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The Emotional Healing Mechanisms and Design Principles of Low-Interaction Products in the Digital-Intelligent Era

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Abstract

INTRODUCTION: While the highly efficient interaction models of digital-intelligent technology bring convenience, they have also triggered widespread social alienation and psychological burnout, highlighting the necessity for critical examination and reshaping of digital spaces.
OBJECTIVES: This paper aims to employ Lefebvre's theory of the production of space as a framework to systematically analyze the emotional healing mechanisms of low-interaction products as a "restorative micro-space," clarifying the intrinsic pathways through which their "production" process influences user psychology and emotions.
METHODS: The study constructs a chained mediation model encompassing the three dimensions of spatial production (12 design elements), basic psychological needs (autonomy, competence, relatedness), and emotional healing. Through the development of low-interaction product design practices and the establishment of a mainstream calendar application as a reference group, the theoretical model was empirically examined using structural equation modeling (SEM) and multi-group analysis.
RESULTS: Empirical results strongly support the theoretical model, indicating that the core advantage of low-interaction products lies in their "non-performative" and "nurturing" design. These elements effectively restore users' sense of autonomy and relatedness, thereby achieving significant emotional healing effects
CONCLUSION: This research provides empirically grounded theoretical guidance for design practices focused on digital mental health, validating the effectiveness and superiority of using the theory of spatial production to guide the construction of a "restorative micro-space."

Keywords: Theory of Spatial Production; Low-Interaction Products; Emotional Healing; Structural Equation Modeling; Restorative Micro-Space

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1. Introduction

As a fundamental domain of contemporary society, the digital-intelligent environment is characterized by algorithmic dominance, high-speed flows, and hyper-connectivity. Algorithms function as invisible "spatial planners," shaping information cocoons through personalized content delivery to maximize user engagement time, thereby fostering a model centered on the "attention economy." Digital-intelligent media further intensifies the "performative" aspect of daily life, as users' meticulous curation of "digital personas" leads to a profound rupture between their authentic and online selves.

However, within this highly connected digital-intelligent environment, the mental health crisis among urban youth is intensifying [1]. Studies indicate that digital-intelligent technologies generate certain adverse effects: for instance,

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electronic screen use contributes to increased depression and reduced well-being [2]; user engagement with these technologies induces digital stress and fear of missing out (FoMO) [3]. This situation reveals a profound emotional paradox: technological connectivity has reached unprecedented levels in form, yet genuine emotional nourishment is increasingly scarce [4].

The root cause lies in the structural deficiencies of mainstream highly interactive digital products in fulfilling three fundamental human psychological needs. Firstly, as user behavior is precisely guided by algorithms, the sense of autonomy is imperceptibly eroded, reducing individuals to passive nodes within data flows. Secondly, information overload and social comparison leave individuals feeling inadequate and frustrated in the virtual world, severely undermining their sense of competence. Lastly, interactions based on performance metrics such as likes and comments remain superficial, failing to foster deep, reliable social support and instead exacerbating the lack of relatedness. Structurally, these products are ill-equipped to deliver emotional healing; indeed, they often constitute a source of the problem itself.

Exploring a new interaction paradigm that transcends the existing model and centers on human well-being has thus become particularly urgent. While existing digital wellness frameworks often focus on individual-level psychology or task efficiency, this study introduces a paradigm shift by conceptualizing digital products not merely as interfaces, but as dynamically produced "social spaces." By adopting Lefebvre's theory of the production of space, we offer a macro-level, political, and generative perspective that reveals how underlying algorithmic logic systematically shapes user experience. This spatial lens is distinct from established frameworks as it moves beyond symptom relief to address the root causes of digital alienation—the very logic of space production itself. In an era of increasing "digital burnout" and algorithmic fatigue, designing for emotional well-being has become a critical priority[4]. This research addresses this urgent need by proposing a theoretically grounded and empirically validated framework for creating "restorative micro-spaces." It contributes to the thematic area by offering a new design lexicon and a validated pathway to counteract the emotional alienation inherent in mainstream digital-intelligent environments, thereby advancing the discourse on human-centered technology design.

2. Theoretical Basis and Research Hypotheses

2.1. Theory of the Production of Space

In traditional perspectives, products are often viewed merely as tools for functional purposes. However, based on Henri Lefebvre's theory of the production of space, this paper proposes a paradigm shift: digital-intelligent products should be understood as dynamically generated "social spaces." Lefebvre's core argument is that space is not a static physical container but a product of social relations and practices, constantly reshaped through an ongoing "production" process. The spatial triad constitutes a spatial epistemology further developed by Lefebvre within this theoretical framework. He argued that the production of space encompasses three dialectical dimensions: spatial practice, representations of space, and spaces of representation. These three layers correspond to the behavioral, conceived, and lived spaces, respectively [5].

