Gestural Music Symphony Composes a New Chapter in Relieving Sorrow: The Regulatory Effect of Music-Gesture Integration on Negative Emotions

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Abstract

[Objective] To investigate the unconscious emotion regulation effects of music integrated with gestures. [Method] Through gesture and video emotion induction experiments, participants' emotional changes were examined under different conditions of Five Elements music integrated with hand-manipulating gestures. [Results] The Shang note was superior to the Jue note in enhancing pleasure, arousal, and inhibiting parasympathetic nervous activity; gesture intervention activated dominance and the sympathetic nervous system; bead manipulation intervention further enhanced pleasure and inhibited parasympathetic nervous activity. [Limitations] Cross-cultural effects remain to be explored. [Conclusion] Multimodal regulation effects are superior to music alone, and the regulation effects are better when music is consistent with negative emotional style and when gestures exhibit higher flexibility and stability.

Full Text

The Symphony of Fingertip Rhythm and Music: A New Chapter in Alleviating Sorrow—The Regulatory Effect of Music Integrated with Gestures on Negative Emotions

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Abstract:
[**Objective**] To investigate the unconscious emotional regulation effects of integrating music with gestures.

[**Methods**] Through gesture and video emotion induction experiments, we examined participants' emotional changes under different conditions of playing gestures integrated with Five-element music.
[**Results**] The Shang (商) tone was more effective than the Jue (角) tone in enhancing pleasure and arousal while inhibiting parasympathetic activity. Gesture intervention activated dominance and sympathetic activity. Rosary playing additionally enhanced pleasure and inhibited parasympathetic activity.
[**Limitations**] Cross-cultural effects require further investigation.
[**Conclusions**] Multimodal regulation is superior to music alone. Regulation is most effective when music style aligns with negative emotional states and gestures exhibit higher flexibility and stability.

Keywords: unconscious emotion regulation, multimodal, heart rate variability
Classification Number: B842

Modern fast-paced lifestyles often leave young people with insufficient energy for emotion regulation. Depression risk detection rates among Chinese nationals reach 10.6%, with the 18–24 age group accounting for as high as 24.1% (Chen et al., 2023). Previous research has focused primarily on traditional strategies such as cognitive reappraisal, which rely on sustained cognitive resource investment (Gross et al., 2015) and are difficult to embed in fragmented daily scenarios like work or commuting, resulting in high dropout rates (Gao et al., 2018). In contrast, unconscious emotion regulation offers the advantage of low cognitive consumption (Gross et al., 2015). Recent findings indicate it can leverage lightweight sensory or motor stimuli—such as music (Berthold et al., 2021) and vibration (Béquet et al., 2022)—to function through bottom-up pathways, demonstrating strong contextual embeddability and promising to enhance intervention compliance as a contextual supplement for emotion management. However, existing studies have focused on single sensory modalities, lacking investigation into multimodal integration effects and mechanisms, which may constrain regulatory effectiveness. This study innovatively integrates music with gestures to explore their emotional regulation effects and modal fusion mechanisms, aiming to provide insights for a precision-oriented unconscious emotion intervention system.

Five-element music therapy induces resonance between internal organs and sound waves through five tones (Gong, Shang, Jue, Zhi, Yu), emphasizing an emotional regulation approach of "applying music according to organ functions." The Shang tone is solemn and high-pitched, associated with metal and the lungs, capable of relieving sorrow; the Jue tone is smooth and melodious, associated with wood and the liver, effective for dispersing depression (Feng et al., 2022). Previous studies have confirmed the effectiveness of Five-element music in emotion regulation (Yang et al., 2021). Negative emotion granularity may weaken adverse emotional states (Li et al., 2025), yet the lack of comparative research based on negative emotion granularity and Five-element music styles hinders precise music selection. Emotion congruence theory posits that individuals in negative emotional states prefer music with similar affective qualities to achieve emotional identification and facilitate acceptance and transformation (Hunter et al., 2011; Vanden Tol et al., 2016). Based on this, we propose **Hypothesis 1 (Music Difference):** The Shang tone demonstrates superior regulatory effects on negative emotions compared to the Jue tone.

