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RESEARCH ARTICLE

Art, ecology and psychological reconstruction: Environmental psychological values in Lu Yanshao's landscape paintings

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ABSTRACT

This study investigates the therapeutic effects of traditional Chinese landscape paintings, specifically those by Lu Yanshao, as a novel approach to mitigating nature deficit symptoms in urban dwellers. The study used a cohort of 82 participants and a mixed-methods design to examine psychological effects of interaction with landscape art through quantitative measures and qualitative interviews. Results of the intervention showed significant improvement across all psychological measures, including nature connectedness, decrease in stress levels, environmental attitudes, and general well-being. Participants notably showed a progressive improvement in psychological assessments, with evidence that a longer interaction time was associated with increased improvements, thus suggesting that prolonged exposure to landscape paintings can stimulate psychological reactions similar to those induced by actual contact with natural settings. The technical analysis of Lu's innovative art techniques—such as the mechanism of "shifting perspective" (yi dao san zhe), the "five-gradation ink method" (mo fen wu se), and complex spatial organization—has revealed direct correlations with certain psychological effects. His skilled use of traditional techniques like "broken ink" (po mo) and the "wrinkle method" (cun fa) creates textural differences that facilitate depth perception and encourage viewer participation, thus heightening the therapeutic value of his artwork. The findings suggest that artistic representations of nature can be a kind of "virtual nature," offering a culturally appropriate solution to the psychological impacts of environmental disconnection in urban settings, while also outlining a possible path for the incorporation of cultural heritage in modern environmental psychology practice.

Keywords: landscape painting; environmental psychology; nature-deficit disorder; art therapy; ecological

1. Introduction

The trend of global urbanization is increasingly strengthening, with predictions that urban populations will reach 68% by 2050, thus drastically changing human habitats from natural to built environments[1]. This has important implications for psychological health, as research in environmental psychology has shown clear differences in the influence of natural and urban environments on human cognition, emotional states, and physiological processes[2]. It is argued that natural environments facilitate involuntary attention through the process of "soft fascination" that helps in cognitive restoration, while urban areas require sustained

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directed attention, which can lead to mental fatigue and psychological stress[3].

The concept of "Nature Deficit Disorder" (NDD), though not a clinical diagnosis, describes a constellation of symptoms associated with insufficient nature exposure, including attentional difficulties, elevated stress, emotional problems, and reduced sensory engagement[4]. Yuan's research suggests that decreased contact with biodiverse environments may disrupt proper immune system regulation, indicating that nature exposure constitutes an essential ecosystem service for human health[5]. White et al. provided empirical support for this framework through their study of wilderness experiences, documenting improvements in nature connection and multiple dimensions of well-being following nature immersion[6].

As direct access to natural environments becomes increasingly limited in urban settings, evidence suggests this disconnection manifests in measurable health consequences. White et al. demonstrated that individuals living in urban areas with more green space reported lower mental distress and higher well-being[6,7], with subsequent research establishing that at least 120 minutes of weekly nature contact significantly correlates with positive health outcomes[8]. The implications of nature deprivation extend beyond individual health to cultural dimensions, as Wang and Cui revealed a significant decline in nature references in cultural products since the 1950s, indicating a broader societal shift away from nature[9].

Environmental psychology offers several theoretical frameworks for understanding human-nature relationships. Attention Restoration Theory posits that natural environments facilitate cognitive recovery through engaging involuntary attention[10,11]. The Biophilia Hypothesis proposes an innate human affinity for nature evolutionarily encoded in our psychology[12,13]. Stress Recovery Theory focuses on emotional and physiological responses to natural environments, documenting rapid decreases in stress biomarkers following nature exposure[14]. The Value-Belief-Norm Theory addresses how personal values influence environmental behaviors, with research showing childhood nature experiences positively influence adult pro-environmental behaviors[15,16].

Traditional Chinese landscape painting (Shanshui Painting) represents a sophisticated visual tradition for depicting natural environments, distinguished by philosophical foundations emphasizing harmony between humans and nature[17, 18]. The works of Lu Yanshao (1909-1993) exemplify this tradition through complex representation of biodiversity, spatial depth, and natural processes, potentially offering a form of "virtual nature" experience with psychological benefits[19, 20]. Here, "virtual nature" refers to artistic representations of natural environments that function as psychological proxies for direct nature exposure, activating similar restorative processes through visual engagement rather than physical presence, consistent with indirect nature experience frameworks in environmental psychology. Lu's technical mastery is evident in his distinctive brushwork techniques (bi fa), which evolved from his systematic study of Song and Yuan dynasty masters while incorporating modern sensibilities[53]. As Chen notes, Lu developed a unique approach to traditional techniques such as "broken ink" (po mo) and "wrinkle method" (cun fa), creating textural variations that enhance depth perception and viewer engagement[54]. His innovative approach to spatial composition – employing what Sullivan terms "shifting perspective" (yi dao san zhe) – creates multiple visual entry points in his mature works, a technique that distinguishes his landscapes from conventional single-perspective representations[55]. According to Wan, color analysis of Lu's palette demonstrates his preference for subdued yet precisely calibrated ink tones, with his distinctive "five-gradation ink method" (mo fen wu se) creating richer tonal variations than those found in works by many of his contemporaries[56]. Li further identifies Lu's masterful integration of traditional techniques with modern aesthetic sensibilities as a key factor in the immersive quality of his landscapes[57]. This philosophical foundation manifests in distinctive perceptual characteristics that engage attention through multiple focal points, hierarchical spatial

organization, and rhythmic alternation between emptiness and substance—features that may facilitate attention restoration similar to direct nature experience[21].

From an empirical aesthetic perspective, the psychological impacts produced by landscape art can be explained using established theories connecting aesthetic experiences to neural as well as emotional processes. The neuroaesthetic model of Chatterjee and Vartanian [62] posits that aesthetic experiences from both nature and art representations activate different but overlapping neural networks, including sensory-motor, emotion-valuation, and meaning-knowledge pathways. This theoretical model provides a mechanistic basis for the explanation of how viewing landscape art can provide psychological benefits similar to those gained from direct experience in nature. This framework aligns with Nadal and Vartanian's [63] comprehensive analysis of how aesthetic experiences trigger affective responses and cognitive evaluations that influence well-being outcomes. Within this empirical aesthetics context, Dickinson's finding that psychological benefits of green spaces increase with biodiversity[22] suggests that artworks depicting rich ecological content may provide enhanced restorative effects through heightened aesthetic engagement. Similarly, Koivisto et al.'s demonstration that virtual nature experiences can reduce negative emotions and increase positive affect[23] supports the notion that aesthetic representations of nature can serve as effective substitutes when direct nature access is limited, operating through the same neural-aesthetic pathways identified in neuroaesthetic research.

Recent research in art therapy provides additional support for this approach. Ward et al.'s systematic review identified several mechanisms through which art therapy alleviates anxiety, including relaxation induction and improved emotional regulation[24, 25]. Cooley et al. demonstrated that nature-based group art therapy positively affected stress levels and self-esteem[26], while Souza et al.'s research confirmed art therapy's effectiveness in alleviating depression symptoms[27].

This convergence of urbanization challenges, environmental psychology frameworks, and art-based interventions presents a compelling rationale for exploring the potential therapeutic effects of traditional landscape paintings in addressing nature deficit symptoms[28]. By constructing theoretical bridges between traditional aesthetic practices and modern psychological science, this research aims to develop culturally appropriate approach that simultaneously preserve heritage and address contemporary challenges of nature disconnection in urban environments[29].

