

Article

From Digital Connection to Consumption: How Emotional Attachment and Trust Mediate Purchase Intentions in Virtual Idol Live Streaming

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Abstract

As virtual idols increasingly permeate the live-streaming e-commerce landscape, their influence on consumer behavior has emerged as a pivotal topic within digital marketing. However, empirical evidence on how emotional and cognitive mechanisms jointly shape purchase intentions in virtual idol contexts remains highly limited. This study investigates the complex mechanisms of virtual idol live-streaming by examining three core dimensions: physical attractiveness, technological realism, and social content value. By integrating emotional attachment and perceived trust as key mediating variables, the research empirically tests the pathway structure through which these factors drive purchase intentions. Data were collected via convenience sampling from 839 undergraduate students in Yunnan Province with experience in virtual idol live-streaming. The structural model was estimated and validated using Partial Least Squares Structural Equation Modeling (PLS-SEM) via SmartPLS 4.1.1.1. Findings reveal that purchase intentions in virtual idol contexts are shaped by a synergy of affective responses and cognitive judgments. Specifically, physical attractiveness does not directly influence purchase intention but operates primarily through the mediation of emotional attachment. Conversely, technological realism exerts both direct effects on purchase intention and indirect influence by bolstering perceived trust. Notably, social content value serves as the most critical driver, significantly promoting both emotional and cognitive mediators while simultaneously exerting a robust direct impact on purchase intention. These results suggest that while visual and technical elements are foundational, the social resonance and emotional bond established by virtual idols are paramount in driving consumer decisions in the digital economy. These findings not only extend the S-O-R framework into the domain of AI-driven marketing but also provide actionable strategic insights for platforms and brands seeking to optimize virtual influencer design and enhance young consumer engagement.

Academic Editor: Aweewan
Panyagometh

Received: March 19, 2026
Revised: June 2, 2026
Accepted: June 29, 2026
Published: July 1, 2026

Keywords: Virtual idols;
Live-streaming E-commerce;
Purchase intention;
Emotional attachment;
Perceived trust

1. Introduction

Over the past decade, the rapid evolution of digital technologies has fundamentally reshaped the paradigms of commercial communication, with virtual avatars becoming systematically integrated into the broader live-streaming ecosystem. This technological trajectory has propelled digital human e-commerce from its nascent stage—historically

centered on "reducing labor costs" through automation—into a more sophisticated "value-added" phase. According to industry insights from iiMedia Research, this sector is currently undergoing a profound transformation in its industrial attributes, shifting its strategic focus toward the enhancement of content value and service efficiency. This transition signifies that virtual idols are no longer merely technical novelties but are functional agents capable of delivering complex marketing value within the digital economy.

From a multi-disciplinary perspective, the practical foundation for this development is twofold. Technically, advancements in high-speed communication infrastructure and real-time rendering have provided the necessary stability for immersive live-streaming environments. Psychologically, research in human-computer interaction (HCI) posits that the machine agency and anthropomorphic cues exhibited by these technological media significantly shape users' cognitive understanding of virtual entities [1]. By projecting human-like traits and social behaviors, virtual idols align with users' pre-existing interaction expectations, providing a robust mechanism-level explanation for their seamless integration into commercial live-streaming scenarios.

Within the domain of consumption and marketing research, empirical inquiry has begun to incorporate virtual hosts into the established analytical frameworks of e-commerce. Preliminary studies by scholars such as LI et al. [2] and Zhao & Chung [3] indicate that specific attributes—including a virtual host's visual aesthetics, professional performance standards, and interactive fluidity—are critical determinants of consumer purchasing intent. This scholarly approach aligns with the fundamental logic of online consumer behavior theories, which suggest that digital interactions are governed by a mix of sensory stimuli and cognitive evaluations. Notably, perceived trust has long been recognized as the psychological cornerstone for mitigating perceived risk and reducing uncertainty in online transactions [4]. Furthermore, the cultivation of social presence and interactive experiences has been shown to bolster user loyalty and positive attitudes toward digital services [5]. These anthropomorphic manifestations are instrumental in shaping a user's initial heuristic evaluation, thereby setting the stage for deeper communicative engagement [6]. However, current empirical extensions within generic e-commerce marketing predominantly focus on visual presence, leaving a critical knowledge omission regarding how technological features and social content attributes systematically function as distinctive environmental stimuli within immersive virtual live-streaming platforms.

From a platform operations and relationship management standpoint, consumer behavior in virtual idol contexts is increasingly recognized as being embedded within long-term interactional processes. Unlike traditional e-commerce, where transactions may be purely utilitarian, purchase intentions in virtual idol live-streaming are shaped by a duality of influences: external presentation (such as technological realism) and deep-seated relational mechanisms (such as trust formation and emotional bonding) [7]. The expansion of this industry, coupled with its content-driven and relationship-oriented nature, has established a representative new digital consumption scenario. In this framework, multi-dimensional cues—ranging from visual aesthetics and technological simulation to the social value embedded in the content—leverage complex psychological responses to drive eventual consumption. Prior studies typically examine emotional attachment and perceived trust in isolation, thereby lacking an integrated, parallel dual-mediation framework to explain how these affective and cognitive mechanisms jointly translate virtual interactions into purchase intentions.

Despite the burgeoning scale of this industry, a systematic synthesis of existing literature reveals that academic exploration of the internal mechanisms underpinning purchase intent within virtual idol contexts remains relatively fragmented. Specifically,

there is a distinct lack of targeted empirical testing regarding how emotional investment and trust assessment, fostered through sustained parasocial interactions, jointly influence the decision-making process. Current research exhibits certain limitations in terms of subject diversity, mechanism integration, and contextual specificity. To address these critical gaps, it is imperative to introduce key psychological mediators such as emotional attachment and perceived trust into the specific interactive context of virtual idol live-streaming. Concurrently, this study delineates its research objectives to systematically counteract these three literature limitations. First, the primary objective of this study is to integrate emotional attachment and perceived trust into a parallel dual-mediation structure within the S-O-R framework, simultaneously capturing both rational evaluation and affective bonding. Second, the second objective is to deconstruct the stimuli of virtual idols into three independent dimensions—physical attractiveness, technological realism, and social content value—clarifying their respective unique and differentiated transmission pathways. Third, the final objective is to focus on the university student demographic—a cohort characterized by high digital literacy and an open attitude toward virtual culture. By empirically testing these formation mechanisms of purchase intent across these specific dimensions, this research elucidates the affective and cognitive transmission pathways that define the modern virtual consumer experience.

