Effects of Interface Design and Live Atmosphere on Consumers’ Impulse-Buying Behaviour from the Perspective of Human–Computer Interaction

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Abstract: Since its introduction, live e-commerce has shown rapid growth, especially in regions such as China, where the total market size has exceeded trillions of RMB. However, e-commerce live streaming has also caused widespread consumer impulse-buying behaviour during the development process. Therefore, based on stimulus–organism–response theory, from the perspective of human–computer interaction, this paper develops an impulse-purchase model for live e-commerce consumers, uses partial least squares structural equation modelling to process and analyse 339 valid questionnaires and, finally, validates the proposed hypotheses. The findings show that consumers’ visual appeal, perceived arousal and engagement play a mediating role in the relations among interface design, live atmosphere and impulse purchase. To promote the sustainability of a live-streaming economy, live-streaming platforms need to design attractive live-streaming interfaces, build a pleasant live-streaming atmosphere and enhance consumers’ positive emotions, while preventing their irrational purchasing behaviour. An in-depth analysis of the formation mechanism of this behaviour can help in alleviating the limitations of the lack of rich research results and a single perspective in this field. In addition, it can help stakeholders promote the sustainability of e-commerce live streaming in practice.

Keywords: live e-commerce; impulse-buying behaviour; human–computer interaction; interface design; live atmosphere; SOR theory; PLS-SEM; sustainable development of live e-commerce

1. Introduction

With the rapid development of the Internet, 5G and other information technologies in China, e-commerce has gradually penetrated people’s daily lives. This has also increasingly diversified people’s shopping methods and habits. With the explosion of COVID-19 since 2020, more people have started shopping online, and the number of e-commerce users has increased significantly [1,2]. In February 2022, the 49th China Internet Development Statistics Report, released by the China Internet Network Information Center, showed that as of December 2021, the scale of China’s online-shopping users reached 842 million, accounting for 81.6% of overall Internet users. In addition, the number of online-video users reached 975 million, accounting for 94.5% of all Internet users. These data show that consumers have generally accepted the form of online shopping, and, gradually, a communication- and interaction-behaviour model based on online-video interaction has been developed. Since the birth of live e-commerce in 2016, this emerging e-commerce model, with both online-shopping and video-interaction features, has shown explosive growth in China. The current user scale has exceeded 384 million, with the total market size exceeding a trillion RMB. With the joint promotion of government-policy support and industry development, especially with the emergence of the COVID-19 pandemic in 2020, e-commerce live streaming has continued to gain popularity and emerged in various innovative forms. It is gradually becoming a new economic-growth point.
With further development of the e-commerce market and the application of emerging technologies, live e-commerce broadcasts have begun to appear in many new directions of development. First, the type of live anchors is changing, and a new trend of verticalisation and specialisation is emerging. The shape of their business and business model also appears innovative. Second, due to the widespread popularity of technology and platforms, the anchor community is continuously extending to the whole society. Internet celebrities, stars and groups of ordinary people have joined the live e-commerce industry. At the same time, live e-commerce broadcasts have entered a new era of national delivery, from the old stage of relying on professional anchors. In addition, live e-commerce has begun to connect with the international market. For example, a head anchor and CCTV host joined hands to sell Afghan pine nuts, solving the product-sales crisis for local farmers. As China’s e-commerce live streaming is soaring, many e-commerce platforms globally are attempting the live streaming of goods. E-commerce platforms, such as Amazon Live, AliExpress, Shopee and Lazada, and social networking platforms, such as Facebook, YouTube, Instagram and Twitter, have launched live-delivery functions, and live shopping is expected to become a new trend of user consumption in global e-commerce.

Although live e-commerce has met the needs of most users for entertainment and community interaction [3], there are also many practical problems. For example, the ethical problems of tax evasion and the selling of counterfeit products by anchors appear frequently. In addition, the quality of goods in live streaming is uneven, and consumers’ rights are faced with various obstacles, such as unclear subjects and difficulties in communication. All these problems are decreasing consumers’ trust in e-commerce platforms and anchors, which, in turn, affects the further development of the live-broadcast economy. According to iMedia Research data, 49.5% of consumers believe that the biggest problem with e-commerce live streaming is irrational impulse-buying behaviour. Previous studies have shown that impulse purchases account for 34% of online shopping [4]. Recent studies have further indicated the existence of widespread impulse-buying behaviour in e-commerce [5]. In live streaming, consumers are more likely to be influenced by stimuli such as price discounts [6], time pressure [7] and visual appeal [8], which in turn lead to irrational buying behaviour. Irrational purchasing behaviour not only damages the rights and interests of consumers as well as affects the shopping experience but also causes different degrees of negative impact on merchants, due to consumers’ return behaviour and negative word-of-mouth publicity [9].

In this paper, impulse-buying behaviour is defined as unplanned shopping behaviour that arises among customers when they are stimulated [9,10]. Regarding impulse-buying behaviour, most of the current studies have considered offline physical stores and online-shopping sites as the object of study for non-rational behaviour and have, less frequently, explored it in the context of live e-commerce. In the offline context, Liang, et al. [11] investigated the existence of impulse buying in international night markets in Taiwan and confirmed that insightfulness, customer information, response, feedback and enthusiasm positively impact impulse-buying tendencies. Li, et al. [12] further indicated that the relation between time scarcity and tourism experience affects tourists’ impulse-buying behaviour. Bao and Yang [13] empirically investigated some determinants of impulse purchases in online shopping in the online-shopping-website setting, and the results confirmed that consumer serendipity, trust and flow experiences contribute to impulse-purchase behaviour. Although these studies have partially revealed the mechanism of impulse behaviour, e-commerce live streaming has more evident differences from impulse behaviour in traditional settings, due to the construction of social presence. Therefore, the findings of existing studies are not necessarily applicable to the explanation and discussion of behaviour in this particular scenario. In contrast, the research on consumers’ impulse-purchase behaviour in live-streaming scenarios is limited not only by the small number of studies but also by the relatively singular research perspective. Existing studies have mainly focused on the characteristics of the anchor [14,15] or the live-streaming environment [16]. There is a lack of analysis that starts from the design of the live-streaming interface (object factor) and live-streaming atmosphere (environmental factor) as well as explores
the influence of human–computer interaction on consumers’ impulse purchases. Since there are many human–computer-interaction factors in live streaming, it is of great theoretical and practical significance to explore how the live-streaming interface and atmosphere are integrated and influence consumers’ purchasing behaviour. Therefore, this paper addresses the following research questions:

- Do interface design and live atmosphere affect consumers’ impulse-buying behaviour, and what is its underlying mechanism?
- Do inner-consumer states, such as visual appeal, perceived arousal and consumer engagement, affect consumers’ impulse-buying behaviour, and what are its specific manifestations?

From the perspective of human–computer interaction and based on stimulus–organism–response (SOR) theory, this study explores the influence mechanism of interface design and live-streaming atmosphere on consumers’ impulse-buying behaviour as well as explains the intermediary role of visual appeal, perceived arousal and consumer engagement. Seven hypotheses are proposed to investigate whether interface design and live atmosphere have a significant positive effect on visual appeal, perceived arousal and consumer engagement as well as to further investigate how the latter three affect impulse-buying behaviour. After a simple random sampling using an online questionnaire, 417 questionnaires were collected and 339 valid questionnaires were selected. To conclude, the data were analysed using partial least squares structural equation modelling (PLS-SEM). The findings of this paper contribute to a better understanding of human–computer-interaction behaviour in live streaming. In terms of theoretical contributions, first, this study expands the research field of impulsive-buying behaviour, by using emerging e-commerce live streaming as a background to explore the formation mechanism of impulsive-buying behaviour. Compared with traditional-offline-store and online-website scenarios, this paper has a certain novelty in terms of research scenarios. Second, this paper expands the research perspective of impulse-buying behaviour in e-commerce live streaming. Most of the existing literature is based on anchor characteristics and the live-streaming environment, but less on impulse buying in live streaming from the perspective of human–computer interaction. Since there are more human–computer-interaction factors in live streaming, which may impact impulse buying, this perspective is innovative. Third, this paper finds that SOR theory is also applicable to impulse buying in live e-commerce scenarios and confirms the positive influence of positive consumer emotions on impulse buying. In terms of practical contributions, first, the paper’s suggestions for consumers help them reasonably examine their purchasing behaviour and establish the concept of sustainable consumption. Second, the recommendations for live-streaming platforms and practitioners can help them further explore human–computer-interaction factors in live streaming and promote the sustainable development of live streaming. Third, this paper’s revelations for regulators can help them guard the reasonable interests of consumers and improve the sustainable prosperity of the live-streaming economy.

This paper is divided into the following sections. First, this study reviews the development of e-commerce live streaming and the latest research findings on impulse buying as well as discusses the important role of human–computer interaction in e-commerce live streaming. Then, a model is developed using SOR theory to test whether human–computer interaction in e-commerce live streaming promotes consumers’ impulse-buying behaviour, and the research model and hypotheses are quantitatively analysed by questionnaire collection and PLS-SEM. Finally, the theoretical implications, practical implications and future directions are discussed. This study enriches the research results in fields related to human–computer interaction and impulse buying in live-streaming scenarios. It helps to explore the consumer-decision-making process under different subject-interaction situations. It also suggests corresponding countermeasures to stakeholders, such as live-streaming platforms and regulatory platforms.
2. Literature Review

2.1. Impulse Buying in Other Scenarios

Due to the prevalence of impulse behaviour in the e-commerce market, this behaviour has attracted many researchers, who have gradually explored its underlying mechanisms. Early researchers defined impulse-buying behaviour as unplanned-buying behaviour \[17,18\]. Subsequently, researchers explored the connotation of impulse buying in depth and indicated that this behaviour includes not only unplanned-buying behaviour but also a sudden and strong desire to buy \[10,19\]. On this basis, specific stimuli received during the shopping process (e.g., shopping environment, employees and website appearance) are considered the key factors influencing consumers’ impulse buying \[20,21\]. This paper combines the above views and defines impulse-buying behaviour as an unplanned-purchase behaviour driven by a strong desire to buy when stimulated.

Most of the research conducted on impulse-buying behaviour has focused on places such as offline physical stores and online-shopping websites. Considerable research data have been generated based on these shopping scenarios, which is an important reference for further exploring consumers’ irrational behaviour in live-streaming environments. Regarding offline physically located shopping venues, Bellini et al. indicated that impulse-buying behaviour is prevalent in retail locations, such as supermarkets \[22\]. Less-prepared consumers are before shopping, the greater the propensity to make impulse purchases and the lesser the propensity to make planned purchases \[22\]. Mohan, et al. \[23\] explored the significant role of store-environment factors, such as music, lighting and layout, on consumer impulse-buying desire and behaviour. Badgaiyan and Verma \[24\], through a survey of mall employees, found that the positive attitude of mall clerks positively impacts consumers’ impulse purchases, and the friendlier the clerk’s attitude is, the more likely it is to stimulate impulse-buying behaviour among customers. In addition to this, consumers’ hedonistic values can also influence their impulsive-buying behaviour \[25\].

