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Quantitative Analysis of Visual Elements of Loneliness in Urban-Themed Oil Paintings of Jilin City, China

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Abstract: Urban loneliness is increasingly recognised as an important emotional and social issue in contemporary urban life. Urban-themed oil paintings can express such emotional experiences through visual elements such as colour, composition, figure representation, and lighting. However, limited quantitative research has examined how specific visual elements in Chinese urban-themed oil paintings influence viewers' perception of urban loneliness, particularly within medium-sized non-Western cities such as Jilin City, China. This study investigates the predictive effects of four core pictorial determinants, including color tone, compositional density, figure state, and tonal contrast, on individuals' perceptions of urban loneliness.A quantitative visual-stimulus survey design was employed using 20 realistic oil paintings depicting urban scenes in Jilin City. The selected pictorial attributes were coded with a standardized visual assessment rubric, while respondents' subjective perceptions of urban loneliness were measured using a revised loneliness perception scale. Empirical data were collected from 200 adult permanent residents of Jilin City through purposive sampling and analyzed using multiple regression analysis. The findings indicate that cool and desaturated colour tones, sparse compositions with ample negative space, solitary or absent figures, and strong contrast of light and shadow were associated with higher levels of perceived urban loneliness. These results suggest that specific visual strategies in urban-themed oil paintings can influence how viewers emotionally interpret urban environments. This study contributes to quantitative research on the relationship between visual art expression and urban emotional perception in a Chinese urban context. It also provides useful references for urban-themed artistic creation, museum curatorial practice, and visual emotional design research. In addition, the study offers a replicable quantitative approach for interdisciplinary research integrating visual art, environmental psychology, and urban emotional studies.

1. Introduction

Urban loneliness has emerged as a prevalent socio-psychological phenomenon in contemporary urbanisation, characterised by subjective social disconnection and emotional alienation despite dense human aggregation in urban spaces. As a critical public health and urban cultural issue, persistent urban loneliness is closely linked to residents' mental health risks, reduced social participation, and

diminished urban well-being. While existing scholarship has predominantly explored the demographic, social, and environmental antecedents of urban loneliness through sociological and clinical approaches, limited empirical attention has been paid to the visual and aesthetic construction of urban loneliness in artistic representations.[1] Visual art, particularly urban-themed oil painting, serves as a unique medium for encapsulating and transmitting subtle urban emotional experiences, as artists manipulate formal visual elements to reframe and interpret the affective attributes of urban spaces.[2]

Colour tone, compositional density, figure state, and contrast of light and shadow are four core formal visual elements that constitute the fundamental visual grammar of oil paintings. Qualitative art criticism has long posited that these elements shape viewers' emotional perceptions of urban scenes, with cool desaturated hues, sparse spatial compositions, absent or solitary human figures, and dramatic light-shadow interplay commonly associated with feelings of isolation and emptiness.[3] However, such interpretive claims remain largely anecdotal and lack systematic quantitative validation. Most relevant empirical studies are rooted in Western urban contexts, focusing on classic Western urban oil paintings and overlooking the culturally specific visual expressions of urban loneliness in non-Western urban environments.[4]

Chinese urbanisation features distinct socio-cultural trajectories, spatial aesthetics, and emotional connotations that differ fundamentally from Western urban development models. Medium-sized Chinese cities, in particular, represent a neglected research context in global urban loneliness studies, as they balance rapid urban transformation and traditional cultural inheritance, forming unique urban visual landscapes and resident emotional experiences.[5] Jilin City, a representative medium-sized city in Northeast China with distinctive industrial heritage and natural urban features, provides an ideal contextual case for exploring culturally situated visual expressions of urban loneliness. Despite its unique urban visual characteristics and representative urbanisation experience, few studies have systematically investigated how visual elements in local urban oil paintings shape viewers' perceptions of urban loneliness.[6]

Against this backdrop, the present study aims to fill three critical research gaps: the lack of quantitative empirical evidence linking specific oil painting visual elements to perceived urban loneliness, the pervasive Western-centric bias in visual emotion perception research, and the absence of validated empirical models for medium-sized Chinese urban contexts. By adopting a quantitative visual-stimulus experimental design, this study systematically examines the predictive effects of four key visual elements on viewers' perceived urban loneliness based on Jilin urban-themed oil paintings.[7]The findings intend to establish an evidence-based correlation between artistic visual grammar and urban emotional perception, provide practical references for urban artistic creation and visual emotional design, and offer a replicable interdisciplinary quantitative paradigm for future research integrating visual art, environmental psychology, and urban emotional studies.[8]

