



# The Effect of Physical Cues on Customer Loyalty: Based on the Mediating Effect of Customer Engagement and Value Co-creation

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## Abstract

As a new business model, e-commerce live broadcasting has great value in the commercial field. Based on value co-creation theory and the stimulus-organic-response model, this study explores the influence of physical cues in e-commerce live broadcast scenes on customer loyalty. Using the audience of China's e-commerce live broadcasting platform as the research object, 404 valid data points were collected through a questionnaire survey, and a structural equation analysis model was adopted to explore the relationship among the physical clues of the e-commerce live broadcasting scene, customer engagement, value co-creation, and customer loyalty and to verify the mediating effect of customer engagement and value co-creation. The research shows that aesthetic appeal, layout, and function have a positive impact on customer engagement, but financial security has no positive impact on customer engagement. In addition, value co-creation has an intermediary effect, and customer engagement and value co-creation have a double intermediary effect on physical cues and customer loyalty in e-commerce live broadcast scenes. The research not only expands the theory of value co-creation and scene but also provides practical reference value for e-commerce live broadcasting platforms and enterprises and promotes the design of physical cues in e-commerce live broadcasting scenes to improve customer loyalty.

## Keywords:

E-Commerce Live Broadcast;  
Customer Engagement;  
Value Co-Creation;  
Customer Loyalty;  
Service Scenario.

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## 1- Introduction

Live e-commerce has become one of the most popular sales channels in China. It is a new competitive business model for companies, with merchants or opinion leaders selling products via live streaming, involving video content, real-time communication, and consumption [1]. It has promoted the structuring of industry and supply chains and has become a new engine of consumption and economic growth [2–5]. Since 2011, Twitch has become the world's largest live gaming platform, followed by Facebook, YouTube, and social media services such as Instagram and WeChat. Online retail platforms like Amazon have also opened a live broadcast function. In China, Alibaba first launched Taobao Live in 2016, before Byte Dance began its e-commerce commercialization and launched TikTok Live in 2018. Since then, e-commerce live streaming has begun to flourish in China. According to the news released by China's Ministry of Commerce, e-commerce platforms monitored more than 120 million e-commerce live streaming sessions in 2022, with more than 1.1 trillion viewers and more than 95 million live commodities. Due to its considerable commercial value, e-commerce live streaming deserves in-depth research.

Combining livestreaming with e-commerce creates even greater potential. In an interactive cyber-physical environment, customers can enjoy richer, real-time and real shopping experiences [6]. This innovative live commerce

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changes e-commerce from a product-oriented shopping environment to a social, fun, and customer-centered environment [7, 8]. In the virtual shopping environment, consumers complete various purchases in novel and fashionable ways and enrich traditional commerce in various ways [6]. This innovative business model not only improves consumers' ability to make informed purchasing decisions but also enables them to access more high-quality information in the form of real-time video. In addition, advanced streaming media business technologies, such as bullet screens and real-time video, facilitate the development of harmonious and interpersonal relationships between sellers and consumers [8, 9]. Consumers can enjoy more social and shopping experiences in e-commerce live streaming, such as the close relationship established with the anchor and shopping experience sharing through social networks [9]. In addition, physical cues in e-commerce live broadcast scenes also have strong attraction and influence, which play a crucial role in guiding consumers to show various behaviors in the shopping and socializing process [10]. Overall, e-commerce live streaming provides a comprehensive channel for customers, enabling them to not only enjoy shopping, fun, and social benefits but also show various loyalty behaviors, such as socializing, enjoyment, and impulse spending, due to the warm atmosphere and high participation of the physical cues of the scene.

Although e-commerce live streaming is booming, academic attention to it is uneven [9], and research on the influencing factors of customer behavior has attracted substantial attention [6]. Earlier academic research has mainly explored the key factors affecting purchase intention toward or participation in e-commerce live streaming [11], including customer values such as utilitarian, hedonic, and social value [8]. In addition, how environmental attributes such as information characteristics [6] (interactivity [12, 13], visualization [8, 14], and entertainment [8, 15]), website content [10], and customer service affect customers' emotional and cognitive states while shopping has also received attention from researchers [16]. However, with the emergence of advanced technology and novel shopping scenes, the physical clues of e-commerce live broadcast scenes have changed, and customers are more inclined to engage in real-time demonstrations [17], interactive games, virtual gifts [11], etc. In such a shopping environment, potential customers can make stimulating shopping decisions, make purchases to enjoy the excitement and pleasure brought by shopping activities, and participate in social activities [18], creating more potential shopping opportunities and sustainable consumers, promoting value co-creation, and forming customer loyalty [19].

E-commerce live broadcasting has outstanding performance in creating a new shopping environment that provides a variety of stimulating factors and provides users with interactive communication service scenarios of resources, information, knowledge, entertainment, friendship, and other aspects across time and space [20] to stimulate the shopping interest of potential customers. Researchers believe that it is becoming increasingly important to have a deeper understanding of the behavioral processes of internet consumers based on the role of contextual cues [21]. In addition, few studies have explored the influencing factors or how to affect customer loyalty from the perspective of interactions with the overall scene's physical environment [8]. To fill the above gaps, this study notes that in the mobile era of the "Internet of Things", applications such as video, shopping, and bullet screens provide customers with deep experiences, dynamic links, warm communities, and big data scenes, connecting the "small world" [22]. In this small world, customers are subject to numerous stimulus cues (stimuli) that can trigger individual emotional and cognitive processes (organisms), leading to approach behaviors (reactions) [23]. This framework helps with an exploration of how physical cues in e-commerce live streaming scenes affect customer loyalty. For example, when customers interact with each other under the stimulation of physical cues in e-commerce live broadcast scenes, the interaction generates a psychological state driven by motivation, brand-related factors, and situational factors, thus enhancing customer engagement [24]. When customers participate in the company and value is created with them in an interactive environment of common interest, such an interaction may generate a higher level of enthusiasm and may even promote customer loyalty behavior [25, 26], for example, through word-of-mouth communication activities or suggestions, helping other customers write reviews, and participating in legal actions [27]. Thus, value co-creation and stimulus-organism-response (S-O-R) frameworks play a key role.

