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Effectiveness of multimodal theatre mapping from four Uncle Vanya versions in self-reconstruction of trauma narratives

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Abstract. Against the backdrop of increasing integration between digital humanities and psychological narrative research, theatre, as a performative art combining language, movement and emotion, is gradually being recognized as a potential intervention tool for trauma memory reconstruction and emotional regulation. However, the mechanism by which multimodal theatrical information activates emotional processing and influences trauma narrative in audiences remains underexplored. This study focuses on four stylistically distinct versions of Chekhov's Uncle Vanya, constructing a structured multimodal dataset comprising text, facial expressions, speech, and movement. A multimodal Transformer and Graph Attention Network were employed to automatically map performance information to emotional structures, and a behavioral experiment was conducted to evaluate its effectiveness in trauma narrative intervention. The results show that the model significantly enhances participants' abilities in emotional recognition, narrative coherence, and emotional integration, with more pronounced effects observed in trauma-experienced individuals. Moreover, stylistic differences among theatrical versions exhibited significant moderating effects on emotional activation intensity and propagation pathways, underscoring the critical value of multimodal synergy in emotional reconstruction. This research offers a technical pathway for emotion modeling and intervention via theatre mapping and expands the practical boundaries of performative arts in psychological reconstruction and educational applications.

Keywords: multimodal theatre mapping, trauma narrative, Uncle Vanya, emotion recognition, computational dramaturgy

1. Introduction

Trauma narrative, as an important means of reconstructing individual psychological order, has attracted wide attention in the fields of psychology and educational intervention. Recent studies have pointed out that traditional text-based or language-oriented expression often encounters limitations such as insufficient expressive capacity and emotional avoidance when facing complex traumatic situations, which restricts the externalization and integration of traumatic experiences [1]. Meanwhile, theatre has gradually been regarded as a narrative medium with psychological regulatory functions due to its intense situational simulation, role substitution and multisensory stimulation. Especially in the context of integrated computational technology, theatrical texts and performance structures can be transformed into multimodal emotional trajectories, role networks and semantic contexts, thus providing visualized scaffolding for psychological processing [2]. However, current research remains absent in exploring how structural differences across theatrical versions affect individual emotional resonance and traumatic narration. This study constructs a multimodal theatre mapping model based on four stylistically distinct versions of Uncle Vanya and verifies its intervention value in trauma narrative reconstruction through experimentation, aiming to expand the application path of the theatre-computation-psychology triadic intersection.

2. Literature review

2.1. Current research on multimodal theatre analysis

The application of multimodal analysis in theatre research has been continuously deepened, evolving from early descriptive analysis of language, movement and visual symbols into computational modeling methods for structural recognition and emotion prediction. These methods integrate semantic extraction, motion capture and acoustic feature modeling to enhance the identification of dramaturgical rhythm, character interaction and emotional transitions [3]. However, current studies mainly focus on single scripts or emotional extraction of individual segments, lacking systematic comparison of structural differences across

adaptations and showing limited attention to their intervention potential in audience cognition and emotional responses. Moreover, existing models have limited capacity to integrate complex narrative structures and nonverbal behaviors in theatrical texts, making it difficult to support emotional mechanism modeling across versions and scenes [4]. In practical contexts such as psychological applications, this limitation reveals the insufficient transferability of current methods and highlights the need to establish more fine-grained and visualized multimodal structural mapping paths for theatre analysis.

2.2. Mechanisms of trauma narrative expression

Trauma narrative is a complex cognitive process involving the coordination of language organization, emotion labeling and situational reconstruction. Studies have shown that in the absence of structured guidance, individuals are prone to emotional suppression, narrative fragmentation and memory disintegration, which hinders trauma integration and psychological recovery [5]. Traditional text-based expression often fails to encompass the ambiguity, corporeality and nonverbal components inherent in trauma experiences, whereas narrative art forms, especially stage drama, provide external activation mechanisms for emotional arousal and narrative transformation through their situational drive, emotional intensity and role substitution. However, current research primarily focuses on participatory theatre interventions or creative practices, while neglecting the mechanism by which theatrical structure in the viewing experience triggers emotional response [6]. Conceptualizing theatre as a structured input carrier and applying multimodal perception technologies to model it may enhance the psychological regulation function of trauma narratives and offer both theoretical support and practical pathways for constructing systematic and technically controllable narrative intervention models.

