

A Comparative Projection Mapping Experiment Based on Laban's Movement Principle: Effects of Congruent and Contrastive Mapping on Emotional Arousal

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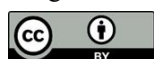
Abstract: Projection mapping, with its strong visual impact and high immersion, enhances the audience's perception of performing arts and increases emotional engagement. In the context of interdisciplinary innovation, the key issue occurs in artistic creation is on how dance art leverages its technological advantages as to enhance physical expression and stimulate emotional arousal. In particular, there is a lack of pairing principles between movement creation and projected visual colour that support the effective construction of vision and body in artistic creation. Counterintuitively, Laban "Effort" provides an analyzable approach to the expression of emotions through movement analysis. In visual perception, colour also provides a visual channel for the arousal of emotions, serving as a cross-modal mapping medium for emotional arousal in movement and vision. Based on this, this paper, using Laban "Effort" movement analysis, proposes a principle for pairing choreographic movements with colour from projection mapping whereby developed two mapping strategies: the congruent and contrastive versions. By pairing movement qualities with colour either congruently (same-direction pairing) or contrastively (opposite-direction pairing), the test evaluates the effects of the mapping on emotional arousal. This paper employed quantitative research methods and SPSS to analyse questionnaire responses. Also, 40 participants viewed two versions of the same artwork (movement, music, saturation value lock, only the direction of the hue distribution was different). Congruent mapping elicited significantly higher emotional arousal than contrastive mapping, proving that matching movement "Effort" with visual projections effectively heightens the perception of bodily expression. Hence, this provides practical suggestions, mapping principles, and insights for choreographic practice and stage visual design regarding the consistency of movement and visuals in projection mapping performances.

Keywords: Projection Mapping, Laban "Effort", Dance Performance, Colour, Emotional Arousal

1. Introduction

Projection mapping can create immersive visual experiences, and its research interest and application scale are showing an active upward trend. Besides, audiences can see it directly without any wearable devices, and it is increasingly being used in the performing arts, becoming a topic of interdisciplinary discussion [1].

In performance contexts, projection mapping is not only used to create visual stimulation, but its visual elements can also serve as clues to meaning and carriers of information, contributing to the audience's consistent understanding of the work's expression. Specifically, when the projected content and the physical object it is attached to are consistent in terms of attributes and expressive intent, it is easier for the audience to form a consistent understanding path [2]. Conversely, it interferes with the integration of meaning, reduces the readability of movement intentions, and fails to form a recognisable



cooperative relationship with mapping logic, thereby weakening the artistic experience [3].

Among visual elements, colour (especially hue) possesses high controllability and immediate perceptibility. A simple change in hue can rapidly alter the spatial atmosphere and directly influence the audience's emotional response [4-5]. Research shows that a preference for warm colours is more likely than a preference for cool colours to be associated with higher arousal experiences. Colour stimuli can influence emotions through the perceptual chain [6]. Meanwhile, saturation and brightness have a relatively strong impact on emotions. Hence, to reduce confusion, maintaining constant saturation and brightness is more helpful for clearly examining the effect of hue on the audience's emotional arousal during movement expression [7]. Therefore, when discussing the impact of mapping strategies between "movement quality and colour" on the audience's emotional arousal, using only hue as the manipulated variable is a clear and effective approach.

Furthermore, stage performance is essentially a multimodal experience, requiring audiences to integrate clues and construct meaning across multiple channels [8]. Besides, in a multimodal context, cross-modal correspondence establishes a regular relationship between the matching tendencies of features across modalities, thereby improving the efficiency and consistency of information integration [9]. Therefore, in stage art, it is necessary to explore the operational pairing principles between movement quality and colour, and to examine the audience's emotional response under different mapping strategies.

Moreover, current research focuses on technological approaches, such as the use of interactive and real-time generation mechanisms to enhance stage visuals and improve visual effects [10-12]. However, these works mainly focus on the technical pathways of "how to achieve" and "how to enhance". From the perspective of audience perception, if the real-time stage visuals lack a perceptible connection with the body expression, it can easily distract and weaken the viewing experience. Therefore, it remains necessary to explore how visual parameters can establish a reproducible correspondence with the emotional cues of movement [13].

In movement analysis, Laban's "Effort" as a structured representation of cue movement emotion, lays the foundation for effective analysis of movement emotion [14]. Laban "Effort" breaks down body movement into four elements: space, time, weight, and flow, to generate eight basic movement style qualities based on these. Through the composition of specific element characteristics, it reveals the specific psychological tension corresponding to the movement style [15]. Hence, these provide observable, analyzable movement element quality for emotion translation and also offer repeatable, quantifiable application channels for cross-media mapping research.

Currently, from an artistic perspective, there is a lack of a systematic discussion of the matching principle between the quality of dance movements and the colour of projection mapping in terms of emotional arousal. Particularly, there are still a few studies on the impact of this principle on audience emotional arousal. Therefore, this paper explored and tested the following question: with some stimuli remaining unchanged, changes in the pairing direction between the hue of the projection mapping and the quality of dance movements can affect the emotional arousal of the audience.

Specifically, in this paper, "Effort" by Laban is the starting point for movement design, organising the practice of movement quality design under "Effort" and the hue changes of projection colours in a congruent mapping and contrastive mapping manner. Through the comparison mechanism, examine the influence of the pairing principle between actions and projection colours on emotional arousal. Therefore, this rule system provides reproducible, quantifiable operational rules for dance projection colour design and a practical basis for the synergistic integration of movement quality and projection visuals from an artistic creation perspective.

2. Literature Review

2.1. Projection Mapping

Projection mapping can project virtual information onto the surfaces of objects in real or three-dimensional space, without being limited by the scene structure, achieving high-quality augmented visual effects. It supports reconstructing the atmosphere of art spaces and creating immersive art experiences for audiences. It has become a measurable and controllable paradigm for emotional innovation on stage [1] [16].

Projection mapping has become an important tool for interdisciplinary collaboration. Compared to some immersive media that require audience members or dancers to wear devices, projection mapping does not require them to wear complex equipment. While ensuring the dancers' freedom of expression of physical, it enhances the audience's visual immersion, promoting the function of artistic expression [17].

In projection mapping, adjustments to the characteristics of visual elements can effectively evoke emotional responses in the audience [10-11] [18-20]. In particular, the perceptual imagination induced by colours in projection mapping establishes a representation similar to the real world, thereby enhancing the expression of the physical world or the appearance of objects [21]. Clues about colour manipulation triggering emotional responses: Semertzidis et al. (2019) used participants' EEG data to drive the RGB colour intensity of images, demonstrating that cognitive arousal and emotion change significantly with variations in colour values [22]. This suggests a potential moderating effect of colour on emotion in projection vision.

Also, this confirms the audience centric visual research findings of Masu and Correia (2020) and Correia et al. (2021), when the perceived connection between physical objects and bodily expressions in projected vision is insufficient, or the mapping intention is unclear, it is easy for the visual points of meaning to become interference sources, thereby affecting the audience's perception of the bodily expressions of dance movements [3] [23].