To fill the gap in the literature, based on value co-creation theory and the SOR model, the relationship among physical cues, customer engagement, and value co-creation in e-commerce live broadcast scenes and customer loyalty is analyzed, and the mediating effect of customer engagement and value co-creation is verified. Using the audience of China's e-commerce live streaming platform as the research object through a questionnaire survey, a structural equation model is used for the analysis. The research expands value co-creation theory and the SOR model and provides a practical reference for e-commerce live streaming platforms and enterprises.

## **2- Literature Review and Hypothesis Inference**

### ***2-1- Value Co-Creation Theory***

The traditional theory of value creation holds that value is exchange value, indicating the ability of an item to be used to purchase goods, with the customer acting only as a recipient and user of value [28]. The information age has lowered the threshold for consumers to acquire resources. Moreover, value creation and value meaning have changed from enterprise and product-centered to customer experience-centered, which is the core of value co-creation [29]. In addition,

Zhou et al. [30] believed in the era of social media-enabled customer co-creation, the networked, dynamic, and interactive nature of service ecosystems, and the value of co-creation. This study discussed the influence of customer psychological ownership on value co-creation from the perspective of in-depth experience and interaction. Several studies confirm specific behaviors and a sense of belonging through specific social media live broadcasts. The value co-creation theory was applied in this research to investigate the users' perceived value and behavior on e-commerce live broadcast platforms.

Nambisan [31] first executed a four-dimensional experience framework in a virtual co-creation environment, which included practicality, sociability, usability, and hedonism. Value co-creation can be divided into functional, social, and emotional values against the background of the sharing economy, and the willingness of consumers to buy varies at different stages [32]. In addition, Linghu [16] divided value co-creation into functional, hedonic, and social values through social media contexts. Functional value refers to a consumer's perception of the achievement of a purchase goal and is generally considered the most significant component of the consumer's perceived value [33]. Hedonic value refers to the emotional benefits customers derive from using a product or service, including elements of pleasure and enjoyment [34]. Social value refers to enhancing social welfare and interpersonal relationships when consumers use a product or service [35]. As a particular social media scene, this paper explored the physical cues and the psychological impact of consumer behavior in three aspects: functional, hedonic, and social values.

The e-commerce scene is rich in physical clues. Through network streaming media technology, the scene information will be text, voice, image, video, bullet screen, and other multimedia forms of the spread of the way, giving the public the ability to carry out real-time live broadcasts and interact in the live broadcasts [36]. Integrating physical cue attributes in live e-commerce scenes into real-time interactions produces purchases [37]. Customer engagement is enhanced when the audience interacts with the host and other viewers in real time through the bullet screen to create a positive experience. Furthermore, value co-creation is realized in the process of customer participation. That is, customers can obtain functional, hedonic, and social values, which promote customer loyalty. Therefore, this study analyzed the significance of value co-creation theory and how participation in the physical cues of the e-commerce live service scene affects customer loyalty.

### ***2-2-E-Commerce Live Scene Physical Cues and Customers Engagement***

According to Bitner [38], "Servicescape" includes ambient conditions, space and function, signs, symbols, and artifacts, which cover temperature, air, music, light, etc. The space layout and functions include the space plan layout, the facility equipment, the quantity, the scale, and the furniture. Signs, symbols, and handicrafts include guidance, personal handicrafts, and decorative style. Eroglu et al. [39] applied the scene theory to the analysis of the online store environment and considered that the image of an online retail store influences customers' purchasing behavior. Harris and Goode [40] proposed that aesthetic appeal, layout, and functional and financial security in web service scenarios positively improve website trust and willingness to buy. Wang [41] defined the e-commerce live broadcast network service scene through three dimensions: aesthetic appeal, layout and functionality, and financial security. Consumers interpret the display interface or service as attractive or seductive in an online environment. The function layout refers to the structure, organization, spatial arrangement, and adaptability of the online store, on behalf of the network service scene to encourage customers to complete shopping tasks. These include site navigation links, search mechanisms, and product information, which are personalized, customized, and interactive. A new feature on online video sites is the bullet screen, where viewers actively read videos and post comments on the screen [42]. Financial security focuses on the payment system, including personal account security and payment convenience. This study considered that the physical cues of the live broadcast scene belong to the network service scene, including aesthetic appeal, layout and functionality, and financial security.

Customer engagement is a psychological or motivational state that reflects the cognitive and emotional processing of customer experiences with brands or companies [43]. Sashi et al. [44] stated that customer engagement is an interactive consumer experience facilitated by communication technologies, such as social media, and that consumer engagement is an emotional commitment. Brodie et al. [45] revealed that customer engagement plays a central role in service relationships, with other related concepts as specific antecedents and consequences. The antecedents of customer engagement include corporate reputation, service quality, organizational support, employee engagement, virtual brand community support, E-service quality, social media data, community relationship management (4Cs Model), Relationship Marketing Orientation, Brand Trust, and e-commerce live broadcast [26, 27, 46–52]. Hollebeek et al. [25] indicated that customer engagement results were brand community participation, value, trust, emotion, commitment, word-of-mouth, and loyalty. This paper argued that the physical cues of the scene lead to other customer behaviors, such as emotion, trust, participation, value, and word of mouth.

The aesthetic appeal, layout, functionality, and financial security of physical cues in live e-commerce scenes positively impact customer engagement [53–55]. Harris & Goode [40] analyzed online consumer behavior from three dimensions: aesthetic appeal, layout and functionality, and financial security, arguing that both design uniqueness and

website entertainment contribute to aesthetic appeal. Website functionality and appearance are assessed in terms of usability, information relevance, customization, and engagement. Financial security can be measured in terms of payment convenience and perceived security [56]. Tankovic & Benazic [53] viewed aesthetic appeal, layout function, and financial security as stimuli in E-service scenarios, perceived e-shopping value as an organism, loyalty as a response, and constructed SOR theory. Tu et al. [57] demonstrated that aesthetic appeal, layout, and functionality in web service scenarios could effectively enhance customers' cognition, emotion, and behavior toward websites. Usefulness and entertainment in live e-commerce service scenarios affect consumer engagement [52]. In a live e-commerce scenario, users influence other customers' participation through real-time scrolling of bullet screens, the number of fans in the live broadcast room, likes, gift-giving, retweeting, purchasing behavior, and other layout and functional factors [4]. Therefore, this study deduced that the physical cues of e-commerce live scenes are relevant to customer engagement and proposed research hypotheses such as H1, H1a, H1b, and H1c:

**H1:** Physical cues of E-commerce live scenes have a positive effect on Customer engagement.

**H1a:** Aesthetic appeal has a positive impact on Customer engagement.

**H1b:** Layout and functional has a positive effect on Customer engagement.

**H1c:** Financial security has a positive impact on Customer engagement.

### **2-3- Customer Engagement and Value Creation**

Normann & Ramirez [28] argued that value co-creation is the process by which firms and customers act as value creators and users, respectively, and that their interactions are fundamental to value creation. Prahalad and Ramaswamy [29] pointed out that the process of value meaning and value creation has shifted from product-centric and enterprise-centric to customer experience-centric. They argued that experiential value, which arises from the interaction between users of the value network, is the core value of enterprise co-creation. Vargo & Lusch [58, 59] argued that Service-Dominant logic (S-D logic for short), in which value is created by both the enterprise and the customer, shifts the focus from exchange value to use value. That is, customers are always co-creators of value. Jessen et al. [60] stated that value co-creation refers to the knowledge, capabilities, and information customers use to create value. This paper argues that value co-creation is the value gained by the interaction between customers and enterprises on social business platforms from the customers' perspective.

Customer engagement is an inherent quality of communication and a psychological or motivational state based on the experience of a focused interaction between a customer and a particular participant, such as a brand [61]. Bowden [62] and Brodie et al. [45] advocated co-creating a customer experience by interacting with a focused agent/target in a service relationship in the form of likes, comments, shares, purchases, recommendations, influence, and feedback on social media platforms [26, 63].

Hollebeek et al. [64] revealed that value creation is the ultimate result of customer engagement. Value creators create personalized customer experiences through continuous dialogue and interaction, including functional, hedonic, and social values [20]. Linghu [16] tested the positive impact of customer engagement on functional, hedonic, and social values in social media. Therefore, this study concluded that customer engagement is relevant to value co-creation and proposed research hypotheses such as H2, H2a, H2b, and H2c:

**H2:** Customer engagement has a positive effect on Value co-creation.

**H2a:** Customer engagement has a positive impact on Functional value.

**H2b:** Customer engagement has a positive impact on Hedonic value.

**H2c:** Customer engagement has a positive impact on Social value.

### **2-4- Customer Engagement, Value Co-Creation, and Customer Loyalty**

According to Oliver [65], customer loyalty is a promise that customers will buy or patronize their favorite products and services again. Ha and Park [66] emphasized consumers' psychological attachment and commitment to a brand or company based on their own preferences, including cognitive, emotional, intentional, and behavioral loyalty. In the context of the Internet, Srinivasan et al. [67] pointed out that customer loyalty is the extent to which consumers pay attention to and prefer a particular platform, which thus leads to repeated consumer behavior. van Doorn et al. [27] argued that motivational drivers, such as word-of-mouth, interaction, and activity, lead to customer engagement behaviors that go beyond transactional behavior. This paper concluded that customer loyalty in the e-commerce live-broadcast context is the behavior that customers buy, repeat purchases, like, Link, comment, retweet, recommend, use word-of-mouth, and experience evaluation based on their satisfaction and trust in the product or service of the enterprise. At this point, customer loyalty includes transaction behavior and non-transaction behavior.

Value co-creation refers to the process by which consumers create value by fully utilizing their own resources and the resources provided by enterprises to solve problems [68]. The subject of value co-creation is the customer, and value is to gain benefits in the process of watching, exchanging, or using the information on the internet in a particular situation, including functional, hedonic, and social values [16, 20]. Functional value refers to an individual’s reasonable and economic assessment of the quality of a product or service [69]. Hedonic value is a critical factor in customer engagement with social media [70]. High hedonic value ensures that customers visit brand pages more frequently [71], and social value is achieved through repeated dialogue and the exchange of ideas. In fact, some users may form friendships that continue at the interpersonal level [35, 72]. Verleye [73] explored the effects of hedonic, cognitive, social, personal, and economic experiences on customer satisfaction to enhance customer loyalty. Therefore, this study concluded that value co-creation is relevant to customer loyalty and proposed H3, H3a, H3b, and H3c:

**H3:** Value co-creation has a positive effect on Customer loyalty.

**H3a:** Functional value has a positive effect on Customer loyalty.

**H3b:** Hedonic value has a positive effect on Customer loyalty.

**H3c:** Social value has a positive effect on Customer loyalty.

Social platforms such as Facebook, Instagram, WeChat, TikTok, Quickhand, Taobao live streaming, and JD.com live streaming are examples of value co-creation. These platforms provide customers with a better interactive experience value through physical cues of live e-commerce scenes, satisfying their functional, hedonic, and social values. As a result, it promotes customer loyalty and behavior [74]. Carlson et al. [69] revealed that usability and hedonic search engine site placement positively affect emotional commitment and establish a long-term, stable relationship with customers. This pleasurable mood leads to a stronger willingness to buy. Brodie et al. [45] suggested that customer engagement results in customer satisfaction, self-brand connection [75], brand attachment, and brand loyalty. Hollebeek et al. [76] pointed out that value co-creation mediates the effect of customer engagement on customer loyalty. Linghu [16] examined the positive impact of value co-creation on customer engagement and loyalty in social media. Therefore, this study concluded that customer engagement and value co-creation are related to customer loyalty and proposed H4, H5, and H6:

**H4:** Customer engagement mediates the relationship between Physical cues and Customer loyalty.

**H5:** Value co-creation mediates the relationship between Physical cues and Customer loyalty.

**H6:** Customer engagement and Value co-creation have mediating effects on Physical cues and Customer loyalty in live e-commerce scenes.

In this paper, an S-O-R model and a set of assumptions were developed. Figure 1 depicts the relationship between the dimensions. The model assumes that aesthetic appeal (AA), layout and functionality (FL), and financial security (FS) affect customer engagement (organism) in the physical cues (stimuli) of live e-commerce scenes. Customer engagement has an impact on value co-creation (response). Value co-creation affects customer loyalty (response). Customer engagement and value co-creation influence customer loyalty. Value co-creation includes functional value (FV), hedonic value (HV), and social value (SV). To sum up, this research framework constructs the research model (Figure 1).