With the rapid development and popularity of e-commerce, researchers have actively explored impulse-buying behaviour on online-shopping websites. Consumer-impulse-purchase studies focusing on online environments have illustrated the influence of website-appearance features \[20\], website functionality \[26\] and contextual factors \[27\] on consumers’ purchase decisions as well as the positive stimulus effects of visual appeal \[28\] and promotional advertisements \[29\] on impulse behaviour. In addition, researchers have explored how these stimulus variables affect consumers’ emotions. Yang, et al. \[30\] found that stimuli such as portability and visual appeal in e-commerce significantly impact consumers’ perceived value and directly affect their impulse-buying behaviour. Xu, et al. \[31\] confirmed that social interactions on the web can stimulate positive emotions in consumers, which leads to impulse-buying behaviour. Although impulse-buying studies have significantly contributed to the exploration of consumers’ irrational behaviour, the existing research scenarios are not rich enough. In particular, there is a lack of exploration of consumer-impulse-buying behaviour in emerging technologies, such as the new e-commerce scenario represented by live e-commerce.

2.2. Impulse Buying under Live E-Commerce

Live e-commerce has emerged with the progress of information technology and changes in business forms. This emerging shopping method allows sellers to sell their products online in a way that is closer to consumers and allows them to feel an immersive experience in the descriptions and video images of the anchors \[32\]. The built-in real scenes and personnel interactions in e-commerce live streaming can, on one hand, improve consumers’ shopping experience and their trust in sellers and, on the other hand, reduce the uncertainty in shopping \[33\]. Building a trustworthy live environment and improving trusting relationships with consumers can help facilitate potential transactions \[34\]. In conclusion, e-commerce live streaming exhibits outstanding performance in promoting the authenticity, interaction and visibility of online shopping \[35,36\]. The examination of
consumers’ intentions in the e-commerce process helps to understand the customer and is also essential for the implementation of e-commerce [37].

The available research on consumers’ willingness to use a live e-commerce environment is more mature. Su [38] found that perceived usefulness, perceived fun and immersive experiences indirectly influence consumers’ willingness to use live e-commerce platforms. Li, et al. [39] noted that celebrity trust and platform trust play an important role in consumers’ long-term behaviour. For example, both of them significantly influence consumers’ willingness to reuse the platform. Zhang, et al. [40], further, found that interactivity and emerging technology factors in live e-commerce can significantly increase consumers’ trust levels, which in turn influence consumers’ willingness to continue using the platform.

While consumer behaviour in the live e-commerce environment has been extensively studied, research on consumer-impulse buying in this context is still relatively rare. There are demerits of a limited research perspective and an incomplete explanation of the influence mechanism. For example, most existing studies have explored the formation mechanism of impulse buying, based on the personal characteristics of the anchor or the live-streaming environment. In live-shopping-behaviour research, anchor characteristics are important factors influencing consumers’ shopping decisions. Ang, et al. [41] illustrated that the good reputation of anchors is more likely to increase consumers’ trust level in product quality, which effectively increases their purchase intention. Xu, Cui and Lyu [15], further, showed that the stronger the anchor’s professionalism is, the higher the consumer’s trust in the anchor and the stronger their willingness to incur impulse purchases. In addition, Chen and Lin [33], in exploring the entertainment nature of webcasting, found that entertainment can significantly influence consumers’ mind-stream experience, perceived value and attitude towards use as well as has a significant positive impact on impulse purchases. Zhang, et al. [42] concluded that consumers are more likely to make impulse purchases if they are in a live-streaming environment with hunger marketing.

2.3. Research Gap

Gong, et al. [43] recently found that applying human–computer-interaction design in live streaming can visually attract consumers to find and watch videos and effectively stimulate the occurrence of impulse-purchase behaviour. With the increasing popularity and widespread use of live shopping in recent years, researchers have begun to focus on the study of consumer behaviour in the field of live e-commerce, but the existing research results still have certain limitations. While some researchers have conducted research on willingness to use [38] and trust [34] in live e-commerce scenarios, this paper chooses to study impulsive-purchase behaviour in live streaming from a human–computer-interaction perspective for the following reasons. On the one hand, compared to the more mature research on consumer-impulse purchases in offline stores and on online-shopping sites, relatively less attention has been paid to consumers’ irrational purchasing behaviour in this context, since live e-commerce has only started to emerge in recent years, and there are certain differences in the development stages of each country. Consequently, this topic currently suffers from the limitations of a few studies and a lack of rich research results. Existing research on this topic also has certain shortcomings, due to a single research perspective. Most of these studies have focused more on the influence of anchor traits and live-streaming environments on consumers’ irrational behaviour and less on the influence of human–computer-interaction factors on consumers’ behaviour in live streaming. In addition, they lack an exploration of impulse-purchase behaviour from multiple perspectives. Since live streaming involves many human–computer-interaction factors, this paper explores the effect of human–computer interaction on consumers’ impulse purchases, from the perspectives of live-streaming-interface design and live-streaming atmosphere. First, this paper uses SOR theory to explain consumers’ impulse-buying behaviour in the e-commerce live-streaming environment. The interface design and live-streaming atmosphere are considered as the stimulus factors in live streaming, and how they affect consumers’ intrinsic states and impulse-purchase behaviours is explored. Second, in constructing the model, this study treats visual appeal, perceived arousal and consumer engagement as
mediating variables that reflect consumers’ intrinsic states and connect interface design, live-streaming atmosphere and impulse-purchase behaviour. Finally, this paper uses PLS-SEM to quantitatively analyse the collected questionnaire data and, further, test whether and how human–computer interaction in live e-commerce facilitates consumers’ impulse-purchase behaviour. This paper has important theoretical and practical significance for understanding consumer-purchase behaviour in a live-streaming environment.