Simple finger tapping can influence autonomic balance (Stearns et al., 2017). "Pan" (盘), a traditional self-cultivation practice, has become widely integrated into modern life and demonstrates excellent contextual embeddability (Fan, 2023). However, no empirical research has investigated the role of this culturally distinctive behavior in emotion regulation. Humans possess an innate motor response to musical rhythm, such as tapping fingers or swaying bodies (Vuust et al., 2022). Characterized by repetitive hand movements, "pan" from an embodied perspective may synchronize limb actions with auditory rhythm, promoting deep pleasurable flow experiences (Trost & Vuilleumier, 2013). Based on this, we propose **Hypothesis 2 (Modal Synergy):** Music integrated with gestures yields superior negative emotion regulation compared to music alone.

Multimodal emotional regulation effectiveness correlates with synchronization between movement and musical rhythm, where flexible and stable movements better maintain this synchronization. Based on this, we propose **Hypothesis 3 (Gesture Characteristics):** Under musical backgrounds, playing gestures with higher flexibility and stability produce superior emotional regulation effects.

For objective emotion assessment, we tracked autonomic nervous activity through Heart Rate Variability (HRV). HF primarily reflects parasympathetic activity, LF is regulated by both sympathetic and parasympathetic systems, and LF/HF indirectly indicates autonomic balance (Appelhans & Luecken, 2006). Typically, enhanced arousal accompanies sympathetic activation (LF/HF increase) and parasympathetic withdrawal (HF decrease). Young populations frequently experience sadness in daily life (Huang et al., 2001). Previous studies show HRV changes under sadness: HF significantly increases while LF/HF significantly decreases (Shi et al., 2017; Ozden et al., 2024).

Considering cultural priors' influence on gesture selection, a pre-experiment screened typical playing gestures aligned with university students' mental models. The formal experiment used video emotion induction to examine participants' emotional changes under different music-gesture integration conditions, with Python-based gesture parameter analysis (all experiments received ethical approval).

2.1 Participants

Following gesture induction research (Bilius et al., 2023), we recruited 15 right-handed university students (7 male) aged 20–25 with no cognitive impairments or psychiatric disorders.

2.2 Experimental Materials

Reference Objects: Based on five movement forms of playing objects—rotation, rolling, kneading, plucking, and tapping (Fan, 2023)—we identified six interaction behaviors across four object types (rosary, walnut, prayer wheel, wooden fish): A) rotating prayer wheel, B) finger rolling, C) playing walnuts, D) kneading single walnut, E) playing rosary, F) tapping wooden fish. Reference object motion videos [Figure 1: see original paper] excluded hand manipulation guidance, retaining only visual object motion stimuli to inspire gestures.

This study was preregistered at [https://os.psych.ac.cn/preregisterdetail/202502.00003]. Experimental data are publicly available at [https://cstr.cn/31253.11.sciencedb.psych.00465].

Video Recording Equipment: One device recorded gesture movements from 50cm left of participants (720p, 60fps).

2.3 Experimental Procedure

Participants remained seated with their right hand placed in a designated desktop area. Reference objects were presented randomly on a screen in front of participants, who performed corresponding playing gestures with their right hand following the motion cues.

2.4 Data Analysis

Drawing from gesture elicitation paradigms in human-computer interaction (Villarreal et al., 2024), we constructed a three-dimensional classification framework for playing gestures: Natural mapping refers to action triggering mechanisms, including physical operation metaphor imitation; Body parts refer to locations producing relative movement, including fingers, wrist, and arm; Spatial position refers to movement paths, including linear, arc, and circular trajectories. Post-experiment, we calculated each reference object' s Agreement Rate (AR(r)) using the framework, where higher rates indicate greater consensus (Vatavu & Wobbrock, 2015). The formula is:

$$AR(r) = \frac{\sum_{i=1}^{n} \delta_i}{n}$$

where n represents participant number and δ_i indicates whether participant i' s gesture matched the reference.

2.5 Experimental Results

AR(r) values for each reference object were obtained using Formula (1) . Playing walnuts (B) and playing rosary (E) showed highest agreement rates, indicating strongest consensus in participants' mental models, and were thus selected for the formal experiment. Playing walnuts involves sequential finger flexion/extension, while playing rosary involves thumb propulsion with coordinated four-finger movement, both following arc trajectories to simulate direct object manipulation.

3.2 Participants

Following relevant research (Lu et al., 2025; Yao & Xu, 2024), we set effect size at 0.5 and used G*Power to calculate the minimum sample size of 10 for repeated-measures ANOVA (α=0.05, Power=0.80). We recruited 24 right-handed university students (male:female=1:1) aged 20–25 with no cognitive impairments or psychiatric disorders, divided equally into Shang and Jue tone groups.