It indicates that in dance performances, when the colours in projection mapping match the quality of the movement, the audience can enhance immersion and emotional resonance through the connection between the visual and kinesthetic senses. Therefore, it is necessary to propose a mapping principle for the colour in projection mapping and movement quality from an artistic perspective, which is of great value for exploring the role of projected visual elements in dance performance.

2.2. *Multimodal Theory and Crossmodal Correspondence*

2.2.1. Multimodal Composition in Dance

Multimodal theory emphasises that people can achieve cognition through the coordinated cooperation of multiple sensory channels. When visual, auditory, and kinesthetic information is presented simultaneously in similar temporal structures or energy intensities, the brain's neural networks tend to automatically integrate these signals, forming a unified multimodal representation that improves the efficiency and accuracy of understanding [24-25]. Therefore, the multimodal construction method provides art with a more effective form of organisation and output.

In dance expression, multimodal mechanisms coordinate the combination of various sensory information, including physical movements, story, music, and visual cues, enhancing the transmission of emotions and information, and significantly improving the efficiency of transmission and reception [26-29]. Based on this, multimodal systems can combine dancers' movements, music, and the colours of light and shadow into the same space and time for enhanced expression. It provides a feasible research direction for integrating projected visual elements and dance movements within the same performance environment.

2.2.2. Dance Practice in Cross-Modal

When refining modal relationships, cross-modal correspondences explain how to establish mapping rules between different channels, i.e., predictable matching trends across sensory channels [9] [30]. Furthermore, Chen et al. (2024) pointed out that multisensory pairing exhibits an automatic and bidirectional matching relationship [31]. Through cross-modal correspondence, the physical attributes of different channels can be "compressed" onto a common dimension for discussion.

Existing research structures the relationship between movement characteristics and different modes. To expand the audience experience, a method is proposed to establish a kinematic-auditory mapping channel from gestures to sounds, thereby enabling cross-modal translation of movement signals in performances. Alternatively, it can transform the temporal and spatial variations of dancers' movements into abstract visual compositions in real time, realising a cross-modal expression path that combines kinesthetic and visual elements [32-33]. These practices demonstrate that cross-modal mapping provides a strategy for effectively showing performing arts forms in multimodal art expression systems. By establishing a reasonable correspondence between the kinesthetic and visual channels, the quality of movement and attributes such as colour, shape, and speed are mutually reinforced on the same dimension, thereby more effectively stimulating emotional arousal from the audience.

2.3. *Laban "Effort"*

In movement analysis, Laban's theory of "Effort" reflects the mode of human movement. It provides a systematic analytical language for describing the quality of movement [34]. Research shows that specific body movements and postures can evoke or express emotions, such as happiness, sadness, fear, and anger, which can be effectively recognized [35].

Traditionally, Laban's "Effort" comprises four dimensions: time, weight, space, and flow. "Weight" refers to the heaviness or lightness of the movement under the influence of gravity. "Space" is the directness or curvature of the movement's trajectory. "Time" is the tempo of the movement, expressing its speed or slowness. "Flow" describes the degree of freedom in the movement's relaxation or control [36].

The four "Effort" factors are each composed of two opposite polarities, forming the eight basic movement elements: Punch, Slash, Float, Dab, Glide, Press, Wring, Flick. Based on the element of "weight", it is divided into "Light Effort" and "Strong Effort", which describe significant differences in the rhythm, intensity, and continuity of a movement, evoking feelings related to emotions or levels of tension [37]. Therefore, people can express the inner emotions in a controllable and perceptible way through the quality of the movements.

Based on this concept, the paper built a model to identify and classify emotions in mo data. This further demonstrates the operability and constructability of movement quality with emotion [38]. Obviously, "Effort" is a means of organising and constructing the emotional content of movement. Its parameters make emotion a medium connecting technical and artistic expression, providing operational support for establishing the principles of movement quality and visual mapping.

2.4. Colour

Jonauskaitė & Mohr (2025) found in 132 studies on colour that the association between colour and emotion typically exhibits a "many to many" correspondence structure. Also, the hue category (warm or cool) influences overall differences in arousal levels [39]. By quantitatively driving emotional and physiological indicators with appropriate colour tones, emotional tone can be actively regulated [4]. Hence, all of this demonstrates the close relationship between colour and emotion.

In projective mapping, colour still plays a guiding role in artistic expression [40]. From a visual experience perspective, colour evoked the perceptual imagination, reinforcing the expression of the physical world [21]. Therefore, improving the internal properties of colours in projection mapping can further enhance the transformation of colour perception patterns [41]. The accuracy of colour expression determines the audience's willingness to immerse themselves in the artwork. This provides a foundation for reconstructing the relationship between colour expression and bodily expression from an artistic creation perspective.

In different colour dimension tests, although the perception of warm and cool tones remained relatively stable at various brightness levels, exhibiting a repeatable perceptual structure [42]. However, the perception of warm and cool colours is affected by the order of presentation, exhibiting a characteristic where the boundary shifts with the sequence. Therefore, the experiment suggests prioritising the core area, avoiding the transition area, or setting up a buffer zone and conducting manipulation checks [43].

From the perspective of colour tone emotional temperature research, when the constant brightness and saturation are control variables, the emotional effect can be attributed to the hue itself [7] [41]. Therefore, under controlled conditions, single-channel studies provide a more stable foundation for explaining emotional effects. Hence, this ensures the attributability of relevant tone for future research centred on colour experiments.

2.5. Emotion Models

Emotion can be defined as a state, or the transient presence of a feeling induced by internal or external stimuli. In the visual and auditory senses, discrete emotion categories or emotional dimensions are frequently used to classify emotions [44]. Discrete emotions refer to mapping stimuli to a series of fixed states, such as anger, sadness and happiness [45], while emotional dimensions refer to the degree to which an individual feels activated and aroused in a specific dimension [46]. In the dimensional emotion model, Russell (1980) proposed a two-dimensional model of Valence and Arousal. The horizontal axis represents continuous changes in valence (pleasure and displeasure), and the vertical axis represents changes in arousal (from low to high), reflecting the degree of calm and excitement [47].

Also, Valence-Arousal models are widely used in multimedia emotion computing tasks. In the domain of vision and music, VA values are used to achieve emotional classification of visual emotional stimuli and data driven emotional modelling and intervention [38] [48]. All of the above demonstrates that the Valence Arousal two-dimensional coordinate system can serve as a quantitative baseline for emotions across stimulus types, becoming a "common coordinate system" for cross sensory research in the field of art. This provides an effective theoretical basis and an operational coordinate system for emotion measurement.

Currently, research on projection mapping in performing arts remains primarily focused on technological implementation. However, from the perspective of stage performance, there is still a lack of systematic quantitative validation of the movement quality and projection mapping colour pairing principle on the audience's emotional arousal level.

