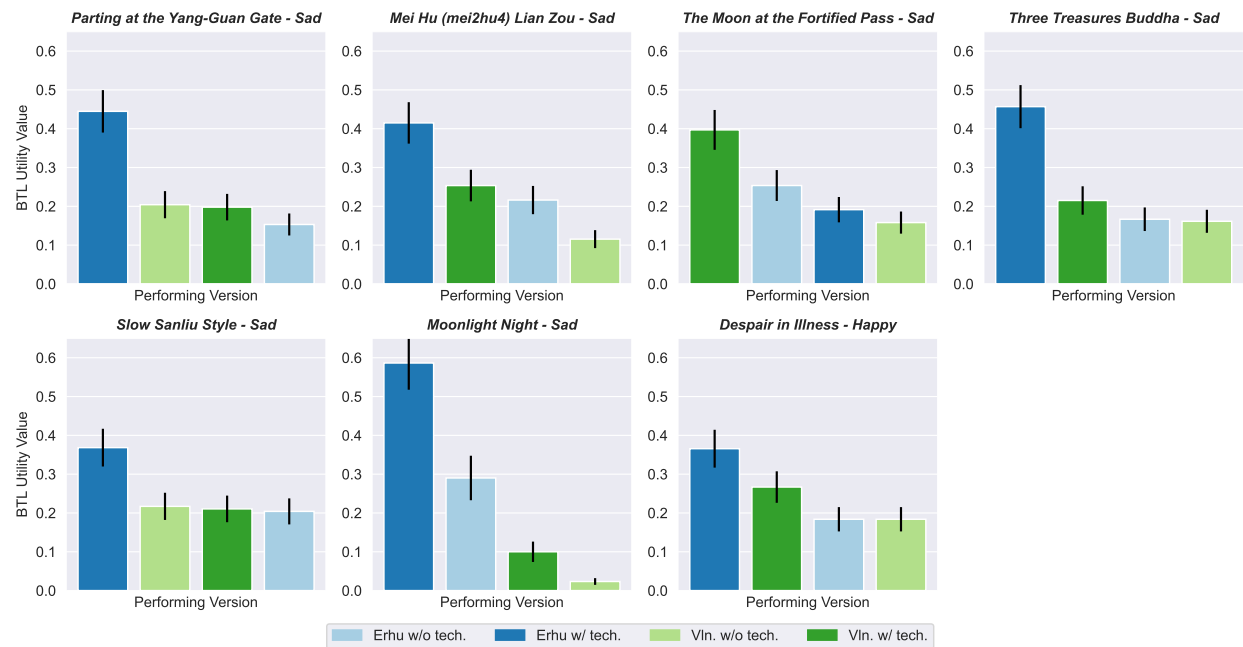
(a) BTL u-value for Chinese style pieces.
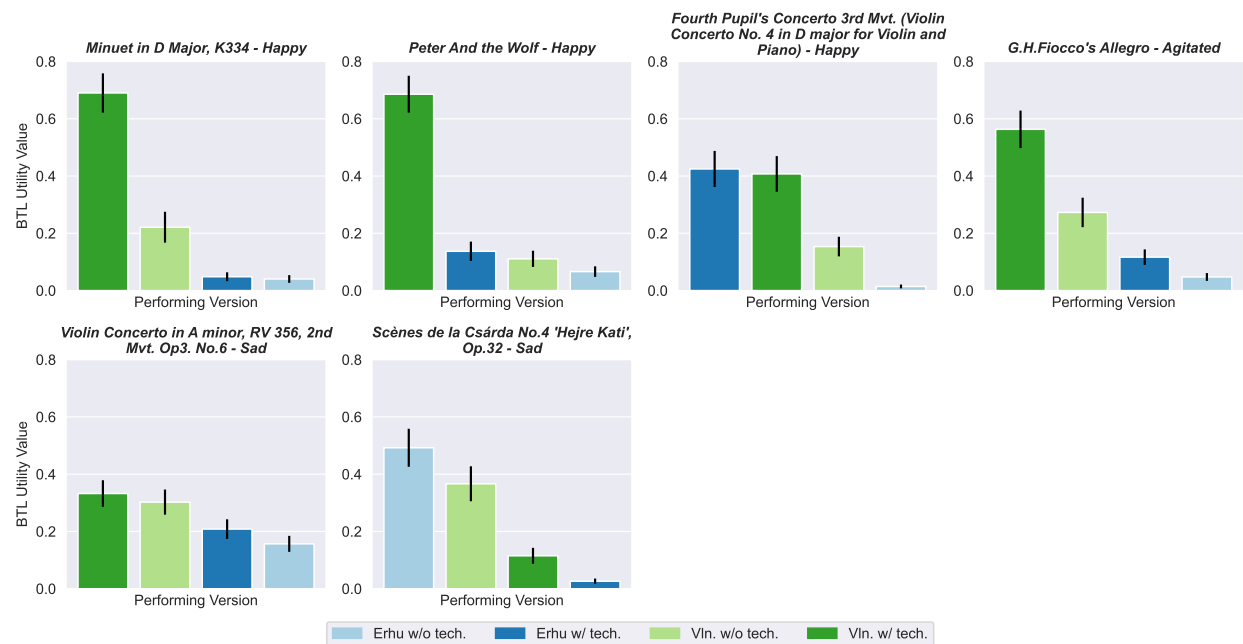
(b) BTL u-value for Western style pieces.