This paper selects the theory of the production of space, rather than emotional design theory, primarily because emotional design theory tends to focus on the emotional responses and user experiences elicited by products, emphasizing micro-level emotional interactions. However, it struggles to explain the systemic impact of the digital-intelligent environment—as a macro socio-technical system—on emotional health [6]. In contrast, the theory of the production of space views digital-intelligent products as social spaces, emphasizing the political and generative nature of space. It can reveal how power relations underlying technology (e.g., algorithmic rules) shape users' emotional experiences through the spatial production process. Unlike existing Digital Wellbeing frameworks, which predominantly focus on individual self-regulation strategies [7], our “restorative micro-spaces” framework proposes a structural reconstruction of the digital environment itself. Furthermore, while Slow Technology advocates for decelerating the pace of interaction [8], our application of Lefebvre’s spatial politics goes a step further by emphasizing User Sovereignty. It does not merely slow down the interaction but fundamentally shifts the power dynamic—transforming the user from a passive data node within an algorithmic space to an active subject in a nurturing environment. As shown in Table 1: The triadic dialectic of the theory of the production of space provides a dynamic analytical framework that integrates technological rules, user behaviors, and emotional experiences into a unified explanatory system, thereby more comprehensively uncovering the roots of emotional alienation and the pathways to healing.

2.2. Emotional Alienation in Mainstream Digital-Intelligent Spaces

The digital-intelligent space is a novel socio-ecological environment underpinned by next-generation information technologies such as big data and artificial intelligence. Through the synergistic drive of in-depth data element mining and intelligent algorithms, it achieves deep integration of the physical and digital worlds, enabling real-time perception, dynamic optimization, and intelligent decision-making [8][9]. Lefebvre's theory of the production of space provides a theoretical basis for analyzing the digital-intelligent space and its impact on emotional health.

Firstly, "spatial practice" refers to daily behaviors and perceptual trajectories in social life. These practices do not occur naturally but are profoundly shaped, constituting the most superficial layer of users' digital life trajectories.

Secondly, "representations of space" are conceptualized spaces conceived and dominated by power elites and

knowledge experts. They manifest as dominant algorithmic logic, user interface design, platform rules, and data models.

Finally, "spaces of representation" are spaces directly "lived" and experienced by users through imagery, symbols, and bodily engagement, filled with complex emotions, memories, imaginations, and symbolic meanings. This constitutes users' subjective perceptual domain of the digital environment, such as a sense of belonging generated on a social platform or anxiety stemming from algorithmically filtered information cocoons.

Table 1. Comparative Analysis of Theoretical Frameworks

Dimension of Comparison	Emotional Design Theory	Slow Technology	Digital Well-being	Spatial Production Theory
Analytical Level	Micro-level (user-product interaction)	Level of interaction tempo	Individual behavioral level	Macro-structural level
Core Focus	How products elicit users' emotional responses and shape experiences.	The speed and frequency of interactions.	How individuals adapt to technology.	The "production" and construction of the digital environment itself.
User Role	Recipient of emotional stimuli and participant in experiences.	Instigator of deep reflection and subject of temporal perception.	Manager of personal technology use.	Transformation from a passive data point to an active agent.
Healing/ Intervention Path	Optimizing the product's emotional expression and interactive feedback mechanisms to improve user experience.	Designing interactions with characteristics of slowness, delay, or waiting to create a sense of "disconnection."	Providing tools (e.g., screen time statistics, app limits) to assist users in self-regulation.	Proactively producing a "restorative micro-space" through structural reconstruction.
Design Logic	Elicitation and Response	Deceleration and Pausing	Monitoring and Limiting	Production and Empowerment
Core Distinction	Instrumental perspective focused on optimizing experience.	Cultural perspective advocating for reflection.	Managerial perspective advocating for self-discipline.	Productive perspective focused on reconstructing space.

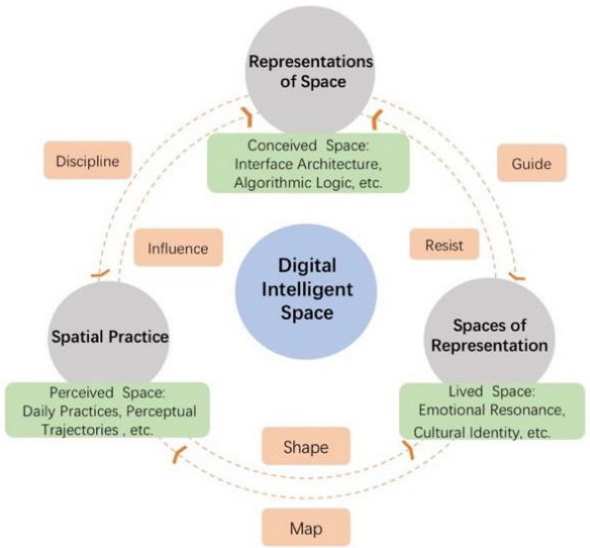

Figure 1. Triadic Dialectical Diagram of the Digital-Intelligent Space

As shown in Figure 1: Beneath the surface convenience of mainstream digital-intelligent spaces lies a profound crisis of emotional alienation. It becomes evident that the "representations of space" conceived by tech elites systematically plan and guide user "spatial practice," and together, these two elements produce the "spaces of representation" ultimately experienced by users. When the logic of "representations of space" centers on capital accumulation and attention capture, the resulting "spaces of representation" are often filled with performance anxiety, social comparison, and a lack of authentic connection, thereby systematically damaging users' emotional well-being.

The underlying psychological mechanism is that this alienating spatial production logic precisely and systematically frustrates innate human psychological needs. According to the self-determination theory proposed by psychologists Deci Edward L. and Ryan Richard M., healthy motivation and well-being stem from the satisfaction of three basic psychological needs: autonomy, competence, and relatedness [9] [11]. However, mainstream digital-intelligent spaces are structurally antithetical to these needs.