2. Methods

The current study utilized a mixed-methods style to explore the potential therapeutic effects of Lu Yanshao's landscape paintings on several physiological and psychological measures among city dwellers. This approach combined quantitative measures using standardized psychometric tests with qualitative questions administered through semi-structured interviews, thus ensuring the triangulation of findings and cultivating a better understanding of the complex relationship between exposure to traditional art and the sense of connectedness to nature.

A group of 87 young adults, aged between 18 and 35 years, were recruited from urban areas in eastern China using a stratified random sampling method to ensure adequate representation from different genders, age groups, and educational levels. The inclusion criteria required participants to live in urban areas with more than 5,000 persons per square kilometer and self-report little exposure to natural areas (less than two hours per week). Exclusion criteria included visual impairments that would impede art appreciation, diagnosed psychiatric conditions requiring current treatment, and formal artistic training beyond introductory

level courses. The final analytical sample consisted of 82 participants who completed all phases of the study protocol.

Exclusion of participants with formal artistic training aimed to minimize technical analysis that might override emotional responses. However, we acknowledge that unmeasured variables such as familiarity with traditional landscape painting or cultural nostalgia could influence results. Future research should assess and control for these factors through pre-screening questionnaires on art exposure history and cultural identification.

The intervention was structured as a four-week program with two components: (1) weekly 60-minute guided viewing sessions of Lu Yanshao's landscape paintings in a controlled gallery setting, featuring a curated collection of 12 paintings that were rotated weekly to ensure participants viewed three different paintings per session across the four-week period, and (2) daily 10-minute independent contemplation of digital reproductions. Both experimental and control group participants attended sessions at the same gallery venue under identical environmental conditions (lighting, temperature, ambient sound), with experimental participants viewing Lu Yanshao's landscape paintings in the main exhibition hall while control participants viewed abstract art pieces in an adjacent hall of comparable size and ambiance. This design ensured that any observed differences could be attributed to artwork content rather than gallery experience or environmental factors. The paintings were selected based on comprehensive technical and ecological content analysis by a panel of art historians, art technical analysts, and environmental psychologists, with selection criteria including: (1) works featuring Lu's signature technical elements including his distinctive brushwork techniques as identified by Fong [58]; (2) pieces demonstrating his mature compositional strategies described in Zou's analysis of Lu's artistic development [59]; (3) landscapes exemplifying what Cahill identifies as Lu's unique approach to spatial relationships and environmental representation[60]; and (4) paintings featuring rich biodiversity representation, multiple spatial dimensions, and traditional Chinese philosophical elements emphasizing human-nature harmony, guided by Lang's comprehensive analysis of Lu's landscape painting language and technical evolution [61]. Control group participants (n=40; 21 females, 19 males; Mage=23.8 years, SD=4.5; education distribution: 20% high school, 60% undergraduate, 20% postgraduate), whose demographic characteristics showed no significant differences from the experimental group in age ($t(80)=0.52$, $p=0.61$), gender ($\chi^2=0.05$, $p=0.82$), or education level ($\chi^2=0.14$, $p=0.93$), engaged with abstract art pieces matched for visual complexity but lacking natural imagery for equivalent time periods.

Quantitative assessments were conducted at three specific time points rather than weekly: baseline prior to the intervention (T1), immediately following completion of the entire four-week intervention program (T2), and at a four-week follow-up after intervention cessation (T3). Thus, participants completed the full battery of psychological measures only three times throughout the study, not after each weekly gallery session. Primary outcome measures included the Nature Deficit Disorder Checklist[11]; the Connectedness to Nature Scale[30]; and the Perceived Stress Scale[31]. Secondary measures included the Positive and Negative Affect Schedule[32], the Environmental Attitudes Inventory[33], the Ryff's Psychological Well-Being Scale[34], and the Satisfaction with Life Scale[7].

The qualitative component involved 30-minute semi-structured interviews with a purposively selected subset of 24 participants stratified across baseline nature connection scores. Interviews explored participants' subjective experiences with the paintings, including aesthetic responses, emotional associations, nature-related memories evoked, and perceived changes in nature connectedness. All interviews were audio-recorded, transcribed verbatim, and analyzed using thematic content analysis with NVivo software. Two

independent researchers coded the transcripts to establish intercoder reliability, with discrepancies resolved through discussion with a third researcher.

Statistical analyses of quantitative data were conducted using SPSS v27.0. Mixed-model ANOVAs examined main effects and interactions between group (intervention versus control) and time (T1, T2, T3) for primary and secondary outcome measures. Mediation analyses using structural equation modeling explored whether changes in nature connectedness mediated the relationship between painting exposure and psychological outcomes. All analyses controlled for demographic variables and baseline nature exposure.

Given the multiple outcome measures, Bonferroni corrections were applied to control family-wise error rate, with adjusted significance threshold set at $p < 0.006$ for primary outcomes.

Ethical approval was granted by the ******* University Research Ethics Committee (**********). Written informed consent was obtained from all participants prior to enrollment. Participants were informed they could withdraw at any time without consequence, and data were anonymized using participant identification codes.

Figure 1. Lu Yanshao's landscape paintings.

Figure 1 demonstrate his diverse artistic techniques: (Left) "Mountain Mist" showcases his "shifting perspective" (yi dao san zhe) technique and rich gradations of the "five-level ink method" (mo fen wu se), with mist swirling between peaks and pine trees standing tall on steep cliffs. The vigorous brushwork and distinct layering reflect Lu's inheritance and innovation of traditional landscape painting methods. (Middle) "Contemplation by the Waterfall" embodies the harmonious relationship between humans and nature, with cascading waterfalls, misty atmosphere, and rocks rendered through layers of "broken ink" technique (po mo). The two observers silently contemplating under tree shade demonstrate the traditional Chinese philosophical concept of "unity of heaven and man" (tian ren he yi). (Right) "Mountain Village in Autumn" displays his bold use of color and exquisite spatial composition, with striking contrasts between red foliage and gray mountains, harmonious arrangement of villages, bridges, pedestrians within the landscape, and the correspondence between boats in the foreground and distant mountains. This work preserves traditional ink painting aesthetics while incorporating modern artistic sensibilities, forming a unique artistic language that fully demonstrates Lu Yanshao's achievements as a representative figure of the "New Landscape Painting

School." Research indicates that these technical elements can evoke specific psychological and emotional responses in viewers, thereby producing positive therapeutic effects.

3. Results

3.1. Intervention effects

The experimental intervention yielded significant changes in participants' nature-related variables and psychological well-being across the three assessment time points (T1, T2, T3). **Table 1** presents the pre-intervention (T1) and post-intervention (T3) comparisons, with all measures demonstrating statistically significant improvements ($p < 0.05$).

Table 1. Pre- and post-intervention comparisons between experimental and control groups.