3. Methodology

3.1. Research Design

This paper used quantitative methods and a within-subjects design, which can better control for individual differences, improve data accuracy and reliability, and make statistical analyses more efficient [49]. The paper used eight movement quality styles from Laban's "Effort" as choreographic indicators, mapping strategies (congruent and contrastive mapping) as independent variables, and the audience's subjective emotional arousal across versions as the dependent variable. Together, to jointly examine the impact of mapping strategies on the audience's emotional arousal.

3.2. Participants

The paper recruited 40 students through stratified sampling for this experiment. All participants were from universities in Shandong, China, and had a dance background. Hence, aims to better control for differences in understanding and improve the consistency of movement quality recognition. All participants viewed two versions of the work and signed informed consent forms.

3.3. Experimental Design

3.3.1. Dance segment design based on Laban's "Effort"

The work uses a modern dance solo as an experimental stimulus context to control the confusion caused by differences in dance styles. The dance consists of eight consecutive movement segments that depict the dancer's personal growth journey. The movements' quality label is used as a choreography label to guide the design. The total duration is approximately 5 minutes. In designing the quality of the movements, two methods are used: "reinforcement" (progressing the expression of movements in a way that is similar in quality) and "contrast" (highlighting the expression of movements in a way that is opposite in quality) to arrange the movements, thereby stimulating the audience's perception of changes in the texture of the movements. At the same time, each movement is controlled within the same duration and tempo range, and the background music remains completely consistent to reduce measurement errors.

3.3.2. Projection Mapping Colour Conditions

In this paper, the colour stimuli were derived from the visual environment created by projection mapping. MadMapper maps calibrated solid colour frames onto performance surfaces, providing repeatable colour stimuli. Considering that the colour classification boundary may drift due to contextual influences, this paper tightens the boundaries for the cool and warm hue parameters during HSV [Hue, Saturation, Value] parameter selection. Hue (H) is marked using a hue angle of 0-360°. Specifically, the warm hue colour stimulation range was H=15°-50° (red, orange, yellow segment), and the cool hue colour stimulation range was H=200°-270° (Cyan, blue, purple segment). The aim is to maximise the recognisability of warm and cool hues and the clarity of contrast, while avoiding transitional hue areas such as yellow, green, and magenta that may lead to ambiguity in categorisation. Figure 1 shows the discrete values of colour in this paper.

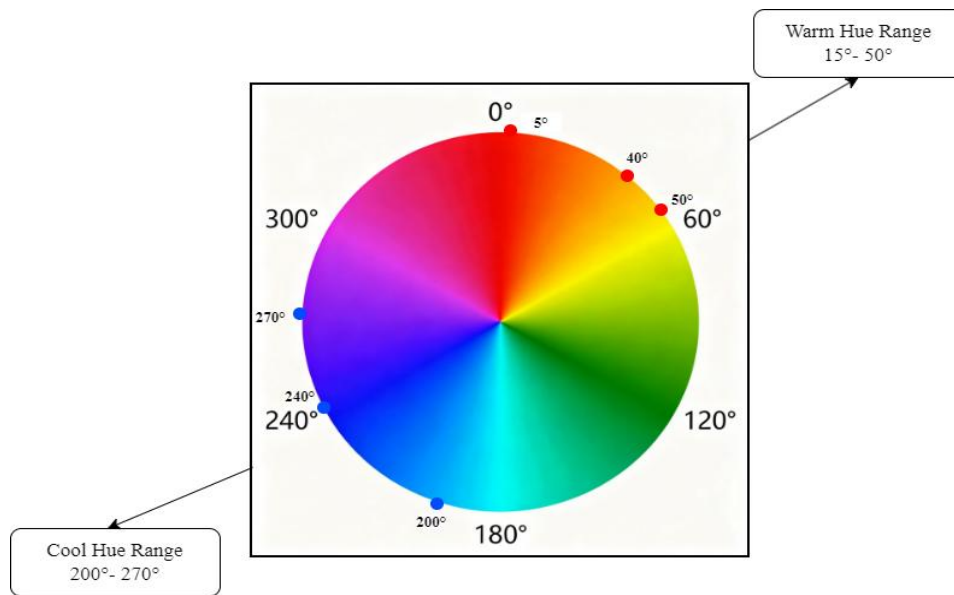


Figure 1. Schematic Diagram of The Colour Wheel

To ensure that the projected hue has sufficient visibility and recognizability under real stage viewing conditions, the saturation is kept constant at (S=75%), and V is set to (V=80%). Hence, this will minimise confusion caused by intensity and brightness. Also, ensure that observed differences are accurately attributed to changes in the hue's warmth or coolness. Before the formal test, the output was calibrated using ColorChecker. Through the RGB automatic rendering conversion, the audience ensured the colour of the two versions was consistent. Before the formal performance, the warm and cool colours of the projection mapping were preset to eliminate subjective deviations.

3.3.3. Pairing Rules

This paper examined the effects of colour in projection mapping and move quality on emotional arousal through paired experiments with artworks. Based on the “strong/light” dimension of “Effort”, a pairing rule is established for movement quality and projected mapping colour: “Strong Effort Group” (Punch, Slash, Press, Wring) is matched with a warm hue range. The “Light Effort Group” (Float, Glide, Flick, Dab) is matched with a cool hue range. Further research established Punch and Float as two extreme “baseline movement groups”, each paired with the most typical representative colours from the warm and cool ranges, respectively.

In addition, the internal quality of the “Punch” movement is “Sudden, Direct, Strong, Bound”. The movement has stronger tension and urgency and belongs to the high-arousal movement quality. In the baseline movement group in the warm colour zone, it matches the red “15°”. The internal quality of the “Float” movement in the “Light Effect Group” is set to “Sustained, Indirect, Light, Free”, making it gentler and more soothing and belonging to the low arousal movement quality. It matches blue (270°) among the baseline movement group in the cool colour range. Section 3.3.4 details the specific elements of changes in movement quality.

In the congruent version, the distribution of the colour features from projection mapping aligns with the movement quality indicated by the “Effort” in the movement. In contrastive works, under the same performance quality, rules, and framework, only the matching relationship between the projected map colour and the quality of the movement is reversed to examine the impact on the audience's emotional arousal.

3.3.4. Pairing Rules Table for Experimental Works

This experiment established a pairing rule table for the experimental works to examine the impact of the two versions on the audience’s emotional arousal. Table 1 shows the experimental pairing rules in two versions of the same work.

Table 1. Experimental Pairing Rules in Two Versions of The Same Work

Paragraph Effort Attribute					Time Interval	Congruent Mapping	Contrastive Mapping
Time	Space	Weight	Flow			Warm Hue Range (15°-50°)	Cool Hue Range (200°-270°)
Dab	Sudden	Direct	Light	Bound	4*8	Cool Hue 200°	Warm Hue 50°
Flick	Sudden	Indirect	Light	Free	8*8	Cool Hue 240°	Warm Hue 40°
Wring	Sustained	Indirect	Strong	Bound	10*8	Warm Hue 50°	Cool Hue 200°
Glide	Sustained	Direct	Light	Free	3*8	Cool Hue 240°	Warm Hue 40°
Punch	Sudden	Direct	Strong	Bound	6*8	Warm Hue 15°	Cool Hue 270°
Press	Sustained	Direct	Strong	Bound	4*8	Warm Hue 40°	Cool Hue 240°
Float	Sustained	Indirect	Light	Free	2*8	Cool Hue 270°	Warm Hue 15°
Slash	Sudden	Indirect	Strong	Free	2*8	Warm Hue 40°	Cool Hue 240°

Note: Hue is the only variable dimension; saturation and brightness are set to 75% and 80%, respectively. “x*8 means x 8-count phrases” or “x 8-count measures”.