2.3. The Emotional Healing Mechanism of Low-Interaction Products

In the digital-intelligent era, product design is evolving towards intelligence, humanization, service-orientation, and emotionalization as key trends [9], giving rise to diverse subcategories of smart products that can be classified and analyzed based on product type, interaction mode, and interaction intensity [10]. The low-interaction products discussed in this paper broadly refer to all digital or hardware-software integrated products characterized by low interaction load and high emotional support, including but not limited to forms such as smart hardware and mobile applications [10]. Their core features are low frequency, low complexity, and zero social pressure in interaction, contrasting sharply with traditional high-interaction products aimed at capturing user attention. Their design purpose is to counteract the emotional alienation caused by mainstream digital-intelligent spaces. In the algorithm-driven digital ecosystem that prioritizes efficiency maximization, users' basic psychological needs—autonomy, competence, and relatedness — are being systematically frustrated. Low-interaction products are designed to correct this trend; their fundamental aim is not to complete specific tasks but to create a "restorative micro-space" that nurtures psychological well-being [11].

The emotional healing capacity of low-interaction products does not stem from any single technological function but is achieved through the production and operation of an integrated "restorative micro-space." Based on Lefebvre's theory of the production of space, this process manifests as a synergistic transformation across the three spatial levels — "representations of space," "spatial practice," and "spaces of representation". From the perspective of art therapy, this process is essentially a form of digital art therapy practice. Through the synergistic effect of the core healing chain—"aesthetic experience → sense of ritual → emotional regulation"—it systematically addresses and repairs the basic psychological needs alienated by the mainstream digital-intelligent environment in Figure 2 [12].

2.3.1 Autonomy Restoration Mechanism: Re-establishing Control in "Representations of Space"

Low-interaction products fundamentally reverse the logic of mainstream digital-intelligent spaces through a series of non-performative rule designs. Their "representations of space" are consciously conceived as a restoration of user sovereignty, which is essentially a process of aesthetic liberation.

- Elimination of Quantitative Metrics: Completely abandoning metrics that quantify social relationships, such as like counts and follower numbers. From an art therapy perspective, this creates a form of "non-judgmental aesthetics."
- Restoration of Data Ownership: Clearly defining data ownership and usage purposes, providing a one-click function to erase interaction history, thereby returning data control to the user.
- Deterministic Feedback: The product's response mode is simple and predictable, allowing users to clearly anticipate the consequences of their actions. This determinism provides a form of "aesthetics of cognitive order."

2.3.2 Burnout Alleviation Mechanism: Reducing Cognitive Load in "Spatial Practice"

Low-interaction products create a "cognitive refuge" free from deliberate performance by shaping "low cognitive load" spatial practices. This is achieved through ritualistic reconstruction, transforming daily behaviors into meaningful artistic practices.

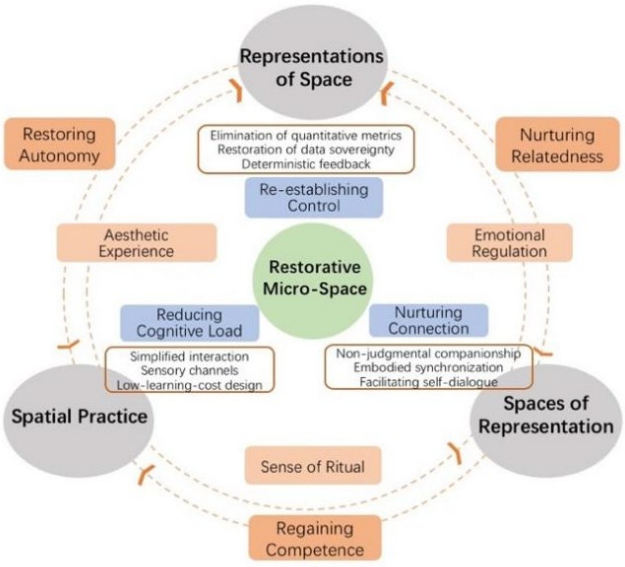

Figure 2. The Emotional Healing Mechanism of Low-Interaction Products

- Simplified Interaction: Simple, repetitive user actions become a meditative, art-like practice, shifting the user from "actively thinking about how to use" to "naturally being," thereby effectively alleviating digital burnout.
- Sensory-Optimized Channels: Prioritizing sensory channels such as light, sound, and touch that directly engage the limbic system. This is a direct manifestation of "multi-sensory aesthetics."
- Low-Cost Learning: Interaction designs that require no learning of complex rules, naturally aligning with human instincts. When skill and challenge are perfectly matched, users easily enter a "flow state."

2.3.3 Loneliness Alleviation Mechanism: Nurturing Connection in "Spaces of Representation"

Low-interaction products aim to produce a "space of representation" within the digital environment that provides secure emotional attachment. This is essentially an art of emotion regulation, facilitating self-awareness and integration through artistic means.

- Non-Judgmental Companionship: Low-interaction products offer unconditional acceptance and companionship. This sense of companionship is conveyed through "caring aesthetics."
- Embodied Synchronization: Physiological resonance is established with the user by simulating life rhythms, such as breathing or heartbeat. This synchronization creates a profound "rhythm ritual."
- Facilitation of Self-Dialogue: Low-interaction products act as a calm "emotional mirror" helping users organize their inner world. This utilizes the "symbolic expression" mechanism from art therapy. By providing simple features for mood logging, doodling, or mood-based image matching, the product helps users externalize and objectify internal, hard-to-express emotions.