2. Literature Review

2.1 Theoretical Framework: S-O-R Model and Parasocial Interaction Theory

The Stimulus-Organism-Response (S-O-R) model, originally developed by Mehrabian and Russell [8] in the field of environmental psychology, serves as the primary overarching framework for this study. This model posits that environmental stimuli (S) do not directly trigger behavioral outcomes (R); instead, they are filtered through the individual's internal psychological state—the organism (O) [9]. To maintain the contemporary relevance of this framework, this environmental psychology logic has been extensively re-validated by recent scholarship in AI-driven consumer behavior and virtual influencer marketing, demonstrating its robust adaptability to immersive synthetic media environments. In the context of virtual idol live-streaming, the S-O-R theory exhibits robust explanatory power for complex consumer dynamics. Empirical evidence from Du et al. [10] and Shen et al. [11] underscores that within virtual interaction scenarios, psychological mediators—such as cognitive evaluations and affective states—play a decisive role in translating digital stimuli into tangible consumption behaviors.

To further elucidate the specific psychological mechanisms through which virtual idol stimuli evoke the internal shifts (the "O" component) of emotional attachment and perceived trust, this study integrates Parasocial Interaction (PSI) Theory. First conceptualized by Horton and Wohl [12], PSI theory describes a psychological phenomenon where media audiences develop a one-sided sense of intimacy and "quasi-friendship" with media personas through sustained exposure. Unlike traditional interpersonal relationships, parasocial interactions allow audiences to perceive virtual characters as familiar, reliable entities, leading to significant emotional investment and companionship. As noted by Zhao [13], the interactions within virtual live-streaming are characterized by unique ritualistic qualities; through repetitive participation, users integrate virtual idols into their personal emotional frameworks, fostering stable, long-term psychological bonds.

Consequently, the synthesis of S-O-R and PSI theories provides a comprehensive theoretical lens: while the S-O-R model outlines the structural pathway of behavioral formation, PSI theory explains the relational depth of the "organism" phase. This integrated approach allows for a nuanced analysis of how the transition from general

media consumption to deep relational bonding drives purchase intentions in the virtual e-commerce landscape.

2.2 Virtual Idol Characteristics and the Formation of Emotional Attachment

Building upon the S-O-R and PSI frameworks, this study identifies emotional attachment as a pivotal mediating variable that bridges the stimulus of virtual idol characteristics with the response of purchase intention. Emotional attachment in this context refers to the specific affective bond characterized by a sense of proximity and psychological security that users develop toward a virtual persona. To empirically examine these causal pathways, this research categorizes virtual idol characteristics into three dimensions: physical attractiveness, technological realism, and social content value, proposing that each serves as a distinct antecedent to emotional investment.

Regarding visual cues, physical attractiveness serves as the primary heuristic stimulus that initiates user engagement. As initial, intuitive perceptual information, a virtual idol's aesthetic appeal does not merely satisfy visual preferences; it triggers a positive affective halo effect, wherein users attribute favorable personality traits to the avatar [6,14]. This positive initial impression lowers the barrier to emotional entry, facilitating a transition from passive viewing to active emotional investment.

From a technical standpoint, technological realism—defined by the sophistication of motion capture, facial expression rendering, and voice synthesis—directly enhances the user's sense of social presence. By narrowing the "uncanny valley" and providing a seamless, lifelike experience, technological realism bolsters the perceived authenticity of the interaction [15,16]. When users perceive the virtual idol as a "sentient" and responsive entity rather than a rigid digital asset, they are more likely to project genuine emotions onto the character, thereby deepening the attachment.

Lastly, in terms of interactive content, social content value serves as the functional foundation for sustained relationship building. Unlike static media, virtual idol live-streaming provides a communal space where content with high social value—such as shared values, community humor, and interactive storytelling—prolongs user exposure and encourages deep participation [17,18]. Through these continuous, ritualized interactions, the virtual idol transcends its role as a mere broadcaster, becoming a significant "social other" in the user's digital life. Consequently, the accumulation of these social experiences fosters a stable and resilient emotional bond, which serves as the psychological prerequisite for subsequent consumption behaviors.

2.3 Virtual Idol Characteristics and the Formation of Perceived Trust

In virtual interactive environments, perceived trust serves as the indispensable psychological foundation that governs user attitudes and behavioral responses. Unlike face-to-face encounters, digital contexts present significant information asymmetry, where users find it challenging to directly assess the motives, capabilities, or integrity of interaction partners. Consequently, they must rely on extrinsic cues to infer credibility [4,19], positioning trust as a pivotal mediating mechanism that bridges subjective perceptions with tangible consumption actions [20].

Within the ecosystem of virtual idol live-streaming, perceived trust is constructed through a comprehensive cognitive synthesis of multi-dimensional characteristics. Physical attractiveness, while primarily an aesthetic stimulus, functions as a critical heuristic cue that shapes initial credibility judgments. According to the "what is beautiful is good" stereotype in social psychology, individuals often employ cognitive shortcuts in online environments, whereby aesthetically appealing subjects are subconsciously perceived as more reliable and professional [21]. Furthermore, high-quality visual design—characterized by refined artistic modeling and cohesive branding—signals the

professional investment and institutional backing behind the virtual idol, thereby enhancing user trust in the entity's long-term stability [22].

Technological realism serves as another fundamental antecedent to trust by ensuring the consistency and naturalness of the virtual idol's behavioral patterns. When the avatar's movements, micro-expressions, and synchronization align with human communicative expectations, it reduces the cognitive load required for interaction and reinforces the perception of the idol as a stable, dependable role [20]. This high degree of realism effectively bridges the psychological distance between the user and the digital human, mitigating the "uncanny" uncertainty that often hinders trust in artificial agents [7].

Finally, the social value of live-streamed content provides the empirical validation necessary for trust formation. Content characterized by high social value—such as community-building dialogue and expert knowledge sharing—undergoes a process of social proof through real-time group interaction [17]. When users witness positive interactive feedback and consensus within the public discourse of a live stream, their perception of both the information's reliability and the publisher's integrity is significantly bolstered [23]. In this sense, trust in a virtual idol is not merely an individual cognitive result but a socially reinforced outcome of consistent, high-value interaction.

2.4 Emotional Attachment, Perceived Trust and Purchase Intention

In the final stage of the S-O-R framework, purchase intention serves as the critical behavioral response (R), representing an individual's conscious plan or clinical inclination to execute a consumption behavior following a comprehensive evaluation of the digital environment [24,25]. Within the specialized context of virtual idol live-streaming, this intention is not merely a reaction to product utility but is deeply rooted in the dual-pathway processing of emotional attachment and perceived trust.