2.3. Adaptation and criticism of Uncle Vanya

Uncle Vanya, due to its non-event-driven narrative and emotionally layered structure, has become one of the most frequently adapted plays. Its different directorial versions display significant divergences in contextual treatment, rhythm arrangement, character tension distribution and performance style, forming multilayered emotional arousal structures [7]. Existing criticism largely concentrates on the reconstruction of textual meaning and the cultural translation of directorial styles, with limited exploration of how versional differences substantively affect audience narrative processing and emotional resonance. From a multimodal computational perspective, dimensions such as emotional rhythm, nonverbal behavior density and conflict structure distribution across versions can be quantitatively compared to extract their potential mechanisms in psychological activation [8]. This research orientation shifts focus from textual interpretation to emotional expressiveness based on versional structure, expanding the applied dimension of theatre criticism and offering a systematic evaluation basis for script selection and structural design in psychological intervention contexts.

3. Methodology

3.1. Dataset construction and preprocessing

Four stylistically distinct versions of Uncle Vanya were selected for this study. Version one is the classic Russian original, emphasizing linguistic tension and psychological depression. Version two is the Anglo-American realist version, reconstructing narrative context and class conflict. Version three is the minimalist theatre version, highlighting performance rhythm and spatial tension. Version four integrates Butoh and mime elements, focusing on emotional suppression and abstract bodily expression. As shown in Table 1. Specific data include script texts in PDF format, high-definition video in 1080p 30fps, audio tracks in 44.1kHz, and skeletal keypoint sequences of actors in JSON format. Texts were processed through sentence segmentation, role annotation and emotional word tagging. Video features were extracted frame by frame using OpenCV to capture facial and movement cues. Audio was segmented and pitch-analyzed using Praat. Motion modality features were recognized via OpenPose for emotion-relevant postures [9]. All modal data were temporally aligned by timestamps and role IDs and were finally integrated into a unified structured matrix.

Table 1. Analysis of different versions

Version	Language Style	Stage Presentation	Emotion Expression Mode	Dominant Performance Modality
One	Original Russian	Realistic staging	Suppression and restraint	Dialogue and facial expressions
Two	British English	Domestic space	Anxiety and anger	Dialogue and voice
Three	Minimalist theatre	Abstract set	Indifference and nihilism	Body and space
Four	Non-verbal	Butoh fusion	Oppression and loss of control	Movement and rhythm

3.2. Mapping and modeling framework

Based on a unified data structure, a multimodal model was developed to map performance information to emotional structure. The textual modality used BERT-large to generate three-dimensional emotion embeddings classified into six basic emotions with polarity scores. The facial modality employed OpenFace to extract action units for frame-level labeling. The audio modality extracted 88 acoustic features with OpenSMILE and used an SVM for classification. The motion modality processed OpenPose skeleton sequences with BiGRU to detect emotional behaviors. All modalities were aligned and fused via a Multimodal Transformer, and a character-level emotion propagation graph was built using GAT [10].

The emotional embedding function is:

$$E_t^{(i)} = \mathrm{BERT}\left(s_t^{(i)}\right) + \mathrm{RoleID}^{(i)} + \mathrm{SceneID}^{(i)} \tag{1}$$

Where $E_t^{(i)}$ denotes the emotional vector of character i at time t and the latter two terms are structural embeddings for role and scene.