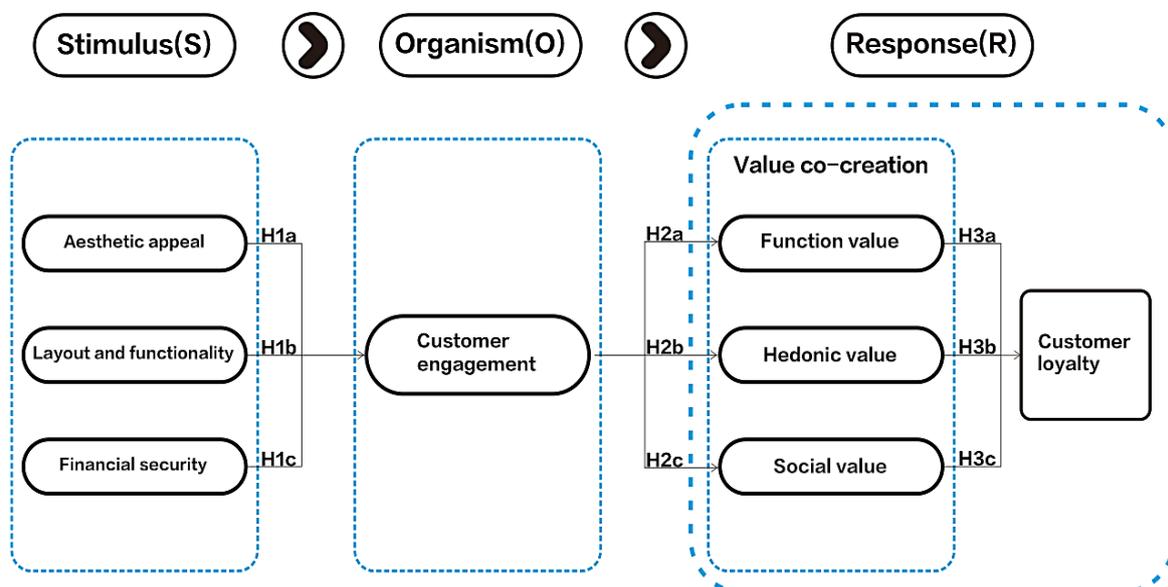


Figure 1. The conceptual model

### 3- Research Methods

#### 3-1- Sample and Data Collection

This study selected China's e-commerce live audience as the research object, including Guangdong, Zhejiang, Shanghai, Jiangsu, Fujian, Hubei, Beijing, Jiangxi, Guangxi, and other regions. These areas cover China's e-commerce developed and non-developed areas, with a certain degree of representation. In addition, respondents need to have seen live e-commerce streaming on platforms such as Taobao, jd.com, TikTok, Kuaishou, Mushroom Street, and Little Red Book, which are the more typical e-commerce live streaming platforms in China. These platforms have gathered many fans and a wide range of attention and influence.

The convenient sampling method was applied to send questionnaires electronically through instant messaging software (WeChat group, WeChat circle of friends, WeChat Friends, QQ Group, and QQ friends). Within 60 days, 475 questionnaires were returned and 404 valid questionnaires were left, for an effective recovery rate of 85.05%. To avoid the bias of social expectations and to ensure honesty, each respondent was assured confidentiality, and the questionnaire data were conveniently collected [77].

Table 1 shows the descriptive statistics of the sample characteristics. Among the participants, the proportion of men and women was equal. Most students were 18–25 years old, college students, and undergraduates. The majority of them were students with an income of less than 3,000 yuan. They preferred Taobao (31.70%) and TikTok (25.19%). 31.44% of the users spent 3-5 years shopping in the live e-commerce room. They mostly visited it 2-4 times a week (41.34%), and the visit time was commonly less than 1 hour (65.59%).

**Table 1. Descriptive statistics of sample characteristics (N = 404)**

Variable	Category	Frequency	Percent (%)	Variable	Category	Frequency	Percent (%)	
Gender	Male	203	50.25	Favorite Platform for Live e-commerce	Taobao	336	31.70	
	Female	201	49.75		JD.com	181	17.08	
Age	Under 18	41	10.15		Tik-Tok	267	25.19	
	18-25 years old	174	43.07		Speedy	107	10.09	
	26-30 years old	118	29.21		Little Red Book	72	6.79	
	31-40 years old	49	12.13		Mushroom Street	41	3.87	
	41-50 years old	13	3.22		Other	56	5.28	
	Over 51 years old	9	2.23		Less than 1 year	97	24.01	
Education	High School and below	14	3.47		E-commerce lives room shopping time	1-2 years	109	26.98
	Specialist	173	42.82			3-5 years	127	31.44
	Undergraduate	197	48.76	More than 5 years		71	17.57	
	Master degree or above	20	4.95	Less than 2 times	142	35.15		
Occupation	Employees of enterprises	124	30.69	Average number of visits per week	2-4 times	167	41.34	
	Workers in government organs and in situations	29	7.18		5-7 times	63	15.59	
	Freelance	6	1.49		More than 7 times	32	7.92	
	Self-employed	27	6.68	Less than 1 hour	265	65.59		
	Students	210	51.98	1-2 hours	85	21.04		
	Other	8	1.98	2-3 hours	33	8.17		
Income	Less than ¥3,000	198	49.01	Visit every day Time	3-4 hours	10	2.48	
	¥3001-¥5000	60	14.85		More than 4 hours	11	2.72	
	¥5001-¥8000	61	15.10					
	Over ¥8,000	85	21.04					

The data collected by a single questionnaire may produce common method variance, affecting the internal validity [78]. Therefore, after the questionnaire was collected, the Harman single-factor model was used to examine the common method variance. Employing confirmatory factor analysis to compare the fit of the "Single factor model" and "Measurement Model" indicated that the univariate model data were not well matched ( $\chi^2 = 4320.172$ ,  $DF = 496$ ,  $\chi^2/DF = 8.71$ ;  $CFI = 0.546$ ;  $TLI = 0.517$ ;  $RMSEA = 0.138$ ,  $SRMR = 0.121$ ). They were significantly lower than the fitness of the measurement model ( $\chi^2 = 780.904$ ,  $DF = 467$ ,  $\chi^2/df = 1.672 < 3$ ,  $P = 0.000$ ;  $CFI = 0.965 > 0.90$ ;  $TLI = 0.961 > 0.90$ ;  $RMSEA = 0.041 < 0.08$ ,  $SRMR = 0.034 < 0.06$ ). The "Measurement Model" fit was shown to be moderately better than the "Single-factor model" ( $\Delta\chi^2 = 3539.268$ ,  $\Delta DF = 29$ ,  $p < 0.001$ ), and the question of representing common method variance could be omitted.