On the affective pathway, emotional attachment significantly modulates users' receptiveness to commercial messages. When consumers develop a parasocial bond with a virtual idol, their resistance to marketing persuasion decreases, as the act of purchasing is often perceived as a form of support or reciprocity toward the virtual entity [26]. On the cognitive pathway, perceived trust constitutes the essential rational foundation for online decision-making. Since the virtual environment inherently involves high perceived risk, the credibility of the streamer—manifested through technological stability and content integrity—acts as a risk-mitigation mechanism that directly converts user interest into purchase intent [23].

Synthesizing the preceding theoretical and literature analysis, this study posits that the influence of a virtual idol's physical attractiveness, technological realism, and social content value on purchase intention is not entirely direct. Instead, these antecedent variables drive consumption by enhancing the "organism's" internal states: specifically, the affective experience of emotional attachment and the cognitive cognition of perceived trust [1,20]. By integrating these variables into a cohesive structural model, this research aims to elucidate the complex transmission mechanisms governing the digital consumption patterns of university students. Based on this theoretical framework, the specific research hypotheses are formulated and summarized in Table 1 below.

Table 1. Summary of Research Hypotheses

Number	Research Hypothesis
H1a	The visual appeal of virtual idol streamers exerts a significant positive influence on university students' emotional attachment.
H1b	The technical realism of virtual idol streamers exerts a significant positive influence on university students' emotional attachment.
H1c	The social value of virtual idol livestream content exerts a significant positive influence on university students' emotional attachment.
H2a	The visual appeal of virtual idol streamers significantly and positively influences university students' perceived trust.
H2b	The technical realism of virtual idol streamers significantly and positively influences university students' perceived trust.
H2c	The social value of virtual idol live-streaming content significantly and positively influences university students' perceived trust.
H3a	University students' emotional attachment to virtual idol streamers significantly and positively influences their purchase intention.
H3b	University students' perceived trust in virtual idol streamers significantly and positively influences their purchase intention.
H4a	Emotional attachment mediates the relationship between physical attractiveness and purchase intention.
H4b	Perceived trust mediates the relationship between physical attractiveness and purchase intention.
H4c	Emotional attachment mediates the relationship between technological realism and purchase intention.
H4d	Perceived trust mediates the relationship between technological realism and purchase intention.
H4e	Emotional attachment mediates the relationship between the social value of live-streamed content and purchase intention.
H4f	Perceived trust mediates the relationship between the social value of live-streamed content and purchase intention.

2.5 Conceptual Framework

Based on the literature review and research hypotheses, a conceptual framework has been developed, as illustrated in Figure 1.

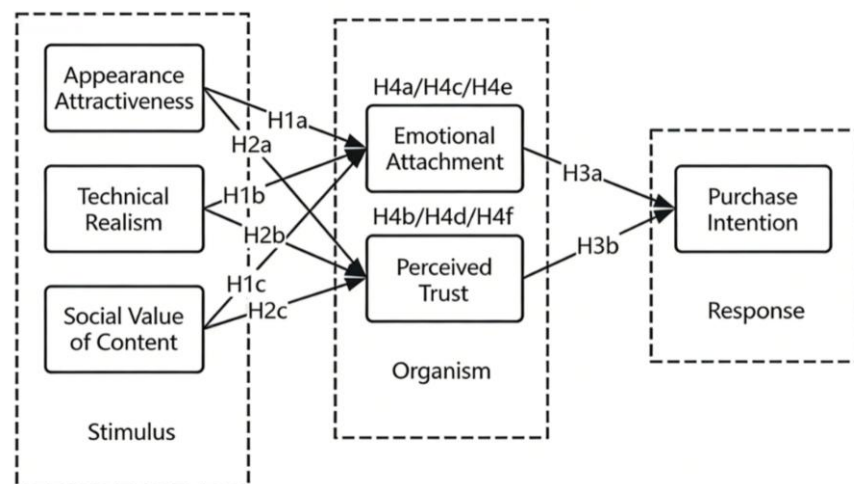


Figure 1. Conceptual Framework

3. Materials and Methods

3.1. Sample and Data Collection

This study adopts a quantitative research design, utilizing a structured questionnaire survey to empirically investigate the formation mechanisms of purchase intentions among university students in the context of virtual idol live-streaming. To ensure a diverse and representative dataset, convenience sampling was employed across various higher education institutions in Yunnan Province, encompassing universities with distinct institutional attributes. The survey was designed to measure students' perceptual evaluations, psychological mediators, and behavioral intentions, providing the empirical basis for subsequent structural equation modeling.

The data collection process was executed in two distinct phases: a pilot study (pre-test) and a formal survey. To ensure the integrity of the results, respondents from the pre-test were excluded from the final data analysis. The pilot study was conducted with 20 randomly selected students from Qujing Health College to evaluate the instrument's reliability. For the main survey, participants were recruited using convenience sampling through course announcements and online class groups (e.g., WeChat and QQ) at four universities in Yunnan Province. To be eligible, students had to be currently enrolled as undergraduates and have at least some prior experience watching virtual idol live-streaming. Participation was entirely voluntary, and no monetary incentives were provided; respondents were informed that the survey was for academic research purposes only and that their responses would remain anonymous and confidential. The results indicated high internal consistency, with Cronbach's alpha coefficients for all latent variables exceeding the recommended threshold of 0.70 (with specific values for each construct detailed in Table 6). Given these robust reliability metrics, the questionnaire content was finalized without further modification.

For the formal survey phase, undergraduate students from four representative universities in Yunnan Province served as the research subjects. A total of 902 questionnaires were initially collected. To ensure data quality, a rigorous screening protocol was applied based on three criteria: completeness of responses, minimum response duration (to exclude "speeders"), and internal consistency (to identify "straight-lining" patterns). Following this process, 63 invalid responses were excluded, resulting in 839 valid questionnaires—an effective recovery rate of 93.02%. This final sample size substantially exceeds the "tenfold rule" required for Partial Least Squares Structural Equation Modeling (PLS-SEM) and provides sufficient statistical power for robust measurement and structural model validation.

3.2. Measures

The measurement scales used in this study are all adapted from established instruments and cover three main categories: characteristics of virtual idol streamers, psychological mechanisms, and outcome variables. The number of items in each scale and their sources are summarized in the table 2 below.

Table 2. Summary Table of Key Information for Measurement Scale

Variable Name	Number of Items	Reference Source
Physical Attractiveness	5	Ohanian[21]
Technical Realism	5	Bartneck et al.[27]
Social Value of Content	3	Calder et al.[17]
Emotional Attachment	4	Thomson et al.[28]

Variable Name	Number of Items	Reference Source
Perceived Trust	3	Gefen et al.[29], Cyr et al.[30]
Purchase Intention	5	Dodds et al.[25]

3.3. Data Analysis Procedures

To systematically examine the interrelationships among research variables within the virtual idol live-streaming context, this study followed a multi-stage analytical protocol. Initially, descriptive statistical analysis was conducted to organize the demographic characteristics of the sample and evaluate the distribution of the primary research variables, providing a comprehensive overview of the dataset's central tendencies and variances.