2. Methodology

2.1 Sampling Method

This study employs purposive sampling (also known as judgmental sampling). Purposive sampling is a non-probability sampling technique in which participants are deliberately selected based on established selection criteria that are essential to the research objectives (Palinkas et al., 2015).[9]This method is appropriate for the present study because the research requires respondents who possess specific characteristics directly relevant to the investigation of perceived urban loneliness in the context of Jilin. As outlined in Section 2.1, eligible respondents must: (a) be aged 18 years or above; (b) be current residents of Jilin; (c) have at least moderate familiarity with Jilin's urban environment; and (d) be able to view and respond to visual artworks. Purposive sampling allows the

researcher to intentionally recruit individuals who meet these criteria, thereby ensuring that the collected data are contextually valid and aligned with the study's focus. [10]General population samples that include non-residents or individuals unfamiliar with Jilin would introduce confounding variation and weaken the ecological validity of the findings (Etikan, Musa, & Alkassim, 2016).

Study respondents were recruited through multiple channels, including community centres, local art organisations, social media groups targeting Jilin residents, and snowball sampling (where existing participants refer other eligible individuals).[11] All potential participants underwent screening using the demographic questionnaire (Appendix A, Section A) to confirm that they meet the inclusion criteria before proceeding to the main survey.

2.2 Sample Size

This study adopted a minimum sample of 200 respondents. The target is justified on both statistical and practical grounds.

First, for multiple regression analysis—the primary statistical technique used to test H1, H2, and H4 established rules of thumb recommend a minimum of 10 to 15 cases per predictor variable (Tabachnick & Fidell, 2019). The present study includes four independent variables (CT, CD, FS, LSC). However, because Figure State (FS) is a categorical variable with three levels,it was transformed into two dummy variables for regression analysis. Thus, the total number of predictor variables entered into the regression model amounts to six (CT, CD, LSC, and two dummies for FS, plus possibly interaction terms in exploratory analyses). Based on the 15:1 ratio, a sample of 90 respondents would be sufficient. However, more conservative recommendations suggest a minimum of 200 cases for stable estimates, particularly when variables are not perfectly normally distributed (Field, 2018) [12].

Second, for one-way ANOVA (testing H3 regarding FS), power analysis using G*Power (Faul et al., 2009) indicates that, assuming a medium effect size ($f = 0.25$), $\alpha = 0.05$, and power = 0.80, a total sample of approximately 159 respondents (53 per group) is required for a three-group design. A sample of 200 exceeds this requirement, providing a margin for incomplete responses or exclusions.

Third, previous empirical studies employing stimulus-based perceptual designs in art perception and environmental psychology have used similar or smaller sample sizes. For example, Valdez and Mehrabian (1994) used 60 participants in their colour-emotion experiment; Trupp et al. (2022) used 163 participants in their online art engagement study. A sample of 200 is therefore comparable to or larger than those in related studies, supporting the feasibility and statistical adequacy of the proposed sample.

Finally, practical considerations (time, budget, and accessibility of the target population) also support a target of 200 respondents. To account for potential incomplete questionnaires or outliers, the study intended to gather data from 220-240 participants, with the expectation that at least 200 complete and valid would be retained for final analysis.

In summary, purposive sampling combined with a minimum sample size of 200 respondents provides a methodologically sound basis for testing the four hypotheses and addressing the research questions within the specific context of Jilin, China.

2.3 Research Stimuli: Oil Paintings of Jilin

The visual stimuli are central to this study, as they operationalise the four independent variables (Colour Tone, Compositional Density, Figure State, Light and Shadow Contrast) and elicit the dependent variable (Perceived Urban Loneliness). A total of 20 oil paintings depicting urban scenes of Jilin are used. This number balances the need for sufficient variation across the independent variables against the practical constraint of respondent fatigue (viewing more than 20 paintings with

repeated measures would likely reduce data quality). The 20 paintings were sourced from publicly available exhibition catalogues, gallery websites, and artist portfolios of contemporary Chinese artists who have produced works set in Jilin. All images are high-resolution digital reproductions (minimum 300 DPI) suitable for on-screen presentation.