R1 (Effort Organisation): The experiment, conducted using a “contrast” and “reinforcement” approach, included eight movement qualities. Using the “Effort” style label as a reference, this paper arranged the movements in the order of Dab, Flick, Wring, Glide, Punch, Press, Float, and Slash.

R2 (Manipulation Dimension): Both versions of the mapped artwork have fixed saturation and brightness at S=75% and V=80%, and only manipulate the hue. Based on the operational definition of the colour wheel, this paper defines the Warm Hue range as 15°-50°, taking discrete values of 15°, 40°, and 50° (red, orange, yellow) and the Cool Hue range as 200°-270°, taking discrete values of 200°, 240°, and 270° (cyan, blue, purple), for stimulus generation and control.

R3 (Congruent mapping Rule): Set “Punch” to 15°, “Wring” to 50°, and the other two styles to 40°. The “light effort segments” are paired with Cool Hue of 200°-270°, where “Dab” is set to 200°, “Float” to 270°, and the other two styles to 240°, so that the warm and cool hues match the movement quality.

R4 (Contrastive Mapping Rule): The system reverses the entire mapping direction of R3: Set “Punch” to 270°, “Wring” to 200°, and the other two styles to 240°. The “light effort segments” were paired with a warm hue, setting “Dab” to 50°, “Float” to 15°, and the other two styles to 40°, creating a contrast between colour and movement.

R5 (Time Alignment): Both versions Transformation hues at the same time rhythm, in conjunction with a specified movement, to eliminate the influence of differences in switching frequency and timing. Figure 2 shows the two versions of the illustrations.

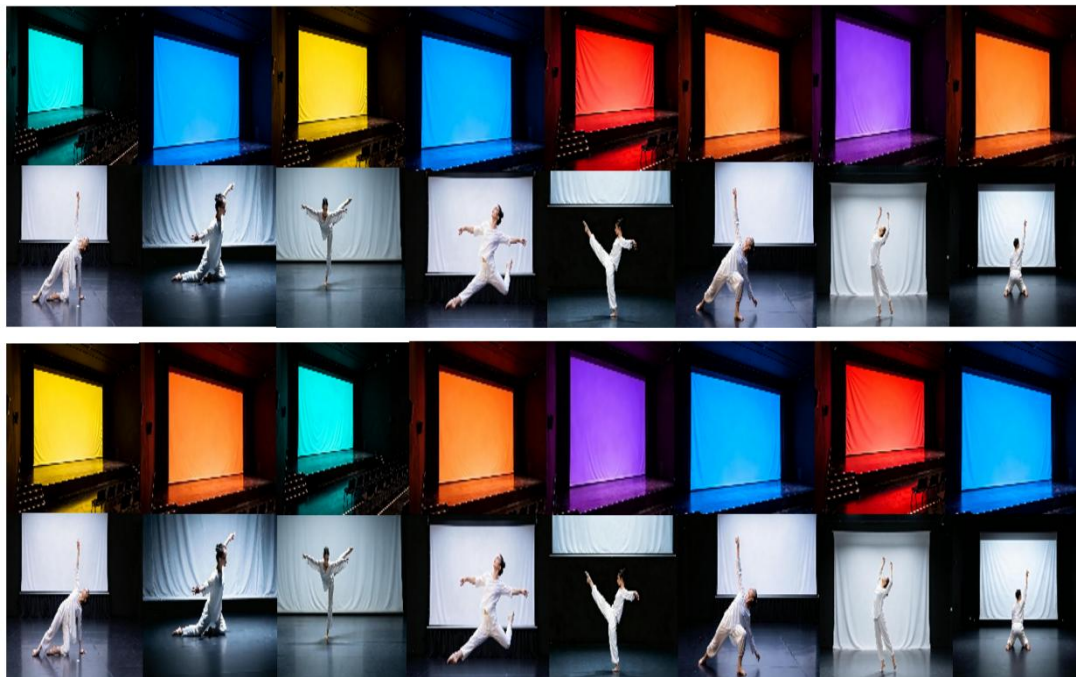


Figure 2. Two versions of illustrations

3.3.5. Experimental Setting and Pre-check

The experiment was conducted in a black box theatre to minimise the impact of the experimental environment on the test. A single white projection screen serves as the sole display surface. This paper used two Epson EB-PU1008W laser projectors to stimulate the visual environment. Both mapping versions were presented in the same venue, using the same screen and projector configuration. Before the formal experiment, hue consistency and discernibility were pre-checked under the same venue, equipment, and viewing conditions. Team members independently judged the cool/warm hue samples and verbally reported classifications, ensuring sufficient hue discernibility for the subsequent questionnaire. Figure 3 shows the experiment environment.



Figure 3. The experiment Environment.

3.4. Measures and Procedure

This paper used a seven-point semantic difference scale to capture the audience’s subjective experiences with two mapped versions. The scale was designed with reference to the two-dimensional valence-arousal model, but only the arousal dimension was retained and simplified into semantic difference items for assessment. Specifically, it was expressed as “calm to excited ($Q1$)”, “relaxed to tense ($Q2$)”, and “perceived emotional intensity ($Q3$)”. The questionnaires will include two additional questions ($Q4$ and $Q5$) to test the audience’s perceptions of colour manipulation in projection mapping and of the pairing between the colours in projected mapping and the quality of the movement.

In this paper, version A is the congruent mapping version, and version B is the contrastive mapping version. This experiment will randomly present two versions of the experimental work, and participants will complete a questionnaire immediately after each version. To avoid carryover effects, this experiment will set a visual washout interval of ≥ 120 seconds, minimising sensory residue and sequence effects.

3.5. Data Analysis

This paper used SPSS for data analysis. First, descriptive statistics for each item, including mean (M) and standard deviation (SD), were computed. At the same time, Cronbach’s alpha (α) of the emotional activation scale ($Q1-Q3$) was calculated to measure internal consistency. After reaching the standard, the average of $Q1-Q3$ forms a composite “emotional arousal” score (E_A and E_B), which serves as the primary dependent variable and indicator to examine the differences between the two versions. Manipulation test questions ($Q4$ and $Q5$) will not be included in the total score. The test results are used only to verify whether participants perceived the colour change and the impact of projection-mapping colour and movement quality.