Prior to testing the theoretical hypotheses, the measurement model was rigorously evaluated for reliability and validity. This included assessing internal consistency, convergent validity, and discriminant validity to ensure the structural soundness of the latent variable constructs. Subsequently, Partial Least Squares Structural Equation Modeling (PLS-SEM) was employed as the primary inferential approach to examine the interdependent relationships within the research framework. PLS-SEM was selected as the primary inferential approach due to several methodological advantages that align precisely with our conceptual framework. First, our conceptual model presents a high level of complexity, characterized by a parallel dual-mediation structure that simultaneously evaluates multiple structural pathways, direct effects, and indirect effects. PLS-SEM is mathematically unconstrained by parameter-to-sample size ratios and carries superior statistical power in resolving such intricate network structures without inflating error rates. Second, while rooted in the established S-O-R and PSI frameworks, this study possesses a distinct exploratory nature by untangling specific live-streaming attributes (e.g., technological realism and social content value) across different psychological dimensions. PLS-SEM is recognized as the optimal choice for prediction-oriented and exploratory research aimed at variance explanation and theoretical extension, rather than strict covariance verification. Finally, PLS-SEM is robust against non-normally distributed data, which frequently arises in behavioral surveys examining emerging digital consumption scenarios [28].

The statistical execution was supported by two specialized software packages: IBM SPSS 27.0 was utilized for initial data screening, descriptive statistics, and fundamental data organization; meanwhile, SmartPLS 4.1.1.1 was employed for the estimation of the measurement and structural models. The path analysis, facilitated by the bootstrapping technique (typically with 5,000 or more sub-samples), ensured the analytical rigor and statistical significance of the results, thereby providing a reliable basis for hypothesis testing.

4. Results

4.1. Respondent Profiles and Descriptive Statistics

The demographic profiles and engagement characteristics of the 839 valid respondents are summarized in Table 3. The gender distribution shows a predominant female presence, accounting for 82.6% (n = 693) of the sample, while males represented 17.4% (n = 146). In terms of academic standing, the cohort was heavily skewed toward first-year undergraduates, who constituted 90.94% of the participants. Regarding the field of study, a significant majority (89.63%) were enrolled in medical disciplines, reflecting the institutional focus of the primary sampling sites.

Economic data revealed that the most prevalent monthly disposable income bracket was ¥1,001–¥2,000, encompassing 65.08% of the respondents, followed by those receiving ¥1,000 or below (29.68%). Only a negligible fraction reported a disposable income exceeding ¥3,000. Furthermore, the survey assessed the respondents' engagement with virtual idol live-streaming. The results indicate a relatively low frequency of active viewing: 74.97% reported watching "very rarely or occasionally," while only 13.47% engaged with such content 1–2 times per month. This distribution suggests that while the university student demographic is aware of virtual idol live-streaming, the majority remain in the early or occasional stages of consumption.

Table 3. Demographic Characteristics of Study Participants (N = 839)

Variable	Category	Frequency	Percentage (%)
Gender	Male	146	17.4
	Female	693	82.6
Year of Study	First Year	763	90.94
	Third Year	21	2.5
	Second Year	44	5.24
	Fourth Year	9	1.07
	Postgraduate and above	2	0.24
Field of Study	Medical disciplines	752	89.63
	Education disciplines	1	0.12
	Science and engineering disciplines (e.g. Computer Science, Physics)	36	4.29
	Business and management disciplines (e.g. Finance, Accounting)	6	0.72
	Arts disciplines	29	3.46
	Humanities and social sciences disciplines (e.g. Chinese Language, Law)	14	1.67
	Other (please specify)	1	0.12
Monthly Disposable Income (RMB)	¥1,000 or below	249	29.68
	¥1,001–¥2,000	546	65.08
	¥2,001–¥3,000	38	4.53
	¥3,001–¥5,000	3	0.36
	Over ¥5,000	3	0.36
Frequency of Viewing Virtual Idol Live Streams	Very rarely/Occasionally	629	74.97
	Once or twice a month	113	13.47
	Once or twice a week	55	6.56
	Three to five times a week	24	2.86
	Almost every day	18	2.15
Total		839	100

4.2. Correlation Analysis

To preliminarily examine the hypothesized relationships within the research model, Pearson correlation analysis was conducted to evaluate the bivariate associations between the primary latent variables. The results, summarized in Table 4, provide an initial empirical basis for the subsequent structural model testing.

Table 4. Pearson Correlation Coefficient Matrix for Core Variables

Variables	Physical attractiveness	Technical realism	Social content value	Emotional attachment	Perceived trust
Physical attractiveness	1				
Technical realism	0.295***	1			
Social content value	0.292***	0.578***	1		
Emotional attachment	0.265***	0.394***	0.696***	1	
Perceived trust	0.346***	0.387***	0.525***	0.460***	1

Note: *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$.

The analysis reveals that all inter-construct correlation coefficients reached statistical significance at the $p < 0.001$ level. Specifically, positive associations of varying magnitudes were observed between the antecedent variables (physical attractiveness, technological realism, and social content value) and the mediating variables (emotional attachment and perceived trust). The correlation coefficients ranging from 0.265 to 0.696 suggest that while the variables are significantly interrelated, they remain sufficiently distinct to avoid immediate concerns of extreme multicollinearity. These significant positive correlations provide preliminary support for the theoretical framework, suggesting that higher perceptions of virtual idol characteristics are systematically associated with stronger emotional and cognitive responses.

4.3. Common Method Bias

To rigorously assess potential Common Method Bias (CMB), this study employed the Marker Variable Technique. This method involves introducing a theoretically unrelated variable into the structural model to capture and control for method-induced variance. By comparing the path coefficients of the initial theoretical model with those of the adjusted model containing the marker variable, the stability of the research findings can be evaluated.

As presented in Table 5, the comparative analysis reveals that the inclusion of the marker variable resulted in only marginal fluctuations in the path coefficients. For instance, the path from Social Content Value (SCV) to Emotional Attachment (EA) shifted slightly from 0.523 to 0.521, while the path from Emotional Attachment (EA) to Purchase Intention (PI) moved from 0.396 to 0.389. Crucially, the statistical significance levels (p -values) for all hypothesized pathways remained consistent across both models. The high degree of stability in these coefficients suggests that the variance observed in the study is driven by the substantive constructs rather than common method variance. Consequently, common method bias does not pose a significant threat to the theoretical integrity or the empirical validity of the results.