2.4. Design Principles: A Triadic Pathway to Constructing a Restorative Micro-Space

The application of Lefebvre's theory provides a novel analytical lens for the digital realm. It allows us to systematically deconstruct the digital environment into its representations of space (algorithmic rules), spatial practice (user behaviors), and spaces of representation (lived experience). Based on Lefebvre's theory of the production of space and incorporating perspectives from art therapy, the design of low-interaction products must infuse functional logic with aesthetic order and healing experiences. The following principles translate emotional healing mechanisms into actionable design practices, constructing a restorative micro-space centered on user well-being in Figure 3.

2.4.1 "Non-performative" Rule Design for "Representations of Space"

The design of low-interaction products must subvert the performance-oriented rules of mainstream digital-intelligent spaces and build an underlying architecture centered on user sovereignty.

- User Sovereignty Principle: Aesthetically, create a form of "non-judgmental aesthetics," eliminating all competitive and comparative visual elements to establish an absolutely safe psychological space.
- Data Minimization and Transparency Principle: In terms of interaction, design functions like data clearance as a "purification ritual." Through aesthetic treatment, allow users to feel a sense of liberation and control emotionally.
- Unobtrusive Interface Principle: Reduce cognitive noise through minimalist visual presentation, providing space for emotional sedimentation and imagination. Alternatively, use physical interfaces made from natural materials (e.g., fabric, wood) to convey a warm and safe tactile emotion.

2.4.2 " Low Cognitive Load" Interaction Design for "Spatial Practice"

The design principles aim to transform interactions from high-energy "performance" to low-energy "being," alleviating psychological burnout.

- Sensory Priority Principle: Experientially, construct "multi-sensory aesthetics," using touch, sound, light, etc., to bypass cognition and directly convey calming emotional messages.
- Simplicity First Principle: Logically, adhere to "minimalist aesthetics," using clear visual hierarchy and a sense of order to counter the user's internal chaos and bring calmness.
- Inclusive Response Principle: Gently transform negative emotional inputs from users (e.g., rapid clicking) into smooth visual or tactile feedback, achieving unconditional acceptance.

2.4.3 "Nurturing" Experience Design for "Spaces of Representation"

The design principles aim to foster long-term emotional health, nurturing a sense of belonging and inner peace.

- Non-judgmental Companionship Principle: In terms of form, use soft shapes, warm lighting, and soothing animations to make the product itself a trustworthy, warm companion.
- Ritual Creation Principle: In terms of rhythm, employ "cyclical aesthetics," using visual themes that change over time or with solar terms to anchor daily usage behaviors within an aesthetically rich rhythm, imbuing them with a sense of meaning.
- Positive Environment Anchoring Principle: In terms of guidance, adopt "anchoring aesthetics," using serene images or encouraging words to create visual and emotional connections between positive experiences within the product and the user's real world.

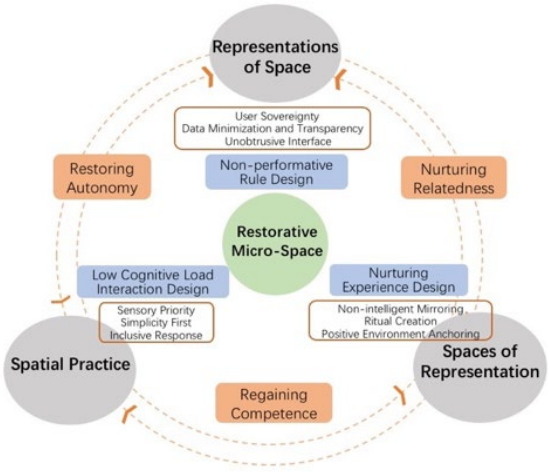

Figure 3. Triadic Design Pathway for a Restorative Micro-space

2.5. Research Model and Hypotheses

To ensure clarity and traceability from theory to measurement, we provide a detailed operationalization of the constructs. For example, the exogenous variable “Non-performative Rules” is measured through three sub-constructs: “User Sovereignty”, “Data Transparency”, and “Unobtrusive Interface”. These sub-constructs directly correspond to the theoretical dimensions of restructuring the “representations of space”. This clear mapping strengthens the technical rigor by explicitly linking philosophical concepts to empirical indicators.

Based on the aforementioned theoretical mechanisms and design principles, this study constructs a chained mediation model to systematically examine the emotional healing mechanism of low-interaction products. The model comprises three levels:

- Level 1: 9 exogenous variables representing the three major design principles of low-interaction products and their sub-dimensions.
- Level 2: 3 mediating variables representing the three repaired basic psychological needs.
- Level 3: 1 dependent variable, namely the ultimate emotional healing effect.

According to the above model, the following 12 research hypotheses are proposed, categorized into direct effect hypotheses and mediation effect hypotheses, as illustrated in Figure 4: Direct Effect Hypotheses (H1–H9):

- H1–H3: Non-performative rules (user sovereignty, data transparency, unobtrusive interface) have a significant positive effect on autonomy.
- H4–H6: Low cognitive load interaction (sensory priority, simplicity first, inclusive response) have a significant positive effect on competence.
- H7–H9: Nurturing experiences (non-judgmental companionship, ritual creation, environment anchoring) have a significant positive effect on relatedness.