Also, use the Shapiro-Wilk test to analyse paired differences. However, given that some differences may deviate from normality and the sample size is relatively small, the Wilcoxon signed-rank test was used as the primary analysis. The report statistic Z , two-tailed p-value, and effect size (r) are also presented (calculated as $r = |Z| / \sqrt{(N^*)}$, where N^* is the effective sample size after removing zero

differences. Additionally, paired t-tests (M , SD , t , df , p) and Cohen's d_z are used as complementary references. Furthermore, report the median and interquartile range (IQR) of the key paired difference variables (interquartiles are calculated using Tukey's hinges). All tests were two-tailed, and uniform values are retained to three decimal places.

4. Result

4.1. Cronbach's α

This paper compared audience pairing scores across the two versions. The emotional arousal scale ($Q1$ - $Q3$) underwent an internal consistency test. The results showed that the congruent mapping version (Work A1 to A3) had a Cronbach's α of 0.773, and the contrastive mapping version (Work B1 to B3) had a Cronbach's α of 0.790, both reaching acceptable levels.

It indicates that the correlations among the items within the scale exhibit acceptable internal consistency. Table 2 presents the results for Cronbach's α . Table 3 presents the descriptive statistics.

Table 2. Cronbach's α for the Emotional Arousal Scale

Cronbach's α for the EA scale (N = 40)		
Measure	Work A	Work B
EA = mean ($Q1$ to $Q3$)	0.773	0.790

Table 3. Descriptive Statistics of Results

Descriptive Statistics Table (Work A and Work B)				
Measure	Work A (Mean)	Work A (SD)	Work B (Mean)	Work B (SD)
$Q1$	5.80	.883	4.28	1.109
$Q2$	5.30	.939	4.05	1.413
$Q3$	5.73	.905	4.38	.897
EA (mean of $Q1$ to $Q3$)	5.608	.754	4.233	.973

As shown in Table 3, the average scores of work A (congruent mapping version) were consistently higher than those of work B (contrastive mapping version), and the differences showed a consistent direction. Therefore, by averaging $Q1$ to $Q3$, the overall emotion arousal score for each version is calculated, thus obtaining EA_A for version A and EA_B for version B. Descriptive statistics indicated that EA_A ($M = 5.608$, $SD = 0.754$) was higher than EA_B ($M = 4.233$, $SD = 0.973$). $Q4$ showed that the accommodative version (A) scored higher ($A: M = 5.75$, $SD = 0.870$; $B: M = 3.50$, $SD = 0.906$), and $Q5$ also showed $A > B$ ($A: M = 5.68$, $SD = 0.944$; $B: M = 3.33$, $SD = 0.694$).

4.2. Normality Test

In the normality test, the difference in total emotional activation score D_{EA} did not deviate significantly from normality ($W = 0.951$, $p = .084$; see Figure 4).

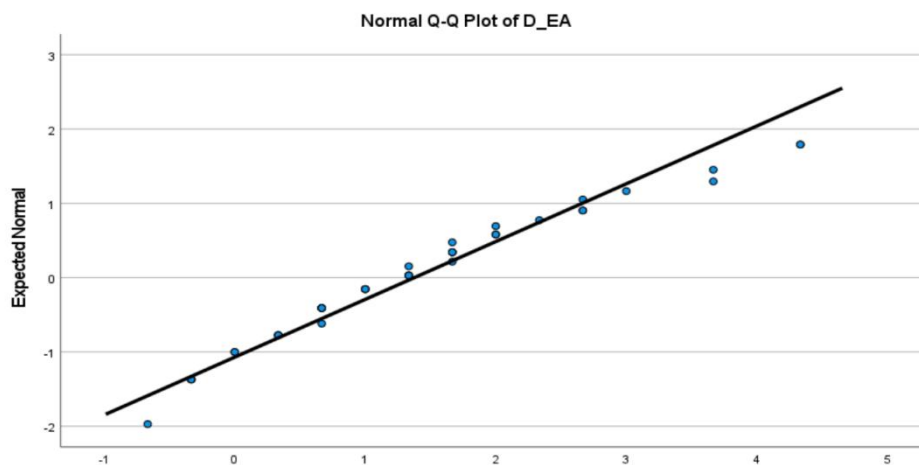


Figure 4. Normal $Q1$ To $Q3$ Plot of The Difference Score for Emotional Arousal ($D_{EA} = EA_A - EA_B$).

However, since some differences deviated from normality, Shapiro-Wilk $p < .05$ ($D_1 : W = .936, p = .026$; $D_2 : W = .911, p = .004$; $D_3 : W = .928, p = .014$; $D_5 : W = .877, p < .001$) and given the relatively small sample size, the Wilcoxon signed-rank test was used as the primary analytical method, with paired t -tests serving as a robustness reference. Given the mixed normality results and the relatively small sample size, the Wilcoxon signed-rank test is used as the primary analysis for each result, with the paired t -test as a robustness check.

4.3. Wilcoxon Signed-Rank Test

This paper used the Wilcoxon signed-rank test. SPSS calculated $B-A$ as the difference with the direction. The output showed that Z was negative (between -3.914 and -5.345). When Version A was rated higher than Version B . The arousal composite score ($EA_B - EA_A$) showed a significant negative difference, corresponding to the test result $Z = -4.992, p < .001$, and effect size $r = 0.810$ ($r = |Z| / \sqrt{N^*}$). Version A received a higher rating than version B ($A > B$).

At the individual item level, the differences between $Q1$ to $Q5$ were all significant (all $p < .001$). The rating system for work A was systematically higher than that for work B (the difference was calculated as $A - B$, corresponding to $A > B$). The effect size r ranged from 0.715 to 0.878 , all reaching a large effect level. The largest differences were observed in $Q4$ and $Q5$, with $r = 0.867$ and $r = 0.878$, respectively. Table 4 presents the Wilcoxon signed-rank tests for versions A and B .

Table 4. Paired Comparisons Between Work A and Work B (Wilcoxon Signed-Rank Test)

Item	Negative	Positive	Ties	N^*	Z	P (2-tailed)	$r = Z / \sqrt{N^*}$	Direction
$EA_B - EA_A$	33	5	2	38	-4.992	<.001	0.810	$A > B$
$Q1$	29	3	8	32	-4.729	<.001	0.836	$A > B$
$Q2$	24	6	10	30	-3.914	<.001	0.715	$A > B$
$Q3$	27	2	11	29	-4.521	<.001	0.840	$A > B$
$Q4$	37	1	2	38	-5.345	<.001	0.867	$A > B$
$Q5$	36	1	3	37	-5.341	<.001	0.878	$A > B$

Note: N^* is the number of valid pairs with non-zero differences ($N - \text{ties}$). r is to determine small/medium/large effects based on $r \approx 0.10/0.30/0.50$. Z is negative, indicating that A 's score is generally higher than B 's score.