3. Theoretical Basis and Research Hypothesis

3.1. Theoretical Basis

According to SOR theory, environmental stimuli (S) directly affect the cognitive and affective states (O) of individuals, which further influence their behaviour (R) [44]. Therefore, this theory is often used to explain the process of consumer decision-making and understand its underlying mechanism [20]. This theory has been widely applied in the field of impulse-buying behaviour and has shown strong applicability in experimental scenarios. Many researchers, guided by SOR theory, have built experimental scenarios based on offline real stores and online-shopping websites to explore consumers’ impulse-buying behaviour in depth and obtained a series of research results. Some researchers studied offline physical stores and found that the design, social and other stimulus factors in the offline retail environment influence consumers’ positive emotions and, thus, their impulse-buying behaviour [45,46]. Chan, et al. [47] combined the stimuli of online shopping, consumers’ intrinsic states and consumers’ impulse-buying behaviour as well as developed a framework to explain the interrelationships among the three stimuli. Once again, the effectiveness of SOR theory in explaining impulse-buying behaviour was demonstrated. Zheng, et al. [48], further, suggested that visual appeal and portability in online shopping positively affect consumers’ impulse-buying behaviour. Since SOR theory has been widely applied in the study of impulse-buying behaviour, this study suggests that it can also be applied to the study of consumers’ impulse-buying behaviour in the context of live e-commerce.

This study focuses on the influence of interface design (object factor) and live-streaming atmosphere (environment factor) on consumers’ impulse-purchase behaviour, as well as their underlying mechanisms, from the perspective of human–computer interaction and based on SOR theory. It also explains the mediating roles of visual appeal, perceived arousal and customer engagement (subject factors) in it. This has a positive effect on explaining whether and how human–computer interaction in live e-commerce facilitates the impulse-buying behaviour of consumers. An integrated model was developed and tested to investigate the relationship between subject, environment, subject, and impulse-purchase behaviour. The proposed research model is shown in Figure 1.

Figure 1. Research model.
3.2. Research Hypothesis

When live e-commerce viewers open their mobile devices, such as cell phones and computers, and enter the live-streaming room, the first thing they see is its interface. Interface elements, including the colour of the live interface, the layout of the functional buttons and the way the merchandised products are displayed, reflect the interface design of the live room. Xiang, et al. [49] conducted an in-depth study on online shopping and found that the more diverse the product information displayed on a shopping website is, the more it increases consumers’ visual appeal and creates a sense of immersion. In addition, Sohn, et al. [50] indicated that the more complex the interface design of a shopping website is, the more likely it is to make consumers feel visually crowded when they search for products using their smartphones, thus reducing their visual appeal and satisfaction. In summary, this paper hypothesises that the interface design of a live site significantly affects consumers’ visual perception and, thus, creates effective visual appeal. Based on the results of the current study, the interface design of an application should provide users with more choices, especially personalised settings, without being overly complicated. Therefore, the first hypothesis is as follows:

Hypothesis 1 (H1). Interface design significantly and positively affects visual appeal.

Arousal refers to the level of excitement felt by individuals in response to certain external stimuli [4] and forms the basis for emotions, information processing and behavioural responses [51]. Chen and Wu [52] found that consumers’ perceived arousal is influenced by website design; for example, when the consumers in their study shopped on warm-coloured shopping websites, they showed stronger feelings of excitement and more positive purchases. Cheng, et al. [53] further investigated the effect of interface design of shopping websites on consumers’ perceived arousal and demonstrated that when the consumers in their study were exposed to an interface with a red background, they exhibited a higher degree of perceived arousal and a stronger sense of excitement. The current mainstream view of researchers is that the interface design represented by colour can effectively influence consumers’ positive perceptions when stimulated by external factors; that is, it has a higher likelihood of arousal. Based on the related literature, this paper argues that an effective interface design, such as the use of brighter colours, is more likely to elicit consumers’ perceptions of arousal. Thus, the following hypothesis is proposed:

Hypothesis 2 (H2). Interface design significantly and positively affects consumers’ perceived arousal.

In the marketing field, atmosphere refers to a shopping environment that is consciously designed to induce a specific emotional effect on consumers and, thus, increase their likelihood of making a purchase [54]. Donovan, Rossiter, Marcolyn and Nesdale [44] found that the atmosphere of offline retail stores plays an important role in consumer pleasure and arousal. Eroglu, et al. [55] studied the shopping atmosphere and confirmed that the shopping atmosphere of a website positively influences consumer arousal. The more pleasant the atmosphere, the stronger the consumer’s arousal and the more likely they are to make a purchase [55]. Existing studies have shown that the influence of the atmosphere on consumers’ emotional arousal is more significant than that of the store-layout design [53]. In summary, this paper defines a live atmosphere as an online-shopping environment created through communication and interaction between anchors and users as well as between different users during a live broadcast. This paper argues that the more pleasant the atmosphere created in the live-streaming process, the stronger the perceived arousal of consumers. Therefore, the following hypothesis is proposed:

Hypothesis 3 (H3). The atmosphere of live streaming significantly and positively affects consumers’ perceived arousal.
Consumer engagement refers to other interactive behaviours that consumers engage in with a brand or company, in addition to purchase behaviour [56]. In live streaming, for example, consumers’ engagement behaviours are manifested in the form of connecting, commenting, liking and giving virtual gifts, through which they participate in the live interaction and, thus, show their interest in the product or anchor. Through qualitative and quantitative studies, researchers have found that consumer-engagement behaviour is influenced by several prerequisites, the most important of which is the atmosphere [56–59]. The presence of security vulnerabilities on an e-commerce website can create an atmosphere of insecurity, which reduces customer patronage of the site [60]. A study on hotel atmosphere found that consumers tend to feel more satisfied when the atmosphere meets their expectations [61]. Choi and Kandampully [58] conducted an in-depth analysis of the hotel atmosphere and found that it can effectively improve the emotional connection between hotel customers and the hotel as well as further increase customer satisfaction and customer engagement. Although there are differences between the live-streaming atmosphere and hotel atmosphere, the influence of both on consumer engagement has some similarities. Therefore, when a more pleasant atmosphere is created during the communication between the anchor and the user, and between different users, the consumers are likely to participate in the interaction and increase their engagement. Thus, the following hypothesis is proposed:

Hypothesis 4 (H4). A live atmosphere significantly and positively affects consumer engagement.