Mediation Effect Hypotheses (H10–H12):

- H10: Autonomy has a significant positive effect on emotional healing.
- H11: Competence has a significant positive effect on emotional healing.
- H12: Relatedness has a significant positive effect on emotional healing.

3. Experimental Design and Methodology

3.1. Experimental Design

This study employed a between-subjects design with two experimental conditions: an experimental group and a control group in Figure 5-6.

(i) Experimental Group: Low-Interaction Product (The Twenty-Four Solar Terms Interactive Calendar)

This product is a desktop companion object developed based on the design principles of this study, characterized by a physically entity-dominated, digitally-assisted design. Its key design features include:

- Screen-Free Design: The calendar itself has no electronic screen, physically eliminating information notifications and interruptions.
- Mindful Charging Mode: When a phone is placed in the designated area on the calendar, it automatically begins charging and simultaneously enters a "Mindfulness Mode," blocking all phone notifications.
- Low-Interaction Logic: All interactions are initiated entirely by the user. The user must pick up the phone and touch the NFC contact points corresponding to the Twenty-Four Solar Terms on the calendar to trigger the playback of white noise unique to each solar term (e.g., the sound of drizzle for Rain Water, distant thunder for Awakening of Insects).
- Design Principles Embodied: The design strictly adheres to the principles of non-performative, low cognitive load and nurturing experience.

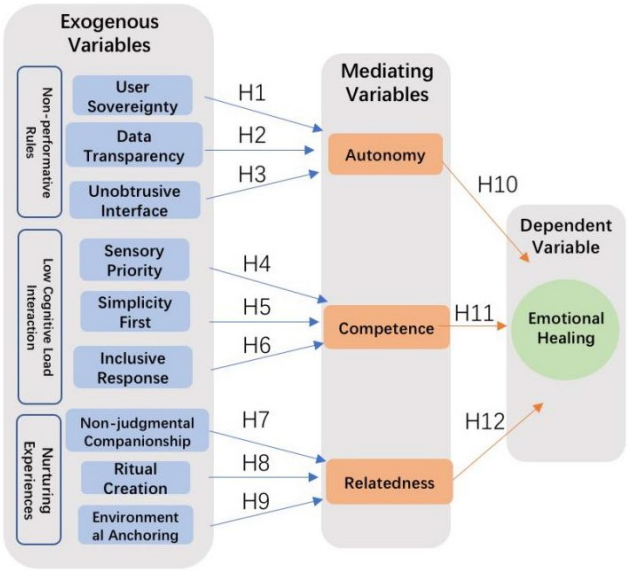

Figure 4. Theoretical Model of the Emotional Healing Mechanism of Low-Interaction Products

Figure 5. Design of the Twenty-Four Solar Terms Interactive Calendar

(ii) Control Group: Mainstream High-Interaction Application (Session App)

This application is a feature-rich mainstream calendar product that embodies the typical design paradigm of digital-intelligent spaces:

- High-Interaction Features: Includes task management, social sharing (e.g., likes, comments), data statistics (e.g., usage duration analysis), and personalized push notifications.
- Performance-Oriented Design: Its core design focuses on maximizing user engagement and data capture, with clear task lists for every moment of the day.

The core design differences between the two groups are shown in the Table 2 below:

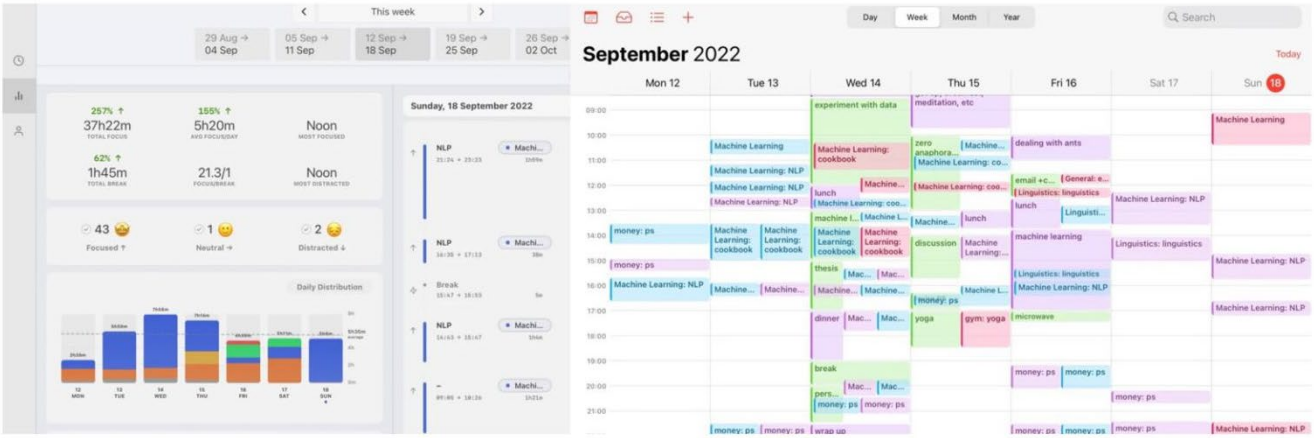

Figure 6. Interface Demonstration of Session App

Table 2. A Comparative Analysis of Product Design Features

Design Dimension	Experimental Group (Low-Interaction Product)	Control Group (Mainstream Application)
Interaction Method	NFC touch, white noise, no notifications, fully user-initiated	Tapping, sliding, task reminders, system-initiated push notifications
Data Usage	No quantitative metrics, local processing, one-click clearance	Quantitative metrics (likes, comments, usage time), cloud synchronization, personalized recommendations
Interface Design	Minimalist interface, paper-based materials, healing-style illustrations	Complex menus, data charts, social information feeds
Aesthetic Style	Ink-wash painting style, simple and sparing	Commercialized UI, high color saturation
Core Objective	Non-performative, Low Cognitive Load, nurturing emotional support and companionship	Performance-driven, high functionality, social connection and engagement