To supplement the distribution information for subsequent nonparametric tests, this paper reports the median and interquartile range (Tukey's hinges) for the variable in each paired difference and uniformly retains three decimal places. The results showed that the median of the total difference in emotional arousal score, D_{EA} , was 1.333 , with $Q1 = 0.5000$, $Q3 = 2.0000$, and $IQR = 1.500$. Regarding the differences between individual items, the median for $D_1 = 2.000$ ($Q1 = 0.000$, $Q3 = 2.000$, $IQR = 2.000$), $D_2 = 1.000$ ($Q1 = 0.000$, $Q3 = 2.000$, $IQR = 2.000$), $D_3 = 1.000$ ($Q1 = 0.000$, $Q3 = 2.000$, $IQR = 2.000$), $D_4 = 2.000$ ($Q1 = 1.000$, $Q3 = 3.000$, $IQR = 2.000$), and $D_5 = 3.000$ ($Q1 = 2.000$, $Q3 = 3.000$, $IQR = 1.000$).

Overall, the medians of all differential variables were positive. The direction of the medians was consistent with the Wilcoxon test results ($A > B$) (see Table 4), indicating that the audience's ratings for emotional arousal and manipulative perception of the congruent mapping version (work A) were systematically higher than those of the contrastive mapping version (work B).

4.4. paired-samples t -test

In the robustness check results of the paired t -test, the differences between the means of the five items ($\Delta M = A - B$) were all positive, and the 95% confidence intervals (CI) were all above zero, indicating that there were significant differences in the sample t -values. Version A scored significantly higher than version B . Table 5 presents the paired-samples t -test results for versions A and B .

Table 5. Paired-Samples *T*-Test Results Comparing Work *A* and Work *B*.

Item	<i>A</i> (<i>M</i> ± <i>SD</i>)	<i>B</i> (<i>M</i> ± <i>SD</i>)	ΔM	<i>t</i> (<i>df</i>)	<i>p</i>	Cohen's <i>d_z</i>
EA (<i>Q1</i> to <i>Q3</i> mean)	5.61±0.754	4.23±0.973	1.375	6.763 (39)	<.001	1.069
<i>Q1</i>	5.80±0.883	4.28±1.109	1.525	6.821 (39)	<.001	1.079
<i>Q2</i>	5.30±0.939	4.05±1.413	1.250	4.555 (39)	<.001	0.720
<i>Q3</i>	5.73±0.905	4.38±0.897	1.350	6.509 (39)	<.001	1.029
<i>Q4</i>	5.75±0.870	3.50±0.906	2.250	10.660 (39)	<.001	1.685
<i>Q5</i>	5.68±0.944	3.33±0.694	2.350	12.504 (39)	<.001	1.977

Note: "95% CI is the confidence interval for the mean difference ΔM ($\Delta M = A - B$). d_z is Cohen's *d* (SPSS 'Paired Samples Effect Sizes' output).

Specifically, the congruent mapping version (work *A*) scored significantly higher than the contrastive mapping version (work *B*) on overall emotional arousal, $t(39) = 6.763$, $p < .001$, $\Delta M = 1.375$, 95% CI [0.964, 1.786], Cohen's $d_z = 1.069$. Consistently significant differences were observed across the categories: *Q1*, $t(39) = 6.821$, $p < .001$, $\Delta M = 1.525$, 95% CI [1.073, 1.977], Cohen's $d_z = 1.079$. *Q2*, $t(39) = 4.555$, $p < .001$, $\Delta M = 1.250$, 95% CI [0.695, 1.805], Cohen's $d = 0.720$. *Q3*, $t(39) = 6.509$, $p < .001$, $\Delta M = 1.350$, 95% CI [0.931, 1.769]. Cohen's $d = 1.029$. For manipulation test items, *Q4*, $t(39) = 10.660$, $p < .001$, $\Delta M = 2.250$, 95% CI [1.823, 2.677], Cohen's $d = 1.685$. *Q5*, $t(39) = 12.504$, $p < .001$, $\Delta M = 2.350$, 95% CI [1.970, 2.730], Cohen's $d = 1.977$.

5. Discussion

This paper uses a quantitative approach, using an inside-subjects experimental design to compare the effects of congruent mapping (Work *A*) and contrastive mapping (Work *B*) on audience emotional arousal. The results showed that, with variables such as movement sequence, music, and brightness strictly controlled, the two versions exhibited a consistent direction in emotional arousal and manipulation test indicators; that is, the congruent mapping version (Version *A*) produced significant subjective differences.

Specifically, congruent version enhances arousal not only in terms of activation (*Q1*), but also in terms of tension-related arousal (*Q2*) and overall sensory intensity (*Q3*). Meanwhile, the manipulation test questions (*Q4*, *Q5*) further corroborated the results of emotional arousal: participants not only effectively identified hue manipulation but also clearly perceived the mapping relationship between hue and movement quality. The participants particularly agreed that matching stronger movement sequences to warm-toned atmospheres and matching cool tones to lighter movement quality was more in line with the cognitive understanding of movement and the psychological expectations for the work's expression. Also, this result provides a practical method for empirically examining the pairing mechanism between movement quality design and colour in projection mapping visual effects. (see Tables 4 and 5).

The research results clearly show that consistent expression of movement quality and colours in projection mapping improves the efficiency of information integration and amplifies the intensity of emotional perception. For choreography practice, choreographers of modern dance and immersive performances can prioritise the strategy of "movement quality and colour quality moving in the same direction" to enhance the audience's emotional peak at a low cost. In the creation process, if choreography deliberately pursues the artistic effect of exaggerated contrast, it must consider the audience's acceptance of the visual effects and the work's actual expressive intent. Hence, avoid misconfigured artistic effects that could undermine the efficiency of artistic communication.

6. Limitations and Future Work

This paper still has some limitations, starting with the sample size ($N=40$), and the range of stimuli is relatively small. Future research should increase sample size and introduce more dance styles to explore their effectiveness in evoking emotions, thereby improving the robustness of the results. In addition, although a washout period (≥ 120 seconds) was included in the paper to account for potential consistency and contrast effects in within-subjects designs, this time cannot rule out the possibility of visual persistence effects on viewers. Further, this paper changed only the hue, keeping saturation and brightness constant. Future research could expand to examine the differential effects of different attributes on emotional arousal. Finally, whether contrastive mapping schemes can evoke emotions through emotional tension in a specific context still needs to be systematically verified in a more specific artistic context, within the framework of movement classification and pre-set emotional goals.

7. Conclusion

This paper used quantitative research methods and a within-subjects design to examine the correlation between colour in projection mapping and movement quality to emotional arousal. With constant saturation and brightness, HSV provided the hue angle for this paper and experimentally matched the two mapping modes. The results show that, compared with the contrastive mapping version (work B), the congruent mapping version (work A) exhibits higher arousal and stronger emotional experience, as indicated by relevant indicators of emotional arousal, thereby significantly enhancing the audience's perception of mapping consistency. Meanwhile, in the colour manipulation perception measurement, the audience clearly identified the correspondence between hue and the direction of movement quality, indicating that manipulation of movement and colour from the projection map is effective in the experiment. Furthermore, the Wilcoxon analysis and the robustness reference (paired-samples t-test) are consistent in the conclusions. Overall, this paper provides empirical evidence from an artistic perspective for the design application of dance movement quality and projection mapping (hue configuration). When the “Effort” of the movement is “strong”, it is paired with a warm hue range, whereas when the “Effort” is “light”, it is paired with a cool hue range to more easily promote the audience's emotional arousal and intensity. In the future, more art research can apply this principle to the creation and performance of different dance styles to verify its robustness in evoking emotions in different movement contexts.