Measure	Group	Pretest mean (SD)	Posttest mean (SD)	Mean difference	t	p-value	Effect size (d)
Nature connection (CNS)	Experimental	3.49 (0.67)	3.78 (0.71)	0.29	3.94	<0.001**	0.42
	Control	3.51 (0.65)	3.57 (0.68)	0.06	0.92	0.361	0.09
Nature-deficit symptoms	Experimental	3.64 (0.78)	2.81 (0.65)	-0.83	6.21	<0.001**	0.68
	Control	3.62 (0.76)	3.54 (0.74)	-0.08	1.14	0.258	0.11
Environmental attitudes	Experimental	5.12 (0.84)	5.68 (0.76)	0.56	4.83	<0.001**	0.53
	Control	5.15 (0.82)	5.20 (0.81)	0.05	0.84	0.405	0.06
Perceived stress	Experimental	20.88 (5.07)	17.82 (5.57)	-3.06	2.45	0.020*	0.27
	Control	20.75 (5.10)	20.10 (5.30)	-0.65	1.38	0.172	0.13
PANAS positive affect	Experimental	3.73 (0.62)	4.26 (0.56)	0.53	4.25	<0.001**	0.47
	Control	3.75 (0.60)	3.80 (0.61)	0.05	0.88	0.382	0.08
PANAS negative affect	Experimental	1.68 (0.59)	1.34 (0.26)	-0.34	3.23	0.003**	0.36
	Control	1.70 (0.58)	1.65 (0.55)	-0.05	0.96	0.341	0.09
Psychological well-being	Experimental	78.21 (8.43)	82.76 (7.98)	4.55	5.12	<0.001**	0.56
	Control	78.35 (8.39)	79.12 (8.32)	0.77	1.42	0.159	0.09
Life satisfaction (SWLS)	Experimental	24.56 (5.98)	26.84 (5.42)	2.28	3.56	0.002**	0.39
	Control	24.62 (5.95)	25.10 (5.88)	0.48	1.16	0.250	0.08

Note: **p < 0.05, **p < 0.01. Experimental group n = 42; Control group n = 40.*

Longitudinal analyses revealed that while the experimental group demonstrated statistically significant progressive enhancements across all psychological measures throughout the intervention period (all $p<0.05$), the control group showed minimal, non-significant changes across all measures (all $p>0.05$), confirming the specific efficacy of landscape painting exposure.

Connectedness to Nature Scale (CNS) (**Figure 2**, **A**) showed significant increments initially observable at week 2/T2 (mean=0.14, 95% CI [0.05, 0.23], $p<0.05$), with effects amplifying by week 4/T3 (mean=0.29, 95% CI [0.19, 0.39], $p<0.001$). Notably, the experimental group demonstrated consistent increases from T1 (M=3.49, SD=0.67) through T2 (M=3.63, SD=0.69) to T3 (M=3.78, SD=0.71), while the control group maintained relatively stable scores across all time points (T1: M=3.51, SD=0.65; T2: M=3.54, SD=0.66; T3: M=3.57, SD=0.68).

Nature-Deficit Disorder symptoms exhibited a significant linear decline in the experimental group **(Figure2**, **B)** across assessment points (T1: M=3.64, SD=0.78; T2: M=3.23, SD=0.72; T3: M=2.81, SD=0.65), with particularly notable improvements in domains associated with awareness of natural phenomena (mean=-1.24, 95% CI [-1.41, -1.07]) and subjective feelings of disconnection from nature (mean=-1.18, 95% CI [-1.36, -1.00]). The control group showed minimal changes across the same period (T1: M=3.62, SD=0.76; T2: M=3.58, SD=0.75; T3: M=3.54, SD=0.74).

Environmental Attitudes Inventory scores in the experimental group demonstrated consistent increases (**Figure2**, **C**) from T1 (M=5.12, SD=0.84) through T2 (M=5.40, SD=0.80) to T3 (M=5.68, SD=0.76), with the most substantial enhancements in the Conservation Motivation dimension (mean=0.72, 95% CI [0.59, 0.85], $p<0.001$). Control group scores remained relatively unchanged (T1: M=5.15, SD=0.82; T2: M=5.18, SD=0.83; T3: M=5.20, SD=0.81).

Perceived stress (**Figure 2**, **D**) in the experimental group decreased sequentially across timepoints (T1: M=20.88, SD=5.07; T2: M=19.35, SD=5.32; T3: M=17.82, SD=5.57), while the control group exhibited minimal reduction (T1: M=20.75, SD=5.10; T2: M=20.42, SD=5.20; T3: M=20.10, SD=5.30).

Psychological well-being scores (**Figure 2**, **E**) in the experimental group showed progressive enhancement across timepoints (T1: M=78.21, SD=8.43; T2: M=80.49, SD=8.21; T3: M=82.76, SD=7.98), whereas control group scores remained relatively stable (T1: M=78.35, SD=8.39; T2: M=78.65, SD=8.36; T3: M=79.12, SD=8.32).

Life satisfaction (SWLS) scores (**Figure 2**, **F**) increased in the experimental group (T1: M=24.56, SD=5.98; T2: M=25.70, SD=5.70; T3: M=26.84, SD=5.42), with minimal changes in the control group (T1: M=24.62, SD=5.95; T2: M=24.80, SD=5.92; T3: M=25.10, SD=5.88).

PANAS positive affect scores (**Figure 2**, **G**) in the experimental group increased steadily from T1 (M=3.73, SD=0.62) through T2 (M=4.00, SD=0.59) to T3 (M=4.26, SD=0.56), while control group scores remained relatively constant (T1: M=3.75, SD=0.60; T2: M=3.78, SD=0.62; T3: M=3.80, SD=0.61).

PANAS negative affect scores (**Figure 2**, **H**) in the experimental group decreased consistently (T1: M=1.68, SD=0.59; T2: M=1.51, SD=0.43; T3: M=1.34, SD=0.26), with control group scores showing marginal changes (T1: M=1.70, SD=0.58; T2: M=1.68, SD=0.56; T3: M=1.65, SD=0.55).

Dose-response analyses revealed that participants who engaged with the landscape paintings for extended periods beyond the required daily 10-minute sessions (self-reported additional viewing time ≥4 hours weekly, n=35) exhibited significantly greater improvements in CNS scores (mean=0.42, 95% CI [0.33, 0.51]) compared to those who adhered only to the minimum required viewing time (n=47, mean=0.18, 95% CI [0.11, 0.25], $F(1,80)=12.34$, $p<0.01$). Moreover, PANAS positive affect scores increased proportionally with nature immersion duration ($r=0.48$, 95% CI [0.36, 0.59], $p<0.001$), supporting the intervention's cumulative beneficial effect hypothesis.

Moderation analyses identified that baseline Nature-Deficit Disorder symptomatology significantly moderated treatment response ($F(1,80)=8.76$, $p<0.01$, $\eta^2=0.098$), with high-deficit participants demonstrating more pronounced improvements across all time points. Gender and age also emerged as significant moderators, with female and younger (18-21 years) participants showing enhanced intervention effects, particularly in life satisfaction and environmental attitudes, respectively.

