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Experimental Study on Emotion-State-Driven Creativity Generation Mechanisms in Clay Art Creation

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Abstract. The state of emotions has become one of the key factors affecting the process of creative cognition and behavioral performance. Nevertheless, previous research has paid little attention to the study of creativity in the field of three-dimensional artistic creation, which contains the embodiment of cognition, operation of materials, and actions of the body. Clay art creation includes cognitive thinking, hand operations, and interaction with materials, and the creation of creativity is related to both emotional changes and behavior strategies. In this paper, we propose an emotion-state-driven creativity analysis framework for clay art creation. A within-subject experiment under positive, negative, and neutral emotions was performed to collect emotion states, physiological measures, creation videos, and artworks' pictures. By using computer vision technologies, hand movement features and visual features of artworks were extracted. Then expert evaluation, linear mixed-effects modeling, and mediation analysis were adopted to explore the mechanism of how emotions affect the creativity. It has been shown that the states of emotions played significant roles in changing the creative behavior patterns. Positive emotions made the action diverse and morphological exploration easy, while negative emotions helped refine actions and structurally controlled the work. Action diversity partly mediates the effects of emotion states on originality.

Keywords: emotional state, clay art creation, creativity generation, computer vision, behavioural analysis

1. Introduction

The creation of clay art is a multifaceted and complex form of creativity which combines cognitive planning, physical operations, and material interactions [1]. Creativity is manifested not only in the novelty of the final art pieces but also in material experiments, movements adjustments, and morphology transformations in the process of creation [2]. As research in the field of creativity shows, emotions impact information processing, allocation of attention, and idea generation, so they can serve as an explanatory factor in individual differences in creative behaviour [3]. It is known from previous studies that positive emotions usually improve cognitive flexibility and association, whereas the effects of emotional arousal extend to exploratory behaviour and involvement in the task [4]. Nevertheless, until now the research concerning the relationship between emotions and creativity was conducted using verbal tasks, visual tasks, or abstract divergent thinking tests, while

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little attention was paid to three-dimensional artistic creation with tactile feedback, continuous movements, and material restrictions [5]. Due to development in computer vision and behaviour analysis, it became possible to transform into quantifiable data such aspects as hand movements, rhythm of the process, and features of artworks. This provides a new perspective on the ways in which emotions affect creativity generation. Thus, this research will focus on studying the effects of emotional states on the behavioural changes in clay creation.

2. Literature review

2.1. Effects of emotional states on creativity

Influence of Emotional States on Creativity Is Governed Jointly by Valence, Level of Arousal and Nature of Tasks. While positive emotions typically broaden attention and association and thus help to generate novel ideas, thus benefiting open-ended creative activities [6], some negative emotional states can help with problem solving and improving creative results through increased error detection and monitoring [7]. This implies that rather than impacting creativity itself, emotions impact creative behaviors through altering the cognitive strategies of processing. In the case of making clay art, the process of ideation involves cognitive flexibility and idea generation while shaping and refining involves sustained attention and control. Thus, analysis of the way in which different emotional states affect various phases of the creative process can provide a more complete explanation of the effects of emotions on creativity.

2.2. Embodied processes in clay art creation

The production of clay artworks possesses very clear characteristics of embodied cognition, as the work is constantly modified by means of gestures, physical senses and visual observation of the result. Due to the high malleability of the clay, the processes of pressing, stretching, cutting and joining change not only the physical shape but also the perceptions of the creators about the structure of space and artistic possibilities [8]. As a result of many studies, it was found that the engagement of the body in the artistic activity is associated with the expression of emotions, perception and regulation of the creative process, and therefore, creative actions become an intermediary link between the psychological state and the result of the artwork [9]. The classical measurement of the process of creativity usually pays attention to the result without taking into account the process of formation of it, including the dynamic aspect created during the exploration and morphological transformation of the material.

2.3. Computational measurement of creativity

Creativity is a psychological process, and subjective measures cannot adequately assess any dynamic changes during the process of creation. Computer vision methods allow for the quantification of creative processes, as they identify hand keypoints, assess speed and range of motion, and action transitions, while simultaneously extracting visual features of contour complexity and structure change of images of the artwork [10]. Nevertheless, computational measures can only define observable behaviors and formal attributes and cannot substitute the human judgment about originality and beauty of artwork. Thus, expert consensus evaluation is necessary to build a multi-dimensional creativity assessment framework [11]. Modern advances in multimodal computing integrate physiological data, visual data, and behavioral data in order to accurately characterize

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emotional states and performance changes [12]. During the process of clay art creation, computational approaches provide objective measurements of the process of creativity, while expert evaluations provide the subjective view on the domain-specific aspects of this process.

