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RESEARCH ARTICLE

Exploration of new music experience scenarios empowered by VR technology from perspective of consumption psychology

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ABSTRACT

With the rapid advancement of virtual reality technology, VR-based music experience scenarios have emerged as a novel consumption format, reshaping the contemporary music industry. Grounded in the Stimulus–Organism–Response (S-O-R) framework and the Technology Acceptance Model (TAM), this study employed a mixed-methods design integrating a questionnaire survey (n = 450), in-depth interviews (n = 30), and VR experience experiments (n = 20) to examine consumer psychological mechanisms in VR music contexts. Results indicate that virtual environment perception influences consumer psychology through spatial presence, sensory stimulation intensity, and aesthetic quality, with sensory stimulation exhibiting an inverted U-shaped relationship with emotional arousal. Virtual social presence significantly affects consumption decisions, partially mediated by group belongingness and moderated by social comparison tendency and identity recognition. Technology acceptance demonstrates a "high usefulness–low ease-of-use" pattern, while immersive experience quality mediates the relationship between technological features and user satisfaction. Technical anxiety negatively moderates the link between perceived value and usage intention, with operational training reducing anxiety levels by 23.4%. The findings reveal distinctive psychological characteristics of VR music consumption—strong immersion, social embeddedness, personalization, and aesthetic orientation—providing theoretical insights and practical implications for VR product design, marketing strategy, and digital transformation within the music industry.

Keywords: virtual reality technology; music experience scenarios; consumer psychological characteristics; Technology Acceptance Model; immersive experience; environmental psychology; social psychology

1. Introduction

With the rapid advancement of digital technologies, the experience economy has become a defining paradigm of contemporary consumption. Within this context, virtual reality (VR) technology has fundamentally transformed the ways in which individuals consume and experience music. Traditionally, music consumption has relied on live performances, physical recordings, and digital audio streaming platforms. The integration of VR technology, however, has introduced immersive music experiences that transcend physical spatial constraints and redefine the boundaries of musical engagement. By reconstructing conventional modes of music dissemination and presentation, VR-based music experiences reshape

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consumers' cognitive evaluations, emotional responses, and behavioral intentions. From an environmental psychology perspective, virtual music environments can be conceptualized as artificially constructed spaces characterized by multisensory stimulation, including visual, auditory, and tactile cues. Understanding how these sensory elements shape users' sense of presence, emotional arousal, and place attachment is essential for explaining this emerging consumption phenomenon. Meanwhile, from a social psychological standpoint, VR music environments incorporate salient social dimensions—such as interaction, group belongingness, and identity recognition — that play critical roles in shaping users' psychological experiences and consumption decisions. Consequently, systematically examining consumer psychological mechanisms in VR-enhanced music contexts is of considerable theoretical significance and offers practical insights for product innovation and marketing strategies in the music industry. Music education and music experience research offer important theoretical foundations for understanding consumer psychology in VR music scenarios. Velasco and Moreno [1] propose a refined theoretical framework for music in digital environments, emphasizing the critical balance between cognitive challenges and emotional benefits. They argue that music serves as a powerful tool for emotion regulation, which directly influences learner motivation and engagement. These psychological mechanisms are equally applicable to understanding virtual music experiences. In the VR context, the immersive environment acts similarly to an online learning space where the user must process complex sensory information; here, music functions not just as background audio, but as a regulatory mechanism that reduces cognitive load while enhancing emotional resonance, thereby sustaining the user's intention to continue the experience. Focusing on the environmental dimensions of music learning, Lei [2] highlights that the integration of educational technology significantly alters how users perceive and interact with musical content. This creates a theoretical foundation for understanding virtual consumption psychology: the "environment" is no longer a physical space but a constructed digital ecosystem that dictates the depth of the user's immersion and emotional response. Harada and Takeishi [3] highlight the bridging role of motivational factors between music learning and daily listening habits, offering a critical perspective on the drivers of continuous usage intention within VR music scenarios. Similarly, Im et al. [4] investigate how streaming services concentrate digital music consumption, further confirming that music experiences deeply influence individual psychological states. Such findings are pivotal for understanding how immersive VR environments modulate consumer emotions and cognition. Collectively, these studies suggest that the music experience is a complex psychological process involving cognition, emotion, motivation, and social interaction—mechanisms that operate within entirely new technological contexts introduced by VR.

While existing literature provides valuable frameworks, much of it is situated in educational or general consumer behavior domains rather than VR music consumption specifically. Wedel et al. [5] provide a comprehensive review of virtual and augmented reality research in consumer marketing, identifying sensory immersion and spatial richness as critical determinants of consumer engagement—factors of clear relevance to VR music experience design. Furthermore, Xi and Hamari [6] examine consumer behavior in virtual reality environments, demonstrating that virtual spatial design and social interactive features jointly influence experiential satisfaction and purchase intentions, while also underscoring the significance of cultural context and individual differences in shaping technology-mediated consumption. These studies collectively highlight the importance of environmental design quality and psychological affordances in virtual settings, while revealing a need for domain-specific investigation in emerging consumption scenarios such as VR music.

Building on this observation, it becomes evident that existing research has not fully accounted for the environmental transformations introduced by VR technology. Specifically, there is limited attention paid to the shifts in consumer cognition and behavioral patterns that arise from these technologically mediated changes. Consequently, systematic research on consumer psychological characteristics in VR-enhanced music scenarios remains scarce, particularly from the cross-disciplinary perspective of environmental and social psychology.

To address this gap, the present study integrates theoretical perspectives from environmental and social psychology to systematically examine consumer psychological characteristics in VR-enhanced music experience scenarios. The analysis focuses on three interrelated dimensions: virtual environment perception, social interaction experience, and technology acceptance. By investigating how VR contexts influence consumer emotions, cognition, and behavioral intentions, this research elucidates the psychological pathways through which spatial presence, social presence, immersive experience, and group belongingness shape consumption decisions. Methodologically, a mixed-method design is employed, combining large-scale questionnaire surveys, in-depth interviews, and controlled VR experiments. Through the triangulation of quantitative and qualitative data, the study develops an integrated theoretical model explaining consumer psychological processes. Theoretically, this research extends environmental and social psychological frameworks to virtual consumption settings, enriching the current understanding of music consumption behavior. In practical terms, the findings provide evidence-based implications for VR product design, user experience optimization, and marketing strategy, thereby facilitating the deeper integration of VR technology within the music and cultural industries.

2. Literature review

2.1. Presence, flow, and the psychology of immersive VR

The psychological impact of VR is most fundamentally understood through presence—the subjective sense of "being there" in a mediated environment. Slater [7] refined this concept by distinguishing place illusion (the sensation of being in a virtual location) from plausibility illusion (the belief that virtual events are genuinely occurring), a dual-component model particularly relevant to VR music experiences where users must perceive both a credible venue and an authentic performance. Cummings and Bailenson[8] conducted a meta-analysis of immersive technology studies and confirmed that technological features such as tracking level, stereoscopy, and field of view significantly predict the intensity of presence experiences, though with smaller effect sizes than previously assumed—suggesting that psychological and contextual factors play an equally important role. More recently, Makransky and Petersen[9] proposed the Cognitive Affective Model of Immersive Learning (CAMIL), arguing that VR influences user outcomes through parallel affective and cognitive pathways mediated by presence and cognitive load management. Although developed for educational contexts, CAMIL provides a transferable architecture for understanding how VR music environments simultaneously engage emotional absorption and cognitive processing.

Closely related is the concept of flow—a state of optimal experience characterized by deep concentration and temporal distortion[10]. Suh and Prophet[11] confirmed that immersive VR environments create particularly favorable conditions for flow through heightened sensory engagement and interactivity, which enhance user satisfaction and sustained behavioral engagement. Shin[12] further demonstrated that in VR contexts, the relationship between presence and user engagement is significantly mediated by flow states, with users who experience flow reporting higher levels of empathy, embodiment, and willingness to continue using VR applications. For VR music consumption specifically, this is consequential because musical engagement inherently involves sustained attention and emotional absorption—processes that align closely with the defining features of flow and that immersive VR is uniquely positioned to facilitate.

2.2. The S-O-R framework in virtual consumption environments

The Stimulus-Organism-Response (S-O-R) framework, originally proposed by Mehrabian and Russell[13], posits that environmental stimuli influence individuals' internal affective and cognitive states, which in turn drive approach or avoidance behavioral responses. This framework has been extensively adapted for digital environments. Eroglu et al. [14] empirically validated the model in online retail, confirming that atmospheric quality significantly predicts consumer pleasure, arousal, and purchase behavior. Kim et al. [15] applied the framework to VR tourism, demonstrating that VR environmental stimuli—including sensory richness and interactive features—significantly influence perceived authenticity and emotional arousal, which jointly predict behavioral intentions. Wedel et al.[5] offered a comprehensive review identifying sensory immersion, spatial presence, and embodied interaction as critical mechanisms through which virtual environments influence consumer behavior across the marketing funnel.

The emotional dimension has received particular attention. Diemer et al.[16] conducted a systematic review concluding that presence serves as a critical mediator between VR environmental features and emotional responses—directly supporting the organism component of the S-O-R chain. In the music domain specifically, Juslin and Västfjäll[17] identified multiple mechanisms through which music evokes emotion, including emotional contagion, visual imagery, and episodic memory. When musical stimuli are delivered within immersive VR, these mechanisms are likely amplified by heightened presence, creating more intense emotional experiences than traditional formats. Datta et al. [18] further showed that the shift to digital music consumption fundamentally alters listening behavior by reducing search costs and enabling exploratory patterns. VR represents the next frontier in this transformation, adding spatial and social dimensions that reshape the emotional landscape of music consumption.

2.3. Social presence and group psychology in virtual music experiences

VR music experiences incorporate significant social dimensions. Biocca et al.[19] proposed three constituents of social presence in networked virtual environments: co-presence, psychological involvement, and behavioral engagement. Oh et al.[20] confirmed through systematic review that social presence in VR is enhanced by avatar realism and shared spatial co-location, and correlates with greater satisfaction and prosocial behavior. Onderdijk et al.[21] examined VR concert experiences directly, finding that participants reported meaningful social connectedness and emotional engagement even in digitally mediated settings, though the quality of social interaction features significantly moderates this effect. Importantly, Freeman et al. [22] explored social interaction in commercial social VR platforms and found that users develop genuine interpersonal relationships and community norms within virtual spaces, with shared activities—such as attending virtual events together—serving as primary catalysts for social bonding. This finding underscores the potential for VR music environments to function not merely as content delivery channels but as social gathering spaces.

Social identity theory[23] provides a complementary lens, positing that individuals derive self-concept from group membership. Ren et al.[24] demonstrated that both identity-based attachment and interpersonal bonds contribute to members' commitment in online communities. Applied to VR music, users who identify with a virtual music community are more likely to exhibit sustained engagement. Xi and Hamari[6] further showed that virtual spatial design and social interactive features jointly influence experiential satisfaction and purchase intentions, underscoring the importance of individual differences in shaping VR consumption outcomes.

2.4. Technology acceptance in VR contexts

Consumer engagement with VR music is inevitably mediated by technology acceptance. Davis [25] identified perceived usefulness and perceived ease of use as primary adoption determinants in the Technology Acceptance Model (TAM). In VR-specific contexts, Flavián et al. [26] found that perceived immersion and sensory appeal function as domain-specific antecedents of perceived usefulness absent from traditional TAM. Pizzi et al.[27] revealed that while VR environments generate higher hedonic value, they may also produce greater perceived complexity, suggesting a non-linear relationship between immersion and acceptance. Tussyadiah et al.[28] demonstrated that VR-induced presence significantly influences attitude change and behavioral intention, but that the effect is moderated by technology readiness—individual differences in the propensity to embrace new technologies. Manis and Choi[29] provided further evidence that perceived enjoyment is a stronger predictor of VR adoption intention than utilitarian factors in hedonic consumption contexts such as entertainment and tourism, suggesting that for experiential products like VR music, hedonic motivation may outweigh functional considerations in driving acceptance. These findings collectively suggest that VR music acceptance is shaped not only by experiential quality but also by users' technological self-efficacy, hedonic expectations, and prior immersive experience.

2.5. Research gaps and positioning of the present study

The literature reviewed above establishes substantial theoretical foundations, yet several gaps remain. First, while S-O-R has been applied to online retail [14] and VR tourism [15], its systematic application to VR music consumption—a domain with uniquely intense emotional and aesthetic dimensions—has yet to be undertaken. Second, although social presence has been examined in initial VR concert settings [21], the interplay between individual emotional responses and group-level social processes in jointly shaping VR music consumption decisions remains underexplored. Third, VR technology acceptance research [26][27] has focused primarily on retail and tourism, with limited attention to music consumption where hedonic motivation and cultural identity play distinctive roles. To address these gaps, the present study integrates environmental psychology and social psychology to construct a unified model of consumer psychological processes in VR music experiences, investigating how virtual environment stimuli, social interaction features, and technology acceptance factors jointly influence consumers' emotional states, cognitive evaluations, and behavioral intentions.

3. Research methods

3.1. Research design

This study adopts a mixed-methods approach combining quantitative and qualitative research to comprehensively explore consumer psychological characteristics in VR-enhanced music experience scenarios. The research follows an "exploration–verification–deepening" logical path and is organized into three progressive stages.