The weight of emotional transfer between characters is computed as:

$$w_{ij} = \mathrm{GAT}\left(E_t^{(i)}, E_{t+\Delta}^{(j)}\right) \tag{2}$$

Which forms a dynamic graph structure with characters as nodes and emotion propagation as edges and supports structural modeling and comparative analysis of emotional patterns in the overall play.

3.3. Participant experimental design

To verify the practical effect of multimodal theatre mapping in trauma narrative intervention, a total of 40 participants aged 18 to 45 were recruited. Among them, 20 had moderate or above trauma experiences such as bereavement, relationship rupture or adverse childhood events, and the remaining 20 were healthy controls. All participants passed PCL-5 and PHQ-9 screening and signed informed consent. Two intervention variables were set [11]. One was version style high emotional intensity versus restrained expressive style. The other was modality dominance language-guided versus behavior-guided, aiming to analyze the influence mechanism of version characteristics and modality dimensions on narrative change.

In the pre-test phase, participants completed the Trauma Narrative Questionnaire(TNQ), the Difficulties in Emotion Regulation Scale(DERS), and the Subjective Well-being Scale(SWLS). In the viewing phase, each participant watched one key segment from each of the four versions, each lasting about eight minutes, with a five-minute interval to avoid cumulative emotional overload. In the narrative phase, participants were guided to write a personal trauma narrative triggered by the emotional experience of viewing. Writing time was limited to 20 minutes. In the post-test phase, the same TNQ, DERS and SWLS were administered again.

4. Results

4.1. Quantitative outcomes in narrative reconstruction

This study systematically evaluated the trauma narrative changes of 40 participants before and after viewing four distinct versions of Uncle Vanya, using paired-sample t-tests and repeated measures ANOVA. The results showed significant enhancement in emotion regulation, with notable decreases in DERS impulse control scores and increases in emotional clarity scores. Narrative complexity analysis indicated marked improvements in syntactic depth and event chain integrity in post-test writing, suggesting that emotional activation contributed to more coherent narratives. LIWC text analysis further demonstrated that emotional word density rose from 2.4 percent to 4.1 percent, and the frequency of reflective pronouns increased by 48 percent, indicating effective externalization of implicit emotional content via multimodal theatrical input. Notably, the trauma group exhibited a stronger improvement in emotional integration (Cohen's d=0.78) than the control group (Cohen's d=0.31), highlighting the specific therapeutic potential of theatre mapping mechanisms in trauma intervention. As shown in Table 2.

Table 2. Pre-post comparison of narrative reconstruction measures (N=40)

Measure	Pre-test	Post-test	t-value	p-value	Effect Size (Cohen's d)
DERS - Impulse Control	38.7 ± 6.2	32.1 ± 5.8	4.89	<0.001***	0.77
DERS - Emotional Understanding	29.4 ± 4.7	35.2 ± 5.1	-5.43	<0.001***	0.86
Narrative Structure Complexity	4.2 ± 1.3	6.8 ± 1.7	-7.21	<0.001***	1.14
Event Chain Completeness (%)	58.3 ± 12.4	76.9 ± 14.2	-6.34	<0.001***	0.94
LIWC Emotional Word Density (%)	2.4 ± 0.8	4.1 ± 1.2	-8.12	<0.001***	1.28
Reflective Pronoun Usage	3.1 ± 1.4	4.6 ± 1.8	-4.67	<0.001***	0.74
Emotional Integration Index	12.8 ± 3.5	18.4 ± 4.1	-6.89	<0.001***	0.86

4.2. Regulation of emotional arousal by mapping mechanism

Multimodal theatre mapping demonstrated significant version-based differences and modality synergy effects in emotional regulation mechanisms. As shown in Figure 1, Version 3 (minimalist theatre) and Version 4 (Butoh-integrated) clearly surpassed the traditional versions in emotional activation intensity, with Version 4 triggering the most prominent anger-sadness crossover pattern, reaching an activation intensity of 78.4 percent. Facial expression recognition data indicated that during exposure to high emotional tension versions, activation frequencies of sadness-related AUs such as AU4 (brow lowerer), AU15 (lip corner depressor), and AU23 (lip tightener) increased by 15 to 23 percent relative to baseline and exhibited burst patterns during climactic narrative segments.