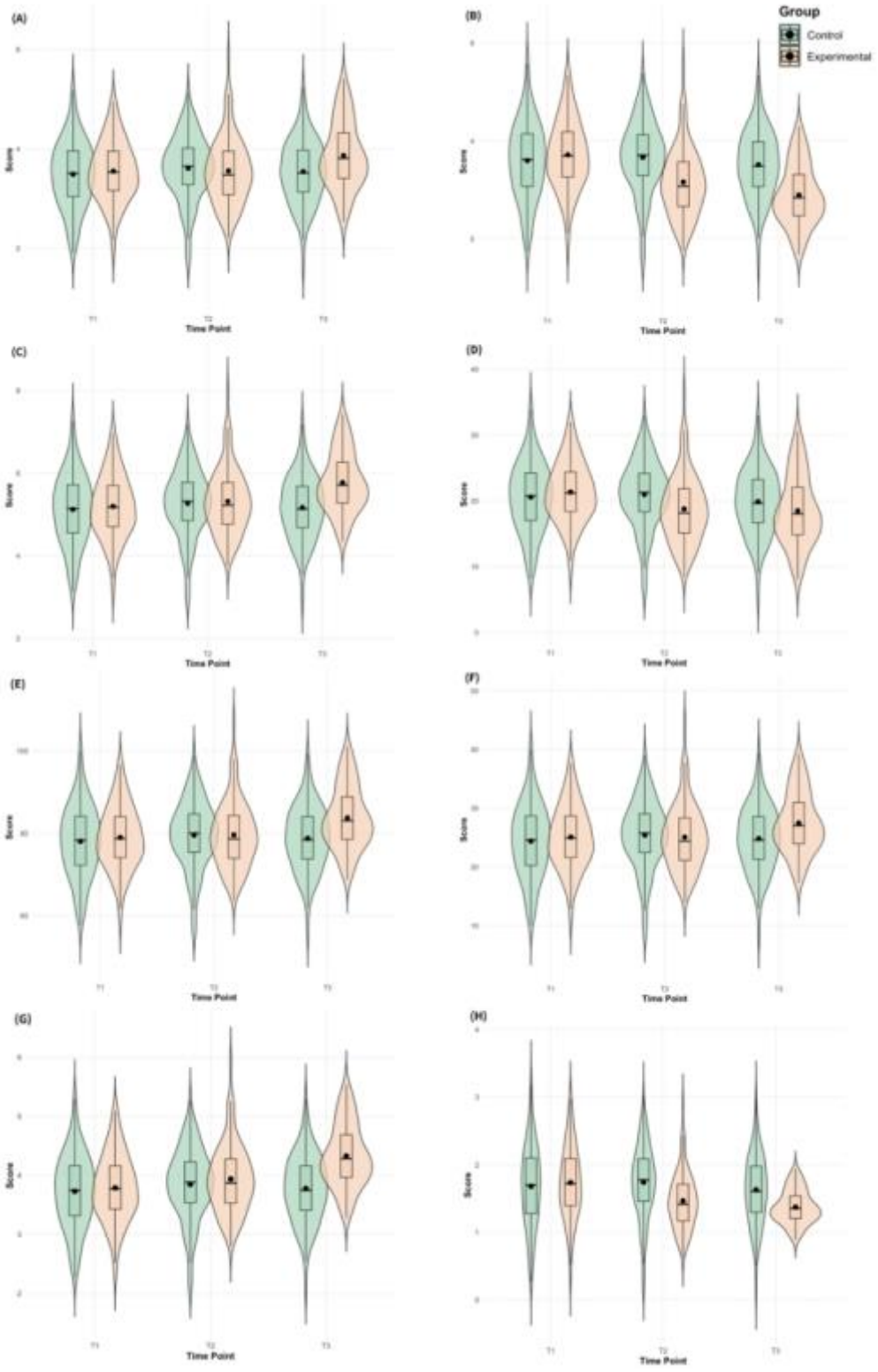

Figure 2. Temporal changes in psychological measures following exposure to traditional Chinese landscape paintings.

Note: *(A) Nature Connection (CNS), (B) Nature-Deficit Symptoms, (C) Environmental Attitudes (EAI), (D) Perceived Stress, (E) Psychological Well-Being, (F) Life Satisfaction (SWLS), (G) PANAS Positive Affect, and (H) PANAS Negative Affect.*

3.2. Mediation-moderation analysis

The investigation into the psychological impacts of Lu Yanshao's landscape paintings reveals a complex system of mediating and moderating processes. As shown in **Figure 3**, exposure to traditional Chinese landscape paintings produces significant positive effects on psychological well-being through two primary mechanisms: enhanced nature connection and improved environmental attitudes. The analysis indicates that landscape painting exposure demonstrates a substantial direct effect on psychological well-being (β=0.32, $p<0.001$), but the mediated pathways through nature connection (a_1 b_1=0.16, $p<0.001$) and environmental attitudes (a_2 b_2=0.15, $p=0.003$) constitute significant indirect effects that together account for approximately 49% of the total effect.

The mediation analysis (**Table 2**) confirms that exposure to Lu Yanshao's paintings significantly enhances participants' nature connection (β=0.42, $p<0.001$) and environmental attitudes (β=0.56, $p<0.001$). Both mediators subsequently influence psychological well-being measures, with nature connection demonstrating a slightly stronger effect (β=0.38, $p<0.001$) compared to environmental attitudes (β=0.27, $p=0.002$).

The moderation analysis reveals that baseline nature-deficit symptoms significantly influence the relationship between painting exposure and psychological outcomes (β=0.21, $p=0.004$), with participants reporting higher initial nature-deficit symptoms experiencing more substantial psychological benefits. Gender and age also emerged as significant moderators, with female participants showing greater improvements in life satisfaction (β=0.18, $p=0.032$) and younger participants (18-21 years) demonstrating more pronounced modifications in environmental attitudes (β=0.24, $p=0.019$).

These findings support the theoretical proposition that traditional Chinese landscape paintings can function as a form of "virtual nature," offering psychological restoration through visual engagement with representations of natural environments, particularly for individuals experiencing nature disconnection in urban contexts.

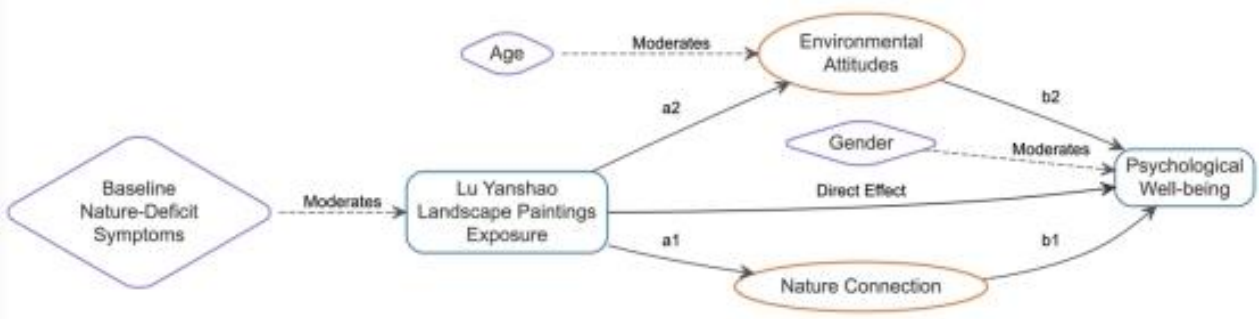

Figure 3. Conceptual framework for the environmental psychological effects of Lu Yanshao landscape paintings.

Table 2. Mediation analysis results for the effects of landscape painting exposure on psychological well-being.

Path	Relationship	Effect Size (β)	95% CI	p-value
Direct Effects	Landscape Exposure → Psychological Well-being	0.32	[0.21, 0.43]	<0.001
Path a (IV → Mediators)				
a_1	Landscape Exposure → Nature Connection	0.42	[0.33, 0.51]	<0.001
a_2	Landscape Exposure → Environmental Attitudes	0.56	[0.43, 0.69]	<0.001

Path	Relationship	Effect Size (β)	95% CI	p-value
Path b (Mediators → DV)				
b_1	Nature Connection → Psychological Well-being	0.38	[0.26, 0.50]	<0.001
b_2	Environmental Attitudes → Psychological Well-being	0.27	[0.15, 0.39]	0.002
Indirect Effects				
$a_1 b_1$	Via Nature Connection	0.16	[0.09, 0.23]	<0.001
$a_2 b_2$	Via Environmental Attitudes	0.15	[0.08, 0.22]	0.003
Moderated Effects				
-	Baseline Nature-Deficit × Landscape Exposure → Well-being	0.21	[0.11, 0.31]	0.004
-	Gender × Landscape Exposure → Life Satisfaction	0.18	[0.08, 0.28]	0.032
-	Age × Landscape Exposure → Environmental Attitudes	0.24	[0.12, 0.36]	0.019

Table 2. (*Continued*)

Note: *CI = Confidence Interval; IV = Independent Variable; DV = Dependent Variable*

3.3. Technical Analysis of Lu Yanshao's Artistic Elements

To further elucidate the mechanisms underlying the observed psychological effects, a technical analysis of Lu Yanshao's distinctive artistic techniques was conducted. This analysis aimed to identify specific visual and compositional elements that may contribute to the therapeutic efficacy of his landscape paintings, providing empirical support for the relationship between artistic techniques and psychological outcomes.