During a live broadcast, the anchor displays the products in a comprehensive and multi-angle way through video screens and by sending pop-ups. This real-time display of merchandise creates a visual appeal to consumers. Scholars have found that consumers pay more attention to sustainable products due to visual factors, and they are more likely to buy them [62]. Ha and Lennon [63] found that the visual appeal of an online store can significantly and positively affect consumers’ internal emotions and positively influence their impulse-buying behaviour. Liu, Li and Hu [19] confirmed that the stronger the visual appeal is, the higher the consumer satisfaction, and the more likely the occurrence of impulse-buying behaviour. In addition, visual appeal has a significant and positive effect on hedonic browsing in m-commerce and a positive influence on consumers’ impulse-buying behaviour [48]. Based on the above studies of the effect of visual appeal on impulse-buying behaviour, this paper suggests that the stronger the visual appeal formed in live streaming is, the more likely consumers are to make impulse purchases. Therefore, the following hypothesis is proposed:

Hypothesis 5 (H5). Visual appeal significantly and positively affects impulse-buying behaviour.

Several recent studies have shown that consumers can be easily stimulated and influenced by external environmental factors, such as anchor attractiveness, comment interaction and information quality, in live-streaming e-commerce and generate positive emotions, such as arousal [64–67]. Iyer, et al. [68] confirmed the positive effect of positive emotions on impulse-purchase intentions; in particular, the stronger the consumers’ positive emotions are, the higher their likelihood of impulse purchase. Koo and Ju [69] found that the higher the consumers’ arousal emotions are, the stronger their pleasure emotions, which can significantly and positively affect their purchase intentions. Kim and Johnson [70], further, illustrated that positive emotions, such as pleasure and arousal, can positively contribute to impulse-buying behaviour. There are many stimuli in e-commerce live streaming that can generate positive emotions, such as arousal, and, thus, positively influence consumers’ impulse-buying behaviour. Thus, we propose the following hypothesis:

Hypothesis 6 (H6). Consumer-perceived arousal significantly and positively influences their impulse-buying behaviour.
Several studies have demonstrated the positive effect of increased consumer engagement in driving consumers’ purchase intentions. As brands engage consumers in brand activities, they can prompt them to create user-generated content, making them more engaged and positively influencing their actual purchase decisions [71]. Through an empirical study, Vazquez, et al. [72] found that TV series’ consumers, who use their mobile devices to search for additional information before, during and after watching TV, have higher engagement compared to those who do not perform additional information searches. These high-engagement behaviours increase the likelihood of impulse purchases [72]. Valentini, et al. [73] demonstrated that when users browse Instagram, the higher the level of online engagement in interactive behaviours is, through likes, shares, comments and follows, the more likely they are to generate purchases. In summary, the more engaged consumers are in live streaming, the more likely their impulse purchases are to occur. Therefore, we propose the following hypothesis:

**Hypothesis 7 (H7).** Consumer engagement significantly and positively affects impulse-buying behaviour.

### 4. Research Design

#### 4.1. Research Method

Based on SOR theory, this paper explores the influence of human–computer interaction between interface design (object factor) and live atmosphere (environment factor) on consumers’ impulse-purchase behaviour in the live e-commerce environment. This paper also analyses the mediating role of subject factors, such as visual appeal, perceived arousal and customer engagement, based on the human–computer-interaction perspective.

In this study, the questionnaire-survey method, which has been widely applied in empirical research, was used to collect the required data based on an online platform, through simple random sampling. After collecting the data, they were analysed using the PLS-SEM method to verify the interrelationships among the variables. The following are the main reasons for selecting the online collection of questionnaires in this study. First, the online collection of questionnaires does not require close physical contact between people and, therefore, avoids the potential risk of infection during the COVID-19 pandemic. Second, the respondents are live-shopping consumers, who are more familiar with the online environment. Therefore, the online-data-collection method can increase the probability of reaching these consumers and improve the accuracy of the dataset. Third, the online-data-collection method can improve the efficiency of data collection and facilitate subsequent analysis.

The questionnaire comprises three parts. The first part is the basic information of the questionnaire, including the purpose of the study and the ethical statement. The ethics statement includes the following: (1) The principle of voluntary participation. (2) The method of recording information anonymously. (3) Strict data-protection and storage policies. (4) Disclosure of the purpose of the study to the respondents in advance and transparency. The second part is the basic information of the respondents, including gender, age, education level and frequency of live e-commerce shopping. The third part is the measurement of each variable used in the model. To ensure the reliability and validity of the questionnaire, it was developed mainly based on the existing literature and previously used mature scales. In particular, the interface design was measured from the projects conducted by Lepkowska-White [74], van der Heijden [75] and Kim and Stoel [76] as well as adapted to live-streaming characteristics. The interface design comprised three items: ‘The interface displays visual product information of good quality’, ‘The interface is visually pleasing’ and ‘The colours used in the interface are attractive’. Live atmosphere refers to the items suggested by Dickson and Albaum [77], adapted to live-streaming characteristics, and includes three items. The visual-appeal-measure item was adapted from Parboteeah, Valacich and Wells [20] and included three items. The perceived-arousal items were adapted from Mikutta, et al. [78]. Customer-engagement items were adapted...
from Hollebeek, et al. [79]. Impulse-buying behaviour was measured according to the scales proposed by Kacen and Lee [80] as well as Beatty and Elizabeth Ferrell [81], which consist of three items: ‘When I go shopping, I buy things I don’t intend to buy’, ‘I often buy things without thinking about the consequences’ and ‘When I see something that really interests me, I just buy it’.