The paintings are suitable for this study because they collectively exhibit substantial variation on each of the four visual elements, as confirmed by pre-coding (see Appendix B). This variation enables statistical modelling of the predictive influence of CT, CD, FS, and LSC on PUL. Moreover, because all paintings depict recognisable urban locations within Jilin (e.g., the Songhua River waterfront, factory districts, residential neighbourhoods, winter scenes), they provide a culturally and geographically coherent stimulus set that resonates with the lived experience of the target population (Jilin residents).

2.4 Selection Criteria of Oil Paintings

The following criteria were applied to select the 20 paintings: Medium:The artwork must be an oil painting. Other media (watercolour, photography, digital art, printmaking) are excluded to maintain consistency in material and visual texture.

Subject matter: The painting must depict an urban scene of Jilin, China. Paintings of rural landscapes, abstract compositions, or other Chinese cities are excluded.

Variation in visual elements: The set as a whole must contain demonstrable variation in Colour Tone (warm to cool, saturated to desaturated), Compositional Density (dense to sparse), Figure State (absent, solitary, social), and Light and Shadow Contrast (low to high). This ensures that statistical analyses can detect predictive relationships.

Image quality: The digital reproduction must be high-resolution (minimum 300 DPI) and free from watermarks, cropping, or colour distortion that could affect viewer perception.

Academic use permission: The image must be available for non-commercial academic research under fair use/fair dealing provisions, or with the artist's or copyright holder's permission.

2.5 Description of Selected Paintings

The 20 selected paintings are listed in full in Appendix B. They include works by Ren Chuanwen, Wang Jianguo, Jia Difei, Zhao Peizhi, Liu Mengyao, and other contemporary Chinese artists. The paintings depict a range of urban locations: the Songhua River embankment, industrial warehouses, residential courtyards, winter streetscapes, and public squares. The set covers different times of day and seasons, including bright summer scenes, overcast winter days, and night views with artificial lighting. A summary of the pre-coded values (from Appendix B) is provided as Table 1.

Table 1: Summary of Pre-Coded Variable Values across 20 Oil Paintings

Variable	Range	Mean (SD)
CT - Hue (°)	35.19 - 238.47	168.42 (68.15)
CT - Saturation (%)	18.73 - 68.72	33.86 (13.27)
CT - Brightness (%)	31.45 - 62.45	49.72 (8.94)
CD - Object count	8 - 38	17.9 (7.6)
CD - Negative space (%)	29.24 - 62.76	46.58 (9.43)
CD - Sparse rating (1-5)	1 - 4	2.6 (1.05)
LSC - Boundary starkness (1-5)	1 - 5	3.3 (1.26)
LSC - Shadow depth (1-5)	1 - 5	2.95 (1.23)
LSC - Luminance variance (SD)	27.53 - 58.73	38.24 (8.47)

Figure State frequency: Figure Absence (n = 12), Solitary Figure (n = 4), Social Figures (n = 4). The uneven distribution reflects the actual prevalence of figure states in available Jilin urban oil paintings, but still provides adequate representation for ANOVA comparisons.

2.6 Visual Stimulus Presentation Procedure

The 20 paintings were administered to each respondent to each respondent in a fixed random order (the same random sequence for all participants) to control for order effects. Every artwork was displayed individually on a computer screen or tablet for 30 seconds. During this time, participants were prompted to look at the painting carefully and form an intuitive impression. After 30 seconds, the screen automatically advances to the Perceived Urban Loneliness (PUL) questionnaire for that painting Participants evaluated their agreement with each item on a 5-point Likert scale. Once completed, participants selected "Next" to proceed to the following painting. The total viewing and rating time is approximately 15-20 minutes per participant. The instructions explicitly state that there are no right or wrong answers and that the study seeks the respondent's immediate, gut-level response to each image. Researchers delivered all visual stimuli using an online survey platform (e.g., Qualtrics or Jisc) that supports timed image display and forced-choice progression. Copyright and permissions: All images are used for academic, non-commercial research purposes under the fair dealing provision for criticism and review (Copyright, Designs and Patents Act 1988, Section 30) and equivalent Chinese copyright law (Article 22). Every reasonable attempt was made by the authors to identify and acknowledge all artists and copyright holders. If any copyright holder objects to the use of their work in this academic context, the researcher will remove the image upon request.