References

1. Sari, I. P., Juhana, A., & Nurhidayatulloh, N. (2023). Global trends in the study of projection mapping technology using bibliometric analysis. *Journal of Print and Media Technology Research*, 12, 219–229.
2. Li, H., Li, B., Ito, H., & Zhang, T. (2025). Architectural influence on narrative content in cultural heritage projection mapping. *Npj Heritage Science*, 13(1), 509. <https://doi.org/10.1038/s40494-025-02094-y>
3. Correia, N. N., Masu, R., Pham, A. H. D., & Feitsch, J. (2021). Connected Layers: Evaluating Visualizations of Embodiment in Contemporary Dance Performances. In R. Wimmer (Ed.), *Proceedings of the Fifteenth International Conference on Tangible, Embedded, and Embodied Interaction* (pp. 1–12). Association for Computing Machinery. <https://doi.org/10.1145/3430524.3440621>
4. Febbraio, F., Collina, S., Lepida, C., & Kourtesis, P. (2025). Colour Perception in Immersive Virtual Reality: Emotional and Physiological Responses to Fifteen Munsell Hues. *Virtual Worlds*, 4(4), 45. <https://doi.org/10.3390/virtualworlds4040045>
5. Xie, X., Cai, J., Fang, H., Tang, X., & Yamanaka, T. (2022). Effects of colored lights on an individual's affective impressions in the observation process. *Frontiers in Psychology*, 13. <https://doi.org/10.3389/fpsyg.2022.938636>
6. Wilms, L., & Oberfeld, D. (2018). Color and emotion: effects of hue, saturation, and brightness. *Psychological Research*, 82(5), 896–914. <https://doi.org/10.1007/s00426-017-0880-8>
7. Valdez, P., & Mehrabian, A. (1994). Effects of color on emotions. *Journal of Experimental Psychology: General*, 123(4), 394–409. <https://doi.org/10.1037/0096-3445.123.4.394>
8. Gowing, M., Kell, P., O'Connor, N. E., Concolato, C., Essid, S., Lefevre, J., Tournemenne, R., Izquierdo, E., Kitanovski, V., Lin, X., & Zhang, Q. (2011). Enhanced visualisation of dance performance from automatically synchronised multimodal recordings. *Proceedings of the 19th ACM International Conference on Multimedia*, 667–670. <https://doi.org/10.1145/2072298.2072414>
9. Motoki, K., Marks, L. E., & Velasco, C. (2023). Reflections on Cross-Modal Correspondences: Current Understanding and Issues for Future Research. *Multisensory Research*, 37(1), 1–23. <https://doi.org/10.1163/22134808-bja10114>
10. Fukamizu, K., Miyashita, L., & Ishikawa, M. (2020). ElaMorph Projection: Deformation of 3D Shape by Dynamic Projection Mapping. *2020 IEEE International Symposium on Mixed and Augmented Reality (ISMAR)*, 164–173. <https://doi.org/10.1109/ISMAR50242.2020.00038>

11. Ishibashi, K., Uchiyama, S., & Goto, H. (2022). Visual Effect System for Projection Mapping with Japanese Drum Performance. *2022 Nicograph International (NicoInt)*, 75–78. <https://doi.org/10.1109/NicoInt55861.2022.00022>
12. Taya, Y., & Takahashi, T. (2023). Dynamic Projection Mapping onto Non-Rigid Objects Using Markers and Skeletal Information. In M. Nakajima, P. Y. Lau, J.-G. Kim, T. Yamasaki, K. Seo, J.-M. Guo, & Q. Kemao (Eds.), *International Workshop on Advanced Imaging Technology (IWAIT) 2023* (pp. 498–502). SPIE. <https://doi.org/10.1117/12.2666971>
13. Correia, N. N., Masu, R., Primett, W., Jürgens, S., Feitsch, J., & Plácido da Silva, H. (2022). Designing Interactive Visuals for Dance from Body Maps: Machine Learning and Composite Animation Approaches. In F. F. Mueller & S. Greuter (Eds.), *Designing Interactive Systems Conference* (pp. 204–216). Association for Computing Machinery. <https://doi.org/10.1145/3532106.3533467>
14. Wu, C., Davaasuren, D., Shafir, T., Tsachor, R., & Wang, J. Z. (2023). Bodily expressed emotion understanding through integrating Laban movement analysis. *Patterns*, 4(10), 100816. <https://doi.org/10.1016/j.patter.2023.100816>
15. Fuhrmann, A., Uytterhoeven, L., & Fensham, R. (2025). Movement Analysis. In L. G. Nibbelink & L. Karreman (Eds.), *Performance Research Methods* (pp. 85–106). Open Book Publishers. <https://doi.org/10.11647/obp.0469.04>
16. Işıkkaya, A. D. (2023). Video Projection Mapping as a Visual Urban Art Performance on Architectural Facade. *Street Art & Urban Creativity*, 9(1), 106–122. <https://doi.org/10.25765/sauc.v9i1.629>
17. Bond, R. (2021). Visualizing Berio’s Sinfonia: Choreographing Animation for Indeterminate Narratives. *International Journal of Film and Media Arts*, 6(2), 63–74. <https://doi.org/10.24140/ijfma.v6.n2.04>
18. Elashmawy, R. (2020). The Use of Historical Architecture in Interactive Performances Using the 3D Projection Mapping. *Journal of Art & Architecture Research Studies - JAARS*, 1(2), 134–148. <https://doi.org/10.47436/jaarsfa.v1i2.69>
19. Nordin, S. A. bin, & Din, S. C. D. (2025). A Study on Components of Interactive Projection Mapping to Enhance Youth Engagement with Kuda Kepang in Malaysia. *Idealogy Journal*, 10, 493–504.
20. Zhong, Y., Fu, X., Liang, Z., & Ning, H. (2024). Application of Three-Dimensional Vision Technology in Dance. *Applied System Innovation*, 7(5), 1–17. <https://doi.org/10.3390/asi7050080>
21. Takeuchi, M., Koida, K., & Iwai, D. (2025). Luminosity thresholds in projection mapping under environmental lighting. *Frontiers in Virtual Reality*, 6. <https://doi.org/10.3389/frvir.2025.1649901>
22. Semertzidis, N. A., Sargeant, B., Dwyer, J., Mueller, F. F., & Zambetta, F. (2019). Towards Understanding the Design of Positive Pre-sleep Through a Neurofeedback Artistic Experience. *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems*, 1–14. <https://doi.org/10.1145/3290605.3300804>
23. Masu, R., & Correia, N. (2020). Pathways to Live Visuals in Dance Performances: a Quantitative Audience Study. *EAI Endorsed Transactions on Creative Technologies*, 7(23), 1–8. <https://doi.org/10.4108/eai.13-7-2018.163987>
24. Mackay, R. R. (2021). *Multimodal Legitimation* (1st Edition). Routledge. <https://doi.org/10.4324/9781315103563>
25. Norris, S. (2020). *Multimodal Theory and Methodology* (1st Edition). Routledge. <https://doi.org/10.4324/9780429351600>
26. Bläsing, B., & Zimmermann, E. (2021). Dance is More Than Meets the Eye—How Can Dance Performance Be Made Accessible for a Non-sighted Audience? *Frontiers in Psychology*, 12, 1–15. <https://doi.org/10.3389/fpsyg.2021.643848>