### 3-2-T-Test

Following Huang & Chen [79] and Huang et al. [80], the approach of Larson & Poist [81] was used to assess response bias. T-test was applied to compare the responses of gender statistical variables and customer loyalty. No significant differences were found between the two groups at 95% confidence intervals, indicating that response bias was not an issue.

### 3-3-Measurements

The questionnaire for this study consists of three parts. The first part is the introduction, introducing the research background and objectives. The second part is descriptive data, which includes the data of respondents (sex, age, education, occupation, and income). It also covers the basic information about participating in live e-commerce (such as favorite live e-commerce platform, time spent shopping in the live e-commerce room, average number of visits per week, and time spent visiting each day). The third part contains four variables. The independent variables are the physical cues of the scene, and the dependent variables are customer loyalty. The intermediary variables are customer engagement and value co-creation. The third part of the question is measured on the Likert 7-point scale, which ranges from 1 (very strongly disagree) to 7 (very strongly disagree). The items in these questionnaires were based on the existing literature. Details of the measurements are shown in Table 2.

**Table 2. Observed indicators for constructs**

Second-order construct	First-order Construct	Item	Observed indicator	Reference
E-commerce live service scene	Aesthetic Appeal (AA)	aa1	The look of the links (pictures, videos, Link styles) in the live webcast room appeals to me	Harris & Goode [40]; Wang [41]
		aa2	The product display in the live broadcast room of e-commerce is my favorite	
		aa3	The design of e-commerce live broadcast room is unique and with brand characteristics	
		aa4	The design of e-commerce live broadcast room is innovative	
		aa5	I like this studio because it can bring me happiness, not only I can buy things	
	Layout and Functionality (LF)	lf1	E-commerce broadcast room operation is simple	
		lf2	E-commerce live room navigation health useful (such as sharing health, coupon collection, etc.)	
		lf3	E-commerce studio is friendly and human	
		lf4	For the first time into the live studio consumers can easily operate	
		lf5	E-commerce live broadcast room product-related information can be easily obtained	
		lf6	There is no irrelevant information in e-commerce live broadcast room	
		lf7	I can customize the e-commerce live room settings (such as changing color, layout and font, etc.)	
		lf8	E-commerce broadcast room to buy suggestions in line with my needs	
		lf9	E-commerce studio can help me to compare products and prices	
	Financial Security (FS)	fs1	E-commerce studio has efficient payment procedures	
fs2		I trust the security procedures in the e-commerce studio		
fs3		E-commerce broadcast room has a higher awareness of consumer security (such as personal information protection, privacy protection, etc.)		
Consumer Engagement	Consumer Engagement (CE)	ce1	I spent a lot of time on the live webcast	So et al. [61]; Li & Zhang [82]
		ce2	My life would be different without this webcast	
		ce3	Anything related to the live webcast room will get my attention	
		ce4	I love sharing the experience of using the live e-commerce room with my friends	
		ce5	When I introduce to others about the live broadcast room of this e-commerce, I will give a very detailed introduction	
		ce6	When the people around me also use the live e-commerce room, I feel happier to use the live e-commerce room	
Value co-creation	Functional Value (FV)	fv1	The knowledge and information of the live e-commerce platform is very helpful to me	
		fv2	Can obtain the knowledge or the information which I need from this e-commerce live broadcast platform	
		fv3	Through the e-commerce platform can solve the problems I encountered	



**Table 3. Reliability and convergence validity**

Construct	Item	Estimate	S.E.	Est./ S.E.	SMC	CR	AVE	Cronbach's alpha
Aesthetic appeal	aa1	0.78 ***	0.02	32.94	0.61	0.88	0.59	0.88
	aa2	0.81 ***	0.02	36.69	0.66			
	aa3	0.82 ***	0.02	39.10	0.68			
	aa4	0.74 ***	0.03	27.96	0.55			
	aa5	0.67 ***	0.03	21.43	0.45			
Layout and functionality	lf1	0.70 ***	0.03	24.81	0.49	0.92	0.55	0.91
	lf2	0.72 ***	0.03	27.49	0.52			
	lf3	0.80 ***	0.02	38.67	0.64			
	lf4	0.76 ***	0.02	31.60	0.57			
	lf5	0.77 ***	0.02	34.29	0.60			
	lf6	0.70 ***	0.03	25.04	0.49			
	lf7	0.63 ***	0.03	19.70	0.40			
	lf8	0.79 ***	0.02	35.90	0.62			
	lf9	0.77 ***	0.02	33.36	0.59			
Financial security	fs1	0.77 ***	0.03	31.39	0.59	0.88	0.71	0.88
	fs2	0.90 ***	0.02	48.11	0.82			
	fs3	0.84 ***	0.02	39.90	0.71			
Customer engagement	ce1	0.79 ***	0.02	37.49	0.63	0.92	0.65	0.92
	ce2	0.76 ***	0.02	31.88	0.58			
	ce3	0.85 ***	0.02	50.26	0.72			
	ce4	0.78 ***	0.02	35.84	0.62			
	ce5	0.83 ***	0.02	44.26	0.68			
	ce6	0.83 ***	0.02	43.94	0.68			
Function value	fv1	0.83 ***	0.02	35.08	0.69	0.86	0.67	0.85
	fv2	0.83 ***	0.02	35.48	0.69			
	fv3	0.79 ***	0.03	31.66	0.63			
Hedonic value	hv1	0.88 ***	0.02	48.85	0.78	0.89	0.73	0.88
	hv2	0.86 ***	0.02	44.35	0.73			
	hv3	0.82 ***	0.02	38.43	0.67			
Social value	sv1	0.88 ***	0.02	41.55	0.88	0.87	0.69	0.86
	sv2	0.74 ***	0.03	26.88	0.74			
	sv3	0.85 ***	0.02	38.70	0.853			
Customer loyalty	cl1	0.87 ***	0.02	55.44	0.75	0.92	0.68	0.92
	cl2	0.83 ***	0.02	44.95	0.69			
	cl3	0.85 ***	0.02	51.34	0.73			
	cl4	0.843 ***	0.02	48.45	0.71			
	cl5	0.731 ***	0.036	28.48	0.53			