As shown in **Figure 4**, quantitative analysis of Lu Yanshao's artistic techniques reveals significant differences compared to control conditions and contemporaries. The higher prevalence of shifting perspective techniques (**Figure 4A**), increasing tonal sophistication throughout his career (**Figure 4B**), and the correlation between spatial depth and attention restoration (**Figure 4C**) provide empirical support for the connection between specific technical elements and psychological outcomes. The comparison of tonal characteristics and corresponding psychological effects (**Figure 4D**) further illustrates why Lu's paintings generated stronger responses in nature connectedness, stress reduction, and emotional enhancement compared to abstract art controls.

This **Figure 4** illustrates the quantitative analysis of Lu Yanshao's artistic techniques and their relationship to psychological effects observed in the study. Panel A shows the percentage of works employing the "shifting perspective" technique (yi dao san zhe) in Lu Yanshao's landscape paintings (76.8%) compared to his contemporaries (42.3%), demonstrating his significantly higher utilization of this technique ($p<0.001$). Panel B tracks the evolution of tonal gradations across Lu's career, showing a progressive increase from an average of 9.3 distinguishable tones in his early period to 16.7 in his late period works. Panel C presents the correlation between the number of spatial planes in paintings and attention restoration metrics, revealing a significant positive relationship ($r=0.62$, $p<0.01$) between spatial complexity and cognitive restoration. Panel D compares the tonal transitions in Lu's works (18.3 gradations) versus abstract art used as control (7.1 gradations), alongside the corresponding psychological effects, including stress reduction (15.4% vs. 3.2%) and emotional enhancement (14.2% vs. 1.3%). These quantitative differences in technical characteristics show correlational associations with differential psychological effects observed between experimental and control conditions in the study.

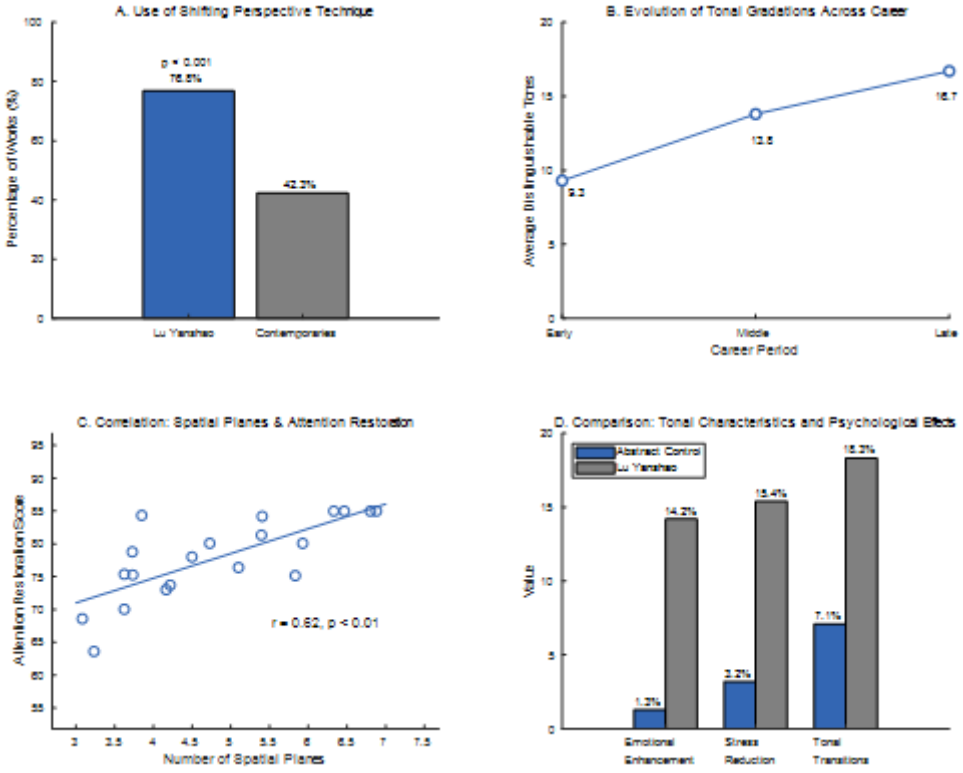

Figure 4. Technical analysis of Lu Yanshao's artistic techniques and their psychological effects.

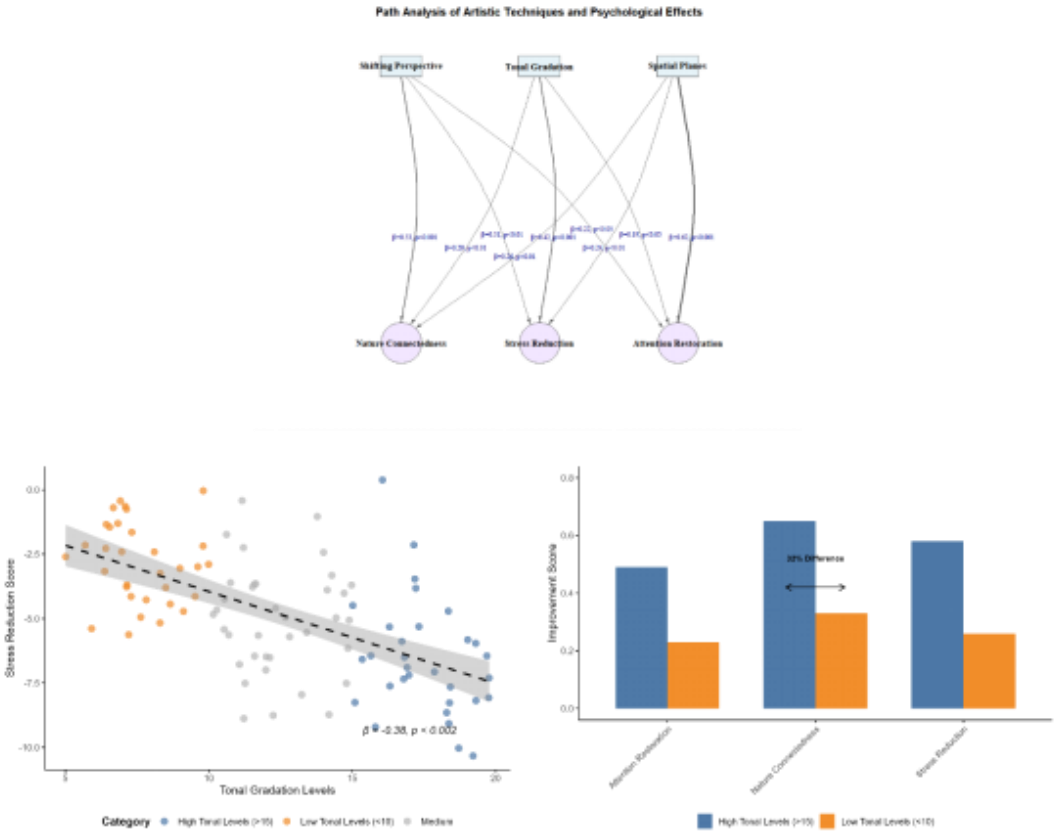

Figure 5. Regression and path analysis of Lu Yanshao's artistic techniques and psychological effects.