The selection of the Twenty-Four Solar Terms as the core design metaphor serves a functional purpose beyond mere aesthetics. It acts as a "Temporal Anchor" derived from natural rhythms, providing a cognitive counter-narrative to the fragmented, accelerated "Algorithmic Time" dominant in digital platforms. By aligning interaction with the slow, cyclical changes of solar terms, the product fosters a "Ritual Creation" mechanism. Additionally, the NFC physical touch

interaction is designed as an “Embodied Spatial Practice”. The physical act of touching the calendar anchors the user’s perception in the physical reality, effectively interrupting the loop of digital immersion and facilitating emotional grounding.

This study employed a questionnaire survey to collect data. All items were measured using a 7-point Likert scale (1=Strongly Disagree, 7=Strongly Agree).

The questionnaire was adapted from established scales and contextualized for this study. The specific constructs and their measurement items are detailed in Table 3.

3.2. Variables and Measurement

Table 3. Research Variable Measurement Scale

Variable	Measurement Items
Non-performative Rules	
User Sovereignty	US1: I have complete control over the interaction with this product and can start or stop it at any time. US2: This product never proactively interrupts me or pushes notifications. US3: I feel I am in charge of the usage process.
Data Transparency	DT1: I clearly understand how my data is being used. DT2: This product provides an option to clear personal records. DT3: I trust this product's approach to data handling.
Unobtrusive Interface	UI1: The product's interface design is very simple and does not distract me. UI2: When not in use, it is almost like a background presence. UI3: Its visual design makes me feel calm.
Low Cognitive Load Interaction	
Sensory Priority	SP1: Interacting with it relies mainly on touch or sound, which feels natural. SP2: This mode of interaction does not require complex thinking from me. SP3: The sensory feedback is very relaxing.
Simplicity First	SS1: Completing any operation is very simple, taking no more than three steps. SS2: I can use it easily without needing to learn how. SS3: Its interaction logic is very intuitive.
Inclusive Response	IR1: It provides positive feedback even when I'm in a bad mood. IR2: It can "catch" any of my emotions without making me feel frustrated. IR3: Its way of responding makes me feel accepted.
Nurturing Experience	
Non-judgmental Companionship	NJ1: It is like a quiet partner that is always there. NJ2: There is no social pressure when being with it. NJ3: Its very presence is a comfort.
Ritual Creation	CR1: Using it daily gives my life a greater sense of rhythm. CR2: It turns my daily behaviors into small rituals. CR3: This sense of regularity makes me feel inwardly settled.
Environmental Anchoring	EA1: It encourages me to bring the sense of calm from the online space into real life. EA2: It helps me focus better on my immediate environment. EA3: It facilitates a connection between online experiences and offline life.
Basic Psychological Needs	
Autonomy	AUT1: When using it, I feel a sense of freedom. AUT2: My choices and intentions are fully respected. AUT3: I can control my digital life.
Competence	COM1: Using it makes me feel at ease and gives me a sense of accomplishment. COM2: I can master its functions well. COM3: It makes me feel capable.
Relatedness	REL1: I feel an emotional connection with it. REL2: It reduces my feeling of loneliness when I am alone. REL3: It is a secure base for me emotionally.
Emotional Healing	
Emotional Healing	EH1: After using it, I feel my inner anxiety has decreased. EH2: It helps me recover from digital burnout. EH3: It provides me with a valuable space for psychological respite.

To bridge the gap between Lefebvre's macro-level spatial philosophy and micro-level interaction design, we established a strict operationalization logic. The theoretical dimension of "Representations of Space", which is typically dominated by algorithmic logic in mainstream apps, is operationalized in our design as "Non-performative Rules". Consequently, this is measured quantitatively through the construct of "User Sovereignty", "Data Transparency" and "Unobtrusive Interface". Reliability analysis confirms the robustness of these measures, with Cronbach's alpha coefficients for all constructs exceeding 0.8 (Table 4), indicating high internal consistency in translating theoretical concepts into measurable variables.

3.3. Data Collection and Analysis Strategy

This study recruited 400 urban young adults (aged 22 – 26, 192 males and 208 females) through both online and offline channels. Participants were randomly assigned to the experimental group or the control group and were required to complete a 30-day product experience period. During this period, invalid questionnaires were primarily due to either failure to complete the product experience or overly patterned responses. The final valid sample size was sufficient for further modeling.

Given the complex relationships among multiple latent variables in this study, structural equation modeling (SEM) was adopted instead of a series of separate regressions. SEM allows us to estimate the measurement errors of latent constructs (spatial production factors, basic psychological needs, and emotional healing) and test the chained mediation effects within one integrated model. This modeling strategy is consistent with previous research on restorative environments and psychological well-being, and therefore is theoretically and methodologically appropriate for our research questions.