Notes: AVE, average variance extraction; CR, composite reliability. \*\*\* p < .001

**Table 4. Average, standard deviation and correlation coefficient matrix**

Concept	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1. Aesthetic appeal	<b>0.79</b>							
2. Layout and functional	0.64	<b>0.77</b>						
3. Financial security	0.53	0.63	<b>0.84</b>					
4. Customer engagement	0.35	0.36	0.33	<b>0.81</b>				
5. Functional value	0.44	0.49	0.45	0.53	<b>0.82</b>			
6. Hedonic value	0.35	0.44	0.46	0.53	0.39	<b>0.85</b>		
7. Social values	0.25	0.38	0.38	0.66	0.40	0.41	<b>0.83</b>	
8. Customer loyalty	0.51	0.61	0.56	0.67	0.66	0.60	0.61	<b>0.83</b>
<b>Mean</b>	4.70	4.83	4.86	4.56	4.65	4.70	4.61	4.75
<b>SD</b>	1.28	1.16	1.33	1.30	1.32	1.28	1.32	1.26

Notes: (1) N = 404. (2) The values of non-diagonal lines represent the values of correlation coefficients of each facet. (3) The values of diagonal lines represent the square root of the average extraction of variance (AVE) of the facet.

## 4-2- Hypothesis Testing

After the evaluation of the measurement models, structural equation model (SEM) assumptions were tested with MPLUS8.0, and bootstrapping was used to set the bootstrapping sample number to 5000 with a confidence interval of 95%.

### 4-2-1- Testing for Direct Effects

This study revealed the relationship among the main model e-commerce live service scenario, customer engagement, value co-creation, and customer loyalty. The present work also discussed the path relationship between the research concepts through path analysis to verify the proposed research hypothesis. Hu and Bentler [87] showed a good fit between the data and the structural model ( $\chi^2 = 874.28$ ,  $DF = 470$ ,  $\chi^2/DF = 1.86$ ; CFI = 0.96; TLI = 0.95; RMSEA = 0.05, SRMR = 0.05). According to the standardized path coefficient, T value, and results of each model, the aesthetic appeal and customer engagement were positively affected ( $\beta = 0.17$ ,  $T = 2.36$ ,  $p < 0.05$ ). Furthermore, the hypothesis of H1a was supported. layout and functional positively affected customer engagement ( $\beta = 0.17$ ,  $T = 2.07$ ,  $p < 0.05$ ), assuming H1b was supported. Financial security did not affect customer engagement ( $\beta = 0.14$ ,  $T = 1.93$ ,  $P > 0.05$ ), assuming H1c was not supported. It shows that the aesthetic appeal and layout and functional of the physical cues in the live scene of e-commerce affect the customer engagement, while financial security does not affect the customer engagement.

Aesthetic appeal, layout and functional physical clues of e-commerce live broadcast service scenes have a direct impact on customer engagement. This finding is confirmed by empirical studies [53, 57], which show that aesthetic appeal, layout and function play a crucial role in influencing customer engagement. Among them, aesthetic appeal ( $\beta=0.17^{**}$ ), layout and function ( $\beta=0.17^{**}$ ) are equally important in influencing customer engagement. This is because the physical clues of e-commerce live broadcast service scenes create a brand atmosphere through stereoscopic visual effects so that the audience has an interest in and psychological reaction to beautiful things. Moreover, the platform functions are very simple and easy to use, so customers can easily participate in them. Financial security does not directly affect customer engagement, which is consistent with the findings of [57, 74], indicating that financial security does not affect customer engagement. This is different from the research results of Harris and Goode [40]; however, today, when online shopping has become a common way to shop, customers no longer need to worry about issues, such as commodity quality and seller credit, and the service that supports 7-day returns and exchanges without reasons, payment security and convenience also provides a guarantee for customers. Therefore, a better understanding of the relationship between customers and physical cues is crucial for e-commerce live streaming platforms and enterprises.

Customer engagement and functional value had positive influences ( $\beta = 0.37$ ,  $T = 7.66$ ,  $p < 0.001$ ), assuming that H2a was supported. Customer engagement and hedonic value had positive effects ( $\beta = 0.40$ ,  $T = 8.33$ ,  $p < 0.001$ ), presupposing H2b was supported. Customer engagement positively impacted social value ( $\beta = 0.60$ ,  $T = 14.21$ ,  $p < 0.001$ ), assuming that H2c was supported, which indicated that customer engagement had a positive impact on value co-creation. Customer engagement has a direct impact on functional value, hedonic value and social value in value co-creation, which confirms the importance of customer engagement to the impact of functional, hedonic and social value in value co-creation. This research result is consistent with the empirical findings of Kumar & Pansari [26] and Pansari, & Kumar [63]. In addition, the customer agrees with the greatest influence on social value, and the function value ( $\beta = 0.37^{***}$ ) and hedonic value ( $\beta= 0.40^{***}$ ) engagement effect is less than the social value of customers ( $\beta = 0.60^{***}$ ). This implies that social values have a stronger impact on customer engagement than do functional and hedonic values. A possible reason is that the visualization, interactivity and entertainment in the physical cues of e-commerce live broadcast scenes stimulate customer participation and encourage customers to share their experience. Therefore, these research results can help e-commerce live streaming platforms or enterprises better understand the internal needs of customers.

Value co-creation affected customer loyalty. Functional value and customer loyalty were positively impacted ( $\beta = 0.26$ ,  $T = 5.23$ ,  $p < 0.001$ ), assuming that H3a was supported. Hedonic value and customer loyalty were positively affected ( $\beta = 0.18$ ,  $T = 3.89$ ,  $p < 0.001$ ), assuming that H3b was supported. Social value and customer loyalty were positively impacted ( $\beta = 0.20$ ,  $T = 3.63$ ,  $p < 0.001$ ), assuming that H3c was supported, which indicates that value co-creation and customer loyalty were positively affected. Functional value, hedonic value and social value in value co-creation have a direct impact on customer loyalty. This fact confirms the importance of functional, hedonic and social value to shaping customer loyalty, which is consistent with the empirical results of Linghu [16]. According to the research, functional value has the most significant effect on customer loyalty, while hedonic value ( $\beta=0.18^{***}$ ) and social value ( $\beta=0.20^{***}$ ) have minimal effects on customer loyalty, which are both smaller than functional value ( $\beta=0.26^{***}$ ). This means that functional value plays a more important role in shaping customer loyalty. Therefore, enterprises need to provide a series of promotional activities or issue coupons to increase the value of products or services to induce customers to be loyal. Therefore, this research result helps e-commerce livestreaming enterprises better understand customers' purchase motivations.