3.3 Experimental Materials

Emotion Induction Videos: Three sadness-inducing clips from the Asian Culture Standard Emotion Video Database (Deng et al., 2017).
Five-element Music: Representative pieces *Yangchun Baixue* (Shang tone) and *Chunfeng Deyi* (Jue tone) with identical beats.
Gesture Reference Videos: Played before each regulation task for familiarization.
Subjective Emotion Measurement: The PAD emotional model quantified Pleasure (valence), Arousal (activation), and Dominance (control) (Mehrabian, 1996) using a 9-point visual scale [-4,4] (Cronbach' s α=0.84).
HRV Acquisition: BITalino PsychoBIT for ECG recording.
Video Recording: Captured gestures from 50cm left of participants' right hand.

3.4 Experimental Procedure

Preparation: Participants wore ECG electrodes and acclimated to the environment.
Resting State: Measured resting HRV and completed subjective scales in comfortable posture.
Emotion Induction: Watched negative videos while measuring engaged-state HRV and completing scales.
Emotion Regulation: With eyes closed, participants listened to music and performed "empty playing" hand movements (without receiving "emotion regulation" instructions), measuring regulated-state HRV and completing scales.
The induction-regulation sequence repeated three times across conditions (music only, music+walnuts, music+rosary) with balanced order. Two-minute rest periods between tasks allowed recovery. Overall flow is shown in [Figure 2: see original paper].

3.5 Data Analysis

Based on basic emotion PAD values (Li et al., 2008), Euclidean distance L_n determined emotion classification:

$$L_n = \sqrt{(p - P_n)^2 + (a - A_n)^2 + (d - D_n)^2}$$

where (p, a, d) represents measured emotion coordinates and (P_n, A_n, D_n) basic emotion coordinates.

SPSS performed 7(phase: rest, engagement A, regulation A, engagement B, regulation B, engagement C, regulation C) × 2(music: Shang, Jue) repeated-measures ANOVA. Bonferroni correction was used for post-hoc comparisons; non-normal data were natural log-transformed.

Using MediaPipe' s deep learning model, we analyzed stable 1-minute video segments. A 21-hand-landmark framework was normalized to the wrist root, with Savitzky-Golay filtering for trajectory smoothing. We extracted four fingertip kinematic parameters: trajectory coefficient of variation C_v (stability), velocity standard deviation σ_v (speed stability), trajectory curvature standard deviation σ_k (bending degree), and trajectory length L (Taranta et al., 2020), with factor analysis for dimensionality reduction. Average gesture skeleton models were constructed from keypoints, with fingertip trajectories overlaid to generate distribution maps.

3.6.1 Subjective Ratings

Pleasure Dimension: Significant main effect of phase, $F(6, 120) = 110.22$, $p < 0.001$, $\eta_p^2 = 0.83$, $BF_{10} = 4.68e + 61$; significant music×phase interaction, $F(6, 120) = 4.27$, $p = 0.001$, $\eta_p^2 = 0.16$, $BF_{10} = 2.42$.

Arousal Dimension: Significant main effect of phase, $F(6, 120) = 13.24$, $p < 0.001$, $\eta_p^2 = 0.38$, $BF_{10} = 7.20e + 11$.

Dominance Dimension: Significant main effect of phase, $F(6, 120) = 15.97$, $p < 0.001$, $\eta_p^2 = 0.42$, $BF_{10} = 5.45e + 14$.

Simple effects analysis (music×phase) for Pleasure showed: In the Shang group, all engagement phases were significantly lower than rest ($p < 0.001$); all regulation phases were significantly higher than corresponding engagement phases and rest ($p < 0.001$); regulation B was significantly higher than regulation A ($p < 0.001$) and C ($p = 0.013$). In the Jue group, all engagement phases were significantly lower than rest ($p < 0.001$); all regulation phases were significantly higher than corresponding engagement phases ($p < 0.001$); regulation B was significantly higher than regulation A, C, and rest ($p < 0.001$). Simple effects (phase×music) showed Shang tones were significantly higher than Jue tones across all regulation phases ($p = 0.003$, $p = 0.030$, $p = 0.001$). In summary, negative videos significantly reduced pleasure, while music and music-gesture integration significantly enhanced it. Music+rosary produced significantly higher pleasure enhancement than other conditions, and Shang tone (with gestures) was superior to Jue tone.