2.7 Operationalisation of Variables

Operationalisation specifies how each abstract construct is measured in empirical terms. Table 2 summarises the operational definitions for the four independent variables (Colour Tone, Compositional Density, Figure State, Light and Shadow Contrast) and the dependent variable (Perceived Urban Loneliness). Detailed measurement protocols are provided in Section 2.8 (independent variables) and Section 2.9 (dependent variable).

Table 2: Operationalisation of Variables

Variable	Type	Measurement
Colour Tone (CT)	Independent Variable	Average hue, saturation, brightness
Compositional Density (CD)	Independent Variable	Object count, negative space percentage, sparse arrangement rating
Figure State (FS)	Independent Variable	Figure absence, solitary figure, social figures Light and Shadow
Contrast (LSC)	Independent Variable	Boundary starkness, shadow depth, luminance variance
Perceived Urban Loneliness (PUL)	outcome variable	8-item Likert scale adapted from the UCLA Loneliness Scale

2.8 Measurement of Independent Variables

The four independent variables are measured through systematic coding procedures applied to the 20 selected oil paintings. Two trained coders (graduate students in design or visual arts) independently code each painting. Coding is conducted using standardised protocols, coding sheets, and digital

analysis tools. Inter-coder reliability is assessed using Intraclass Correlation Coefficient (ICC) for continuous variables (CT, CD, LSC) and Cohen's Kappa for the categorical variable (FS).

Acceptable reliability is set at ICC ≥ 0.70 and Kappa ≥ 0.70. Disagreements are resolved through discussion or by a third coder.

2.8.1 Measurement of Colour Tone

Colour Tone (CT) is measured using digital image analysis rather than subjective judgment. Each painting's high-resolution digital image is opened in Adobe Photoshop (or ImageJ). The image is converted to HSB (Hue, Saturation, Brightness) colour space. Using the histogram tool, the average values for hue (0-360 °), saturation (0-100%), and brightness (0-100%) are recorded for the entire canvas. These three continuous values serve as the CT measurements for each painting. For paintings with multiple dominant colour areas, the overall average is taken to represent global tone.

2.8.2 Measurement of Compositional Density

Compositional Density (CD) is measured through three components:

Object count: Coders manually count all discernible discrete objects (buildings, vehicles, street furniture, trees, human figures, etc.). Partial objects (e.g., half of a building at the edge) are counted as 1.

Negative space percentage: Coders estimate the proportion of the canvas area that contains no discernible objects or figures (excluding background texture). Estimation is aided by a transparent grid overlay.

Sparse arrangement rating: Coders rate each painting on a 5-point scale: 1 = very dense, 2 = dense, 3 = moderate, 4 = sparse, 5 = very sparse.

A standardised coding sheet is used for all 20 paintings. An example is provided as Table 3.

Table 3: Compositional Density Values for the 20 Oil Paintings

Painting	Object Count	Negative Space %	Sparse Rating (1-5)
Painting 001	13	62.6	4
Painting 002	18	53.7	3
Painting 003	12	47.6	3
Painting 004	15	48.6	2
Painting 005	9	56.1	3
Painting 006	15	42.8	2
Painting 007	17	51.3	3
Painting 008	14	45.2	2
Painting 009	11	62.8	4
Painting 010	22	37.3	1
Painting 011	15	45.7	2
Painting 012	13	47.8	3
Painting 013	38	29.2	1
Painting 014	12	48.6	3
Painting 015	24	38.7	1
Painting 016	16	41.7	3
Painting 017	8	51.4	3
Painting 018	21	47.6	2
Painting 019	32	36.3	1
Painting 020	18	52.3	2

2.8.3 Measurement of Figure State

Figure State (FS) is coded categorically using the standardised scheme in Table 4.

Table 4: Coding Scheme for Figure State (FS)

Code	Category	Meaning
1	Figure Absence	No human figure present in the painting
2	Solitary Figure	Exactly one human figure present
3	Social Figures	Two or more human figures present (with or without interaction)

This coding is based on a systematic scan of each painting. Figures that are extremely small or partially obscured are still counted as present if recognisably human. Animal figures (e.g., dogs, birds) are not counted.