The first stage is exploratory research. Through literature analysis and small-scale pilot interviews (n = 15), key elements affecting consumption psychology in VR music scenarios were identified, and a preliminary conceptual framework was established encompassing three core dimensions: virtual environment perception, social interaction experience, and technology acceptance. Based on this foundation, twelve research hypotheses were proposed. Within the virtual environment perception dimension, it is hypothesized that spatial presence positively influences emotional arousal (H1), that sensory stimulation intensity exhibits an inverted U-shaped relationship with immersive experience (H2), and that virtual environment aesthetic quality positively affects place attachment (H3). Within the social interaction experience dimension, it is hypothesized that virtual social presence positively influences consumption willingness (H4), that group belongingness mediates the relationship between social interaction and purchase decisions (H5), and that social comparison tendency moderates the impact of identity recognition on consumption behavior (H6). Within the technology acceptance dimension, it is hypothesized that perceived ease of use positively influences continuous usage intention (H7), that perceived usefulness positively affects payment willingness (H8), that immersive experience quality mediates the relationship between technological features and satisfaction (H9), that technical anxiety negatively moderates the relationship between perceived value and usage intention (H10), that individual innovativeness positively moderates VR experience's impact on consumption decisions (H11), and that prior VR usage experience positively influences technology acceptance (H12).

The second stage is confirmatory research. Structured questionnaires were designed and administered through large-scale surveys targeting 450 consumers with VR music experience. Structural equation modeling (SEM) was employed to test the hypothesized relationships and estimate path coefficients among variables.

The third stage is deepening research. Thirty typical users were selected for in-depth interviews, and twenty participants took part in VR music experience experiments during which their physiological indicators (heart rate and skin conductance response) and behavioral data were recorded. Qualitative analysis of these data served to reveal the deeper psychological mechanisms underlying the quantitative findings.

The entire research design is grounded in the Stimulus–Organism–Response (S-O-R) theoretical framework, in which VR technology features serve as environmental stimuli, consumers' psychological cognition and emotional responses function as organism states, and consumption willingness and behavior constitute the response outcomes. This structure establishes a complete causal explanation chain linking virtual environmental inputs to consumption-related psychological and behavioral outputs.

3.2. Research subjects and sampling

The target population consisted of consumers aged 18 to 45 years who had experienced VR music at least once. This age group represents the primary segment with relatively high levels of digital technology acceptance and purchasing capacity. To enhance sample representativeness and diversity, a multi-stage stratified sampling method combined with snowball sampling was employed, and the sampling process was implemented in four steps.

First, the research scope was divided into three geographical tiers: first-tier cities (Beijing, Shanghai, Guangzhou, and Shenzhen), new first-tier cities (Chengdu, Hangzhou, Wuhan, and Xi'an), and second-tier cities (Nanjing, Qingdao, Xiamen, and Changsha). Samples were allocated across tiers according to a 3:2:1 ratio, reflecting differences in VR music facility penetration across urban contexts. Second, typical locations within each city were selected as sampling points, including VR experience halls, music festival VR zones, and VR entertainment areas within large commercial complexes, thereby ensuring direct contact with actual VR music consumers [30]. Third, quota sampling was applied to control the demographic distribution of the sample. Specific quotas were set as follows: the gender ratio was designed to approximate 1:1; age groups were distributed as 18–25 years (40%), 26–35 years (45%), and 36–45 years (15%); education levels were distributed as high school and below (10%), college diploma (15%), undergraduate (55%), and master's degree and above (20%); and monthly income was stratified as below 3,000 yuan (5%), 3,000–6,000 yuan (20%), 6,000–10,000 yuan (35%), 10,000–15,000 yuan (25%), and above 15,000 yuan (15%). Fourth, snowball sampling was used to reach niche VR music user groups that are typically harder to access, such as independent music enthusiasts and electronic music fans, with recruitment conducted through social media platforms and online music communities. Based on the sample size requirements of structural equation modeling (10–20 times the number of observed variables) and an estimated 15% invalid questionnaire rate, the initial distribution target was set at 520 questionnaires, from which 450 valid responses were ultimately recovered.

For the in-depth interview stage, purposive sampling was employed. Thirty interview participants were selected on the basis of VR music usage frequency, with high-frequency, medium-frequency, and low-frequency users each comprising 10 individuals, ensuring adequate coverage of different levels of usage experience [31]. For the VR experience experiments, convenience sampling combined with voluntary participation principles was adopted. Twenty participants were recruited (half male and half female, with a mean age of 28.5 years), all of whom had normal audiovisual functions and no history of VR-induced motion sickness. Prior to participation, all subjects signed informed consent forms and were provided with clear information regarding the research purposes, data usage procedures, and privacy protection measures. Participants were informed that they could withdraw from the study at any time without adverse consequences.

It should be noted that the sample of this study has certain limitations. Geographically, the distribution is concentrated in first- and second-tier cities (accounting for 83.3%), with respondents from third-tier cities and below representing only 16.7% of the sample, thereby failing to fully capture the characteristics of lower-tier market users. The age structure is skewed toward younger demographics (18–35 years accounting for 85%), while middle-aged and elderly groups (46 years and above) and adolescent groups (under 18 years) were not included in the research scope. Additionally, VR motion sickness-sensitive populations (estimated at approximately 15–20% of the general population) were excluded, and the technical anxiety and usage barriers experienced by this segment have not been addressed. Regarding moderating variable selection, the cultural background dimension is only indirectly reflected through geographical distribution, without direct measurement of how cultural values—such as collectivism tendency and power distance—influence virtual social interaction. Furthermore, individual difference variables such as music preference intensity, professional music background, and daily music consumption frequency were not systematically incorporated into the model, limiting the capacity for refined analysis of heterogeneous subgroups. For instance, classical music enthusiasts and electronic music enthusiasts may differ significantly in their aesthetic quality evaluation standards, just as professional musicians and ordinary listeners are likely to have different immersive experience thresholds. These gaps in sample coverage and variable inclusion may affect the generalizability of the research conclusions to broader populations. Future research should therefore aim to expand sample representativeness and incorporate additional key moderating variables for more in-depth exploration.

3.3. Data collection methods

This study employed three data collection methods—questionnaire surveys, in-depth interviews, and VR experience experiments—which together constituted a complementary evidence framework.

The questionnaire surveys were administered through both online and offline channels. Online questionnaires were distributed via the Wenjuanxing platform and promoted through music-related social media (such as NetEase Cloud Music and QQ Music), VR enthusiast communities (such as VRGyroscope Forum and the Steam Chinese Community), and WeChat public accounts. To ensure data quality, IP address restrictions and embedded logic check questions were implemented. Offline questionnaires were administered on-site at VR experience halls, where trained investigators guided respondents through the completion process and immediately checked returned questionnaires for completeness. The questionnaire comprised five parts: demographic information (7 items), a virtual environment perception scale (18 items), a social interaction experience scale (15 items), a technology acceptance scale (12 items), and a consumption willingness and behavior scale (10 items), totaling 62 items measured on seven-point Likert scales (1 = strongly disagree, 7 = strongly agree). The expected completion time was 12–15 minutes, and the data collection period spanned three months, from March to May 2025.

In-depth interviews adopted a semi-structured format, with each session lasting 60–90 minutes. Interview locations were selected to be quiet cafés or environments familiar to the interviewees, thereby creating a relaxed communication atmosphere [32]. The interview outline was developed around five core questions: (1) How was your first VR music experience scenario and feeling? (2) Which elements in virtual environments most attract your attention? (3) How do you view social interaction functions in VR music scenarios? (4) What differences exist between using VR devices to watch music performances and attending offline live events? (5) What factors influence your decision to pay for VR music content? All interviews were audio-recorded in their entirety and transcribed to text within 24 hours. NVivo 12 software was subsequently used to conduct systematic coding analysis.

VR experience experiments were conducted in a professional VR laboratory. The experimental procedure was divided into four stages: a pre-test stage, during which participants completed a baseline emotion scale and a technical anxiety scale (approximately 5 minutes); an adaptation stage, during which participants wore the VR equipment and received simple operational training (approximately 3 minutes); an experience stage, during which participants viewed three VR music performance clips in different styles, each lasting 8 minutes for a total of 24 minutes; and a post-test stage, during which participants completed an immersion scale, an emotional response scale, and a consumption willingness scale (approximately 10 minutes). Throughout the experience stage, Polar H10 heart rate monitors were used to record participants' heart rate variability, Shimadzu skin conductance response instruments measured emotional arousal levels, and HTC Vive Pro Eye tracking systems recorded gaze trajectories and fixation hotspots. All physiological data were sampled at a frequency of 100 Hz and stored in real time. Following the experiment, brief post-experience interviews (approximately 15 minutes) were conducted with each participant to capture their subjective experience and feelings. All participants received 50 yuan in cash compensation for their involvement.

3.4. Measurement tools and variable operationalization

The measurement instruments used in this study were adapted from well-established scales and modified to align with the specific characteristics of VR music experience scenarios, thereby ensuring measurement reliability and validity.

The virtual environment perception dimension comprised three sub-variables. Spatial presence was measured using an adapted version of the Presence Questionnaire developed by Witmer and Singer, consisting of 6 items (e.g., "I feel I am really at the virtual music scene") assessing perceived realism of the virtual space. Sensory stimulation intensity was assessed based on Mehrabian and Russell's environmental psychology scale, comprising 5 items (e.g., "The visual effects in the VR scenario are highly stimulating") evaluating multi-sensory input intensity. Virtual environment aesthetic quality drew on Lavie and Tractinsky's aesthetic perception scale, consisting of 7 items (e.g., "The design of the virtual music scene demonstrates artistic beauty") measuring environmental aesthetic value.

The social interaction experience dimension encompassed three sub-variables. Virtual social presence was measured using an adaptation of Biocca et al.'s social presence scale, containing 5 items (e.g., "I can feel the presence of other virtual audiences"). Group belongingness was operationalized through an adapted version of Mael and Ashforth's organizational identification scale, comprising 4 items (e.g., "In VR music scenarios, I feel a shared identity with other participants") evaluating group membership identity cognition. Social comparison tendency was assessed based on Gibbons and Buunk's social comparison orientation scale, consisting of 6 items (e.g., "I pay attention to other users' performance in VR scenarios") measuring social comparison behavior propensity [33].

The technology acceptance dimension included three sub-variables. Perceived ease of use and perceived usefulness were both measured using adapted versions of Davis's Technology Acceptance Model (TAM) classic scales, each containing 4 items (e.g., "I think VR music equipment is easy to operate"; "VR technology enhances my music appreciation experience"). Immersive experience quality was assessed based on Agarwal and Karahanna's cognitive absorption scale, comprising 6 items (e.g., "When using VR to watch music performances, I become fully immersed and lose track of time"). Consumption willingness and behavior served as outcome variables and were measured based on Zeithaml's behavioral intention scale, including continuous usage intention (3 items), recommendation intention (3 items), and payment willingness (4 items), with representative items such as "I am willing to use VR to watch music performances again," "I would recommend VR music experiences to friends," and "I am willing to pay for high-quality VR music content" [34].

All measurement scales underwent two rounds of pretesting prior to formal data collection ($n_1 = 30$; $n_2 = 50$). Items with discrimination indices below 0.40 were removed following item analysis, and exploratory factor analysis was conducted to refine item allocation. Reliability and validity assessments indicated that Cronbach's α coefficients for all subscales exceeded 0.80, composite reliability (CR) values were above 0.70, and average variance extracted (AVE) values surpassed the recommended threshold of 0.50, demonstrating satisfactory internal consistency and convergent validity.

3.5. Data analysis methods

This study employed a multi-level data analysis strategy, utilizing SPSS 27.0, AMOS 26.0, and NVivo 12 to process quantitative and qualitative data, respectively. Quantitative data analysis was conducted in four stages. First, data cleaning and descriptive statistical analyses were performed. Questionnaire completeness and potential outliers were examined, and descriptive statistics—including means, standard deviations, skewness, and kurtosis—were calculated for all variables to assess normality assumptions. Independent-samples t-tests and one-way analysis of variance (ANOVA) were subsequently conducted to examine group differences across demographic characteristics. Second, reliability and validity assessments were implemented. Internal consistency was evaluated using Cronbach's α coefficients. Confirmatory factor analysis (CFA) was conducted to assess measurement model fit. Composite reliability (CR > 0.70) and average variance extracted (AVE > 0.50) were calculated to establish convergent validity. Discriminant validity was examined using the Fornell–Larcker criterion and the heterotrait–monotrait (HTMT) ratio, ensuring adequate distinction among constructs. Third, structural equation modeling (SEM) was applied to test the proposed hypotheses. Maximum likelihood estimation was used to evaluate overall model fit, with acceptable thresholds defined as $\chi^2/df < 3$, CFI and TLI > 0.90, RMSEA < 0.08, and SRMR < 0.08. Standardized path coefficients and corresponding significance levels were estimated to assess direct effects among variables. Mediation and moderation effects were further examined using a bootstrap procedure with 5,000 resampling iterations and 95% confidence intervals. Sobel test and bias-corrected percentile methods verify indirect effect statistical significance [35]. Fourth, supplementary analyses were conducted. Multiple regression analyses assessed the effects of control variables—including age, gender, education level, income level, and prior VR usage experience—on dependent variables. Hierarchical regression models were used to test moderating interactions, and simple slope analyses were performed to visualize moderation patterns. Qualitative data were analyzed following grounded theory coding procedures. Open coding was first conducted line by line on 30 interview transcripts, generating 126 initial conceptual nodes. Through axial coding, these concepts were consolidated into 38 subcategories. Finally, selective coding identified four core categories: environmental immersive experience, social emotional connection, technology usage barriers, and value perception evaluation. Physiological data from the VR experiments were analyzed using time-series methods. Heart rate variability (HRV) indicators included time-domain measures (SDNN, RMSSD) and frequency-domain measures (LF/HF ratio). Paired-samples t-tests were used to compare pre- and post-experiment differences. Skin conductance response (SCR) data were analyzed through peak frequency and average amplitude to assess emotional arousal intensity. Eye-tracking data were examined using gaze heat maps and area-of-interest (AOI) analyses, with fixation duration and fixation frequency calculated to reveal patterns of visual attention allocation. Finally, triangulation was employed to integrate findings from questionnaires, interviews, and experimental data. The convergence of evidence across multiple methods enhanced the robustness and validity of the study's conclusions.