Table 5. Common Method Bias Sensitivity Analysis (Marker Variable Method)

Path	Initial model	Model with Marker Variable
PA → EA	0.163***	0.149***
TR → EA	0.035ns	0.035ns
SCV → EA	0.523***	0.521***
PA → PT	0.086ns	0.073ns
TR → PT	0.113*	0.112*
SCV → PT	0.337***	0.335***
EA → PI	0.396***	0.389***
PT → PI	0.186***	0.184***

Note: *** $p < 0.001$, * $p < 0.05$, ns non-significant. PA: Physical Attractiveness; TR: Technical Realism; SCV: Social Content Value; EA: Emotional Attachment; PT: Perceived Trust; PI: Purchase Intention.

4.4. Measurement Model: Reliability and Validity Analysis

To ensure the psychological constructs were accurately captured, the measurement model was rigorously evaluated for reliability and validity. Preliminary checks revealed that item PA5 in the physical attractiveness dimension exhibited a factor loading below the recommended 0.70 threshold [31]; consequently, it was excluded to maintain the structural integrity of the construct. Following this refinement, the internal consistency of the revised scale was confirmed, as both Cronbach's alpha and Composite Reliability (CR) for all latent variables exceeded the established benchmark of 0.70 [32], indicating robust reliability across the measurement instruments.

Furthermore, the model demonstrated satisfactory convergent validity, with the Average Variance Extracted (AVE) for each construct surpassing the critical value of 0.50 [33]. This signifies that the latent variables account for a majority of the variance in their respective indicators, rather than being overshadowed by measurement error. To ensure the stability of the subsequent path estimations, potential multicollinearity was assessed using the Variance Inflation Factor (VIF). All item-level VIF values remained below the conservative threshold of 5.0 (and the stricter criterion of 3.3) [32,34], confirming that multicollinearity does not pose a significant bias to the structural model estimations. The comprehensive results of these reliability and validity tests are summarized in Table 6.

Table 6. Reliability and Convergent Validity Analysis of the Measurement Model (After Deleting PA5)

Construct	Item	Factor Loadings	CR	AVE	Cronbach's Alpha
Physical Attractiveness	PA1	0.829	0.919	0.686	0.848
	PA2	0.880			
	PA3	0.837			
	PA4	0.764			
Technical Realism	TR1	0.796	0.897	0.670	0.877
	TR2	0.812			

Construct	Item	Factor Loadings	CR	AVE	Cronbach's Alpha
Social Content Value	TR3	0.814	0.937	0.712	0.797
	TR4	0.840			
	TR5	0.827			
	SCV1	0.787			
	SCV2	0.887			
	SCV3	0.854			
Emotional Attachment	EA1	0.864	0.927	0.741	0.883
	EA2	0.841			
	EA3	0.873			
	EA4	0.864			
Perceived Trustworthiness	PT1	0.903	0.881	0.810	0.883
	PT2	0.899			
	PT3	0.898			
	PI1	0.842			
Purchase Intent	PI2	0.808	0.910	0.748	0.915
	PI3	0.873			
	PI4	0.890			
	PI5	0.908			

Following the assessment of convergent validity, the discriminant validity of the model was evaluated using the Fornell-Larcker criterion [33]. This criterion requires that the square root of the Average Variance Extracted (AVE) for each latent construct should exceed its highest correlation with any other construct in the model. As presented in Table 7, the diagonal elements (bolded values representing the square root of AVE) are consistently higher than the off-diagonal elements (representing inter-construct correlations). This relationship indicates that each construct shares more variance with its assigned indicators than with other variables in the structural framework. Consequently, the results provide strong empirical evidence that the measurement model possesses adequate discriminant validity, ensuring that the constructs are statistically distinct and suitable for subsequent path analysis.

Table 7. Discriminant Validity Results (Fornell-Larcker Criterion)

	PA	TR	SCV	EA	PT	PI
PA	0.828					
TR	0.652	0.818				
SCV	0.293	0.295	0.844			
EA	0.339	0.295	0.580	0.861		
PT	0.258	0.267	0.395	0.695	0.900	

	PA	TR	SCV	EA	PT	PI
PI	0.326	0.347	0.387	0.526	0.462	0.865

Note: Diagonal bolded values are the square roots of the Average Variance Extracted (AVE); off-diagonal values are the inter-construct correlations. PA: Physical Attractiveness; TR: Technical Realism; SCV: Social Content Value; EA: Emotional Attachment; PT: Perceived Trust; PI: Purchase Intention.

To further cross-validate the discriminant validity, this study employed the Heterotrait-Monotrait Ratio (HTMT) of correlations, which is increasingly recognized as a more rigorous and sensitive criterion than traditional methods in variance-based SEM. The results are presented in Table 8.

The HTMT analysis reveals that all values between construct pairs remained below the stringent conservative threshold of 0.85, and well within the more relaxed upper limit of 0.90 [35]. Specifically, while the HTMT value between Physical Attractiveness (PA) and Technical Realism (TR) reached 0.754—the highest among all pairs—it nonetheless remained well within the acceptable range for establishing distinctiveness. For the remaining constructs, the HTMT values were notably lower, ranging from 0.292 to 0.787. These findings collectively confirm that the measurement dimensions for each construct are empirically independent and possess robust discriminant validity, allowing for a reliable assessment of the structural model.

Table 8. Results of Discriminant Validity Testing (HTMT Ratio)

	PA	TR	SCV	EA	PT	PI
PA						
TR	0.754					
SCV	0.358	0.354				
EA	0.385	0.33	0.688			
PT	0.292	0.299	0.468	0.787		
PI	0.363	0.384	0.453	0.583	0.512	

Note: HTMT values < 0.85 indicate strict discriminant validity; values < 0.90 indicate acceptable discriminant validity.

4.5. Structural Model Assessment: Hypotheses Testing and Path Analysis

4.5.1 Main Effect

The structural model was estimated using the PLS-SEM algorithm, with statistical significance determined through a bootstrapping procedure of 5,000 resamples. The results of the path analysis, including standardized path coefficients, t-statistics, and p-values, are summarized in Table 9. The data reveal a clear hierarchical pattern of influence, providing empirical evidence for the majority of the proposed research hypotheses.