Arousal simple effects (music×phase) revealed: In the Shang group, all engagement phases were significantly lower than rest ($p = 0.005$, $p = 0.034$, $p = 0.034$); all regulation phases were significantly higher than corresponding engagement phases ($p = 0.013$, $p = 0.005$, $p = 0.034$). In the Jue group, engagement phases A and C were significantly lower than rest ($p = 0.034$); regulation phases A and B were significantly higher than corresponding engagement phases ($p = 0.013$, $p < 0.001$); regulation B was significantly higher than regulation C ($p = 0.002$). Simple effects (phase×music) showed regulation C was significantly higher for Shang than Jue ($p = 0.028$). Overall, negative videos significantly reduced arousal (except Jue B phase), and music/gesture integration significantly increased arousal (except pure Jue tone). Jue+rosary produced higher arousal than pure Jue tone, and pure Shang tone exceeded pure Jue tone.

Dominance simple effects (music×phase) indicated: In the Shang group, engagement C was significantly lower than rest ($p = 0.016$); regulation A and B were significantly higher than corresponding engagement phases ($p = 0.007$, $p < 0.001$). In the Jue group, engagement B was significantly lower than rest ($p = 0.016$); regulation A and B were significantly higher than corresponding engagement phases ($p = 0.001$, $p < 0.001$). Thus, while negative videos inconsistently affected dominance, music-gesture integration significantly enhanced it.

PAD emotional tendency analysis showed: During engagement phases, negative videos induced "sadness"; during regulation with pure music and walnut playing, participants shifted from "sadness" to "gentleness"; during music+rosary regulation, Shang group shifted to "joy" while Jue group shifted to "relaxation."

3.6.2 HRV Assessment

HF Analysis: Significant main effect of phase, $F(6, 120) = 19.74$, $p < 0.001$, $\eta_p^2 = 0.47$, $BF_{10} = 2.36e + 18$.

LF/HF Analysis: Significant main effect of phase, $F(6, 120) = 18.34$, $p < 0.001$, $\eta_p^2 = 0.46$, $BF_{10} = 1.16e + 17$.

HF simple effects (music×phase) showed: In the Shang group, engagement phases A and C were significantly higher than rest ($p = 0.036$, $p = 0.006$); all regulation phases were significantly lower than corresponding engagement phases ($p = 0.029$, $p < 0.001$, $p = 0.036$); regulation B was significantly lower than regulation C ($p = 0.038$). In the Jue group, all engagement phases were significantly higher than rest ($p = 0.006$, $p = 0.045$, $p = 0.001$); regulation phases A and B were significantly lower than corresponding engagement phases ($p = 0.019$, $p < 0.001$); regulation B was significantly lower than regulation C

($p < 0.001$). Simple effects (phase×music) showed regulation C was significantly higher for Jue than Shang ($p = 0.047$). Overall, negative videos significantly increased HF (except Shang B phase), while pure Shang tone and music-gesture integration significantly decreased HF. Rosary integration decreased HF more than pure music, and pure Shang tone decreased HF more than pure Jue tone. [Figure 3: see original paper] shows HF violin plots across phases for both groups.

LF/HF simple effects (music×phase) revealed: In the Shang group, engagement C was significantly lower than rest ($p = 0.006$); regulation B was significantly higher than corresponding engagement phase ($p < 0.001$); regulation A and B were significantly higher than engagement C ($p = 0.021$, $p < 0.001$); rest was significantly higher than regulation C ($p = 0.004$). In the Jue group, engagement phases A and C were significantly higher than rest ($p = 0.008$, $p = 0.043$); regulation B was significantly higher than corresponding engagement phase ($p < 0.001$); regulation B exceeded regulations A and C ($p = 0.047$, $p < 0.001$); regulation C was significantly lower than rest ($p = 0.010$). Overall, negative videos partially reduced LF/HF, while music+rosary significantly increased LF/HF above pure music. Shang+walnuts increased LF/HF more than pure Shang tone, and Jue+rosary exceeded Jue+walnuts. [Figure 4: see original paper] shows LF/HF violin plots across phases.