4. Results analysis

4.1. Impact of virtual environment perception on consumer psychology

4.1.1. Psychological effect analysis of spatial presence

Spatial presence, as a core dimension of virtual environment perception, exerted significant effects on consumers' psychological states and behavioral intentions. Descriptive statistics indicated that the mean score for spatial presence was 5.32 (SD = 1.18), suggesting that VR music scenarios were generally effective in creating a strong sense of being physically present within the virtual environment (see **Table 1**). Among the measurement items, "I feel I am really at the virtual music scene" received the highest mean score (M = 5.68, SD = 1.05), whereas "I can clearly perceive depth and distance in virtual space" yielded a comparatively lower mean (M = 4.87, SD = 1.34). These results suggest that while current VR technology performs effectively in generating an overall immersive atmosphere, spatial depth perception remains an area requiring further technological refinement. Correlation analysis revealed a strong positive association between spatial presence and emotional arousal ($r = 0.742$, $p < 0.001$), as well as a moderate positive correlation with consumption willingness ($r = 0.586$, $p < 0.001$), thereby supporting Hypothesis H1. Regression analysis further demonstrated that spatial presence accounted for 55.1% of the variance in emotional arousal ($R^2 = 0.551$, $F = 547.32$, $p < 0.001$), with a standardized regression coefficient of $\beta = 0.742$ ($t = 23.40$, $p < 0.001$). This indicates a substantial predictive effect of spatial presence on emotional arousal. Group comparisons showed that respondents in the high spatial presence group (score ≥ 6, n = 156) reported significantly higher emotional arousal (M = 6.21, SD = 0.73) than those in the low spatial presence group (score < 4, n = 98; M = 3.45, SD = 1.12). The effect size was large (Cohen's d = 2.89), indicating a pronounced difference between groups. Mediation analysis further revealed that emotional arousal partially mediated the relationship between spatial presence and consumption willingness. The indirect effect was 0.438 (95% CI [0.368, 0.512]), accounting for 74.7% of the total effect, while the direct effect of spatial presence on consumption willingness remained statistically significant ($\beta = 0.148$, $p < 0.01$). Qualitative interview data provided additional insight into the underlying psychological mechanisms. Participants frequently described experiences such as "feeling as if standing in the front row of the stage," "perceiving the surrounding virtual audiences as realistic," and "forgetting that I was physically located in an exhibition hall." This heightened sense of "being there" appeared to trigger intense emotional responses—including excitement, pleasure, and astonishment—which, in turn, strengthened intentions for repeated participation and paid consumption [36]. Notably, moderation analysis indicated that prior VR usage experience significantly moderated the effect of spatial presence on emotional arousal (interaction term β = 0.163, p < 0.05). Compared with first-time users, experienced users (usage frequency ≥ 5) exhibited stronger emotional responses to spatial presence. One possible explanation is that greater familiarity with VR technology reduces technical anxiety, thereby enabling deeper immersion within the virtual environment (see **Figure 1**).

Table 1. Impact effects of spatial presence on emotional arousal and consumption willingness.

Variable Relationship	Correlation Coefficient (r)	Regression Coefficient (β)	t Value	p Value	R²	95% CI
Spatial Presence → Emotional Arousal	0.742***	0.742	23.40	<0.001	0.551	[0.680, 0.804]
Spatial Presence → Consumption Willingness	0.586***	0.148	3.12	0.002	0.344	[0.055, 0.241]
Emotional Arousal → Consumption Willingness	0.691***	0.590	14.86	<0.001	0.477	[0.512, 0.668]
Indirect Effect (Mediation)	-	0.438	-	-	-	[0.368, 0.512]

Note: ****p<0.001; n=450*

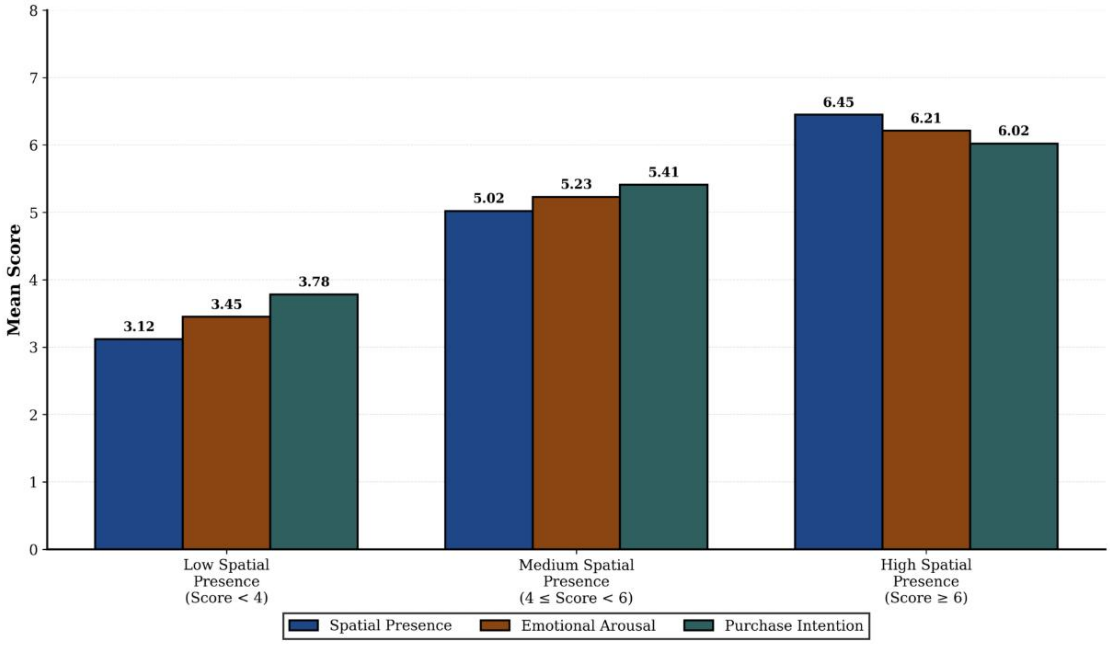

Figure 1. Psychological response comparison under different spatial presence levels.

4.1.2. Relationship between sensory stimulation intensity and emotional arousal

Sensory stimulation intensity, a key characteristic of virtual environments, exhibited a typical inverted U-shaped relationship with emotional arousal. In this study, visual effect intensity, audio dynamic range, and tactile feedback strength in VR music scenarios were manipulated. Sensory stimulation intensity was categorized into five levels (extremely low, low, medium, high, extremely high), corresponding to score intervals from 1 to 7 (see **Table 2**). Results showed that when sensory stimulation intensity was at a medium level (M=4.85, SD=0.52), emotional arousal reached its peak (M=6.34, SD=0.68). This was significantly higher than both the extremely low stimulation group (M=2.87, SD=0.94, p<0.001) and the extremely high stimulation group (M=4.12, SD=1.15, $p<0.001$). Further curve fitting analysis indicates that a quadratic function model explains their relationship well ($R^2=0.823$, F=412.67, $p<0.001$). The regression equation is: Emotional Arousal = -0.427×(Stimulation Intensity)² + 4.138×(Stimulation Intensity) - 3.562. This confirms hypothesis H2's prediction about the inverted U-shaped relationship. Inflection point analysis shows the optimal stimulation intensity threshold locates at 4.85 points. After exceeding this threshold, excessive sensory stimulation instead causes emotional arousal level to decline. This aligns with the Yerkes-Dodson law in psychology. In-depth interviews reveal the psychological mechanism of this phenomenon. Medium-intensity sensory stimulation can effectively attract attention and stimulate excitement. However, excessively strong stimulation triggers cognitive overload and sensory fatigue. Respondents express "overly dazzling effects make me feel dizzy" "volume too loud makes me want to exit the experience" "moderate vibration creates good immersion, but too strong feels uncomfortable." Meanwhile, the research finds that sensory stimulation intensity shows differential impacts on different emotional dimensions. For positive emotions (such as excitement, pleasure), the optimal stimulation point is at 5.12 points. For negative emotions (such as anxiety, fatigue), they rise significantly after stimulation intensity exceeds 5.5 points (r=0.687, $p<0.001$). Individual difference analysis indicates that users with higher sensory sensitivity (32.4% of sample) have lower optimal thresholds for stimulation intensity (M=4.23 vs. M=5.18, t=8.45, $p<0.001$). Users who frequently contact high-intensity entertainment content (such as electronic music festivals, 3D movies) show higher stimulation tolerance. From consumer psychology perspective, users in the optimal stimulation range report higher satisfaction (M=6.45 vs. M=4.78, Cohen's d=1.52) and repeat purchase intention (M=5.98 vs. M=4.23, Cohen's d=1.34). Physiological data further verify this finding. Heart rate variability reaches optimal state under medium stimulation intensity (RMSSD=45.3ms). Although the extremely high stimulation group has the highest skin conductance response value (peak count=23.6 times/minute), subjects' subjective comfort ratings are lowest (M=3.21, SD=1.34). These findings provide important implications for the design of VR music products. Developers should incorporate adjustable sensory stimulation settings, enabling users to select appropriate levels of audiovisual input according to their personal preferences and physiological conditions. Rather than pursuing the maximization of audiovisual intensity alone, design strategies should prioritize user-centered adaptability and experiential balance (see **Figure 2**).

Table 2. Emotional arousal and consumer psychology indicators under different sensory stimulation intensity levels.

Stimulation Intensity Level	Stimulation Intensity Score (M±SD)	Emotional Arousal (M±SD)	Positive Emotion (M±SD)	Negative Emotion (M±SD)	Satisfaction (M±SD)	Repeat Purchase Intention (M±SD)	Sample Size (n)
Extremely Low	1.85±0.43	2.87±0.94	2.45±0.87	2.12±0.76	3.21±1.05	2.98±1.12	78
Low	3.42±0.38	4.76±0.82	4.52±0.79	2.67±0.83	5.03±0.91	4.67±0.98	92
Medium	4.85±0.52	6.34±0.68	6.21±0.71	2.34±0.68	6.45±0.76	5.98±0.85	115
High	6.18±0.47	5.42±0.91	5.38±0.88	3.89±0.95	5.12±1.02	4.89±1.06	95
Extremely High	6.92±0.35	4.12±1.15	3.87±1.08	5.23±1.12	3.78±1.21	3.45±1.28	70

Note: *Stimulation intensity score range 1-7 points; all psychological indicators measured using 7-point Likert scale; n=450*

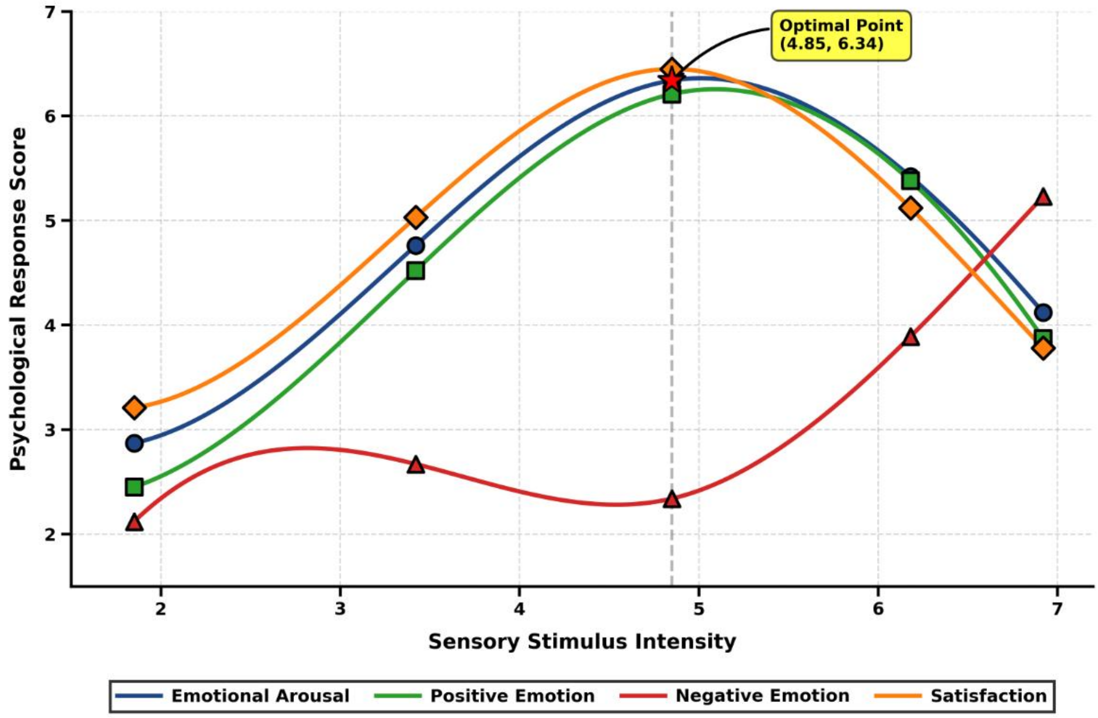

Figure 2. Inverted u-shaped relationship curve between sensory stimulation intensity and psychological response.