Data analysis was performed using AMOS 26.0 software for SEM, following these steps:

- Confirmatory Factor Analysis (CFA): To examine the reliability and validity of the measurement model.
- Structural Model Analysis: To test the overall model fit and hypotheses H1–H12.
- Mediation Effect Test: To examine the mediating role of psychological needs using the Bootstrap method (5000 samples).
- Multi-Group Analysis: To compare the differences in model paths between the experimental and control groups, verifying the relative advantages of the low-interaction product.

4. Data Analysis and Results

4.1. Measurement Model Test

Prior to testing the structural model, a confirmatory factor analysis (CFA) was first conducted on the measurement model to assess the reliability and validity of the scales. The standardized factor loadings of all measurement items exceeded 0.7, the composite reliability (CR) values were all greater than 0.8, and the average variance extracted (AVE) values were all above 0.5, indicating good convergent validity of the model. Discriminant validity was verified by comparing the square roots of the AVEs of each construct with the correlation coefficients between the latent variables. Subsequently, the overall fit of the structural equation model was examined. The results indicated that the model fitted the data well, with specific indices as follows in the Table 4:

Table 4. Model Fit Indices

Index	Criterion	Model Value	Result
χ^2/df	< 3	2.15	Good
CFI	> 0.9	0.93	Good
TLI	> 0.9	0.92	Good
RMSEA	< 0.08	0.067	Good
SRMR	< 0.08	0.041	Good

4.2. Structural Model Test

After the measurement model passed the test, we analyzed the structural model shown in Figure 4. The overall model fit was good (Table 4). The standardized regression coefficients for each path are shown in Table 5. The mediation effect test results showed that autonomy, competence, and relatedness all played significant partial mediating roles between the spatial production elements and emotional healing.

4.3. Comparative Validation

To examine the advantages of low-interaction products compared to mainstream products, we conducted a multi-group analysis. By applying model constraints, we compared differences in all path coefficients between the experimental group and the control group. Key results are presented in Table 6. The multi-group analysis results clearly revealed:

- At the " Non-performative rules" level, all paths (H1, H2, H3) in the experimental group were significantly stronger than those in the control group.
- At the "nurturing experience" level, the paths of "non-judgmental companionship" (H7) and "ritual creation" (H8) in the experimental group were significantly stronger than those in the control group.
- At the " low cognitive load interaction" level and the "psychological needs → emotional healing" level, no significant differences were found between the two groups.

To more intuitively display the core differences,

we created a comparative diagram of the key path coefficients for the two groups in Figure 7:

Table 5: Hypothesis Testing Results of Path Coefficients

Hypothesis	Path	Standardized Coefficient (β)	S.E.	C.R.	p-value	Result
H1	User Sovereignty → Autonomy	0.65	0.05	11.82	< 0.001	Supported
H2	Data Transparency → Autonomy	0.48	0.06	7.55	< 0.001	Supported
H3	Unobtrusive Interface → Autonomy	0.32	0.07	4.89	< 0.001	Supported
H4	Sensory Priority → Competence	0.51	0.06	8.12	< 0.001	Supported
H5	Simplicity First → Competence	0.59	0.05	10.33	< 0.001	Supported
H6	Inclusive Response → Competence	0.41	0.07	6.15	< 0.001	Supported
H7	Non-judgmental Companionship → Relatedness	0.58	0.05	9.88	< 0.001	Supported
H8	Ritual Creation → Relatedness	0.43	0.06	6.97	< 0.001	Supported
H9	Environmental Anchoring → Relatedness	0.36	0.07	5.44	< 0.001	Supported
H10	Autonomy → Emotional Healing	0.45	0.08	5.98	< 0.001	Supported
H11	Competence → Emotional Healing	0.38	0.09	4.67	< 0.001	Supported
H12	Relatedness → Emotional Healing	0.29	0.10	3.15	< 0.01	Supported

Table 6: Multi-Group Analysis Comparison of Path

Hypothesis	Path	Experimental Group (β)	Control Group (β)	Coefficient Difference (Δβ)	p-value	Comparative Result
H1	User Sovereignty → Autonomy	0.71	0.32	0.39	< 0.001	Significantly stronger in experimental group
H2	Data Transparency → Autonomy	0.55	0.21	0.34	< 0.001	Significantly stronger in experimental group
H3	Unobtrusive Interface → Autonomy	0.4	0.15	0.25	< 0.01	Significantly stronger in experimental group
H4	Sensory Priority → Competence	0.53	0.48	0.05	0.45	No significant difference
H5	Simplicity First → Competence	0.61	0.57	0.04	0.52	No significant difference
H6	Inclusive Response → Competence	0.44	0.38	0.06	0.38	No significant difference
H7	Non-judgmental Companionship → Relatedness	0.65	0.28	0.37	< 0.001	Significantly stronger in experimental group
H8	Ritual Creation → Relatedness	0.5	0.22	0.28	< 0.01	Significantly stronger in experimental group
H9	Environmental Anchoring → Relatedness	0.38	0.35	0.03	0.61	No significant difference
H10	Autonomy → Emotional Healing	0.47	0.42	0.05	0.41	No significant difference
H11	Competence → Emotional Healing	0.4	0.36	0.04	0.48	No significant difference
H12	Relatedness → Emotional Healing	0.31	0.27	0.04	0.55	No significant difference

Figure 7: Coefficient Comparison of Key Paths Between Experimental and Control Groups

5. Findings and Discussion

This study systematically empirically tested the emotional healing mechanism of low-interaction products through structural equation modeling. The results strongly support our constructed chained mediation model and reveal the core advantages of low-interaction products compared to mainstream products.