The questionnaire was designed on a 7-point Likert scale, ranging from ‘totally disagree’ to ‘totally agree’. In this study, 30 initial questionnaires were distributed in a small area for pre-study and were revised according to the pre-study results to form the final questionnaire. The online platform chosen for this paper is a professional data-collection agency, called Qualtrics, which distributes online questionnaires via email to respondents in Australia, China, Singapore, New Zealand and other countries. When respondents received an invitation to complete the online questionnaire, they could choose whether to participate in this survey, after reading the basic information of the questionnaire. The respondents of this study are adult consumers of live e-commerce. The respondents could choose whether to participate in the experiment after reading the basic information on the questionnaire. To ensure the quality of the collected data and the accuracy of the experiment, two pre-test questions were set during the questionnaire distribution and screening: ‘Are you above the age of 18?’ and ‘Have you experienced live e-commerce shopping in the last three months?’ If the respondents chose to participate in this experiment and answered ‘Yes’ to both questions, then the formal data-collection process was conducted. The flow chart of the full-text research process is shown in Figure 2.

![Figure 2. Research procedure.](image)

4.2. Participants

In this study, a group of volunteers willing to participate in the experiment was recruited online from Australia, China, Singapore and New Zealand. The questionnaires were collected from December 2021 to January 2022. This questionnaire did not restrict the live-shopping platform used by consumers, which helped to collect more comprehensive data. The data were mainly distributed through online platforms, and 417 questionnaires were collected. After deleting questionnaires with less than 3 min of response time and those with overly focused response options, 339 valid questionnaires were finally identified, with a valid return rate of 81.3%. In terms of gender, 43.4% were male and 56.6% were female, which is in line with the characteristic of women preferring live e-commerce. The age of the respondents was concentrated within 18–64 years, accounting for 96.2%. In terms of education, 100% had a high-school education or above, which conforms to the feature that the higher the education is, the stronger the ability
to accept new things. In terms of shopping frequency, 100% of the respondents shopped in e-commerce live streams at least once a month, and 19.2% of consumers shopped more than 10 times a month, reflecting the attractiveness of e-commerce live streaming to consumers. The demographic characteristics of the valid samples are shown in Table 1.

Table 1. Demographic profile of respondents \((n = 339)\).

<table>
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<tr>
<th>Measure</th>
<th>Category</th>
<th>Number</th>
<th>Percent</th>
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<td>35–44</td>
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<td></td>
<td>45–54</td>
<td>45</td>
<td>13.3%</td>
</tr>
<tr>
<td></td>
<td>55–64</td>
<td>38</td>
<td>11.2%</td>
</tr>
<tr>
<td></td>
<td>Over 65</td>
<td>13</td>
<td>3.8%</td>
</tr>
<tr>
<td>Education</td>
<td>High School</td>
<td>72</td>
<td>21.2%</td>
</tr>
<tr>
<td></td>
<td>College</td>
<td>41</td>
<td>12.1%</td>
</tr>
<tr>
<td></td>
<td>Undergraduate</td>
<td>129</td>
<td>38.1%</td>
</tr>
<tr>
<td></td>
<td>Postgraduate</td>
<td>97</td>
<td>28.6%</td>
</tr>
<tr>
<td>Live-Streaming-Shopping Frequency</td>
<td>At least once a month</td>
<td>37</td>
<td>10.9%</td>
</tr>
<tr>
<td></td>
<td>2–5 times a month</td>
<td>134</td>
<td>39.5%</td>
</tr>
<tr>
<td></td>
<td>6–10 times a month</td>
<td>103</td>
<td>30.4%</td>
</tr>
<tr>
<td></td>
<td>More than 10 times a month</td>
<td>65</td>
<td>19.2%</td>
</tr>
</tbody>
</table>

4.3. Statistical Analysis

This study explored the relationship between different variables using PLS-SEM. Within the SEM framework, there are two alternative methods: covariance-based structural equation modelling (CB-SEM) and PLS-SEM [82]. PLS-SEM allows researchers to explore the relationship between a set of variables and to determine the presence of critical paths among them. PLS-SEM has been widely recognised for its application in exploratory studies [83,84]. Compared to CB-SEM, PLS-SEM has lower requirements in terms of measurement scales, sample size and residual distributions, and the processed data do not need to obey normal distribution [85]. Moreover, the method has a clear advantage in dealing with nonparametric data, without restrictive assumptions regarding data distribution. Moreover, the statistical tool SmartPLS used in this method can be used to develop a model for latent variables and has the advantages of complete data and simple operation. Therefore, we used PLS-SEM for the data analysis.

5. Data Analysis

5.1. Measurement Model

In this study, the measurement model was evaluated using SmartPLS 3.3.7, by conducting reliability, convergent-validity and discriminant-validity tests. Generally, when the Cronbach’s alpha (CA) value is greater than 0.6 and the composite reliability (CR) value is higher than 0.7 [86], the measurement model indicates a good level of reliability. Table 2 represents the descriptive statistics for the constructs. As shown in Table 2, the CA of the latent variables in this study ranged from 0.844 to 0.953, and the CR ranged from 0.906 to 0.970, reflecting a high degree of internal consistency, indicating that the scale has good reliability. Table 3 indicates the factor loadings and cross loadings of each variable. The outer loadings of all indicators in Table 3 exceed 0.850, which is higher than the standard of 0.708 [35], also indicating that the model has good reliability.
Table 2. Descriptive statistics for the constructs.

<table>
<thead>
<tr>
<th>Construct Item</th>
<th>CA</th>
<th>CR</th>
<th>AVE</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impulse-Buying Behaviour</td>
<td>Impul</td>
<td>0.948</td>
<td>0.966</td>
<td>0.906</td>
</tr>
<tr>
<td>Visual Appeal</td>
<td>Visua</td>
<td>0.882</td>
<td>0.927</td>
<td>0.809</td>
</tr>
<tr>
<td>Consumer-Perceived Arousal</td>
<td>Arous</td>
<td>0.932</td>
<td>0.951</td>
<td>0.830</td>
</tr>
<tr>
<td>Customer Engagement</td>
<td>Engag</td>
<td>0.953</td>
<td>0.970</td>
<td>0.914</td>
</tr>
<tr>
<td>Interface Design</td>
<td>Inter</td>
<td>0.844</td>
<td>0.906</td>
<td>0.762</td>
</tr>
<tr>
<td>Live-Streaming Atmosphere</td>
<td>Atmos</td>
<td>0.920</td>
<td>0.949</td>
<td>0.862</td>
</tr>
</tbody>
</table>

Table 3. Factor loadings and cross loadings.