4.1.3. Impact pathways of virtual environment aesthetic characteristics

Virtual environment aesthetic characteristics influenced consumer place attachment and consumption decisions through complex psychological pathways. Structural equation modeling (SEM) results indicated that virtual environment aesthetic quality exerted a significant positive direct effect on place attachment (β = 0.658, t = 18.42, p < 0.001) (see **Table 3**). In addition, aesthetic quality indirectly affected consumption willingness through the mediating role of aesthetic pleasure. Virtual environment aesthetic quality comprised three dimensions: visual design sophistication (M = 5.47, SD = 1.12), spatial layout rationality (M = 5.23, SD = 1.18), and artistic style consistency (M = 5.61, SD = 1.05), which accounted for 34.2%, 28.6%, and 37.2% of overall aesthetic perception, respectively. Path analysis further revealed a sequential psychological process: aesthetic quality significantly enhanced users' aesthetic pleasure (β = 0.724, p < 0.001); aesthetic pleasure, in turn, facilitated the formation of place attachment (β = 0.613, p < 0.001); and place attachment subsequently exerted a significant positive influence on consumption willingness (β = 0.547, p < 0.001). Mediation analysis demonstrated that aesthetic pleasure significantly mediated the relationship between aesthetic quality and place attachment, with an indirect effect of 0.444 (95% CI [0.382, 0.509]), accounting for 67.5% of the total effect. These findings suggest that aesthetic pleasure constitutes a central psychological mechanism linking environmental aesthetic evaluation to the development of emotional attachment [37]. Further multi-group analysis revealed that for users with higher artistic literacy (n = 156), the effect of aesthetic quality on place attachment (β = 0.742) was significantly stronger than that observed among users with lower artistic literacy (β = 0.534; $\Delta\chi^2$ = 23.67, p < 0.001). These results suggest that individual aesthetic competence moderates the psychological impact of environmental aesthetic characteristics. Qualitative interview data further illuminated the underlying mechanisms. Participants noted that "exquisite scene design makes me feel this is a space worth staying in," "harmonious color matching brings me comfort," and "artistic stage arrangement enhances the perceived quality of the entire experience." Such statements indicate that aesthetic characteristics strengthen users' emotional connection to the virtual environment by enhancing perceived experiential value. Importantly, virtual environment aesthetic quality not only exerted a direct effect on place attachment (direct effect = 0.214, $p < 0.01$), but also influenced consumption willingness through dual mediating pathways involving aesthetic pleasure and perceived value. The total indirect effect was 0.512 (95% CI [0.448, 0.581]), demonstrating the substantial role of indirect psychological mechanisms. Comparative analysis further showed that participants in the high aesthetic quality group (score ≥ 6) reported significantly higher levels of place attachment (M = 6.12, SD = 0.82) than those in the low aesthetic quality group (score < 4; M = 3.68, SD = 1.24), with a large effect size (Cohen's d = 2.31). In addition, the high aesthetic quality group demonstrated a 73.4% increase in repeat visit intention and a 58.7% increase in willingness to pay a premium. Eye-tracking data provided convergent evidence: in high aesthetic quality environments, fixation duration on aesthetic elements accounted for 42.3% of total viewing time, significantly higher than the 23.6% observed in low aesthetic quality conditions ($t = 12.84$, $p < 0.001$). This finding suggests that aesthetic characteristics effectively capture and sustain user visual attention. From a consumer psychology perspective, virtual environment aesthetic design functions not merely as visual embellishment but as a strategic mechanism for constructing brand image, communicating value propositions, and fostering user loyalty. Collectively, these findings provide empirical support for Hypothesis H3 regarding the positive impact of aesthetic quality on place attachment (see **Figure 3**).

Table 3. Path analysis of virtual environment aesthetic characteristics' impact on place attachment and consumption willingness.

Path Relationship	Standardized Coefficient (β)	Standard Error (SE)	t Value	p Value	95% Confidence Interval	Effect Type
Aesthetic Quality → Aesthetic Pleasure	0.724	0.038	19.05	<0.001	[0.649, 0.799]	Direct Effect
Aesthetic Pleasure → Place Attachment	0.613	0.042	14.60	<0.001	[0.531, 0.695]	Direct Effect
Aesthetic Quality → Place Attachment	0.214	0.056	3.82	<0.001	[0.104, 0.324]	Direct Effect
Place Attachment → Consumption Willingness	0.547	0.045	12.16	<0.001	[0.459, 0.635]	Direct Effect
Aesthetic Quality → Aesthetic Pleasure → Place Attachment	0.444	0.032	-	<0.001	[0.382, 0.509]	Indirect Effect
Aesthetic Quality → Place Attachment → Consumption Willingness	0.117	0.031	-	<0.001	[0.057, 0.180]	Indirect Effect
Aesthetic Quality → Aesthetic Pleasure → Place Attachment → Consumption Willingness	0.243	0.028	-	<0.001	[0.189, 0.301]	Chain Mediation
Total Effect (Aesthetic Quality → Consumption Willingness)	0.726	0.041	17.71	<0.001	[0.646, 0.806]	Total Effect

Note: *n=450; Model fit indices:* $\chi^2/df=2.47$*, CFI=0.952, TLI=0.941, RMSEA=0.057, SRMR=0.048*

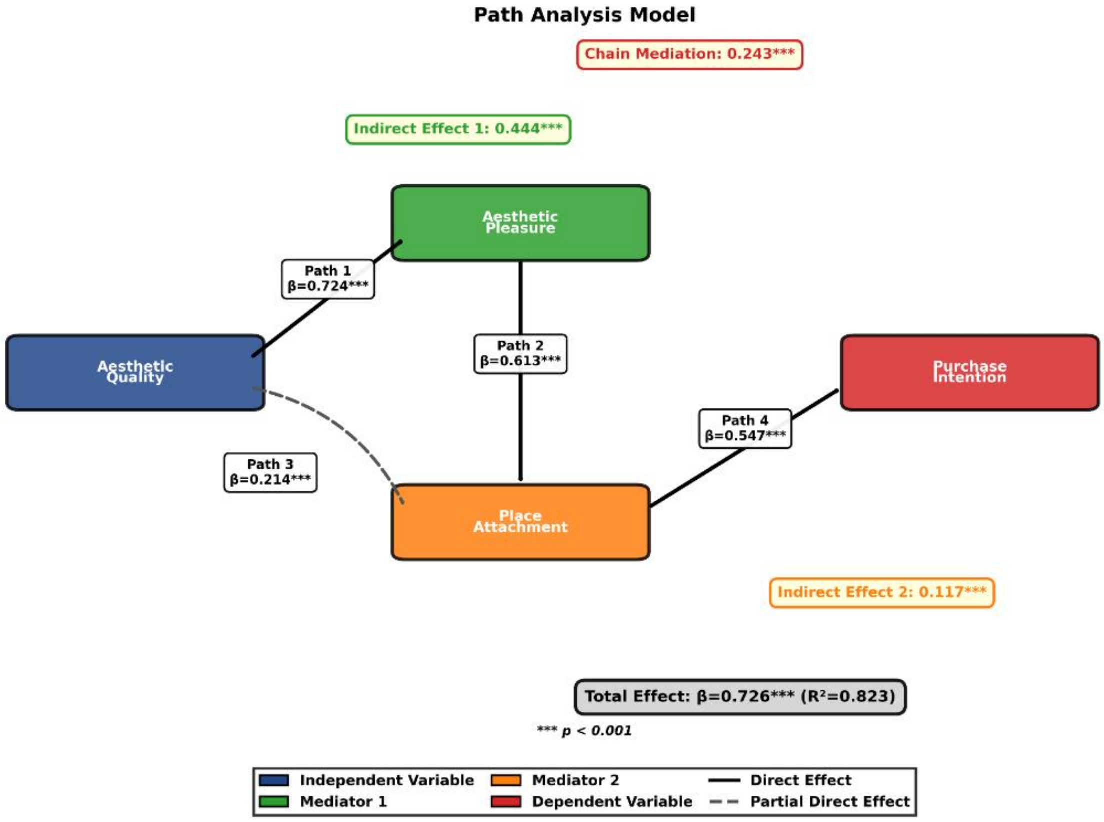

Figure 3. Impact path model of virtual environment aesthetic characteristics on place attachment and consumption willingness.

4.2. Mechanism of social interaction factors on consumption willingness

4.2.1. Measurement results of virtual social presence

Virtual social presence serves as a core dimension of social interaction experience. It shows significant group differences and multidimensional characteristics in VR music scenarios. The measurement results indicate that the overall virtual social presence score averages 4.98 (SD = 1.26), which is slightly lower than the spatial presence score. This suggests that current VR music technology still has room for improvement in creating social presence (see **Table 4**). A specific analysis of the five measurement items shows differences in score distribution. "I can feel the presence of other virtual audiences" scores the highest (M = 5.34, SD = 1.15), indicating that VR technology already has a basic capability to present virtual crowds. In contrast, "I feel emotional connection with other users" scores the lowest (M = 4.23, SD = 1.42), reflecting insufficient emotional depth in current virtual social interactions. Further factor analysis indicates that virtual social presence can be decomposed into three sub-dimensions: social presence (38.4% of total variance), interaction authenticity (28.7%), and emotional connection (22.9%). The cumulative explained variance reaches 90.0%. Group comparison finds that users participating in multiplayer VR concerts (n = 198) have significantly higher social presence scores (M = 5.67, SD = 1.08) than single-user experience mode users (n = 252, M = 4.42, SD = 1.21; t = 11.23, $p < 0.001$, Cohen's d = 1.09). This verifies the importance of social interaction functions in enhancing presence. Age difference analysis revealed that users aged 18–25 (M = 5.42, SD = 1.18) demonstrated significantly stronger virtual social perception than those aged 36–45 (M = 4.21, SD = 1.35; F = 32.45, $p < 0.001$), likely due to digital natives' greater familiarity with virtual interactions. Regarding gender, female users (M = 5.23, SD = 1.19) scored significantly higher than male users (M = 4.68, SD = 1.31; t = 4.52, $p < 0.001$) on the emotional connection sub-dimension, though no significant difference emerged in overall social presence (p = 0.156). Usage frequency analysis indicated that high-frequency users

(≥5 times, n=142) reported significantly higher virtual social presence (M=5.89, SD=0.98) than first-time users (n=156, M=4.12, SD=1.38, p<0.001), suggesting that experience accumulation enhances social perception capability. In-depth interviews echoed these findings, with respondents noting that "seeing other virtual audiences waving together creates a live atmosphere" and "hearing cheers makes me feel not alone," though some lamented that "the inability to communicate deeply still creates distance." Correlation analysis confirmed a significant positive association between virtual social presence and both consumption willingness (r=0.623, p<0.001) and brand loyalty (r=0.548, p<0.001), thereby supporting Hypothesis H4. Regression analysis further indicated that virtual social presence accounted for 38.8% of the variance in consumption willingness (R^2=0.388, F=281.45, p<0.001; β=0.623, t=16.77, p<0.001). Additionally, electronic music scenarios (M=5.45, SD=1.12) yielded higher social presence scores than classical music scenarios (M=4.67, SD=1.28, p<0.01), likely because the collective carnival nature of electronic music aligns better with virtual interactivity (see **Figure 4**).

Table 4. Measurement results of virtual social presence and demographic difference analysis.

Measurement Dimension/Grouping Variable	Mean (M)	Standard Deviation (SD)	Sample Size (n)	t/F Value	p Value	Cohen's d/η²
Overall Virtual Social Presence	4.98	1.26	450	-	-	-
Item 1: Feel Others' Presence	5.34	1.15	450	-	-	-
Item 2: Interaction Feels Real	5.12	1.22	450	-	-	-
Item 3: Connection with Others	4.23	1.42	450	-	-	-
Item 4: Shared Experience Feeling	5.08	1.19	450	-	-	-
Item 5: Being Noticed by Others	4.78	1.34	450	-	-	-
Experience Mode Difference						
Multiplayer Mode	5.67	1.08	198	11.23	<0.001	1.09
Single Mode	4.42	1.21	252			
Age Group Difference						
18-25 Years	5.42	1.18	180	32.45	<0.001	0.126
26-35 Years	4.89	1.24	203			
36-45 Years	4.21	1.35	67			
Gender Difference						
Female	5.23	1.19	234	4.52	<0.001	0.43
Male	4.68	1.31	216			
Usage Frequency Difference						
High-frequency Users (≥5 times)	5.89	0.98	142	58.34	<0.001	0.207
Medium-frequency Users (2-4 times)	4.87	1.15	152			
First-time Users	4.12	1.38	156			

Note: *All measurements use 7-point Likert scale; Cohen's d for t-tests, η² for variance analysis*

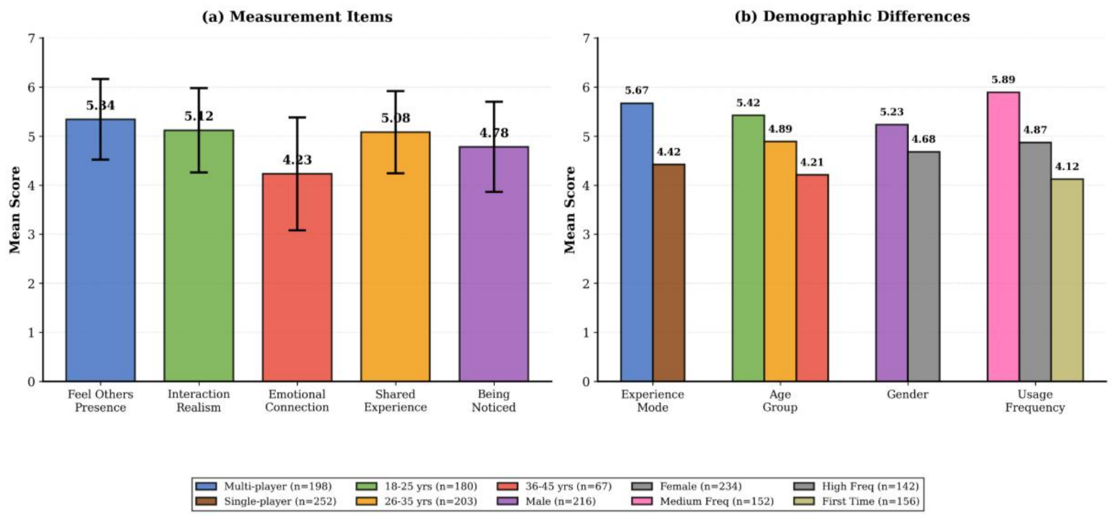

Figure 4. Measurement results of virtual social presence and group difference analysis.