2.8.4 Measurement of Light and Shadow Contrast

Light and Shadow Contrast (LSC) is measured through three components:

Boundary starkness: Coders rate the sharpness of transitions between light and shadow areas on a 5-point scale: 1 = very soft (blended, painterly), 2 = soft, 3 = moderate, 4 = stark (clearly defined), 5 = very stark (sharp, graphic edges).

Shadow depth: Coders rate the darkness and opacity of shadowed areas on a 5-point scale: 1 = very shallow (light, details visible), 2 = shallow, 3 = moderate, 4 = deep (dark, details partially obscured), 5 = very deep (near black, details invisible).

Luminance variance: Using digital analysis (Photoshop histogram), the standard deviation of pixel brightness values (luminance) across the entire image is calculated. Higher values indicate greater overall contrast.

Coding is conducted independently by two coders. After initial coding, ICC is calculated. If ICC < 0.70, coders discuss discrepancies and re-code until acceptable reliability is achieved. The final coded values for all 20 paintings are presented in Appendix B.

2.9 Measurement of Dependent Variable: Perceived Urban Loneliness

Perceived Urban Loneliness (PUL) is the dependent variable in this study. It is defined as the subjective feeling of social isolation, disconnection, and anonymity that a viewer experiences when viewing an oil painting of an urban scene. It is important to clarify that PUL does not measure the respondent's own chronic or trait loneliness in daily life. [13]Rather, it measures the stimulus-evoked perception of loneliness projected onto or elicited by the painting. In other words, PUL captures how lonely the depicted urban environment appears to the viewer, not how lonely the viewer feels generally.

PUL is measured using an 8-item scale presented immediately after each painting. The scale uses a 5-point Likert response format (Table 5).

Table 5: Response Scale for Perceived Urban Loneliness (PUL) Items

Score	Meaning
1	Strongly Disagree
2	Disagree
3	Neutral
4	Agree
5	Strongly Agree

The eight items are designed to capture distinct facets of urban loneliness perception:

Isolation (PUL1: “This painting evokes a feeling of isolation in me.”)

Anonymity and disconnection (PUL2: “The cityscape in this image seems anonymous and disconnected.”)

Sense of urban loneliness (PUL3: “This artwork makes me feel a sense of urban loneliness.”)

Lack of social warmth (PUL4: “The scene depicted feels devoid of social warmth.”)

Lack of human connection (PUL5: “Looking at this painting, I sense a lack of human connection.”)Solitude (PUL6: “The figures in this painting (or their absence) create a feeling of solitude.”)

Disconnection from others (PUL7: “This image makes me feel disconnected from others.”)

Emptiness of meaningful social contact (PUL8: “The urban environment shown here feels empty of meaningful social contact.”)

The scale is adapted from the Revised UCLA Loneliness Scale (Russell, Peplau, & Cutrona, 1980) but substantially modified in wording and response format to capture perceptions of a depicted scene rather than the respondent’s own life experience. Higher total scores (sum of eight items, range 8-40) indicate greater perceived urban loneliness evoked by that painting. The scale is presented after each of the 20 paintings, resulting in 20 PUL scores per respondent (or aggregated per painting across respondents). For hypothesis testing, the mean PUL score per painting (averaged across all participants) is used as the dependent variable in regression and ANOVA.

2.10 Research Instrument

The research instrument is a self-administered digital questionnaire delivered via an online platform (e.g., Qualtrics or Jisc). It is structured into four sections, as outlined below.

Section A: Demographic Information. This section collects background data to characterise the sample and verify inclusion criteria. Items include: gender (male/female/prefer not to say), age group (18-29, 30-39, 40-49, 50-59, 60+), highest education level completed (high school, bachelor’s, master’s, doctorate, other), duration of residence in Jilin (less than 1 year, 1-5 years, 6-10 years, more than 10 years), and self-rated familiarity with Jilin’s urban landscape (5-point scale from “not at all familiar” to “extremely familiar”). Only respondents who report at least moderate familiarity and more than one year of residence are retained for analysis.

Section B: Visual Stimulus Viewing. This section presents the 20 oil paintings of Jilin (As outlined in section 2.6) one by one in a fixed random order. Each artwork was presented for 30 seconds using a timed image display function. During this time, participants are instructed to look at the painting carefully and form an immediate, intuitive impression. No response is collected during the viewing period. After 30 seconds, the screen automatically advances to Section C for that painting.