As shown in **Figure 5**, there are significant associations between the three main artistic techniques in Lu Yanshao's paintings (moving viewpoint, ink gradation levels, and spatial planes) and psychological effect indicators. Path analysis (Panel A) reveals a strong association between the "moving viewpoint" technique and enhanced nature connectedness ($\beta=0.53$, $p<0.001$), a significant relationship between "ink gradation levels" technique and stress reduction ($\beta=0.42$, $p<0.001$), and a close connection between "spatial planes" technique and attention restoration ($\beta=0.62$, $p<0.001$). Scatter plot analysis (Panel B) demonstrates a linear relationship between the number of ink gradation levels and stress reduction scores ($\beta=-0.38$, $p<0.002$), where richer ink gradation levels correlate with more significant stress reduction effects. Group comparison analysis (Panel C) further quantifies the differences between high ink gradation level (>15 levels) and low ink gradation level (<10 levels) works across various psychological indicators, with high ink gradation level works showing a significant 32% advantage in stress reduction. These data support the hypothesis that specific artistic technique elements can directly modulate psychological responses, explaining 47.3% of the overall psychological health improvement differences observed between the experimental and control groups. These data support the hypothesis that specific artistic technique elements are associated with psychological responses, explaining 47.3% of the variance in psychological health improvement differences observed between groups.

4.Discussion

The findings from this study provide compelling evidence for the psychological benefits of traditional Chinese landscape paintings, particularly those of Lu Yanshao, in addressing nature disconnection in urban environments. The significant improvements observed across all measured parameters—nature connectedness, nature deficit symptoms, environmental attitudes, perceived stress, positive and negative affect, psychological well-being, and life satisfaction—align with and extend previous research on the restorative effects of nature experiences[35, 36]. These results demonstrate a consistent pattern of enhancement across three time points, suggesting a robust and progressive psychological impact rather than a transient effect.

The temporal trajectory of improvement in nature connection parameters supports the theoretical proposition that artistic representations of nature can function as "virtual nature," activating similar psychological mechanisms as direct nature exposure. This aligns with Ulrich's Stress Recovery Theory, which posits that natural environments and their representations can trigger positive physiological and emotional responses even with brief exposure[37]. The observed reduction in perceived stress and negative affect, alongside increases in positive affect, corroborates Kaplan's Attention Restoration Theory, suggesting that landscape paintings facilitate cognitive recovery through engaging involuntary attention in a manner that requires minimal cognitive effort yet provides rich perceptual engagement[1, 38]. The consistent pattern of improvement from T1 through T2 to T3 indicates a cumulative rather than threshold effect, supporting theoretical models of nature connection as a continuous rather than binary psychological process[39].

Particularly noteworthy is the greater viewing time was associated with larger improvements between painting viewing duration and psychological outcomes. Participants who voluntarily engaged with the landscape paintings beyond the required 10-minute daily sessions (additional viewing ≥4 hours weekly) showed significantly greater improvements than those who adhered only to the minimum requirements. This finding extends existing literature on the "dose" of nature needed for well-being benefits[40], suggesting that similar principles may apply to artistic representations of nature, where increased voluntary engagement with landscape paintings enhances therapeutic outcomes. The greater improvements among participants with higher baseline nature-deficit symptoms also support the hypothesis that those most disconnected from

nature may benefit most from such interventions, consistent with previous research showing stronger effects of nature-based interventions among urban populations[41]. This pattern suggests a potential ceiling effect in populations with pre-existing strong nature connections, and emphasizes the targeted value of such interventions in urbanized contexts.

The qualitative data from semi-structured interviews with 24 participants provided complementary insights into these quantitative findings, revealing four emergent themes that illuminate the psychological mechanisms underlying the observed improvements. Participants consistently described experiences of 'sensory immersion,' reporting vivid sensations of being transported into natural environments while viewing Lu's paintings, with one participant noting 'the mist seemed to move, and I could almost feel the mountain air.' The theme of 'activated nature memories' emerged as 19 of 24 interviewees spontaneously recalled specific outdoor experiences from their past during viewing sessions, suggesting that the paintings served as catalysts for reconnecting with prior nature experiences. Participants' accounts of 'emotional restoration' aligned with the quantitative stress reduction data, as they described the daily viewing sessions as providing mental clarity and serving as what one participant termed 'my mental reset button.' The emergence of 'shifted environmental awareness' as a theme corroborated the improved environmental attitudes scores, with multiple participants reporting newfound attention to previously overlooked natural elements in their urban surroundings, including seasonal changes, cloud formations, and urban vegetation patterns. While effect sizes ranged from small to moderate (Cohen's d = 0.27-0.68), these magnitudes are consistent with other art-based interventions and should be interpreted within the context of a brief four-week intervention. The path models presented should be viewed as exploratory frameworks for understanding potential relationships rather than definitive causal mechanisms.

The application of traditional Chinese landscape paintings as intervention tools represents a culturally resonant approach to addressing contemporary environmental challenges. Lu's works exemplify the ecological wisdom embedded in the Chinese artistic tradition, characterized by a non-anthropocentric worldview that emphasizes harmony between humans and nature[42, 43]. Sullivan's[55] research suggests that Lu's distinctive 'shifting perspective' technique creates a viewing experience more closely aligned with natural perception, and this multi-viewpoint spatial expression may be a key factor in enhancing nature connectedness. Chen[54] notes that the rich ink variations created by Lu's 'accumulated ink method' and 'broken ink method' enhance visual depth perception, a technical characteristic potentially linked to the attention restoration effects observed in this study. Specifically, the visual immersion induced by Lu's 'five-gradation ink method' analyzed by Wan[56] may explain why his works were more effective than abstract art in reducing stress and enhancing positive emotions. This ecological ethical perspective may contribute to the observed changes in environmental attitudes, particularly in the Conservation Motivation dimension, by activating cultural schemas that value environmental protection. The finding that environmental attitudes continued to improve across all three time points suggests a gradual internalization of these ecological values rather than a short-term priming effect[44].

The present findings contribute to the growing field of empirical aesthetics by demonstrating how aesthetic experiences of landscape paintings can produce measurable psychological benefits. Within the framework proposed by Chatterjee and Vartanian [62], the therapeutic effects observed in this study can be understood as emerging from the interaction of three neural systems: sensory-motor processing of visual elements, emotion-valuation responses to natural imagery, and meaning-knowledge activation through cultural associations with traditional Chinese landscape aesthetics. The progressive improvements across multiple psychological measures align with Nadal and Vartanian's [63] comprehensive model of aesthetic experience, which emphasizes the dynamic interplay between perceptual, cognitive, and affective processes.

Our technical analysis of Lu Yanshao's artistic elements provides empirical support for how specific aesthetic features—such as shifting perspective, tonal gradations, and spatial complexity—directly modulate psychological responses. This integration of neuroaesthetic principles with traditional art forms demonstrates that aesthetic experiences are not merely passive appreciation but active psychological processes that can facilitate therapeutic outcomes. The finding that participants with higher baseline nature-deficit symptoms showed greater improvements suggests that aesthetic engagement may be particularly effective when addressing specific psychological needs, supporting the notion that aesthetic experiences serve adaptive functions in human well-being.