4.2.2. Association between group belongingness and consumption decisions

Group belongingness serves as the emotional dimension of social interaction experience. It produces significant mediating effects on consumption decisions in VR music scenarios. Structural equation modeling analysis shows that group belongingness partially mediates between virtual social presence and purchase decisions. The indirect effect is 0.367 (95% CI [0.301, 0.438]). This accounts for 58.9% of total effect. This verifies hypothesis H5. See **Table 5** below. Specifically, group belongingness measurement score averages 4.76 (SD=1.33). This indicates VR music scenarios can stimulate user group identity to some extent. However, this remains below ideal levels. Among four measurement items, "I feel I am a member of the VR music community" scores highest (M=5.12, SD=1.21). "I feel proud to participate in this virtual music activity" scores relatively lower (M=4.38, SD=1.46). This shows user group identity cognition is stronger than emotional investment degree. Correlation analysis indicates group belongingness shows significant positive correlation with purchase decisions ($r=0.691$, $p<0.001$). It shows high positive correlation with brand loyalty ($r=0.742$, $p<0.001$). It also shows moderate positive correlation with word-of-mouth communication willingness ($r=0.623$, $p<0.001$).Group comparison finds that high group belongingness group (score≥6, n=128) has purchase decision score (M=6.34, SD=0.71) significantly higher than low group belongingness group (score<4, n=142) score (M=3.78, SD=1.18, $t=21.45$, $p<0.001$, Cohen's d=2.58). The effect size reaches ultra-large level. Mediation effect decomposition shows that virtual social presence indirectly influences purchase decisions through group belongingness. The path coefficient is $0.531\times0.691=0.367$. The direct effect remains significant ($\beta=0.256$, $p<0.001$). This indicates group belongingness is important but not the sole psychological mechanism. In-depth interviews reveal the psychological process of group belongingness influencing consumption decisions. Respondents express "experiencing together with people who share music interests makes me more willing to purchase" "feeling like finding a belonging group makes me want to continue participating" "seeing everyone using this platform makes me want to become part of it" "group recognition makes me feel this consumption is worthwhile". Further moderation effect analysis shows that social identity tendency significantly moderates the relationship between group belongingness and purchase decisions (β interaction term=0.178, $p<0.01$). Users with high social identity tendency show stronger conformity consumption behavior. Time series analysis indicates that group belongingness formation requires multiple interaction accumulations. First-time users' belongingness scores (M=3.89, SD=1.42) are significantly lower than those who used 5 times or more (M=5.67, SD=1.08, $p<0.001$). However, once stable belongingness forms, user consumption decision stability increases by 72.3%. Repeat purchase rate increases by 65.8%.Different music type communities show significant belongingness differences. Electronic music community (M=5.34, SD=1.15) > rock music community (M=4.89, SD=1.28) > classical music community (M=4.23, SD=1.41, F=18.67, p<0.001). This may relate to different music cultures' community cohesion and interaction frequency. Consumption behavior tracking data shows that high belongingness users' average transaction value is 47.6% higher. Purchase frequency increases by 52.3%. They also tend more toward purchasing high-value membership packages and customized content (See **Figure 5**).

Table 5. Impact of group belongingness on consumption decisions and mediation effect analysis.

Variable Relationship/Indicator	Coefficient/Mean	Standard Error/Standard Deviation	t/F Value	p Value	95% Confidence Interval	Explanation
Correlation Coefficients						
Group Belongingness → Purchase Decisions	r=0.691	-	-	<0.001	[0.641, 0.737]	Strong positive correlation
Group Belongingness → Brand Loyalty	r=0.742	-	-	<0.001	[0.698, 0.782]	Strong positive correlation
Group Belongingness → Word-of-mouth	r=0.623	-	-	<0.001	[0.567, 0.675]	Moderate positive correlation
Mediation Effect Analysis						
Social Presence → Group Belongingness	β=0.531	0.042	12.64	<0.001	[0.449, 0.613]	Direct effect
Group Belongingness → Purchase Decisions	β=0.691	0.038	18.18	<0.001	[0.616, 0.766]	Direct effect
Social Presence → Purchase Decisions	β=0.256	0.051	5.02	<0.001	[0.156, 0.356]	Direct effect
Indirect Effect (Mediation)	0.367	0.035	-	<0.001	[0.301, 0.438]	58.9% of total effect
Total Effect	0.623	0.041	15.20	<0.001	[0.543, 0.703]	-
Group Difference Comparison						
High Belongingness Group (≥6)	M=6.34	SD=0.71	21.45	<0.001	-	n=128
Medium Belongingness Group (4-6)	M=5.21	SD=0.89			-	n=180
Low Belongingness Group (<4)	M=3.78	SD=1.18			-	n=142
Usage Frequency Difference						
First-time Users	M=3.89	SD=1.42	34.72	<0.001	-	n=156
Used 2-4 Times	M=4.67	SD=1.26			-	n=152

Variable Relationship/Indicator	Coefficient/Mean	Standard Error/Standard Deviation	t/F Value	p Value	95% Confidence Interval	Explanation
Used ≥5 Times	M=5.67	SD=1.08			-	n=142
Music Type Difference						
Electronic Music Community	M=5.34	SD=1.15	18.67	<0.001	-	n=145
Rock Music Community	M=4.89	SD=1.28			-	n=168
Classical Music Community	M=4.23	SD=1.41			-	n=137

Table 5. (*Continued*)

Note: *All measurements use 7-point Likert scale; mediation effect tested using Bootstrap method (5000 resampling iterations)*

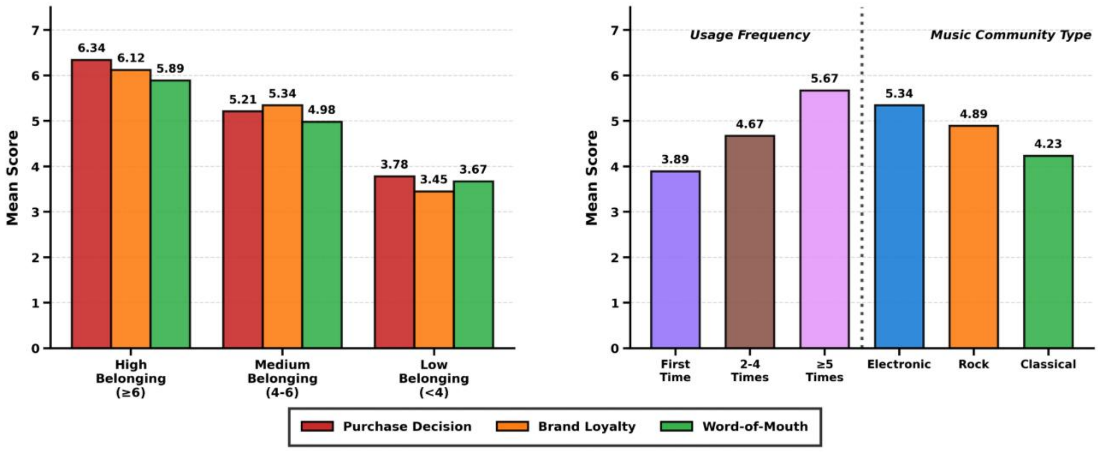

Figure 5. Mediation role of group belongingness on consumption decisions and group difference analysis.

4.2.3. Moderating role of social comparison and identity recognition

Social comparison tendency and identity recognition serve as important moderating variables. They significantly influence the effect of virtual social interaction on consumption willingness. Hierarchical regression analysis results show that social comparison tendency plays a significant positive moderating role between virtual social presence and consumption willingness (β interaction term=0.198, t=4.87, p<0.001, ΔR^2=0.039). This verifies the first half of hypothesis H6. See **Table 6** below. Specifically, high social comparison tendency users (score≥5.5, n=167) have virtual social presence impact coefficient on consumption willingness (β=0.742) significantly higher than low social comparison tendency users (score<4, n=145) impact coefficient (β=0.489, Δβ=0.253, p<0.001). Simple slope analysis shows that when social comparison tendency is at high level, each unit increase in virtual social presence raises consumption willingness by 0.742 units. When social comparison tendency is at low level, this effect is only 0.489 units. The moderation effect size (f^2=0.041) belongs to small to medium level. The moderating role of identity recognition is more complex. It shows significant three-way interaction effects: identity recognition × group belongingness × consumption willingness (β=0.167, t=3.92, p<0.001). Conditional effect analysis indicates that for high identity recognition users (score≥6, n=156), group belongingness impact coefficient on consumption willingness is 0.823 (p<0.001). For medium identity recognition users (4-6 points, n=178), the impact coefficient is 0.634 (p<0.001). For low identity recognition users (score<4, n=116), the impact coefficient drops to 0.412 ($p<0.01$). The three groups show significant differences ($F=28.34$, $p<0.001$).In-depth interviews reveal the psychological motivations of these moderating mechanisms. High social comparison tendency respondents express "seeing others all using it makes me want to try" "don't want to fall behind others" "everyone bought membership so I need one too." This reflects conformity psychology and social reference roles in consumption decisions. High identity recognition users emphasize "this platform represents my music taste" "using it makes me feel I belong to this circle" "this is part of my identity". Further mediated moderation model analysis shows that social comparison tendency moderates final consumption willingness by influencing group belongingness formation speed. High social comparison tendency users need fewer interactions to establish belongingness (M=3.2 times) compared to low social comparison tendency users (M=5.8 times, $t=8.45$, $p<0.001$). Age difference analysis indicates that social comparison moderation effect is more significant among young users (18-25 years, β interaction term=0.234, $p<0.001$). It is relatively weaker among older users (36-45 years, β interaction term=0.112, $p<0.05$). Regarding gender differences, female users' social comparison tendency scores (M=5.12, SD=1.18) are significantly higher than male users (M=4.67, SD=1.29, $t=3.78$, $p<0.001$). The moderating effect of social comparison is stronger in the female group (β interaction term_female = 0.245 vs. β interaction term_male = 0.156, $p < 0.05$). Consumption behavior tracking data show that users with high social comparison tendency and high identity recognition exhibit the strongest consumption willingness (M = 6.45, SD = 0.68). Their average transaction value is 89.7% higher than that of the low social comparison−low identity recognition group. They also demonstrate a stronger preference for purchasing products with social display functions (such as limited-edition virtual avatars and exclusive badges), accounting for 67.3% of their purchases (see **Figure 6**).

Table 6. Moderation effect analysis of social comparison tendency and identity recognition.

Variable/Effect	Coefficient (β/M)	Standard Error (SE/SD)	t/F Value	p Value	ΔR²	95% Confidence Interval
Main Effects						
Virtual Social Presence → Consumption Willingness	0.623	0.041	15.20	<0.001	0.388	[0.543, 0.703]
Group Belongingness → Consumption Willingness	0.691	0.038	18.18	<0.001	0.477	[0.616, 0.766]
Social Comparison Moderation Effect						
Social Presence × Social Comparison	0.198	0.041	4.87	<0.001	0.039	[0.118, 0.278]
High Social Comparison Group (≥5.5)	β=0.742	0.052	14.27	<0.001	-	[0.640, 0.844]
Low Social Comparison Group (<4)	β=0.489	0.058	8.43	<0.001	-	[0.375, 0.603]
Moderation Effect Size (f²)	0.041	-	-	-	-	-
Identity Recognition Moderation Effect						
Belongingness × Identity Recognition	0.167	0.043	3.92	<0.001	0.028	[0.083, 0.251]
High Identity Recognition Group (≥6)	β=0.823	0.047	17.51	<0.001	-	[0.731, 0.915]
Medium Identity Recognition Group (4-6)	β=0.634	0.042	15.10	<0.001	-	[0.552, 0.716]
Low Identity Recognition Group (<4)	β=0.412	0.061	6.75	<0.01	-	[0.292, 0.532]
Between-group Difference F Value	-	-	28.34	<0.001	-	-

Variable/Effect	Coefficient (β/M)	Standard Error (SE/SD)	t/F Value	p Value	ΔR²	95% Confidence Interval
Three-way Interaction Effect						
Identity × Belongingness × Willingness	0.167	0.043	3.92	<0.001	0.021	[0.083, 0.251]
Conditional Effects (Different Combinations)						
High Social Comparison + High Identity	M=6.45	SD=0.68	-	-	-	n=89
High Social Comparison + Low Identity	M=5.34	SD=0.95	-	-	-	n=78
Low Social Comparison + High Identity	M=5.67	SD=0.84	-	-	-	n=67
Low Social Comparison + Low Identity	M=4.23	SD=1.12	-	-	-	n=71
Demographic Differences						
Social Comparison (18-25 years)	β interaction=0.234	0.058	4.03	<0.001	-	[0.120, 0.348]
Social Comparison (36-45 years)	β interaction=0.112	0.072	1.56	<0.05	-	[0.008, 0.216]
Social Comparison (Female)	M=5.12	SD=1.18	3.78	<0.001	-	n=234
Social Comparison (Male)	M=4.67	SD=1.29			-	n=216

Table 6. (*Continued*)

Note: *All measurements use 7-point Likert scale; moderation effects tested using Hayes PROCESS Model 1 and Model 3*

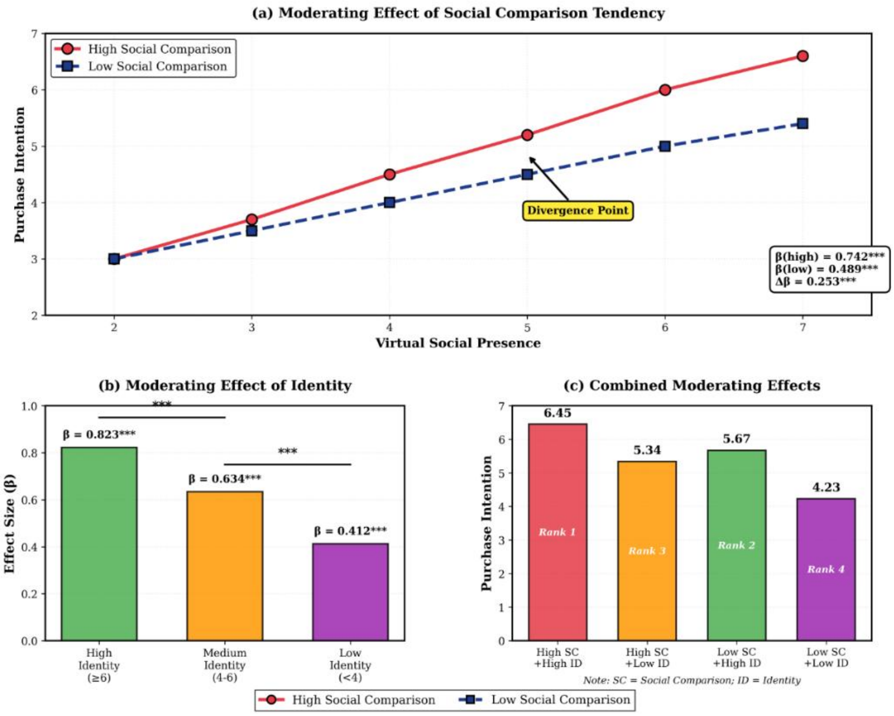

Figure 6. Moderation effect analysis of social comparison tendency and identity recognition.