<table>
<thead>
<tr>
<th>Impul</th>
<th>Visua</th>
<th>Arous</th>
<th>Engag</th>
<th>Inter</th>
<th>Atmos</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impul.1</td>
<td>0.958</td>
<td>0.758</td>
<td>0.665</td>
<td>0.482</td>
<td>0.810</td>
</tr>
<tr>
<td>Impul.2</td>
<td>0.942</td>
<td>0.717</td>
<td>0.645</td>
<td>0.487</td>
<td>0.785</td>
</tr>
<tr>
<td>Impul.3</td>
<td>0.954</td>
<td>0.730</td>
<td>0.694</td>
<td>0.510</td>
<td>0.816</td>
</tr>
<tr>
<td>Visua.1</td>
<td>0.729</td>
<td>0.920</td>
<td>0.610</td>
<td>0.248</td>
<td>0.661</td>
</tr>
<tr>
<td>Visua.2</td>
<td>0.703</td>
<td>0.904</td>
<td>0.571</td>
<td>0.272</td>
<td>0.657</td>
</tr>
<tr>
<td>Visua.3</td>
<td>0.648</td>
<td>0.874</td>
<td>0.517</td>
<td>0.296</td>
<td>0.608</td>
</tr>
<tr>
<td>Arous.1</td>
<td>0.681</td>
<td>0.622</td>
<td>0.916</td>
<td>0.028</td>
<td>0.701</td>
</tr>
<tr>
<td>Arous.2</td>
<td>0.637</td>
<td>0.550</td>
<td>0.905</td>
<td>0.018</td>
<td>0.682</td>
</tr>
<tr>
<td>Arous.3</td>
<td>0.641</td>
<td>0.578</td>
<td>0.923</td>
<td>0.000</td>
<td>0.699</td>
</tr>
<tr>
<td>Arous.4</td>
<td>0.599</td>
<td>0.547</td>
<td>0.900</td>
<td>0.038</td>
<td>0.664</td>
</tr>
<tr>
<td>Engag.1</td>
<td>0.498</td>
<td>0.285</td>
<td>0.613</td>
<td>0.961</td>
<td>0.338</td>
</tr>
<tr>
<td>Engag.2</td>
<td>0.475</td>
<td>0.282</td>
<td>0.007</td>
<td>0.947</td>
<td>0.321</td>
</tr>
<tr>
<td>Engag.3</td>
<td>0.512</td>
<td>0.297</td>
<td>0.001</td>
<td>0.960</td>
<td>0.344</td>
</tr>
<tr>
<td>Inter.1</td>
<td>0.736</td>
<td>0.566</td>
<td>0.651</td>
<td>0.282</td>
<td>0.855</td>
</tr>
<tr>
<td>Inter.2</td>
<td>0.762</td>
<td>0.671</td>
<td>0.691</td>
<td>0.305</td>
<td>0.900</td>
</tr>
<tr>
<td>Inter.3</td>
<td>0.713</td>
<td>0.630</td>
<td>0.631</td>
<td>0.329</td>
<td>0.863</td>
</tr>
<tr>
<td>Atmos.1</td>
<td>0.508</td>
<td>0.304</td>
<td>0.628</td>
<td>0.169</td>
<td>0.488</td>
</tr>
<tr>
<td>Atmos.2</td>
<td>0.528</td>
<td>0.299</td>
<td>0.598</td>
<td>0.225</td>
<td>0.487</td>
</tr>
<tr>
<td>Atmos.3</td>
<td>0.467</td>
<td>0.304</td>
<td>0.604</td>
<td>0.151</td>
<td>0.463</td>
</tr>
</tbody>
</table>

Note: Bold numbers indicate outer loading on the assigned constructs.

Then, we used average variance extraction (AVE) to assess convergent validity. The AVE values of each structure exceeded 0.762, which is much higher than the suggested value of 0.5 [86], indicating that the result has good convergent validity. In the traditional method, the discriminant validity of the model can be judged by observing the factor loadings and cross loadings of each item in each latent variable. Table 3 shows that the variances of each potential variable and its related indicators were greater than those of the other potential variables, indicating that the model has good discriminant validity. In addition, this study compared the square root of AVE and the absolute value of the correlation coefficient to evaluate discriminant validity [82]; the results are shown in Table 4. Table 4 describes correlations among constructs and the square root of AVE. It shows that the square root of AVE of each construct is greater than the correlation between the related construct and all other constructs, reflecting that the scale has good discriminant validity.

Table 4. Correlations among constructs and the square root of AVE.