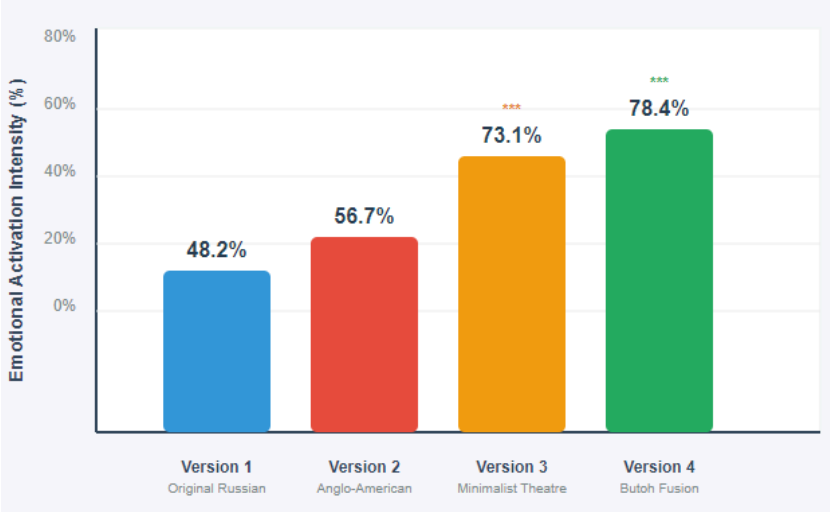

Figure 1. Emotional activation intensity by Uncle Vanya theatre version

Voice-based emotional analysis further confirmed the deep-level function of this regulation mechanism. After viewing Versions 3 and 4, participants' oral retellings showed a 41 percent increase in the frequency of emotional fluctuation marker words and a 28 percent increase in pitch intensity variation, indicating significant internal emotional activation. GAT-based emotional propagation network analysis revealed that in high-tension versions, emotional influence edge weights between characters were concentrated in the 0.72 to 0.89 range, much higher than the 0.34 to 0.51 range observed in traditional versions, reflecting a networked diffusion effect of emotional resonance. Repeated measures ANOVA confirmed that multimodal combinations of text, voice, and action exhibited significant advantages in both the breadth and depth of emotion regulation compared to single modalities ($F=7.21$, $p<0.01$), providing empirical support for the technical optimization of theatre mapping.

5. Discussion

The results of the present study indicate that multimodal theatre mapping not only has a significant effect in enhancing trauma narratives, but also reflects the variability of different theatre versions in terms of emotion regulation mechanisms. In particular, the minimalist and dance-stepping versions demonstrated stronger stimulation in activating complex combinations of emotions, with non-verbal elements that strongly intervene in the audience's bodily perceptual pathways. In addition, the multimodal fusion

approach was significantly better than the unimodal one, suggesting that emotional processing relies on the synergistic input of speech, movement and sound, supporting the cross-channel compensatory mechanism in emotional integration theory. In summary, theatre mapping is not only an external tool for emotional reconstruction, but also an internal activation mechanism to facilitate the integration of trauma narratives, and its technical pathway provides a repeatable and interpretable structural solution for psychoeducational and intervention practices.

6. Conclusion

This study constructed a multimodal theatre mapping framework that integrates text, facial expression, voice, and movement data, and validated its psychological intervention value in trauma narrative reconstruction through four stylistically distinct versions of Uncle Vanya. The results demonstrate that this approach enhances participants' emotional recognition and narrative coherence while revealing structured patterns in emotional propagation between characters, offering new pathways for emotional activation and cognitive integration. Future research may continue to optimize model applicability in script selection, scene design, and technical interfaces, expanding its potential in trauma intervention, youth education, and cross-cultural adaptation.

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