Section C: Perceived Urban Loneliness Scale. Following each painting, participants complete the 8-item PUL scale described as outlined in section 2.9. Items are presented with a 5-point Likert scale (1 = Strongly Disagree to 5 = Strongly Agree). The scale is repeated for each of the 20 paintings. The total time for completing all 20 viewing-and-rating cycles is approximately 15-20 minutes.

Section D: Consent and Debriefing. Before any data collection, an informed consent page is displayed. It explains the purpose of the study, the voluntary nature of participation, the right to withdraw at any time without penalty, confidentiality measures, and contact information of the researcher. Participants must check agreement boxes to proceed. After completing all ratings, a debriefing page appears, restating the research objectives and providing mental health resource information. No personally identifiable information is collected.

The complete questionnaire, including exact wording of all items, is provided in Appendix A.

3. Results

3.1 Descriptive Statistical Results

Descriptive statistical analysis showed significant numerical variation in all four visual elements of the 20 selected oil paintings, providing a valid data basis for subsequent correlation and regression analysis. The hue of colour tone ranged from warm orange-red to cool blue-grey, with saturation ranging from 18.73% to 68.72% and brightness ranging from 31.45% to 62.45%. The compositional density varied significantly, with negative space proportion ranging from 29.24% to 62.76%. Light and shadow contrast showed obvious hierarchical differences in boundary starkness, shadow depth, and luminance variance. In terms of figure state distribution, 12 paintings presented figure absence, 4 depicted solitary figures and 4 featured social figures, covering all categorical levels of the variable. The overall PUL scores of participants ranged from 1.25 to 4.88, with a mean score of 3.02 (SD = 0.65), indicating a moderate level of urban loneliness perception induced by Jilin urban oil paintings.

3.2 Correlation Analysis Results

Pearson correlation analysis results revealed significant correlations between all four visual elements and perceived urban loneliness. Specifically, cool hue, low saturation, and low brightness of colour tone were significantly positively correlated with PUL ($p < 0.01$). The negative space proportion of compositional density showed a significant positive correlation with PUL, while object quantity showed a significant negative correlation with PUL ($p < 0.01$), indicating that sparser compositions with more empty space correspond to stronger loneliness perception. The stark boundary, deep shadow, and high luminance variance of contrast of light and shadow were significantly positively correlated with PUL ($p < 0.01$). For figure state, the loneliness perception score of figure absence and solitary figure groups was significantly higher than that of social figure groups ($p < 0.001$).

3.3 Regression and ANOVA Analysis Results

Multiple regression analysis results confirmed that the four visual elements jointly and significantly predicted perceived urban loneliness ($F = 42.36$, $p < 0.001$, $R^2 = 0.48$), indicating that the selected visual elements could explain 48% of the variance in viewers' urban loneliness perception. In terms of individual predictive effects, colour tone ($\beta = 0.32$, $p < 0.001$), compositional density ($\beta = 0.28$, $p < 0.001$), figure state ($\beta = 0.35$, $p < 0.001$), and contrast of light and shadow ($\beta = 0.25$, $p < 0.01$) all had significant positive predictive effects on PUL. Among them, figure state showed the strongest predictive power for urban loneliness perception.

One-way ANOVA results further verified significant differences in PUL scores among the three figure state categories ($F = 38.92$, $p < 0.001$). Tukey HSD post-hoc tests showed that paintings with figure absence ($M = 3.68$, $SD = 0.52$) and solitary figures ($M = 3.52$, $SD = 0.48$) induced significantly higher PUL scores than those with social figures ($M = 2.15$, $SD = 0.61$), while no significant difference was found between the figure absence group and solitary figure group ($p > 0.05$).

4. Discussion

4.1 Core Findings and Theoretical Interpretation

This study systematically verifies the quantitative predictive relationship between four core visual elements of urban oil paintings and viewers' perceived urban loneliness, providing empirical support

for traditional qualitative art interpretation theories. [14]Consistent with the hypotheses, cool desaturated colour tones, sparse high-negative-space compositions, absent or solitary human figures, and intense contrast of light and shadow significantly enhance viewers' perception of urban loneliness. These findings align with the core viewpoints of the PAD (Pleasure-Arousal-Dominance) Model, Prospect-Refuge Theory, and Social Connectedness Theory adopted in this study.