First, the findings validate the core pathway of "spatial production elements → psychological need restoration → emotional healing." The support for all hypotheses (H1-H12) indicates that the design principles of low-interaction products can ultimately achieve emotional healing by restoring users' sense of autonomy, competence, and relatedness. This provides solid empirical evidence for the application of Lefebvre's theory of the production of space in the field of human-computer interaction, demonstrating that consciously "producing" a "restorative micro-space" centered on user well-being can effectively counteract the alienating effects of mainstream digital-intelligent spaces.

Second, the results of the multi-group analysis constitute the core contribution of this study. They precisely pinpoint the advantage of low-interaction products: their superior healing effect stems primarily from " non-performative" and "nurturing" design, rather than "low cognitive load" design. The path coefficients for "user sovereignty," "data transparency," and "non-judgmental companionship" in the experimental group far exceeded those in the control group. This suggests that, within the current design environment, performance metrics that deprive user autonomy and interactions lacking emotional warmth are the main culprits of digital burnout. By subverting these rules, low-interaction products accurately address the root of the problem. In contrast, "low cognitive load" has become a standard feature of modern applications and thus did not create a significant difference. Users perceive "ease of use" as a basic threshold for modern applications, not a unique advantage. It alleviates cognitive load but fails to address the core burnout issues caused by lack of autonomy and emotional isolation. Further analysis shows that although there was no significant difference in paths related to "competence" between the control group and the experimental group, the emotional healing effect in the control group was still lower. This implies that mere functional ease of use cannot compensate for the lack of autonomy and relatedness, thereby reinforcing the completeness of this study's theoretical model.

The findings of this study have clear implications for design practice:

- Priority Setting: Designers should assign high priority to " non-performative " and "nurturing experiences" when developing digital wellness products.
- Design Focus: The core of design should shift from "task completion efficiency" to "creating a safe, autonomous, and emotionally supportive atmosphere."
- Value Rationality: This study demonstrates that a "value-rational" design paradigm can succeed in both commercial terms and user well-being. Enterprises can use this to build differentiated advantages while enhancing user loyalty.

This study provides empirically grounded theoretical guidance for design practices focused on digital mental health. By validating the effectiveness of a spatially informed approach, it advances the field's understanding of how to systematically design digital environments that foster autonomy, competence, and relatedness. The triadic design pathway offers a concrete and actionable model for researchers and practitioners aiming to mitigate the negative psychological impacts of pervasive technology. However, developers may face constraints, including balancing minimalism with functional necessity and demonstrating ROI for wellness-focused features to stakeholders. Furthermore, long-term user engagement remains a key challenge; future research should explore how to maintain the perceived value of “being” over “doing” to prevent user attrition. Addressing these challenges will be crucial for the successful real-world implementation of our proposed framework.

Certainly, this study has limitations, such as the sample being confined to a youth demographic and the lack of longitudinal tracking. Future research could expand to users of different ages and cultural backgrounds and conduct long-term experiments to examine the sustained efficacy of low-interaction products. While this study provides a robust framework, it is important to acknowledge that perceptions of aesthetics, ritual, and companionship may have cultural variations. Future research should explore how our proposed design principles are perceived across different cultural contexts to ensure the global applicability of “restorative micro-spaces”.

6. Conclusion

Through rigorous empirical analysis, this study not only validated the theoretical model of the emotional healing mechanism of low-interaction products but also quantified their specific advantages relative to mainstream products through comparative experiments, providing a scientific basis and practical pathways for constructing a healthier and more human-centered digital-intelligent environment. The research confirms that the healing power of low-interaction products does not stem from technological sophistication or feature accumulation but from their conscious application of Lefebvre's theory of the production of space to construct a "restorative micro-space" that operates on a logic contrary to mainstream digital-intelligent spaces. By reconstructing the triadic dialectical relationship between spatial practice, representations of space, and spaces of representation, this micro-space provides users with a valuable psychological sanctuary to counteract digital alienation.

On a theoretical level, this study innovatively applies the theory of spatial production to human-computer interaction and design research, offering a fresh perspective for understanding the socio-psychological impact of digital-intelligent environments. On a practical level, the triadic pathway for constructing a healing micro-space proposed in this study—the "non-performative" rules for representations of space, the "low cognitive load" interaction for spatial practice, and the "nurturing" experiences for spaces of representation—provides clear theoretical guidance and actionable pathways for design focused on digital mental health. This research paradigm offers not only guidance for low-interaction product design but also serves as a methodological reference for broader digital wellness design practices.

Ethics Statement.

This study has been approved by the Ethics Committee of the School of Art and Design, Communication University of China, Nanjing (Approval No. 2025032406). All participants provided signed informed consent. The form clearly explained the research purpose, procedures, potential risks (minimal), and data anonymization methods. Participants were assured of their right to withdraw from the study at any time without consequences. All collected questionnaire data were anonymized and used solely for aggregate statistical analysis in this study. Under no circumstances will individually identifiable information of participants be disclosed. The researchers declare that there are no known competing financial interests or personal relationships that could have influenced the outcomes reported in this study.

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