#### 4-2-2- Testing for Indirect Effects

Table 5 discusses the mediating effects of customer engagement, value co-creation, and customer loyalty. The results showed that the mediating effect of customer engagement on customer loyalty through physical cues in live e-commerce scenes was ( $\beta = 0.03$ ,  $P > 0.05$ ), and the 95% confidence interval was between (-0.13, 0.16), including 0. Therefore, hypothesis H4 was not supported. The mediating effect of value co-creation on customer loyalty via physical cues in live e-commerce scenes was ( $\beta = 0.44$ ,  $p < 0.005$ ), with a 95% confidence interval between (0.23, 0.78) and without 0. That is, hypothesis H5 was supported. The mediating chain effect of customer engagement and value co-creation on customer loyalty through physical cues in live e-commerce scenes was ( $\beta = 0.24$ ,  $p < 0.005$ ), and the 95% confidence interval was between (0.14, 0.43), which did not contain 0. Thus, hypothesis H6 was supported.

The results are shown in Table 5. Customer engagement has no mediating effect on physical cues in e-commerce live broadcast scenes and customer loyalty. In contrast, regarding physical cues and customer loyalty in e-commerce live broadcast service scenarios, value co-creation shows a very obvious chain mediating effect. In fact, value co-creation ( $\beta=0.44^{***}$ ) has a stronger impact on the mediating effect of physical cues and customer loyalty in e-commerce live streaming service scenarios than do customer engagement and value co-creation ( $\beta=0.24^{***}$ ). This may be because when customers receive product information in e-commerce live broadcast scenarios, they may develop positive attitudes, such as through customer engagement [8], providing a positive and pleasant customer experience for evaluations [73]. However, loyalty can only be encouraged if customers genuinely believe that these products or services bring benefits to their social networks. Because of this, enterprises often provide red envelopes, coupons or lottery activities on e-commerce live streaming platforms to enable customers to truly feel the value and thus promote improvements in customer loyalty.

**Table 5. Mediating effect test**

Effect	Point Estimate	Product of coefficient		Bootstrap 5000 TIMES 95% CI Percentile	
		S.E.	Z-value	Lower	Upper
PS → CE → CL	0.03	0.07	0.43	-0.11	0.18
PS → VC → CL	0.44	0.15 ***	2.94	0.15	0.73
PS → CE → VC → CL	0.24	0.07 ***	3.40	0.10	0.38
<b>Total</b>	1.03	0.11 ***	9.07	0.81	1.25

Notes: (1) N = 404; (2) \*\*\* p < .001. Ps-physical clues; CE: Customer engagement; VC: Value Co-creation; CL-Customer loyalty

To sum up, there were six total hypotheses and twelve sub-hypotheses in this study, of which ten were validated, and two were not. The results are shown in Table 6.

**Table 6. Results of hypothesis testing**

Hypothetically	Details	Results
H1	E-commerce live scene Physical cues have a positive impact on Customer engagement	-
H1a	Aesthetic appeal has a positive effect on Customer engagement	support
H1b	Layout and functional has a positive effect on Customer engagement	support
H1c	Financial security has a positive impact on Customer engagement	no support
H2	Customer engagement has a positive effect on Value co-creation	-
H2a	Customer engagement has a positive effect on Customer value	support
H2b	Customer engagement has a positive effect on Functional value	support
H2c	Customer engagement has a positive impact on Hedonic value	support
H3	Customer value has a positive effect on Customer loyalty	support
H3a	Function value has positive effect on Customer loyalty	support
H3b	Hedonic value has a positive effect on Customer loyalty	support
H3c	Social Value has a positive effect on Customer loyalty	support
H4	The physical clues of the live-broadcast scene of Customer engagement agency have a positive effect on Customer loyalty	no support
H5	Value Co-creation intermediary e-commerce live scene physical cues have a positive impact on Customer loyalty	support
H6	Customer engagement and Value co-creation chain-type intermediary E-commerce live scene physical cues have a positive impact on Customer loyalty	support

## 5- Conclusions and Recommendations

### 5-1- Conclusion

This study aims to theoretically explore the physical cues in e-commerce live streaming service scenarios that affect customer engagement and how customer engagement affects value co-creation, as well as how customer engagement and value co-creation jointly affect customer loyalty. Through theoretical discussions using the value co-creation and SOR model frameworks, the researchers identified aesthetic appeal, layout, and functional and financial security as external stimuli in the physical clues of e-commerce live streaming service scenes, customer engagement as customers' psychological states, and value co-creation and customer loyalty as customers' behavioral reactions, and provided a theoretical framework for the relationship among these factors. At the same time, stimulating factors generated by physical cues in e-commerce live broadcast scenes trigger interactive customer behaviors to achieve functional, hedonic, and social value co-creation, thus promoting customer loyalty. In summary, these results overwhelmingly support the proposed research model and result in interesting findings. For example, the physical clues of e-commerce live broadcast scenes, aesthetic appeal, layout, and functionality have a direct impact on customer engagement, while financial security has no direct impact on customer engagement. When customers actively participate in the process, form a good interactive atmosphere, and cocreate functional, hedonic, and social values with enterprises, they promote customer loyalty in the process of creating value. In addition, customer engagement alone cannot bring customer loyalty to an enterprise. Therefore, enterprises can provide red envelopes, coupons, or launch lottery flash sale activities on e-commerce live streaming platforms to enable customers to truly feel the value of co-creation, thus promoting customer loyalty.

### 5-2-Academic Contributions

This study enriches the existing research regarding physical cues, value co-creation, customer engagement, and customer loyalty. Moreover, it verifies the previous theoretical viewpoints. The theoretical contributions are as follows:

The present results confirm the relationship between the research structures. Although the value co-creation theory is applied in the e-commerce live shopping environment, similar to most previous studies, some conclusions of this work can be applied to explore e-commerce live service scene physical cues to provide a useful framework. This research broadens the application of value co-creation.