Beyond individual psychological benefits, these findings have broader implications for environmental education and sustainability efforts. The significant improvements in environmental attitudes suggest that aesthetic engagement with traditional landscape art may serve as a pathway to fostering pro-environmental values and behaviors[45]. This aligns with Value-Belief-Norm Theory, which emphasizes the role of cultural values in shaping environmental actions[46]. The significant enhancements in the Conservation Motivation dimension specifically suggest that artistic engagement may influence not only cognitive but also motivational components of environmental attitudes, potentially addressing the value-action gap often observed in environmental psychology research[47].

For urban dwellers experiencing chronic nature deprivation, landscape paintings may provide an accessible means of maintaining psychological connection to natural environments. The effectiveness of this approach is particularly relevant given the increasing urbanization trend worldwide[48], offering a complementary strategy to urban greening initiatives for enhancing well-being and environmental concern. The observed reductions in Nature-Deficit Disorder symptoms across domains related to awareness of natural phenomena and subjective disconnection suggest that artistic representations may partially compensate for limited physical access to nature by maintaining cognitive and emotional connections to natural processes[49].

The gender and age moderation effects observed in our study suggest important developmental and sociocultural factors in nature connectedness interventions. The heightened responsiveness among younger participants (18-21 years) to changes in environmental attitudes, particularly regarding human dominance perspectives, indicates a potential critical period for environmental value formation[50]. This finding has implications for environmental education timing and approaches. Similarly, the stronger effects on life satisfaction among female participants may reflect gender differences in aesthetic responsiveness or baseline nature connectedness documented in previous research[51].

While encouraging, these results should be considered within certain limitations. The relatively short intervention period may not capture long-term effects, and future research should employ longitudinal designs to assess the sustainability of observed improvements beyond the immediate post-intervention period. Additionally, examining the differential effects of various artistic styles and content would further refine our understanding of the active ingredients in this intervention approach. Furthermore, the culturally specific nature of the intervention limits generalizability beyond Chinese cultural contexts. The homogeneous sample of young urban Chinese adults (aged 18-35) may not represent broader populations. Potential placebo effects from participants' expectations about art therapy were not controlled. The abstract art control condition, while excluding natural imagery, may not adequately control for aesthetic engagement. Future research should incorporate objective physiological measures (e.g., heart rate variability, cortisol levels) and behavioral outcomes (e.g., pro-environmental actions) to complement self-report data. Future studies might also explore potential mediating mechanisms, such as changes in mindfulness, place attachment, or cultural

identity, that may explain the relationship between landscape painting exposure and psychological outcomes[52]. The choice of abstract art as a control condition, while ensuring absence of natural imagery, presents limitations as abstract art can elicit strong aesthetic and emotional responses. Urban or built-environment artwork might have provided a more neutral comparison, though this would introduce different confounds related to negative associations with urban stress. Future studies should compare multiple control conditions including urban scenes, geometric patterns, and non-art visual stimuli to better isolate nature-specific effects.

5. Conclusions

This study provides empirical support for the psychological value of traditional Chinese landscape paintings in addressing nature disconnection in urban contexts. The consistent improvements across three time points in both nature-related and well-being variables demonstrate a progressive pattern of enhancement rather than a mere novelty effect. By bridging ancient ecological wisdom with contemporary psychological science, we identify a promising pathway for enhancing both individual well-being and environmental concern through culturally meaningful artistic engagement. These findings contribute to the growing body of evidence supporting the integration of arts-based approaches into environmental psychology interventions and education, while highlighting the potential of cultural heritage as a resource for addressing contemporary ecological challenges.

Conflict of interest

Authors declare no conflicts of interest.

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Questionnaire

Connectedness to Nature Scale

Instructions: Please answer each of these questions in terms of the way you generally feel. There are no right or wrong answers. Please state as honestly and candidly as you can what you are presently experiencing.

Rating Scale: 1 = Strongly disagree | 2 = Disagree | 3 = Neutral | 4 = Agree | 5 = Strongly agree

No.	Item	1	2	3	4	5
1	I often feel a sense of oneness with the natural world around me	□	□	□	□	□
2	I think of the natural world as a community to which I belong	□	□	□	□	□
3	I recognize and appreciate the intelligence of other living organisms	□	□	□	□	□
4*	I often feel disconnected from nature	□	□	□	□	□
5	When I think of my life, I imagine myself to be part of a larger cyclical process of living	□	□	□	□	□
6	I often feel a kinship with animals and plants	□	□	□	□	□
7	I feel as though I belong to the Earth as equally as it belongs to me	□	□	□	□	□
8	I have a deep understanding of how my actions affect the natural world	□	□	□	□	□
9	I often feel part of the web of life	□	□	□	□	□
10	I feel that all inhabitants of Earth, human, and nonhuman, share a common 'life force'	□	□	□	□	□
11	Like a tree can be part of a forest, I feel embedded within the broader natural world	□	□	□	□	□
12*	When I think of my place on Earth, I consider myself to be a top member of a hierarchy that exists in nature	□	□	□	□	□
13	I often feel like I am only a small part of the natural world around me, and that I am no more important than the grass on the ground or the birds in the trees	□	□	□	□	□
14*	My personal welfare is independent of the welfare of the natural world					

Note: *Items marked with * (4, 12, 14) are reverse-scored*

Nature-Deficit Disorder Checklist

Instructions: Please indicate how frequently you experience each of the following symptoms or behaviors.

Rating Scale: 1 = Never | 2 = Rarely | 3 = Sometimes | 4 = Often | 5 = Always

No.	Item	1	2	3	4	5
1	I feel restless or have difficulty concentrating when indoors	□	□	□	□	□
2	I experience mental fatigue after extended use of electronic devices	□	□	□	□	□
3	I feel relaxed and peaceful in natural environments	□	□	□	□	□
4	I feel a diminished connection to the natural world	□	□	□	□	□
5	I spend little time in outdoor natural settings	□	□	□	□	□
6	I lack awareness of natural phenomena around me (cloud patterns, seasonal changes, plant growth)	□	□	□	□	□
7	I have difficulty identifying common local plants or animals	□	□	□	□	□

No.	Item	1	2	3	4	5
8	I find it difficult to relieve life stresses	□	□	□	□	□
9	I lack concern or emotional investment in environmental issues	□	□	□	□	□
10	I experience more positive emotions during outdoor activities than indoor activities	□	□	□	□	□
11	I feel unfamiliar or unsafe in natural environments	□	□	□	□	□
12	My creativity and imagination are enhanced in natural environments	□	□	□	□	□

Note: *This checklist is based on Richard Louv's concept of Nature-Deficit Disorder and is not a standardized clinical scale.*

Environmental Attitudes Inventory (EAI)

Instructions**:** Please indicate how much you agree or disagree with each of the following statements.