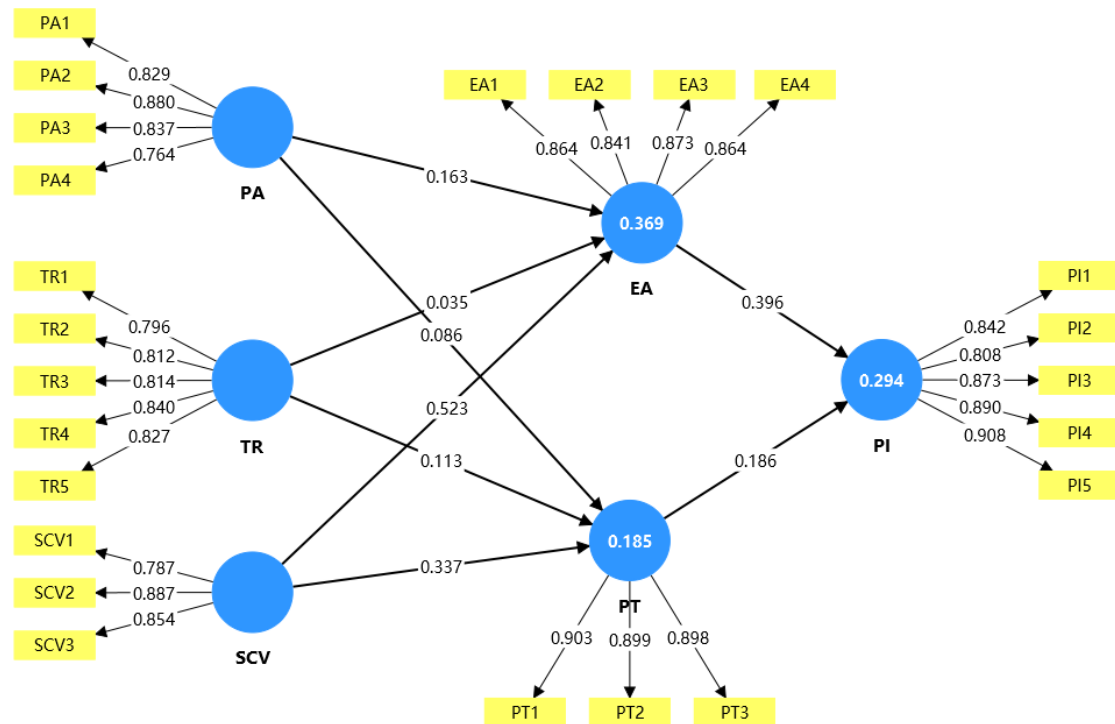


Figure 2. Model validation results

Table 9. Path Analysis Results of the Structural Equation Model

Path	Hypothesis	β	t-value	P-value	Hypothesis Test
PA → EA	H1a	0.163	4.215	<0.001	Support
TR → EA	H1b	0.035	0.928	0.353	Not supported
SCV → EA	H1c	0.523	13.329	<0.001	Support
PA → PT	H2a	0.086	1.938	0.053	Not supported
TR → PT	H2b	0.113	2.532	<0.05	Support
SCV → PT	H2c	0.337	7.661	<0.001	Support
EA → PI	H3a	0.396	9.114	<0.001	Support
PT → PI	H3b	0.186	4.453	<0.001	Support

Path analysis results indicate that the value of social content exerts a significant positive influence on both emotional attachment ($\beta=0.523$, $p<0.001$) and perceived trust ($\beta=0.337$, $p<0.001$); Physical attractiveness significantly influenced only emotional attachment ($\beta=0.163$, $p<0.001$), while technological realism significantly influenced only perceived trust ($\beta=0.113$, $p<0.05$). Furthermore, both emotional attachment ($\beta=0.396$, $p<0.001$) and perceived trust ($\beta=0.186$, $p<0.001$) exerted significant positive effects on purchase intention, jointly constituting the key psychological mechanisms driving user purchase decisions. Among these, hypotheses H1a, H1c, H2b, H2c, H3a, and H3b were supported, while H1b and H2a were not. Following the estimation of path coefficients and hypothesis testing, this study further examined model explanatory power and path effect sizes to comprehensively evaluate the overall performance of the structural model.

To evaluate the overall performance of the structural model, the Coefficient of Determination (R^2) was examined to determine the proportion of variance explained for

each endogenous construct. The model demonstrates varying degrees of explanatory power across the psychological and behavioral variables.

Specifically, Emotional Attachment yielded an R^2 value of 0.369, indicating that the combined influence of physical attractiveness, technological realism, and social content value provides a moderate level of explanation for users' emotional bonds. Purchase Intention reached an R^2 of 0.294; while this is categorized as moderately weak in certain rigid frameworks, it remains highly significant in consumer behavior research, where individual decision-making is influenced by a vast array of unobserved external factors. Finally, Perceived Trust showed a relatively lower explanatory power ($R^2 = 0.185$). Although this is considered weak, it still falls within the acceptable range for exploratory studies in emerging digital contexts [28], suggesting that while the identified antecedents contribute to trust, other factors—such as platform reputation or security—may also play a role.

Effect size analysis indicates that the effect size of social content value on affective attachment ($f^2 = 0.388$) is large, constituting a core driver of affective attachment; The effect sizes for social content value on perceived trust ($f^2 = 0.125$) and emotional attachment on purchase intention ($f^2 = 0.115$) were small to medium. Perceived trust on purchase intention and other pathways exhibited small effects, while effect sizes for remaining pathways approached or fell below 0.02. This aligns with path significance results, indicating these variables offer limited independent explanatory contribution within their respective relationships.

The Q^2 predict for emotional attachment was 0.362, that for purchase intention was 0.179, and that for perceived trust was 0.175. All three values were significantly greater than zero, indicating that the structural model constructed in this study possesses a certain degree of predictive capability for these three endogenous variables.

4.5.2 Mediation Effect

To further examine the specific mechanisms through which virtual idol characteristics influence purchase intention, a mediation analysis was performed using the Bootstrapping resampling method (with 5,000 sub-samples). This approach assesses the indirect effects of the antecedent variables via emotional attachment and perceived trust. The results, including point estimates and 95% bias-corrected confidence intervals, are summarized in Table 10.