3. Experimental methods

3.1. Participants and experimental design

A total of 48 adults aged 18 to 35 years were recruited as participants. The inclusion criteria were at least three months of clay art training, the ability to independently complete basic shaping operations, no physical conditions affecting hand movements, and no history of severe emotional disorders. A within-subject randomized crossover design was adopted. Each participant completed three independent clay creation tasks under positive emotion, negative emotion, and neutral emotion conditions. The experimental order was balanced using a Latin square method to reduce learning effects, fatigue effects, and sequence-related differences. Prior to each testing, participants viewed a pre-tested emotion induction video and filled out the PANAS scale and the valence-arousal rating in order to verify the presence of changes in emotions. Next, the participants performed a clay modeling task for up to 30 minutes, under the same conditions concerning the weight of the clay, arrangement of the tools, and the experimental environment. Three topics of modeling were matched based on difficulty ratings obtained from a pilot study.

3.2. Creative process data collection

In order to analyze the connection between emotional changes and the creation process, data related to emotions, physiology, and behavior were collected simultaneously in the course of the experiment [13]. Emotion data include positive and negative emotions measured by PANAS scale, and valence and arousal, which were used to validate the success of emotion induction. Physiology data include electrodermal activity and heart rate changes to measure autonomic arousal level. Behavioral data were collected by means of a fixed-angle camera through the whole process of creation. MediaPipe was utilized to obtain trajectories of hand keypoints and to calculate movement speed, range of movement, duration of pause, and switching frequency of actions. Major actions, such as pressing, stretching, cutting, joining, and refining, were labeled by two professional coders based on unified criteria. Cohen's kappa was used to estimate inter-coder reliability. All data were synchronized by means of timestamping. The process of creativity is structured into the exploration phase, shaping phase, and refining phase based on real behavioral change, thus linking emotional changes to specific behaviors.

3.3. Artwork evaluation and statistical analysis

Artwork evaluation combined computational indicators and expert assessment. First, the action diversity index was calculated based on the proportion of action categories extracted from creation videos to measure material exploration under different emotional conditions [14]. The calculation method is shown in Equation (1).

$$DI = -\sum_{i=1}^{n} p_i \log(p_i) \quad (1)$$

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Where DI represents the action diversity index, p_i represents the proportion of the i-th action category among all actions, and n represents the number of action categories. A higher DI value indicates a more diverse set of operation strategies during clay creation.

Then, visual features including contour complexity, edge density, structural ratio, and symmetry deviation were extracted from standardized artwork images. Five clay art experts independently evaluated originality, aesthetic quality, and technical execution without knowing the emotional conditions [15]. A composite creativity score was calculated according to Equation (2).

$$CI=w_1O+w_2A+w_3T \tag{2}$$

Where CI represents the composite creativity score, O represents the originality score, A represents the aesthetic quality score, and T represents the technical execution score. w_1, w_2, and w_3 represent the weights assigned to each evaluation dimension.

To examine the effects of emotional conditions on creative behaviours and artwork performance, a linear mixed-effects model was constructed. The model incorporated emotional condition as a fixed effect and participant identity as a random effect to control individual differences in artistic experience and creative ability [16]. The model formulation is shown in Equation (3).

$$Y_{ij}=\beta_0+\beta_1 Emotion_{ij}+u_i+\epsilon_{ij} \tag{3}$$

where Y_{ij} represents the behavioural or creativity indicator of participant i under condition j, β_0 represents the model intercept, β_1 represents the effect coefficient of emotional condition, $Emotion_{ij}$ represents the emotional condition, u_i represents the participant-level random effect, and u_i represents the residual error. Mediation analysis was further conducted to examine whether action diversity mediated the relationship between emotional states and creativity outcomes.

4. Results

4.1. Emotion induction and creative behaviour

The emotion induction results showed that the three experimental conditions produced distinct emotional states. The positive condition increased the PANAS positive emotion score from 26.4±4.8 to 34.7±5.2, while the negative condition increased the negative emotion score from 18.9±3.6 to 29.8±4.5. Physiological indicators further confirmed changes in arousal, with electrodermal activity increasing by 12.6% under the positive condition and 15.3% under the negative condition. Behavioural analysis showed that the positive condition achieved the highest action transition frequency (8.7±1.6 times/min) and action diversity index (1.42±0.18), whereas the negative condition showed the longest refining duration (38.6±7.1%). The linear mixed-effects model indicated a significant effect of emotional condition on action diversity ($F(2,94)=8.63$, $p<0.001$), demonstrating that emotional states altered exploration strategies during clay creation.