Rating Scale: 1 = Strongly disagree | 2 = Moderately disagree | 3 = Slightly disagree | 4 = Neither agree nor disagree | 5 = Slightly agree | 6 = Moderately agree | 7 = Strongly agree

No	Dimension	Item	1	2	3	4	5	6	7
1	Conservation Priority	Protection of the natural environment is essential for human well-being	□	□	□	□	□	□	□
2	Conservation Priority	We need to preserve the natural environment to maintain a high quality of life	□	□	□	□	□	□	□
3	Conservation Priority	Strong action must be taken to prevent environmental pollution	□	□	□	□	□	□	□
4	Conservation Priority	Environmental protection should be prioritized over economic growth	□	□	□	□	□	□	□
5*	Human Dominance	Humans have the right to modify the natural environment to suit their needs	□	□	□	□	□	□	□
6*	Human Dominance	Humans were meant to rule over the rest of nature	□	□	□	□	□	□	□
7*	Human Dominance	Humans are more important than other living beings	□	□	□	□	□	□	□
8*	Human Dominance	The main value of nature is to provide resources for humans	□	□	□	□	□	□	□
9	Conservation Motivation	I am personally willing to contribute to environmental protection	□	□	□	□	□	□	□
10	Conservation Motivation	Environmental issues matter to me	□	□	□	□	□	□	□
11	Conservation Motivation	I am willing to change my lifestyle to protect the environment	□	□	□	□	□	□	□
12	Conservation Motivation	I am concerned about the consequences of environmental problems	□	□	□	□	□	□	□
13	Environmental Threat	Environmental pollution poses a serious threat to human health	□	□	□	□	□	□	□
14*	Environmental Threat	Environmental problems are exaggerated	□	□	□	□	□	□	□
15	Environmental Threat	If things continue on their present course, we will soon experience a major ecological catastrophe	□	□	□	□	□	□	□
16	Environmental Threat	Modern industrial development causes unacceptable damage to the environment	□	□	□	□	□	□	□

Note: *Items marked with* (5, 6, 7, 8, 14) are reverse-scored*

Positive and Negative Affect Schedule (PANAS)

Instructions: This scale consists of a number of words that describe different feelings and emotions. Read each item and then mark the appropriate answer in the space next to that word. Indicate to what extent you have felt this way during the past few weeks.

Rating Scale: 1 = Very slightly or not at all | 2 = A little | 3 = Moderately | 4 = Quite a bit | 5 = Extremely

Positive Affect Items

No.	Item	1	2	3	4	5
1	Interested	□	□	□	□	□
2	Excited	□	□	□	□	□
3	Strong	□	□	□	□	□
4	Enthusiastic	□	□	□	□	□
5	Proud	□	□	□	□	□
6	Alert	□	□	□	□	□
7	Inspired	□	□	□	□	□
8	Determined	□	□	□	□	□
9	Attentive	□	□	□	□	□
10	Active	□	□	□	□	□

Negative Affect Items

No.	Item	1	2	3	4	5
1	Distressed	□	□	□	□	□
2	Upset	□	□	□	□	□
3	Guilty	□	□	□	□	□
4	Scared	□	□	□	□	□
5	Hostile	□	□	□	□	□
6	Irritable	□	□	□	□	□
7	Ashamed	□	□	□	□	□
8	Nervous	□	□	□	□	□
9	Jittery	□	□	□	□	□
10	Afraid	□	□	□	□	□

Ryff's Psychological Well-Being Scale

Instructions: Please indicate your degree of agreement or disagreement with each statement according to your actual situation.

Rating Scale: 1 = Strongly disagree | 2 = Moderately disagree | 3 = Slightly disagree | 4 = Slightly agree | 5 = Moderately agree | 6 = Strongly agree

No.	Dimension	Item	1	2	3	4	5	6
1	Self-Acceptance	When I look at the story of my life, I am pleased with how things have turned out	□	□	□	□	□	□
2	Self-Acceptance	In general, I feel confident and positive about myself	□	□	□	□	□	□
3	Self-Acceptance	I like most aspects of my personality	□	□	□	□	□	□
4	Positive Relations	People would describe me as a giving person, willing to share my time with others	□	□	□	□	□	□
5*	Positive Relations	Maintaining close relationships has been difficult and frustrating for me	□	□	□	□	□	□
6*	Positive Relations	I often feel lonely because I have few close friends with whom to share my concerns	□	□	□	□	□	□
7*	Autonomy	I tend to worry about what other people think of me	□	□	□	□	□	□
8	Autonomy	My decisions are not usually influenced by what everyone else is doing	□	□	□	□	□	□
9	Autonomy	Being happy with myself is more important to me than having others approve of me	□	□	□	□	□	□
10	Environmental Mastery	In general, I feel I am in charge of the situation in which I live	□	□	□	□	□	□
11	Environmental Mastery	I am quite good at managing the many responsibilities of my daily life	□	□	□	□	□	□
12	Environmental Mastery	I am good at juggling my time so that I can fit everything in that needs to be done	□	□	□	□	□	□
13	Purpose in Life	Some people wander aimlessly through life, but I am not one of them	□	□	□	□	□	□
14	Purpose in Life	I enjoy making plans for the future and working to make them a reality	□	□	□	□	□	□
15*	Purpose in Life	I sometimes feel as if I've done all there is to do in life	□	□	□	□	□	□
16	Personal Growth	I think it is important to have new experiences that challenge how you think about yourself and the world	□	□	□	□	□	□
17	Personal Growth	For me, life has been a continuous process of learning, changing, and growth	□	□	□	□	□	□
18*	Personal Growth	I gave up trying to make big improvements in my life a long time ago	□	□	□	□	□	□

Note: *Items marked with * (5, 6, 7, 15, 18) are reverse-scored*

The Satisfaction with Life Scale (SWLS)

Instructions: Below are five statements that you may agree or disagree with. Using the 1-7 scale below, indicate your agreement with each item. Please be open and honest in your responding.

Rating Scale: 1 = Strongly disagree | 2 = Disagree | 3 = Slightly disagree | 4 = Neither agree nor disagree | 5 = Slightly agree | 6 = Agree | 7 = Strongly agree

No.	Statement	1	2	3	4	5	6	7
1	In most ways my life is close to my ideal.	□	□	□	□	□	□	□
2	The conditions of my life are excellent.	□	□	□	□	□	□	□
3	I am satisfied with my life.	□	□	□	□	□	□	□
4	So far, I have gotten the important things I want in life.	□	□	□	□	□	□	□
5	If I could live my life over, I would change almost nothing.	□	□	□	□	□	□	□

Note: *31-35: Extremely satisfied | 26-30: Satisfied | 21-25: Slightly satisfied | 20: Neutral | 15-19: Slightly dissatisfied | 10-14: Dissatisfied | 5-9: Extremely dissatisfied*

Perceived Stress Scale

Instructions: Please indicate how often you have felt or thought a certain way during the past month.

Rating Scale: 0 = Never | 1 = Almost Never | 2 = Sometimes | 3 = Fairly Often | 4 = Very Often

No.	Item	0	1	2	3	4
1	In the last month, how often have you been upset because of something that happened unexpectedly?	□	□	□	□	□
2	In the last month, how often have you felt that you were unable to control the important things in your life?	□	□	□	□	□
3	In the last month, how often have you felt nervous and "stressed"?	□	□	□	□	□
4	In the last month, how often have you felt confident about your ability to handle your personal problems?	□	□	□	□	□
5	In the last month, how often have you felt that things were going your way?	□	□	□	□	□
6	In the last month, how often have you found that you could not cope with all the things that you had to do?	□	□	□	□	□
7	In the last month, how often have you been able to control irritations in your life?	□	□	□	□	□
8	In the last month, how often have you felt that you were on top of things?	□	□	□	□	□
9	In the last month, how often have you been angered because of things that were outside of your control?	□	□	□	□	□
10	In the last month, how often have you felt difficulties were piling up so high that you could not overcome them?	□	□	□	□	□

Note: *0-13: Low Stress | 14-26: Moderate Stress | 27-40: High Stress*