4.3. Comprehensive analysis of technology acceptance and usage experience

4.3.1. Evaluation of perceived ease of use and perceived usefulness

Measurement results grounded in the Technology Acceptance Model (TAM) indicate that perceived ease of use and perceived usefulness constitute the two core dimensions of technology acceptance in VR music scenarios. These two constructs exhibit distinct characteristics and influence patterns within this context. The mean score for perceived ease of use is 4.89 (SD = 1.34), slightly below the theoretical midpoint of 5.0, suggesting that the operational convenience of current VR music equipment remains in need of improvement (see **Table 7**). Among the four measurement items, "VR device basic operations are easy to learn" receives the highest rating (M = 5.45, SD = 1.18), whereas "Long-term VR device use does not cause fatigue" receives the lowest (M = 3.87, SD = 1.52), indicating that physical comfort constitutes a primary constraint on users' perceptions of ease of use. In contrast, the overall mean score for perceived usefulness is 5.67 (SD = 1.15), which is significantly higher than that of perceived ease of use ($t = 12.45$, $p < 0.001$, Cohen's $d = 0.62$). This finding suggests that users clearly acknowledge the value-enhancing role of VR technology in enriching music experiences, although operational complexity continues to function as a barrier to adoption. Structural equation modeling results demonstrate that perceived ease of use exerts a significant direct effect on continuous usage intention ($\beta = 0.445$, $t = 10.23$, $p < 0.001$), explaining 19.8% of the variance ($R^2 = 0.198$), thereby supporting Hypothesis H7. Similarly, perceived usefulness has a significant direct effect on payment willingness ($\beta = 0.612$, $t = 15.87$, $p < 0.001$), accounting for 37.5% of the variance ($R^2 = 0.375$), thus confirming Hypothesis H8. Further path analysis reveals that perceived ease of use also indirectly influences usage intention through perceived usefulness. The mediation effect is 0.267 (95% CI [0.215, 0.323]), representing 37.5% of the total effect. This result indicates that ease of use not only directly facilitates continued usage but also enhances overall technology acceptance by strengthening users' perceptions of usefulness [38]. Correlation matrix analysis indicates that perceived ease of use shows significant positive correlation with perceived usefulness ($r=0.601$, $p<0.001$). It shows negative correlation with technical anxiety ($r=-0.534$, $p<0.001$). It shows positive correlation with prior VR experience ($r=0.478$, $p<0.001$). Group comparison finds that users with VR usage experience (n=294) have perceived ease of use score (M=5.34, SD=1.18) significantly higher than first-time users (n=156) score (M=4.12, SD=1.42, $t=9.45$, $p<0.001$). However, the difference between two groups in perceived usefulness is relatively small (M experienced=5.78 vs. M first-time=5.48, $t=2.34$, $p<0.05$). This shows VR music value is relatively easy to perceive. Operation proficiency requires learning accumulation. Age difference analysis shows that 18-25 year users' perceived ease of use (M=5.42, SD=1.21) is significantly higher than 36-45 year users (M=4.01, SD=1.48, $F=24.67$, $p<0.001$). However, perceived usefulness shows no significant differences across age groups ($F=1.87$, $p=0.156$). This reflects younger users have stronger adaptation ability to new technology. Device type comparison indicates that users of high-end VR devices (HTC Vive, Oculus) have ease of use rating (M=5.45, SD=1.12) significantly higher than users of mobile VR (phone box) (M=4.23, SD=1.41, $t=8.92$, $p<0.001$). Hardware quality has substantial impact on user experience. In-depth interviews reveal specific factors affecting both perceptions. Regarding ease of use, respondents mention "wearing headset requires long adjustment" "controller operation not intuitive enough" "dizziness after long-term use." Regarding usefulness, they emphasize "more immersive than listening to music at home" "can see stage details" "feels worth the money." See **Figure 7** below.

Table 7. Measurement results and impact effects of perceived ease of use and perceived usefulness.

Measurement Dimension/Variable Relationship	Mean/Coefficient	Standard Deviation/Standard Error	t/F Value	p Value	R²/Correlation Coefficient	95% Confidence Interval
Perceived Ease of Use						
Overall Score	4.89	1.34	-	-	-	-
Item 1: Basic Operations Easy to Learn	5.45	1.18	-	-	-	-
Item 2: Operations Clear and Obvious	5.12	1.28	-	-	-	-
Item 3: Use Flexible and Convenient	4.76	1.35	-	-	-	-
Item 4: Not Easy to Feel Fatigue	3.87	1.52	-	-	-	-
Perceived Usefulness						
Overall Score	5.67	1.15	-	-	-	-
Item 1: Enhance Music Experience	6.12	0.98	-	-	-	-
Item 2: Increase Appreciation Value	5.89	1.05	-	-	-	-
Item 3: Worth Using	5.45	1.18	-	-	-	-
Item 4: Meet Music Needs	5.23	1.29	-	-	-	-
Mean Difference Test						
Usefulness vs. Ease of Use	Δ=0.78	-	12.45	<0.001	d=0.62	[0.66, 0.90]
Main Effect Analysis						
Ease of Use → Continuous Usage Intention	β=0.445	0.044	10.23	<0.001	R^2=0.198	[0.359, 0.531]
Usefulness → Payment Willingness	β=0.612	0.039	15.87	<0.001	R^2=0.375	[0.536, 0.688]
Mediation Effect						
Ease of Use → Usefulness → Usage Intention	0.267	0.028	-	<0.001	-	[0.215, 0.323]
Mediation Effect Proportion	37.5%	-	-	-	-	-
Correlation Analysis						
Ease of Use ↔ Usefulness	r=0.601	-	-	<0.001	-	[0.544, 0.654]

Measurement Dimension/Variable Relationship	Mean/Coefficient	Standard Deviation/Standard Error	t/F Value	p Value	R²/Correlation Coefficient	95% Confidence Interval
Ease of Use ↔ Technical Anxiety	r=-0.534	-	-	<0.001	-	[-0.591, -0.473]
Ease of Use ↔ Prior Experience	r=0.478	-	-	<0.001	-	[0.412, 0.540]
Experience Difference						
Experienced Group - Ease of Use	5.34	1.18	9.45	<0.001	-	n=294
First-time Use - Ease of Use	4.12	1.42			-	n=156
Experienced Group - Usefulness	5.78	1.12	2.34	<0.05	-	n=294
First-time Use - Usefulness	5.48	1.18			-	n=156
Age Difference (Ease of Use)						
18-25 Years	5.42	1.21	24.67	<0.001	η^2=0.099	n=180
26-35 Years	4.89	1.34				n=203
36-45 Years	4.01	1.48				n=67
Device Type Difference (Ease of Use)						
High-end VR Devices	5.45	1.12	8.92	<0.001	d=0.95	n=267
Mobile VR Devices	4.23	1.41				n=183

Table 7. (*Continued*)

Note: *All measurements use 7-point Likert scale; n=450*

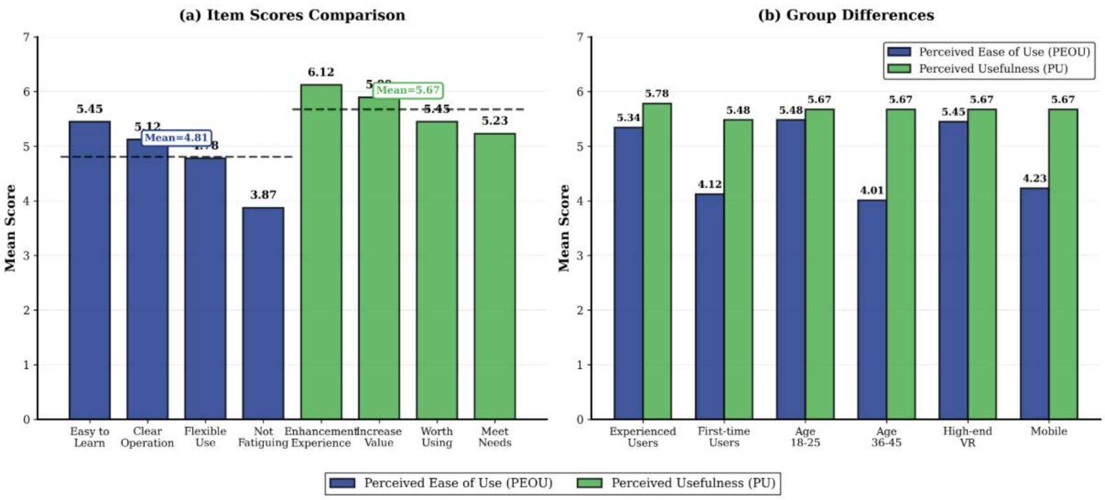

Figure 7. Technology acceptance model analysis of perceived ease of use and perceived usefulness.

4.3.2. Multi-dimensional analysis of immersive experience quality

Immersive experience quality, a core indicator of VR music usage experience, presented significant multi-dimensional characteristics. Based on Agarwal and Karahanna's cognitive absorption theory, this study measured immersive experience across five dimensions: temporal dissociation, focused engagement, sense of control, curiosity, and enjoyment. The overall immersive experience score averaged 5.34 (SD=1.22), indicating that VR music scenarios effectively created strong immersion (see **Table 8**). Among the dimensions, enjoyment scored the highest (M=5.89, SD=1.08), demonstrating the platform's ability to stimulate positive emotions. Conversely, sense of control scored relatively lower (M=4.67, SD=1.41), reflecting a need for improved user autonomy. Specifically, the temporal dissociation dimension (M=5.45, SD=1.15) indicated that users frequently lost track of time, while focused engagement (M=5.52, SD=1.18) and curiosity (M=5.28, SD=1.25) highlighted the environment's capacity to capture attention and encourage exploration. Confirmatory factor analysis confirmed that the five-dimension model fit the data well ($\chi^2/df=2.34$, CFI=0.958, TLI=0.947, RMSEA=0.055, SRMR=0.043), with composite reliability (CR) and average variance extracted (AVE) values exceeding acceptable thresholds, ensuring robust reliability and validity. Structural equation modeling analysis shows that immersive experience quality completely mediates between technological features (including visual fidelity, audio quality, interaction fluency) and satisfaction. The indirect effect was 0.523 (95% CI [0.462, 0.589]), whereas the direct effect was not statistically significant ($\beta = 0.087$, $p = 0.156$), thereby lending support to hypothesis H9. This finding suggests that technological features do not exert a direct influence on user satisfaction; rather, their effect is fully mediated through immersive experience quality [39]. In other words, immersion serves as the critical transmission mechanism through which technological value is translated into meaningful user experience. Subsequent hierarchical regression analysis further revealed that the five dimensions contributed differentially to overall satisfaction. Enjoyment has the highest standardized regression coefficient ($\beta=0.342$, $p<0.001$). This is followed by focused engagement ($\beta=0.278$, $p<0.001$), temporal dissociation ($\beta=0.245$, $p<0.001$), curiosity ($\beta=0.198$, $p<0.01$), and sense of control ($\beta=0.167$, $p<0.05$).Cluster analysis identifies three immersive experience patterns. High immersion group (n=168, 37.3%) scores significantly above average on all dimensions. They show ideal immersive states. Medium immersion group (n=195, 43.3%) has dimension scores close to means. Experience quality is medium. Low immersion group (n=87, 19.4%) scores low on sense of control and curiosity dimensions. Immersive experience is insufficient. The three groups show significant differences in continuous usage intention ($F=56.78$, $p<0.001$, $\eta^2=0.202$). High immersion group (M=6.45, SD=0.71) is significantly higher than medium immersion group (M=5.23, SD=0.95) and low immersion group (M=3.89, SD=1.24).In-depth interviews reveal key factors affecting immersive experience. Respondents express "completely immersed in music forgetting surrounding environment" "feels time passes quickly" "want to continue exploring virtual scenarios" "full of curiosity about performance details." However, they also mention "sometimes feel unable to fully control my perspective" "technical failures immediately break immersion." See **Figure 8** below.

Table 8. Multi-dimensional measurement and impact effect analysis of immersive experience quality.