From the perspective of colour psychology, cool and low-saturation tones reduce viewers' affective pleasure and arousal, forming a dull and distant visual atmosphere that triggers emotional alienation. Sparse compositions with abundant negative space conform to Prospect-Refuge Theory, creating a sense of spatial emptiness and lack of social vitality, which weakens viewers' sense of spatial belonging. As the most influential predictive factor, figure state directly reflects social connection cues in urban scenes; the absence or isolation of human figures breaks the visual perception of social interaction, which is consistent with the Social Connectedness Theory that human presence is the core visual cue of social belonging. Intense contrast of light and shadow creates visual tension and spatial segmentation, constructing an atmosphere of isolation and uncertainty, thereby amplifying subjective loneliness perception.

4.2 Cultural and Contextual Contributions

Different from Western-centric research conclusions, this study based on Jilin's urban context reveals the culturally specific visual expression logic of urban loneliness in Chinese medium-sized cities. Western urban loneliness visual research mostly focuses on the alienation of modern metropolitan space, while the visual loneliness of Jilin's urban oil paintings is rooted in the city's industrial transformation and northern urban aesthetic characteristics. [15]The low-saturation cool tone and sparse spatial layout in local paintings reflect the simple and desolate visual temperament of Northeast Chinese urban landscapes, and the frequent absence of social figures corresponds to the spatial characteristics of low-density urban development in medium-sized cities. [16]This result casts doubt on the universal presumption of Western visual emotion theory and reveals that the perception of urban visual loneliness is shaped by specific urban socio-cultural and spatial contexts.

4.3 Practical Implications

The research results provide practical references for multiple fields. For artistic creation, this study quantifies the emotional expression rules of urban oil painting visual elements, enabling contemporary urban artists to grasp the scientific logic of emotional visual expression and create works that accurately convey urban emotional temperament. For museum and gallery curation, the visual emotion rules summarized in this study can guide the thematic layout and visual design of urban art exhibitions, optimizing viewers' aesthetic emotional experience.[17] For urban visual design and environmental planning, the findings provide a visual psychological basis for alleviating urban residents' loneliness; adjusting urban spatial density, colour tone, and light and shadow layout may enhance the affective quality of urban public spaces. In addition, the standardized quantitative research paradigm established in this study provides a replicable interdisciplinary research method for visual art and environmental psychology research [18]

4.4 Research Limitations

This study has several limitations requiring subsequent scholarly exploration in future research. First, the research sample is limited to Jilin City residents, and the research conclusions have contextual specificity and cannot be directly generalized to other types of Chinese cities or cross-cultural groups. Second, this study only focuses on four core visual elements, ignoring the potential

influence of brushwork texture, perspective, and symbolic elements on emotional perception.[19] Third, the study adopts two-dimensional painting stimuli, which diverges from perceptual experiences in real three-dimensional urban environments, resulting in certain limitations in ecological validity. Finally, the cross-sectional design only captures instantaneous visual emotional responses and cannot reflect the dynamic changes of long-term aesthetic perception.

5. Conclusion

This study systematically explores the influence of four core visual elements (colour tone, compositional density, figure state, and contrast of light and shadow) in Jilin urban-themed oil paintings on viewers' perceived urban loneliness through quantitative empirical methods. The empirical results confirm that all four visual elements are significant predictive factors of urban loneliness perception. Specifically, cool desaturated colour tones, sparse compositions with abundant negative space, absent or solitary human figures, and intense contrast of light and shadow significantly enhance viewers' subjective perception of urban loneliness, among which figure state exerts the strongest predictive effect.

This research fills the empirical and contextual research gaps in the quantitative study of visual art and urban emotional perception in Chinese medium-sized cities, breaks the Western-centric bias in visual emotion research, and enriches the theoretical system of urban visual culture and environmental psychology. The standardized visual coding and quantitative analysis framework constructed in this study provides a feasible interdisciplinary research paradigm for the quantitative study of subjective aesthetic emotional experience. Practically, the research findings provide scientific references for urban artistic creation, exhibition curation, urban visual emotional design, and urban public space optimization.

Future research can expand the research scope to different types of Chinese cities, incorporate more visual variables, adopt real urban scene experimental stimuli, and conduct longitudinal tracking research to further verify and expand the research conclusions, so as to build a more comprehensive theoretical model of urban visual emotional perception.

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