Table 10. Results of Mediation Effect

Path	Hypothesis	Mediation effect value			P-value	Hypothesis test
		Estimate	Lower bound of the interval (2.5%)	Upper bound of the interval (97.5%)		
PA → EA → PI	H4a	0.065	0.033	0.102	<0.001	Support
PA → PT → PI	H4b	0.016	-0.000	0.036	0.362	Not supported
TR → EA → PI	H4c	0.014	-0.015	0.046	0.084	Not supported
TR → PT → PI	H4d	0.021	0.005	0.045	<0.05	Support
SCV → EA → PI	H4e	0.207	0.153	0.265	<0.001	Support
SCV → PT → PI	H4f	0.063	0.033	0.096	<0.001	Support

The results of the mediation effect analysis indicate that the causal mechanisms of each antecedent variable differ, with varying levels of support for the mediation hypotheses: Physical attractiveness exerted a significant indirect effect on purchase intention solely through emotional attachment (95% CI: [0.033, 0.102]), supporting H4a. The path via perceived trust was non-significant (95% CI: [-0.000, 0.036]), thus failing to support H4b; Technological realism exerted a significant mediating effect solely through perceived trust (95% CI: [0.005, 0.045]), supporting H4d; the mediating effect via emotional attachment was insignificant (95% CI: [-0.015, 0.056]), thus failing to support H4c; Social content value exerted significant partial mediation effects through both emotional attachment (95% CI: [0.153, 0.265]) and perceived trust (95% CI: [0.033, 0.096]), with H4e and H4f both supported.

All hypothesis testing results are presented in Table 11.

Table 11. Summary of Hypotheses Testing Results

Hypothesis	Path	β / Effect	P-value	Conclusion
H1a	PA $\rightarrow$ EA	0.163	<0.001	Support
H1b	TR $\rightarrow$ EA	0.035	0.353	Not supported
H1c	SCV $\rightarrow$ EA	0.523	<0.001	Support
H2a	PA $\rightarrow$ PT	0.086	0.053	Not supported
H2b	TR $\rightarrow$ PT	0.113	<0.05	Support
H2c	SCV $\rightarrow$ PT	0.337	<0.001	Support
H3a	EA $\rightarrow$ PI	0.396	<0.001	Support
H3b	PT $\rightarrow$ PI	0.186	<0.001	Support
H4a	PA $\rightarrow$ EA $\rightarrow$ PI	0.065	<0.001	Support
H4b	PA $\rightarrow$ PT $\rightarrow$ PI	0.016	0.362	Not supported
H4c	TR $\rightarrow$ EA $\rightarrow$ PI	0.014	0.084	Not supported
H4d	TR $\rightarrow$ PT $\rightarrow$ PI	0.021	<0.05	Support
H4e	SCV $\rightarrow$ EA $\rightarrow$ PI	0.207	<0.001	Support
H4f	SCV $\rightarrow$ PT $\rightarrow$ PI	0.063	<0.001	Support

5. Discussions

5.1. Main findings

This study examines the role of virtual streamer characteristics in influencing university students' purchase intentions through emotional attachment and perceived trust, using virtual idol livestreaming as the contextual setting. Empirical findings reveal significant variations in the direction, intensity, and psychological pathways of different virtual streamer characteristics, indicating that purchase intentions arise from the synergistic interaction of emotional and cognitive mechanisms.

Both emotional attachment and perceived trust exert a significant positive influence on university students' purchase intentions, which is consistent with existing research on media persona influence mechanisms. Emotional attachment, as the affective bond formed through prolonged user-virtual idol interaction, was validated as a core driver of consumption intent [12,28]. Similarly, perceived trust, representing users' cognitive assessment of virtual idol and information reliability, remains a critical prerequisite for purchase decisions in virtual consumption scenarios [36], aligning with prior research.

Path analysis reveals differentiated effects of distinct virtual host characteristics on affective attachment and perceived trust. At the affective attachment level, physical attractiveness and social content value exert significant positive influences [5,17,28], whereas technical realism shows no significant effect. This aligns with the notion that technical realism primarily ensures foundational viewing experiences and struggles to translate into enduring emotional bonds [28]. Regarding perceived trust, both technical realism and social content value exert significant positive influences [23,29], whilst visual appeal showed no significant effect. This stems from trust in virtual consumption scenarios relying more on functional cues than stylized visual design [21,30]. These non-significant pathways (H1b and H2a) offer critical theoretical nuances. Regarding H1b, although advanced animation and micro-expression rendering mitigate the uncanny valley, they function merely as a basic utilitarian hygiene factor. For digital-native university students, technological stability is taken for granted; it lacks the capacity to independently cultivate customized emotional intimacy. Regarding H2a, the failure of physical attractiveness to bolster perceived trust indicates that stylized visual charm operates purely as a fleeting visual heuristic. Within competitive live-streaming e-commerce, aesthetic spectacle carries insufficient diagnostic value to establish functional credibility, which strictly demands content reliability and transactional integrity.

Mediation analysis indicates that within the affective attachment mediation pathway, both visual appeal and social content value significantly influence purchase intention via affective attachment [12,17,37]. The mediating effect of technological realism was insignificant, as it struggles to translate into stable emotional dependence. Within the perceived trust mediation pathway, technological realism and social content value significantly influenced purchase intention via perceived trust [29], while the mediating effect of visual appeal was insignificant, owing to its limited diagnostic significance as a trust cue. While Zhao & Chung [3] asserted that virtual anchor traits broadly stimulate purchase intentions through non-differentiated resonance, our empirical dissection clarifies that this drive is highly bifurcated: aesthetic stimuli must be filtered exclusively through affective attachment, whereas technological cues rely entirely on cognitive trust to achieve commercial conversion.

In summary, university students' purchase intention exhibits multi-path concurrent characteristics influenced by virtual idol livestreaming. Various virtual host attributes exert differentiated effects through emotional attachment and perceived trust. These findings contribute to a deeper understanding of the formation logic of purchase intention within virtual idol livestreaming contexts. In contrast to Du et al. [10],

who investigated virtual idol compliance via a monolithic attribute approach, our multidimensional deconstruction explicitly proves that social content value—rather than mere visual novelty or technical specification—exerts the heaviest independent weight on driving young consumer decisions, shifting the research paradigm from passive presence to interactive value creation.

5.2. Theoretical Contributions

From a theoretical perspective, this study systematically examines the formation mechanism of purchase intentions among university students within the specialized context of virtual idol live-streaming. By utilizing the Stimulus-Organism-Response (S-O-R) framework, this research conducts an empirical analysis that refines and expands the known relationships between virtual idol characteristics, internal psychological mechanisms, and subsequent behavioral intentions. This contribution is particularly significant as it moves beyond generic digital marketing models to address the unique ontological nature of virtual entities.

A primary contribution of this research lies in its nuanced categorization of virtual idol characteristics into three distinct dimensions: physical attractiveness, technical realism, and social content value. By distinguishing these attributes, the study elucidates the differentiated effects of various stimulus variables across emotional and cognitive pathways. Empirical findings reveal that physical attractiveness does not directly influence purchase intention but operates entirely through the mediation of affective attachment. In contrast, technical realism primarily influences purchase intention via perceived trust while also maintaining a significant direct effect. Meanwhile, social content value influences both affective attachment and perceived trust, demonstrating robustness through both direct and indirect pathways. This differentiation represents a departure from previous research that often treated virtual idol characteristics as a monolithic entity, thereby expanding the theoretical depth regarding stimulus variable mechanisms in virtual consumption environments.