3.6.3 Gesture Kinematics and Audio Analysis

Significant main effects of gesture were found for velocity standard deviation, $F(1, 22) = 60.36$, $p < 0.001$, $\eta_p^2 = 0.73$, $BF_{10} = 1.55e + 6$; trajectory length, $F(1, 22) = 66.01$, $p < 0.001$, $\eta_p^2 = 0.75$, $BF_{10} = 3.43e + 6$; and trajectory curvature standard deviation, $F(1, 22) = 39.58$, $p < 0.001$, $\eta_p^2 = 0.64$, $BF_{10} = 4.72e + 6$. Walnut playing showed significantly higher velocity standard deviation and trajectory length than rosary playing, while rosary playing showed significantly higher trajectory curvature standard deviation. Trajectory distribution maps are shown in [Figure 5: see original paper].

This study examined the emotional regulation effects and modal fusion mechanisms of Five-element music integrated with playing gestures. Results showed that from rest to sadness to regulation, pleasure, arousal, dominance, and LF/HF first decreased then increased, while HF first increased then decreased, consistent with previous research (Shi et al., 2017; Ozden et al., 2024). Sadness is a low-arousal emotion (Li et al., 2008); thus, during regulation, parasympathetic withdrawal and sympathetic activation may mark individuals' transition from low-energy negative states to more active positive states, reflecting the autonomic nervous system' s homeostatic pursuit.

Specifically, the Shang tone demonstrated advantages over the Jue tone in enhancing pleasure and arousal and reducing parasympathetic activity during sadness regulation, validating Hypothesis 1 and providing empirical support for emotion congruence theory. Emotion-congruent sad music strengthens sadness cue processing and reduces regulation costs from contextual mismatch, potentially inducing consolatory pleasure via prolactin pathways in safe contexts (Huron et al., 2011). Therefore, music intervention practices should consider emotion granularity to match music characteristics, such as introducing emotion-sensing modules in music therapy product design for precision regulation.

We also found gesture intervention advantages in dominance enhancement and sympathetic activation, plus increased arousal under Jue tone conditions. Thus, even subtle hand movements can enhance emotional control and excitability through bodily participation, validating Hypothesis 2 and supporting 4E theory (Embodied, Embedded, Extended, and Enactive) (Ye et al., 2021). Gesture participation transforms emotion regulation into an embodied process, strengthening interaction with the embedded musical environment; extending to sociocultural connotations (e.g., "cultivating inner peace" metaphors) influences mental states, while affordances provide natural opportunities for action execution through evoked individual experiences, ultimately promoting automated emotion regulation. Results suggest that incorporating behaviors with positive cultural associations in emotional interventions can activate embodied processing advantages to enhance regulation effects, providing a basis for designing emotion management tools integrating traditional cultural semantics (e.g., digital meditation devices). Moreover, music-gesture integration demonstrates excellent contextual embeddability, suggesting future integration with wearable devices like headphones and smart bracelets using micro-motion cues for gentle, natural emotional guidance.

Furthermore, compared to pure music and walnut playing, rosary integration showed superior pleasure enhancement and HF reduction, plus increased arousal under Jue tone conditions. Kinematic analysis revealed rosary playing focuses on thumb fine motor control, exhibiting shorter trajectories, more directional changes, smaller velocity fluctuations, and higher trajectory repeatability—combining higher flexibility and stability, validating Hypothesis 3. We speculate these movement characteristics more easily form stable coupling with musical rhythm, thereby promoting flow experiences that enhance pleasure (Trost & Vuilleumier, 2013). This study did not directly quantify music-gesture rhythmic synchronization, though tools exist to objectively assess its presence, degree, and magnitude (Innocenti et al., 2022). Future research should explore relationships between music-gesture rhythmic synchronization characteristics and emotion regulation effects. Additionally, rosary playing often involves thumb-index finger contact, where tactile stimulation may trigger perceptions of attachment and comfort, promoting autonomic homeostasis (Fotopoulou et al., 2022)—specific effects requiring validation. Therefore, multimodal intervention system design (e.g., immersive interfaces) should fully consider modality parameters and fusion mechanisms to optimize intervention effects.

Conclusions: (1) Multimodal music-gesture intervention demonstrates superior negative emotion regulation compared to pure music; (2) Regulation is optimal when music style is congruent with negative emotions and gestures exhibit high flexibility and stability.

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Note: Figure translations are in progress. See original paper for figures.