In previous studies, scenario theory has focused on the impact of network service scenarios on consumer behavior. However, in this study, the scope of scene research is expanded, and the impact of physical cues in e-commerce live streaming scenes on customer loyalty, such as the live streaming background, the goods placed, and even the clothes of the host, is mainly explored. These physical cues leave a deep impression on customers and affect their behaviors and decisions, thus impacting customer loyalty. This study enriches the research content of scene theory and conforms to the scene theory proposed by Bitner [38].

The present study enriches the relationship between customer engagement, value co-creation, and customer loyalty. Previous research has concentrated on the impact of customer engagement on value co-creation, focusing on web service scenarios [57] or social media [16]. There are few studies on the physical cues, customer engagement, value co-creation, and customer loyalty of live e-commerce scenes. This study makes up the theoretical framework of value co-creation and the SOR model's joint loyalty to customers in the e-commerce live scene.

### 5-3- Management Implications

The conclusion of this study enriches the management ideas and theoretical resources of e-commerce live-scene physical cues, customer engagement, value co-creation, and customer loyalty. It provides theoretical and practical guidance for e-commerce live broadcast platforms and enterprise managers to carry out e-commerce live broadcasts. This study puts forward the following suggestions for enterprises to integrate social resources and realize customer loyalty by emphasizing the full use of new media platforms and scene technology through e-commerce live scenes and physical cues:

Customer needs must be identified, and the behavioral results of value co-creation and customer loyalty should be maximized. In e-commerce live broadcast marketing, we should first understand consumers' characteristics and interests in the e-commerce live broadcast room. Furthermore, we must design the layout and functionality according to the fans' interests in the live broadcast room and enhance the sense of presence and engagement of customers. Thus, their joyful mood stimulates the customers' intrinsic drive and makes them participate positively. It also encourages them to like, comment, retweet, and purchase the product. The realization of function, enjoyment, and social values promotes customer loyalty.

Through e-commerce live-scene physical clue design, customer engagement must be enhanced. Accordingly, e-commerce live broadcast platforms and enterprises can design the scene around aesthetic appeal, layout, and

functionality to meet the aesthetic feelings of consumers, functional convenience, interaction, and diversity. They can fully use the atmosphere design of the physical cues in the live broadcast room to attract customers, increase traffic, and encourage customers to actively participate in the platform.

Customer engagement in the physical clues of the e-commerce live scene promotes value co-creation and customer loyalty. Customer engagement, which transcends transaction behavior, plays a remarkable role in enhancing value co-creation and customer loyalty. The customer with a high degree of fit is the enterprise partner who can bring value-added to the enterprise and realize value co-creation. E-commerce live broadcast enterprises should enhance customer engagement to make them participate more actively in platform activities. This participation enhances the value of co-creation and customer loyalty behavior. The marketing of an e-commerce live broadcast platform is an essential means of motivating customers to fit in. The marketing strategy affects the feelings and participation of other customers on the e-commerce live broadcast platform. The interaction on the bullet screen also affects other customers' psychological activities and lets them feel the value. The value creates further development and, thus, promotes customer loyalty.

#### ***5-4- Research Limitations and Future Prospects***

This paper studied e-commerce live broadcasts from the perspective of service scenarios and expanded the research field of e-commerce live broadcasts. The present work adopted the S-O-R (stimulus-organism-response) theoretical model and studied the e-commerce live broadcast from the perspective of the service scenario. The model framework has been widely used in studying online consumer behavior in the e-commerce environment to study how environmental cues and signals lead to transaction behavior. The research on value co-creation and customer loyalty in the context of e-commerce live broadcast services has specific theoretical significance. Furthermore, it helps live broadcast enterprises select and lay out e-commerce live broadcast service scenarios more pertinently to provide effective training suggestions for the behavior, attitude, language communication, and service skills of the service staff in live broadcast enterprises and to make clear the personality characteristics of consumers in the e-commerce live broadcast room. The physical and social cues of e-commerce live broadcast service site staff match the value co-creation intention of consumers and stimulate the adaptability of potential customers through practice. They obtain a variety of external incentives from environmental factors and stimulate the internal motivation of customers. Therefore, they produce the corresponding value of the co-creation effect and promote the performance of customer loyalty. This study has some theoretical and practical significance for studying customer loyalty through customer participation and value co-creation in the e-commerce live service scene in China.

Physical cues in live e-commerce scenes are cross-sectional studies. This study design is limited to the direct assessment of causality, limiting the assertion and testing of exact causality between structures. Future studies should encourage the use of long-term methods to investigate cause-and-effect relationships. This work focused on Chinese college students aged 18 to 25, which facilitated the sampling and reduced the external validity of the study. Although a survey showed that this age group is the most active audience for live e-commerce, different age groups may have different online video viewing habits. Therefore, future research will need to include more diverse samples. As the first step in assessing the impact of physical cues on customer loyalty, the model highlighted the positive and negative effects of real-time communication. For example, negative comments from customers may affect other customers differently. Further research can extend the results of this study by investigating the dark side of live e-commerce scenes. The research only focused on the physical cue in the live e-commerce scene, but the social cue is also a critical cue in the service scene, which can be combined with the physical cue in the future.

## **6- Declarations**

### ***6-1- Author Contributions***

Conceptualization, X-M.Y., and H.B.; methodology, X-M.Y.; software, H.B.; validation, X-M.Y., H.B., and S-Z.H.; formal analysis, X-M.Y.; investigation, H.B.; resources, X-M.Y.; data curation, H.B.; writing—original draft preparation, X-M.Y.; writing—review and editing, H.B.; visualization, X-M.Y.; supervision, H.B.; project administration, S-Z.H. All authors have read and agreed to the published version of the manuscript.

### ***6-2- Data Availability Statement***

The data presented in this study are available on request from the corresponding author

### ***6-3- Funding***

The authors received no financial support for the research, authorship, and/or publication of this article.

### ***6-4- Institutional Review Board Statement***

Not applicable.

### 6-5- Informed Consent Statement

Not applicable.

### 6-6- Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancies have been completely observed by the authors.

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