Figure 4: Bradley-Terry-Luce (BTL) utility value with 95% CI and parameter estimated p value for each piece.

- The violin consistently evoked more positive and energetic perceptions compared to the erhu, and this effect was further enhanced by the use of playing techniques like vibrato.
- While the erhu with playing techniques tended to be perceived as more negative, it still elicited greater energy and positivity than the erhu without techniques.

B.   EFFECTS OF INSTRUMENTS, PLAYING TECHNIQUES, AND MUSICAL ORIGINS

We formulated three hypotheses to explore how instruments, playing techniques, and musical origins affect emotional characteristics, and the results supported these hypotheses.

i.   Instrument Differences

The results from Experiment 2 showed that for sad pieces, the erhu was preferred over the violin in 6 out of 8 cases. Conversely, for happy or agitated pieces, the violin was preferred over the erhu in 3 out of 5 cases. This supported our first hypothesis that the violin conveys more positive and energetic emotions, while the erhu is perceived as sadder.

ii.   Impact of Playing Techniques

For 11 out of the 13 pieces, the version with playing techniques was preferred over the version without techniques, either for the erhu or the violin. This means that playing techniques had a stronger emotional impact than no techniques, supporting our second hypothesis.

iii.   Musical Origins

For the 7 Chinese-style pieces (originally composed for the erhu), the erhu with playing techniques was preferred in 6 out of 7 cases. For the 6 Western-style pieces (originally composed for the violin), the violin with playing techniques was preferred in 4 out of 6 cases. This means that 10 out of 13 pieces were chosen for the instrument the piece was originally composed for, supporting the idea that emotional impact is correlated with the cultural origin of the musical composition.

C.   LIMITATIONS AND FUTURE WORK

i.   Piece Selection

The 13 selected pieces (7 Chinese, 6 Western) may not be sufficient to fully capture the differences in emotional impact based on cultural origins. Additionally, the pieces were mostly focused on sadness for the Chinese style. Future studies should include a larger and more diverse set of pieces to better explore this factor.

ii.   Participant Diversity

The current participant pool was relatively small and lacked diversity in terms of nationality, age, gender, and musical training background. Expanding the participant pool and conducting group-level analyses could provide deeper insights.

iii.   Acoustic Features

The current study did not examine the underlying acoustic features associated with the playing techniques. Future work could design single-note experiments to investigate how specific techniques affect emotions at a lower level.

5.   CONCLUSION

In this study, we set out to uncover the emotional characteristics that distinguish the Chinese erhu and the Western violin.

The key findings are as follows:

- Instrument Differences: The violin was found to convey more positive and energetic emotions, while the erhu was perceived as evoking sadder feelings.
- Technique Impacts: Playing techniques had a stronger emotional impact than pieces without techniques, for both instruments.
- Cultural Influences: The emotional impact of the music was correlated with the cultural origin of the composition, whether Chinese or Western.

These results provide fascinating insights into how the unique tonal qualities and playing styles of these two instruments can elicit distinct emotional responses in listeners. The findings have important implications for understanding cross-cultural musical expression and the role of instrumentation in shaping the effective experience of music.

While further research is needed, this study represents an important step forward in uncovering the nuanced emotional characteristics of the erhu and violin. As the world becomes more globally connected, understanding these cultural differences in musical expression will only become more crucial.

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