Furthermore, the introduction of emotional attachment and perceived trust as parallel mediating variables verifies that virtual idol live-streaming influences purchase intention through a sophisticated dual-mechanism process rather than a linear, single-pathway trajectory. Emotional attachment is found to play a pivotal role in the pathways linking physical attractiveness and social content value to consumption, while perceived trust demonstrates stable mediating effects in the pathways connecting technological realism and social content value to the final decision. These results provide clear empirical evidence for the synergistic effects of emotional and cognitive mechanisms in virtual subject consumption behavior. Consequently, this study further expands the application boundaries of S-O-R theory within the burgeoning fields of virtual idol research and live-streaming e-commerce.

Finally, the findings highlight that social content value possesses the strongest explanatory power within the model. It significantly facilitates the formation of both emotional attachment and perceived trust while simultaneously exerting a direct influence on purchase intention. This discovery underscores the central role of content interactivity and social attributes, suggesting that the "social" essence of the live-stream is more influential than its purely aesthetic or technical components. By providing fresh empirical support for the value of digital content, this study deepens the theoretical understanding of the interplay between content-driven stimuli, psychological responses, and behavioral intentions in the digital age.

5.3. Practical implications

From a management perspective, the findings of this study provide targeted strategic guidance for virtual idol live-streaming operations, brand collaborations, and platform governance. First, operators should prioritize enhancing the social attributes and interactivity of live-streamed content. Given that social content value is the most potent driver in the model, increasing interaction frequency and fostering collaborative topic creation with the audience can significantly boost conversion effectiveness through both direct and indirect pathways.

Second, technical realism and live-stream stability must be strictly maintained as foundational infrastructure. Ensuring high-quality rendering and low-latency interaction reduces the perceived uncertainty inherent in digital environments, thereby strengthening user trust in both the virtual idols and the commercial content they endorse. This technical reliability serves as a critical cognitive anchor that validates the legitimacy of the virtual entity in the eyes of the consumer.

Thirdly, the design of virtual idol personas should focus strategically on fostering long-term emotional connections rather than mere visual spectacle. By employing approachable, highly recognizable, and consistent personas, operators can strengthen the emotional attachment of university students. Since physical attractiveness influences purchase intention primarily through this affective bond, the "relatability" of the virtual character becomes a vital asset in indirectly stimulating consumption through emotional reciprocity.

Finally, virtual idol operations must move away from short-term, high-intensity stimulus strategies. Sustainable commercial conversion is not achieved through fleeting visual novelty but by the gradual accumulation of user affection and trust. This requires a commitment to consistent, high-quality content output, the nurturing of genuine interactive relationships, and the meticulous cultivation of credible, value-driven personas. By focusing on these long-term psychological assets, brands can ensure more resilient and loyal consumer behavior within the volatile virtual economy.

5.4. Limitations and Future Research

Despite its contributions, this study acknowledges several limitations that provide a foundation for future inquiry. First, the sample was restricted to university undergraduates, whose specific psychological and consumption traits may limit the generalizability of the findings to broader demographic groups. Second, the research model included only three virtual idol attributes and two psychological mediators; as such, it does not account for all potential variables influencing virtual consumption, such as platform algorithms or social influence. Finally, the use of purchase intention as the primary outcome variable may not perfectly mirror actual consumption behavior, which is often subject to immediate situational and financial constraints.

Future research could advance this field in three key directions. To enhance generalizability, studies should encompass more diverse populations across different ages and occupations. Additionally, incorporating moderating variables—such as individual personality traits or digital literacy—would build a more comprehensive explanatory framework. Finally, moving beyond self-reported intentions to analyze actual purchasing data and objective consumption behavior would significantly increase the practical predictive power of the research and deepen the understanding of the virtual idol live-streaming economy.

6. Conclusion

This study, set against the backdrop of virtual idol live-streaming, empirically examines the operational mechanisms through which physical attractiveness, technological realism, and social content value influence university students' purchase intentions within a stimulus-organism-response (S-O-R) framework. Emotional attachment and perceived trust are identified as the key mediating factors representing the "organism" state. Findings reveal that social content value exerts the strongest overall effect, driving purchase intentions both directly and via dual mediating pathways. In contrast, physical attractiveness influences purchase intentions solely indirectly through emotional attachment, while technological realism exerts an indirect influence primarily via perceived trust.

By integrating emotional attachment and perceived trust into a unified dual-pathway mechanism, it advances current understanding of how affective and cognitive processes jointly shape consumer responses in virtual idol environments, which represents an area where empirical evidence has been limited. The findings also extend S-O-R theory by demonstrating how multi-dimensional virtual idol characteristics activate distinct psychological pathways that ultimately drive consumption.

From a practical perspective, the results highlight the centrality of social content value in virtual idol marketing. Platforms and brands should prioritize creating socially resonant, community-oriented content and invest in trust-building interaction designs to strengthen user engagement and purchasing motivation. Enhancing technological realism remains important, but its influence operates primarily through trust rather than direct persuasion.

By addressing gaps in mechanism research within virtual consumption, this study highlights the centrality of the social attributes of content and providing both theoretical and practical guidance for business model optimization. Despite these insights, limitations remain, including a substantial sampling bias arising from the highly homogeneous composition of the sample. Specifically, 89.63% of respondents were medical students and 90.94% were first-year undergraduates, resulting in a narrow demographic profile that restricts the generalizability of the findings. In addition, the variable system does not capture all potential influencing factors, and the study relies solely on purchase intention as the outcome variable. Future research should therefore broaden the participant base across disciplines and grade levels, incorporate situational and contextual variables, and integrate behavioral data from actual consumption records to enhance the robustness and predictive validity of the model.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The data presented in this study are available on request from the corresponding author. The data are not publicly available due to privacy and confidentiality agreements with the participants.

Conflicts of Interest: The authors declare no conflicts of interest.

Abbreviations

The following abbreviations are used in this manuscript:

AVE	Average Variance Extracted
CI	Confidence Interval
CMB	Common Method Bias
CR	Composite Reliability
HTMT	Heterotrait-Monotrait Ratio
PLS-SEM	Partial Least Squares Structural Equation Modeling
Q ² predict	Predictive Relevance Q-Square
SmartPLS	Software for partial least squares structural equation modeling (version 4.0)
S-O-R	Stimulus-Organism-Response
SPSS	Statistical Package for the Social Sciences (version 26)
VIF	Variance Inflation Factor

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