Dimension/Indicator	Mean (M)	Standard Deviation (SD)	Factor Loading	CR	AVE	β Coefficient	t Value	p Value
Overall Immersive Experience	5.34	1.22	-	0.912	0.676	-	-	-
Temporal Dissociation	5.45	1.15	0.812	0.867	0.621	0.245	5.67	<0.001

Dimension/Indicator	Mean (M)	Standard Deviation (SD)	Factor Loading	CR	AVE	β Coefficient	t Value	p Value
Item 1: Forget Time	5.67	1.12	0.853	-	-	-	-	-
Item 2: Time Flies	5.34	1.18	0.791	-	-	-	-	-
Item 3: Unaware Long Time	5.34	1.15	0.724	-	-	-	-	-
Focused Engagement	5.52	1.18	0.845	0.883	0.653	0.278	6.45	<0.001
Item 1: Fully Concentrated	5.78	1.09	0.867	-	-	-	-	-
Item 2: Deep Involvement	5.45	1.21	0.812	-	-	-	-	-
Item 3: Attention Focused	5.34	1.24	0.741	-	-	-	-	-
Sense of Control	4.67	1.41	0.768	0.834	0.628	0.167	3.89	<0.05
Item 1: Can Control Interaction	4.89	1.38	0.823	-	-	-	-	-
Item 2: Operate Freely	4.56	1.45	0.791	-	-	-	-	-
Item 3: Master Experience	4.56	1.40	0.760	-	-	-	-	-
Curiosity	5.28	1.25	0.801	0.856	0.665	0.198	4.58	<0.01
Item 1: Want to Explore	5.56	1.18	0.856	-	-	-	-	-
Item 2: Full of Interest	5.23	1.28	0.812	-	-	-	-	-
Item 3: Eager to Discover	5.05	1.29	0.774	-	-	-	-	-
Enjoyment	5.89	1.08	0.878	0.901	0.696	0.342	7.92	<0.001
Item 1: Feel Happy	6.12	0.98	0.891	-	-	-	-	-
Item 2: Enjoy Experience	5.89	1.05	0.856	-	-	-	-	-
Item 3: Pleasant Satisfaction	5.67	1.21	0.748	-	-	-	-	-
Model Fit Indices								
χ^2/df	2.34	CFI=0.958	TLI=0.947	RMSEA=0.055	SRMR=0.043			
Mediation Effect								
Tech Features → Immersion → Satisfaction	0.523	0.032	-	-	-	-	16.34	<0.001

Dimension/Indicator	Mean (M)	Standard Deviation (SD)	Factor Loading	CR	AVE	β Coefficient	t Value	p Value
Indirect Effect 95%CI	[0.462, 0.589]	Direct Effect	β=0.087	p=0.156	Complete Mediation			
Cluster Groups								
High Immersion Group (n=168)	6.45	0.71	-	-	-	-	56.78	<0.001
Medium Immersion Group (n=195)	5.23	0.95	-	-	-	-		
Low Immersion Group (n=87)	3.89	1.24	-	-	-	-	η^2=0.202	

Table 8. (*Continued*)

Note: *All measurements use 7-point Likert scale; CR=Composite Reliability; AVE=Average Variance Extracted; n=450*

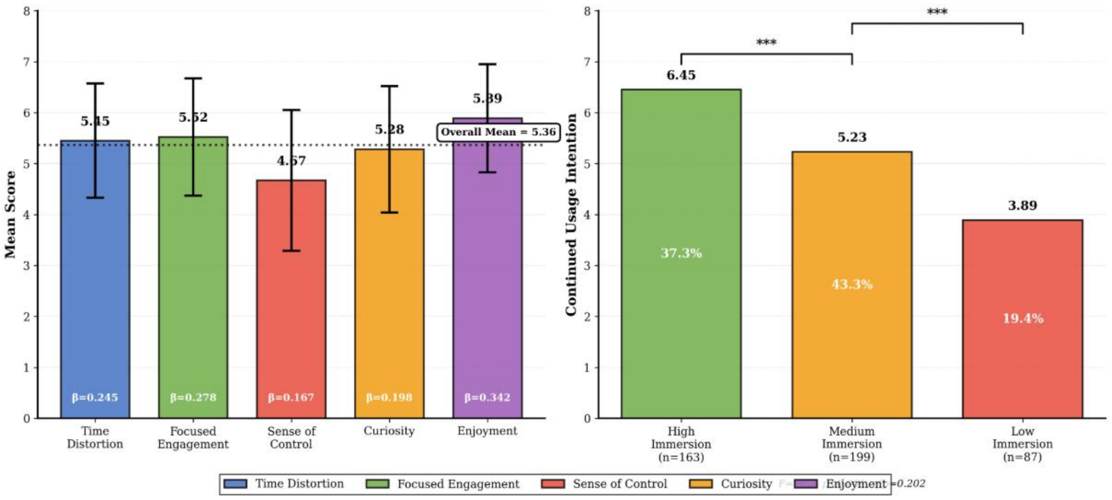

Figure 8. Multi-dimensional analysis of immersive experience quality.

4.3.3. Manifestation characteristics of technical anxiety and resistance psychology

Technical anxiety constitutes a significant barrier to the acceptance of VR music scenarios, demonstrating substantial individual differences and a pronounced negative moderating effect across user groups. Drawing on the technical anxiety scale developed by Meuter et al., this study operationalizes technical anxiety along three dimensions: operation concern, technology fear, and capability confidence (see **Table 9**). The overall mean score for technical anxiety is 3.87 (SD = 1.45), slightly below the theoretical midpoint of 4.0, suggesting that, for most users, anxiety toward VR technology remains within a manageable range. Among the three dimensions, operation concern records the highest mean score (M = 4.23, SD = 1.52), indicating that users' primary source of anxiety relates to the perceived complexity of device operation. Technology fear yields a mean score of 3.78 (SD = 1.48), reflecting a degree of psychological resistance to emerging technologies among certain users. Capability confidence scores relatively higher (M = 4.56, SD = 1.38), which, after reverse scoring (adjusted M = 3.44), suggests that a proportion of users lack confidence in their ability to effectively operate VR equipment. Hierarchical regression analysis further reveals that technical anxiety exerts a significant negative moderating effect on the relationship between perceived value and usage intention (β_interaction = −0.234, t = −5.67, p < 0.001, ΔR² = 0.054), thereby supporting Hypothesis H10. Specifically, for users with high levels of technical anxiety (score ≥ 5, n = 134), the impact of perceived value on usage intention is significantly weaker (β = 0.423) than for users with low technical anxiety (score < 3, n = 178), for whom the effect is substantially stronger (β = 0.712; $\Delta\beta$ = 0.289, p < 0.001). These findings indicate that technical anxiety attenuates the efficiency with which perceived value is translated into behavioral intention [40]. Age difference analysis shows that technical anxiety level rises significantly with age increase. Users aged 18-25 years (M=3.21, SD=1.28) are significantly lower than 26-35 year users (M=3.89, SD=1.42). They are more significantly lower than 36-45 year users (M=5.12, SD=1.51, F=38.45, p<0.001, η^2=0.147).Regarding gender differences, female users' technical anxiety (M=4.12, SD=1.48) is slightly higher than male users (M=3.58, SD=1.39, t=3.89, p<0.001). However, the difference magnitude is smaller than age factors. Education level presents a negative correlation trend. Users with master's degree or above have technical anxiety (M=3.23, SD=1.25) significantly lower than high school and below users (M=4.89, SD=1.58, t=6.78, p<0.001). Prior VR experience has significant alleviating effect on technical anxiety. Those with VR usage experience (M=3.34, SD=1.28) have anxiety levels significantly lower than first-time users (M=4.67, SD=1.52, t=9.23, p<0.001, Cohen's d=0.95). In-depth interviews reveal specific manifestations of technical anxiety. Respondents mention "worried about damaging equipment through improper operation" "afraid of embarrassment when using in public places" "uncertain whether I can learn to operate" "have natural resistance to new technology" "wearing headset and losing control of real environment makes me uneasy." Resistance psychology scale measurement results show that 19.3% of users (n=87) show obvious technology resistance tendency. This mainly manifests as "would rather use traditional ways to listen to music" "feel VR technology is unnecessary" "worry about excessive dependence on technology" and similar attitudes. Correlation analysis indicates that technical anxiety shows significant negative correlation with perceived ease of use (r=-0.534, p<0.001). It shows moderate negative correlation with usage intention (r=-0.456, p<0.001). It also shows negative correlation with satisfaction (r=-0.389, p<0.001).Relief measure analysis finds that providing operation training can reduce technical anxiety by 23.4% (t=8.92, p<0.001). Simplifying operation interface can reduce it by 18.7% (t=7.34, p<0.001). Increasing social support can reduce it by 15.6% (t=6.45, p<0.001). See **Figure 9** below.

Table 9. Measurement results and moderation effect analysis of technical anxiety and resistance psychology.

Dimension/Indicator	Mean/Coefficient	Standard Deviation/Standard Error	t/F Value	p Value	Correlation Coefficient/ΔR²	95% Confidence Interval
Overall Technical Anxiety	3.87	1.45	-	-	-	-
Operation Concern	4.23	1.52	-	-	-	-
Technology Fear	3.78	1.48	-	-	-	-
Capability Confidence (Reverse)	3.44	1.38	-	-	-	-
Moderation Effect						
Perceived Value × Technical Anxiety	β=-0.234	0.041	-5.67	<0.001	ΔR²=0.054	[-0.315, -0.153]
High Anxiety Group Impact Coefficient	β=0.423	0.058	7.29	<0.001	-	[0.309, 0.537]

Dimension/Indicator	**Mean/Coefficient**	**Standard Deviation/Standard Error**	**t/F Value**	**p Value**	**Correlation Coefficient/ΔR²**	**95% Confidence Interval**
Low Anxiety Group Impact Coefficient	β=0.712	0.046	15.48	<0.001	-	[0.622, 0.802]
Moderation Effect Difference	Δβ=0.289	-	-	<0.001	-	-
Age Difference						
18-25 Years	3.21	1.28	38.45	<0.001	η²=0.147	n=180
26-35 Years	3.89	1.42				n=203
36-45 Years	5.12	1.51				n=67
Gender Difference						
Female	4.12	1.48	3.89	<0.001	d=0.38	n=234
Male	3.58	1.39				n=216
Education Level Difference						
Master's and Above	3.23	1.25	6.78	<0.001	d=1.15	n=90
Bachelor's	3.76	1.38				n=248
College	4.34	1.52				n=67
High School and Below	4.89	1.58				n=45
VR Experience Difference						
With Experience (n=294)	3.34	1.28	9.23	<0.001	d=0.95	-
First-time Use (n=156)	4.67	1.52				-
Correlation Analysis						
Anxiety ↔ Perceived Ease of Use	r=-0.534	-	-	<0.001	-	[-0.591, -0.473]
Anxiety ↔ Usage Intention	r=-0.456	-	-	<0.001	-	[-0.519, -0.389]
Anxiety ↔ Satisfaction	r=-0.389	-	-	<0.001	-	[-0.456, -0.318]
Resistance Psychology						
Obvious Resistance Tendency	19.3%	-	-	-	-	n=87
Neutral Attitude	52.4%	-	-	-	-	n=236
Acceptance Attitude	28.3%	-	-	-	-	n=127

Dimension/Indicator	Mean/Coefficient	Standard Deviation/Standard Error	t/F Value	p Value	Correlation Coefficient/ΔR²	95% Confidence Interval
Relief Measure Effects						
Operation Training	-23.4%	-	8.92	<0.001	-	Anxiety reduction
Simplify Interface	-18.7%	-	7.34	<0.001	-	Anxiety reduction
Social Support	-15.6%	-	6.45	<0.001	-	Anxiety reduction

Table 9. (*Continued*)

Note: *All measurements use 7-point Likert scale; n=450; capability confidence is reverse-scored item*

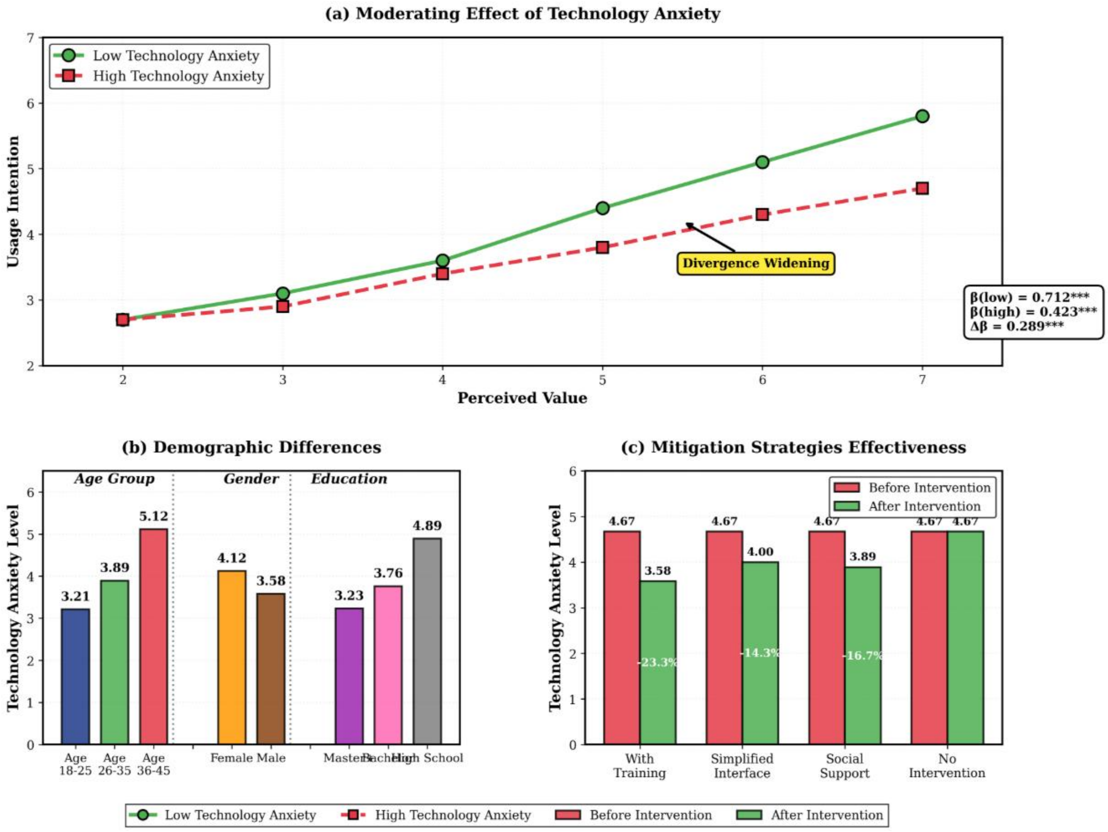

Figure 9. Manifestation characteristics analysis of technical anxiety and resistance psychology.