27. Burger, B., & Toiviainen, P. (2020). See how it feels to move: Relationships between movement characteristics and perception of emotions in dance. *Human Technology*, 16(3), 233–256. <https://doi.org/10.17011/ht/urn.202011256764>
28. Krug, M. (2025). Coordinating multiactivity transitions in dance rehearsals: spatial configurations and instructional practices. *Frontiers in Communication*, 10. <https://doi.org/10.3389/fcomm.2025.1520005>
29. Pan, W. (2025). Dance as a Multimodal Semiotic System: A Linguistic Perspective on Bodily Expression. *Forum for Linguistic Studies*, 7(9). <https://doi.org/10.30564/fls.v7i9.10046>
30. Li, W., Gao, C., Niu, G., Xiao, X., Liu, H., Liu, J., Wu, H., & Wang, H. (2021). UNIMO: Towards Unified-Modal Understanding and Generation via Cross-Modal Contrastive Learning. Proceedings of the 59th Annual Meeting of the Association for Computational Linguistics and the 11th International Joint Conference on Natural Language Processing (Volume 1: Long Papers), 2592–2607. <https://doi.org/10.18653/v1/2021.acl-long.202>
31. Chen, N., Sørensen, T. A., & Spence, C. (2024). Editorial: Crossmodal correspondence. *Frontiers in Psychology*, 15. <https://doi.org/10.3389/fpsyg.2024.1385480>
32. Leonard, J., & Giomi, A. (2020). Towards an Interactive Model-Based Sonification of Hand Gesture for Dance Performance. In R. Michon & F. Schroeder (Eds.), Proceedings of the International Conference on New Interfaces for Musical Expression (pp. 369–374). Birmingham City University. <https://doi.org/10.5281/zenodo.4813421>
33. Nogueira, M. R., Menezes, P., & Carvalho, J. M. de. (2022). “F O R M S”: Creating Visual Composition Through the Movement of Dance and Artificial Intelligence. *The Paris Conference on Arts & Humanities 2022 Official Conference Proceedings*, 95–101. <https://doi.org/10.22492/issn.2758-0970.2022.8>
34. Melzer, A., Shafir, T., & Tsachor, R. P. (2019). How Do We Recognize Emotion From Movement? Specific Motor Components Contribute to the Recognition of Each Emotion. *Frontiers in Psychology*, 10. <https://doi.org/10.3389/fpsyg.2019.01389>
35. Ahmed, F., Bari, A. S. M. H., & Gavrilova, M. L. (2020). Emotion Recognition From Body Movement. *IEEE Access*, 8, 11761–11781. <https://doi.org/10.1109/ACCESS.2019.2963113>
36. Fdili Alaoui, S., Françoise, J., Schiphorst, T., Studd, K., & Bevilacqua, F. (2017). Seeing, Sensing and Recognizing Laban Movement Qualities. Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems, 4009–4020. <https://doi.org/10.1145/3025453.3025530>
37. Ewan, V., & Sagovsky, K. (2018). *Laban’s Efforts in Action: A Movement Handbook for Actors with Online Video Resources* (1st ed.). Bloomsbury Publishing.
38. Li, Q., Zhao, Y., Gong, B., Li, R., Wang, Y., Yan, X., & Wu, C. (2022). Visual Affective Stimulus Database: A Validated Set of Short Videos. *Behavioral Sciences*, 12(5), 137. <https://doi.org/10.3390/bs12050137>
39. Jonauskaitė, D., & Mohr, C. (2025). Do we feel colours? A systematic review of 128 years of psychological research linking colours and emotions. *Psychonomic Bulletin & Review*, 32(4), 1457–1486. <https://doi.org/10.3758/s13423-024-02615-z>
40. Iwai, D. (2024). Projection Mapping Technologies: A Review of Current Trends and Future Directions. *Proceedings of the Japan Academy, Series B*, 100(3), 234–251. <https://doi.org/10.2183/pjab.100.012>
41. Takeuchi, M., Kusuyama, H., Iwai, D., & Sato, K. (2024). Projection Mapping under Environmental Lighting by Replacing Room Lights with Heterogeneous Projectors. *IEEE Transactions on Visualization and Computer Graphics*, 30(5), 2151–2161. <https://doi.org/10.1109/TVCG.2024.3372031>
42. Manalansan, J., Whitehead, L. A., & Webster, M. A. (2025). Warm versus cool colors and their relation to color perception. *Journal of Vision*, 25(4), 13. <https://doi.org/10.1167/jov.25.4.13>
43. Min, J., & Park, Y. (2024). Order Effect of Warm-Cool Judgment of Colors. *Archives of Design Research*, 37(4), 119–131. <https://doi.org/10.15187/adr.2024.08.37.4.119>

44. Morgan, S. D. (2019). Categorical and Dimensional Ratings of Emotional Speech: Behavioral Findings From the Morgan Emotional Speech Set. *Journal of Speech, Language, and Hearing Research*, 62(11), 4015–4029. https://doi.org/10.1044/2019_JSLHR-S-19-0144
45. Baudouin, J.-Y., Gallian, F., Pinoit, J.-M., & Damon, F. (2025). Arousal, valence, and discrete categories in facial emotion. *Scientific Reports*, 15(1), 40268. <https://doi.org/10.1038/s41598-025-24032-5>
46. POSNER, J., RUSSELL, J. A., & PETERSON, B. S. (2005). The circumplex model of affect: An integrative approach to affective neuroscience, cognitive development, and psychopathology. *Development and Psychopathology*, 17(03). <https://doi.org/10.1017/S0954579405050340>
47. Russell, J. A. (1980). A circumplex model of affect. *Journal of Personality and Social Psychology*, 39(6), 1161–1178. <https://doi.org/10.1037/h0077714>
48. Patil, S., Patil, R., Goudar, S., Sangani, S., & Goudar, R. H. (2025). Review on music emotion analysis using machine learning: technologies, methods, datasets, and challenges. *Discover Applied Sciences*, 7(7), 692. <https://doi.org/10.1007/s42452-025-07178-9>
49. Montoya, A. K. (2023). Selecting a Within- or Between-Subject Design for Mediation: Validity, Causality, and Statistical Power. *Multivariate Behavioral Research*, 58(3), 616–636. <https://doi.org/10.1080/00273171.2022.2077287>

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