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Table 1. Comparison of creative behaviour indicators under different emotional conditions

Emotional Condition	Action Transition Frequency (times/min)	Action Diversity Index	Average Pause Time (s)	Refining Stage Ratio (%)
Positive	8.7±1.6	1.42±0.18	4.8±1.2	27.4±5.6
Neutral	6.3±1.4	1.09±0.15	6.2±1.5	32.1±6.3
Negative	5.8±1.5	0.96±0.17	8.5±1.8	38.6±7.1

4.2. Creativity outcomes and mechanism pathways

The creativity evaluation results revealed differences in artwork features across emotional conditions. Expert assessments showed that the positive condition achieved the highest originality score (4.32±0.41), followed by the neutral condition (3.86±0.37) and negative condition (3.71±0.45). Artwork images under the positive condition also presented higher contour complexity (0.68±0.09), indicating more diverse morphological exploration. Principal component analysis based on contour complexity, edge density, structural ratio, and symmetry deviation showed distinct distributions among emotional conditions, as illustrated in Figure 1. The linear mixed-effects model demonstrated a significant effect of emotional condition on composite creativity scores ($F(2,94)=6.27$, $p<0.01$). Mediation analysis further indicated that action diversity partially mediated the relationship between emotional states and originality (indirect effect=0.15, 95% CI [0.06,0.27]), suggesting that emotional states influenced creativity outcomes through changes in creative behaviours.

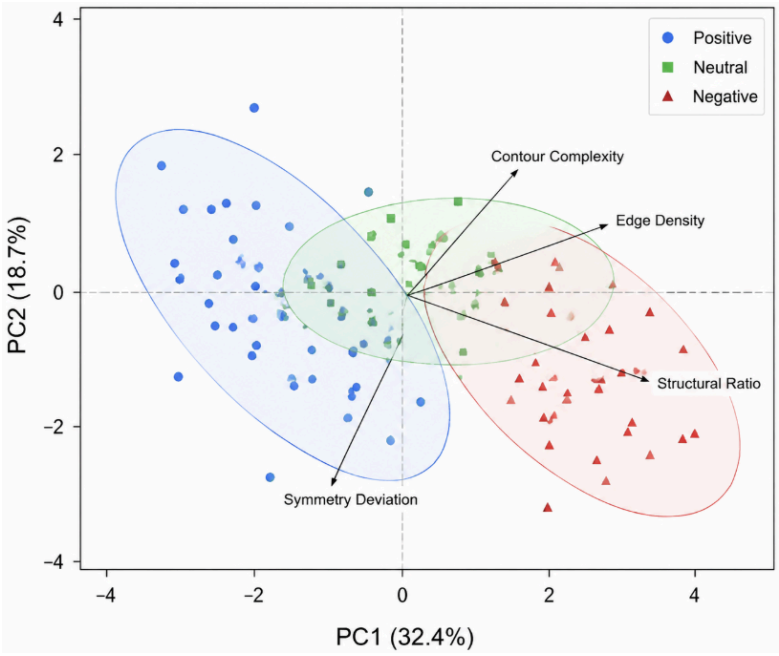

Figure 1. PCA distribution of artwork visual features under different emotional conditions

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5. Discussion

The results indicate that emotional states influence clay creativity mainly by modifying behavioural strategies during the creative process. Based on the increased frequency and diversity of action transitions in the positive emotional condition, it is believed that the more open-minded cognitive state is likely to help in exploration and morphology development, allowing designers to develop visually better solutions. Based on the longer refinement time and stronger structure control in the negative emotional condition, it is believed that the more focused process could be useful for local adaptation and technical improvement. It seems that creativity is not based on one specific emotion but depends on the matching of the emotions and the stages of creativity. This is because it is demonstrated by computational metrics and professional evaluations that morphological complexity could mirror some processes of creativity, while artistic value depends on the interpretations of the specific field.

6. Conclusion

This study investigated the emotion-state-driven mechanisms of creativity generation in clay art creation by examining behavioural changes and artwork outcomes under different emotional conditions. A system combining the methods of emotion induction, behavioral data acquisition, computer vision techniques, and expert assessment was created to investigate the connection between the emotional states, creativity process, and creativity outcomes. It was found that the emotional states considerably affected the way of exploration and the visual qualities of the artworks created. In case of positive emotions, it was more likely to conduct the open-ended exploration, while negative emotions made one pay attention to the details. The use of linear mixed-effects modeling and mediation analysis also demonstrated the importance of action diversity in the link between emotional states and originality.

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