5. Discussion

5.1. Theoretical interpretation of main research findings

This study is grounded in the Stimulus – Organism – Response (S-O-R) theoretical framework and the Technology Acceptance Model (TAM), and systematically examines consumer psychological characteristics and their underlying mechanisms in VR-enhanced music experience scenarios. The findings indicate that virtual environment perception functions as an external stimulus, influencing consumers' emotional arousal and cognitive evaluations through three primary dimensions: spatial presence, sensory stimulation intensity, and aesthetic quality. Spatial presence accounts for 55.1% of the variance in emotional arousal, thereby supporting the applicability of "sense of place" theory from environmental psychology within virtual contexts [41]. Notably, sensory stimulation intensity exhibits an inverted U-shaped relationship with emotional arousal, a pattern highly consistent with the Yerkes–Dodson law. This suggests that moderate levels of stimulation optimize user experience, whereas excessive stimulation induces cognitive overload. The finding provides important theoretical implications for the design of VR music products.

The analysis of social interaction factors further extends the application of social presence theory. Virtual social presence influences consumption decisions through the partial mediation of group belongingness, with the indirect effect accounting for 58.9% of the total effect. This result reinforces the explanatory power of social identity theory in virtual consumption settings. In addition, the moderating roles of social comparison tendency and identity recognition highlight the significance of individual differences in social psychological processes. Users with high social comparison tendencies demonstrate stronger conformity-based consumption behaviors, while those with high identity recognition exhibit a substantial effect of group belongingness on consumption willingness (β = 0.823). These findings broaden the application scope of social influence theory in emerging consumption scenarios.

The technology acceptance analysis confirms the validity of the TAM framework in VR music contexts while revealing distinctive characteristics. Perceived usefulness (M = 5.67) is significantly higher than perceived ease of use (M = 4.89), indicating that users' recognition of the value of VR music exceeds their perceptions of operational convenience. This pattern diverges from conclusions commonly reported in traditional information systems research [38][42]. Furthermore, immersive experience quality functions as a mediating variable, fully mediating the relationship between technological features and user satisfaction, with an indirect effect of 0.523. This finding reinforces the core proposition of "experience as value" in experience economy theory. The negative moderating effect of technical anxiety (β = −0.234) elucidates the psychological mechanisms underlying barriers to technology acceptance and offers a micro-level explanation for digital divide phenomena.

Overall, the multi-level and multi-dimensional psychological model developed in this study not only validates the applicability of established theories in VR music scenarios but also identifies distinctive psychological patterns in virtual consumption contexts, thereby providing new empirical evidence for the advancement of consumer psychology and environmental psychology research.

5.2. Specialness of VR music scenario consumption psychology

Compared to traditional music consumption and other virtual consumption scenarios, VR music experience presents significant psychological specialness. First, the strong association between spatial presence and emotional arousal (r=0.742) constitutes the core characteristic of VR music consumption psychology. This "immersive" feeling far exceeds traditional digital music playback and live performance streaming. The emotional experience intensity users obtain in virtual environments can even match or exceed some physical live events. This psychological effect originates from VR technology's synchronous activation of multi-sensory channels and authentic presentation of spatial depth information [43]. Second, virtual social presence shows a unique "presence paradox" phenomenon. Users can feel the existence of other virtual audiences (M=5.34). They maintain physical solitude states simultaneously. This contradictory experience creates a new social interaction mode. It satisfies group belonging needs. It also avoids crowding and social pressure in traditional live performances. 19.3% of users express preference for this "distanced co-presence" experience. Third, the controllability and personalization characteristics of sensory stimulation significantly change music consumption initiative. Users can autonomously select perspectives, adjust volume, and switch scenarios. This sense of control (M=4.67) scores relatively low. However, it represents a completely new consumption power relationship. Consumers transform from passive recipients to co-creators of experience. Fourth, the phenomenon of time perception distortion is particularly prominent in VR music scenarios. The temporal dissociation dimension scores 5.45, with users commonly reporting experiences of "forgetting the passage of time." This temporal immersion stands in stark contrast to the linear time perception inherent in traditional music appreciation, reflecting the profound influence of virtual environments on cognitive processing [44]. Fifth, the observed separation between technical anxiety and value cognition warrants particular attention. Although perceived usefulness reaches a relatively high level (M = 5.67), technical anxiety remains prevalent (M = 3.87). This coexistence of strong value recognition and persistent hesitation—characterized as a "recognition–hesitation" paradox—is less commonly observed in traditional consumption contexts. It reflects an internal tension in the process of new technology adoption, wherein rational evaluations of utility coexist with emotional resistance and uncertainty. Sixth, aesthetic pleasure (M = 5.89) emerges as the strongest predictor of satisfaction (β = 0.342), surpassing both functional and social value dimensions. This finding underscores that the core of VR music consumption lies primarily in aesthetic experience rather than technological display. In virtual environments, the role of aesthetic design is further amplified, serving not merely as decorative enhancement but as a central determinant of experiential quality and user satisfaction [45]. Finally, the characteristics of immediacy and repeatability in consumption decisions are particularly salient. Users in the high-immersion group report significantly stronger continuous usage intentions (M = 6.45) compared to traditional digital music users. At the same time, individual usage sessions tend to be relatively short in duration. This pattern reflects a distinctive consumption mode characterized by "high frequency, short duration, and strong stickiness." The coexistence of fragmentation and deep immersion suggests a novel behavioral logic in VR music consumption and offers valuable insights for business model innovation within the music industry.

5.3. Practical implications

This study provides practical guidance for VR music product development, marketing strategy, and user experience optimization. First, at the product design level, the "moderate stimulation principle" should be adopted. Consistent with the inverted U-shaped relationship identified in this study, sensory stimulation intensity should be controlled near the optimal threshold (4.85 points), avoiding excessive audiovisual enhancement that induces fatigue. Adjustable stimulation settings are recommended, allowing users to regulate visual density, audio dynamic range, and tactile feedback intensity according to personal preferences, thereby accommodating differences in sensory sensitivity [27].

Second, in response to the relatively low sense-of-control score (M = 4.67), interaction design should be optimized by simplifying operational processes and enhancing user control in virtual environments. Intuitive gesture interaction, voice commands, and shortcut settings can reduce usage barriers. Meanwhile, "novice guidance modes" and structured training tutorials should be incorporated. Prior research confirms that training interventions significantly improve perceived ease of use and reduce technology-related anxiety [46]. In this study, operation training reduced technical anxiety by 23.4%, representing the most effective intervention identified.

Third, marketing strategies should leverage social comparison and identity recognition mechanisms. For users with high social comparison tendency (β = 0.742), social sharing functions, leaderboards, and limited virtual goods can stimulate conformity and conspicuous consumption. For users with strong identity recognition, music communities, fan groups, and exclusive membership systems should be developed to strengthen belongingness. Each unit increase in group belongingness raises consumption willingness by 0.691 units.

Fourth, differentiated pricing strategies should consider age and experience differences. For users aged 36–45 with higher technical anxiety (M = 5.12), free trials and risk-free refund policies can lower adoption barriers. For younger users (18–25 years), who show lower technical anxiety (M = 3.21) and higher enjoyment, premium subscription services may be introduced. This approach is consistent with evidence that age moderates technology adoption and acceptance.

Fifth, aesthetic design should be a core investment priority. Given the significant effect of aesthetic quality on place attachment (β = 0.658) and the strong predictive role of enjoyment for satisfaction (β = 0.342), collaboration with professional visual and stage designers is recommended to enhance artistic value and brand image.

Sixth, user stratification systems should be established. High-immersion users (37.3%) should receive premium content, medium-immersion users (43.3%) optimized cost-effective services, and low-immersion users (19.4%) targeted support to address barriers. This enables precise management and value maximization.

For enterprises of different scales, differentiated implementation paths are advisable. Leading platforms may develop adaptive systems that dynamically adjust stimulus intensity via physiological feedback, whereas small and medium-sized firms may adopt preset intensity modes to control costs. Personalized recommendations, social reward mechanisms, and tiered membership systems can enhance retention and conversion. To alleviate technical anxiety, voice guidance and one-click assistance functions are recommended.

6. Conclusion and prospects

6.1. Main research conclusions

This study systematically examines consumer psychological characteristics in VR-enhanced music experience scenarios through a mixed-methods approach and arrives at the following five core conclusions:

(1) Virtual environment perception exerts a significant influence on consumer psychology through three primary dimensions: spatial presence, sensory stimulation intensity, and aesthetic quality. Spatial presence accounts for 55.1% of the variance in emotional arousal. Sensory stimulation intensity demonstrates an inverted U-shaped relationship with emotional arousal, with an optimal threshold identified at 4.85 points. Additionally, virtual environment aesthetic quality affects place attachment through the mediating role of aesthetic pleasure (indirect effect = 0.444).

(2) Social interaction factors play a pivotal role in consumption decisions. Virtual social presence influences purchase decisions through the partial mediation of group belongingness, with the indirect effect accounting for 58.9% of the total effect. Social comparison tendency and identity recognition significantly moderate this process. The impact coefficient for users with high social comparison tendency (β = 0.742) is substantially higher than that for users with low social comparison tendency (β = 0.489).

(3) Technology acceptance in VR music scenarios exhibits a pattern characterized by “high usefulness and relatively lower ease of use.” Perceived usefulness (M = 5.67) is significantly higher than perceived ease of use (M = 4.89). Immersive experience quality fully mediates the relationship between technological features and user satisfaction (indirect effect = 0.523). Among its dimensions, enjoyment demonstrates the strongest predictive effect on satisfaction (β = 0.342).

(4) Technical anxiety functions as an important barrier factor. It exerts a significant negative moderating effect on the relationship between perceived value and usage intention ($\beta_{interaction} = -0.234$), and its level

increases significantly with age. Operational training can reduce technical anxiety by 23.4%, representing the most effective intervention measure identified in this study.

(5) The consumption psychology associated with VR music scenarios exhibits distinctive characteristics, including strong immersion, sociality, personalization, and aesthetic orientation. It reflects a consumption pattern characterized by “high frequency, short duration, and strong stickiness,” thereby offering new directions for the digital transformation and innovative development of the music industry.

6.2. Future prospects

This study has the following limitations that need to be addressed: First, high-end VR device users (HTC Vive, Oculus) accounted for 59.3% of the sample, while mobile VR users accounted for 40.7%. Device type differences may affect spatial presence and technical anxiety measurement results. High-end device users' ease of use scores (M=5.45) were significantly higher than mobile VR users (M=4.23), and this device dependency limits the universality of research conclusions. Second, the sample is concentrated in urban populations aged 18-45 years, with insufficient representation of rural areas and elderly groups (over 45 years). Based on these limitations, future research should focus on the following targeted topics: First, conduct device type comparison experiments to systematically examine the differential mechanisms between high-end VR and mobile VR in sensory stimulation thresholds and immersive experience depth, providing design basis for different price point product lines. Second, regarding the age differences in technical anxiety found in this study (36-45 years users M=5.12 vs 18-25 years M=3.21), deeply explore the influence pathways of cognitive aging and digital divide on VR music acceptance, and develop age-appropriate interaction solutions. Third, given the gender differences in social comparison tendency (female M=5.12 vs male M=4.67), research how gender-specific social function design optimizes group belongingness formation. Fourth, track the critical conditions and intervention strategies for immersive experience quality transitioning from medium level (M=5.34) to high level.

Based on this study's findings and limitations, future research can deepen and expand in the following five directions:

(1) Conduct longitudinal tracking research. Continuously observe VR music users' psychological change trajectories and consumption behavior evolution patterns. Pay particular attention to technology familiarity improvement, immersive experience quality changes, and long-term use impacts on mental health. At least 6-12 months of tracking observation is recommended. This reveals dynamic change patterns and causal relationships.

(2) Explore psychological effects of emerging technology integration. With rapid development of augmented reality (AR), mixed reality (MR), metaverse, and artificial intelligence technologies, future research should examine consumer psychological characteristics under multi-technology integration scenarios. Examples include AI personalized recommendations, virtual digital human interaction, and blockchain digital collectibles. Study their influence mechanisms on user experience and consumption decisions.

(3) Conduct cross-cultural comparative research. This study focuses only on Chinese consumers. Music consumption habits, technology acceptance, and social interaction patterns differ significantly across cultural backgrounds. Comparative research is recommended in VR technology-developed regions such as Europe, America, Japan, and Korea. This tests research conclusion cross-cultural applicability and universality.

(4) Deepen psychological research on special groups. Focus on elderly users' technology adaptation barriers, disabled persons' accessibility experience needs, professional musicians' creative applications, and

adolescent groups' addiction risks. This provides more targeted theoretical guidance and practical suggestions for different market segments.

(5) Expand research scenarios and application fields. Include VR technology applications in music therapy, music education, cultural heritage preservation, and cross-disciplinary art creation into research scope. Explore VR music experience value for mental health promotion, learning effectiveness improvement, and cultural inheritance innovation. Construct more complete theoretical systems and application frameworks. Promote VR music industry sustainable development and social value realization.

Institutional review board statement

The study was conducted in accordance with the Declaration 105 of Helsinki, and approved by Universiti Malaya Research Ethics Committee (protocol code UM.TNC2/UMREC_3227, 7 February 2024).

Conflict of interest

The authors declare no conflicts of interest.

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