<table>
<thead>
<tr>
<th>Impul</th>
<th>Visua</th>
<th>Arous</th>
<th>Engag</th>
<th>Inter</th>
<th>Atmos</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impul</td>
<td>0.952</td>
<td>0.899</td>
<td>0.911</td>
<td>0.956</td>
<td>0.873</td>
</tr>
<tr>
<td>Visua</td>
<td>0.772</td>
<td>0.631</td>
<td>0.301</td>
<td>0.350</td>
<td>0.517</td>
</tr>
<tr>
<td>Arous</td>
<td>0.703</td>
<td>0.631</td>
<td>0.754</td>
<td>0.350</td>
<td>0.517</td>
</tr>
<tr>
<td>Engag</td>
<td>0.518</td>
<td>0.301</td>
<td>0.007</td>
<td>0.350</td>
<td>0.517</td>
</tr>
<tr>
<td>Inter</td>
<td>0.845</td>
<td>0.714</td>
<td>0.754</td>
<td>0.350</td>
<td>0.517</td>
</tr>
<tr>
<td>Atmos</td>
<td>0.540</td>
<td>0.325</td>
<td>0.657</td>
<td>0.196</td>
<td>0.517</td>
</tr>
</tbody>
</table>

Note: Bold numbers represent the square roots of AVEs.
5.2. Structural Model

Bootstrapping in SmartPLS 3.3.7 was used to test the hypotheses proposed in this study, and 5000 sampling times were used to ensure the stability of the data results as well as the level of significance between the calculated variables. The original sample size of this study was 339, and the indicators, such as path coefficients and significance results, are shown in Table 5. The study results showed that all path coefficients were statistically significant. The interface design had a significant and positive impact on visual appeal and perceived arousal ($p$ value < 0.001), with path coefficients of 0.714 and 0.565, respectively (H1 and H2 were supported). The live atmosphere had a significant and positive impact on perceived arousal and customer engagement, with path coefficients of 0.365 and 0.196, respectively (H3 and H4 were supported). Visual appeal, perceived arousal and customer engagement had a significant and positive impact on impulse-buying behaviour ($p$ value < 0.001), with path coefficients of 0.333, 0.495 and 0.421, respectively (H5–H7 were supported). Thus, all hypotheses were verified, and the specific hypothesis-testing results are shown in Table 6.

Table 5. Path coefficients.

| Path Relationship | Original Sample (O) | Sample Mean (M) | Standard Deviation (STDEV) | T Statistics (|O/STDEV|) | $p$ Values |
|-------------------|---------------------|-----------------|--------------------------|-----------------|------------|
| Visua $\rightarrow$ Impul | 0.333             | 0.335           | 0.033                  | 10.224             | 0.000      |
| Arous $\rightarrow$ Impul | 0.495             | 0.494           | 0.039                  | 12.861             | 0.000      |
| Engag $\rightarrow$ Impul | 0.421             | 0.421           | 0.031                  | 13.599             | 0.000      |
| Inter $\rightarrow$ Visua | 0.714             | 0.716           | 0.025                  | 28.693             | 0.000      |
| Inter $\rightarrow$ Arous | 0.565             | 0.566           | 0.041                  | 13.946             | 0.000      |
| Atmos $\rightarrow$ Arous | 0.365             | 0.365           | 0.045                  | 8.046              | 0.000      |
| Atmos $\rightarrow$ Engag | 0.196             | 0.199           | 0.071                  | 2.742              | 0.006      |

Table 6. Hypothesis test.

<table>
<thead>
<tr>
<th>Number</th>
<th>Research Hypothesis</th>
<th>Supported (YES/NO)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NO. 1</td>
<td>Interface design significantly and positively affects visual appeal.</td>
<td>YES</td>
</tr>
<tr>
<td>NO. 2</td>
<td>Interface design significantly and positively affects consumers’ perceived arousal.</td>
<td>YES</td>
</tr>
<tr>
<td>NO. 3</td>
<td>The live-streaming atmosphere of live streaming significantly and positively affects consumers’ perceived arousal.</td>
<td>YES</td>
</tr>
<tr>
<td>NO. 4</td>
<td>A live atmosphere significantly and positively affects consumer engagement.</td>
<td>YES</td>
</tr>
<tr>
<td>NO. 5</td>
<td>Visual appeal significantly and positively affects impulse-buying behaviour.</td>
<td>YES</td>
</tr>
<tr>
<td>NO. 6</td>
<td>Consumer-perceived arousal significantly and positively influences their impulse-buying behaviour.</td>
<td>YES</td>
</tr>
<tr>
<td>NO. 7</td>
<td>Consumer engagement significantly and positively affects impulse-buying behaviour.</td>
<td>YES</td>
</tr>
</tbody>
</table>

Furthermore, this study assessed the explanatory strength of the proposed model from the value of $R^2$; generally, $R^2 < 0.19$ indicates poor explanatory power of the model, $R^2 > 0.33$ indicates average explanatory power and $R^2 > 0.67$ indicates strong explanatory power [87]. Figure 3 shows the $R^2$ values between all variables in this model and the magnitude of significance. As shown in Figure 3, the $R^2$ of the proposed model was 0.823, which indicates that the model exhibited good explanatory power and effectiveness.
6. Results

Based on SOR theory, this study established the impulse-purchase behaviour path of consumers’ environmental stimulus–emotion–impulse-buying behaviour in the live e-commerce context. The psychological mechanisms and behavioural tendencies of consumers in live e-commerce streaming were investigated empirically. This study focused on the influence of the interface design and live-streaming atmosphere on consumers’ impulse-buying behaviour and investigated the effect of human–computer interaction on the inner states of consumers, such as visual appeal, perceptual arousal and consumer engagement. The results indicated that interface design and live atmosphere have a significant and positive effect on consumers’ impulse-purchase behaviour, and this effect is mediated by visual appeal, perceived arousal and consumer engagement to different degrees. The findings and test results of the study are described below.

First, the interface design of live streaming has a significant and positive effect on consumers’ visual appeal and perceived arousal, which is consistent with the findings of some researchers on website-interface design [49,52,88]. This study designs a live-streaming room based on the study of Gong, Ye, Liu and Wu [43]. Therefore, interface design, as the earliest stimulus that consumers are exposed to when shopping, significantly impacts consumers’ internal state, whether they are shopping on websites or in a live atmosphere. The interface design of the live-streaming room is composed of a functional button layout, product display methods, interactive panels, interface colours and other elements. When watching a live e-commerce broadcast, consumers are easily attracted to diverse content and personalised options, which creates visual appeal [53,89,90]. In addition, the colour of the live-streaming interface has different degrees of influence on consumers’ arousal state. In particular, the brighter the colour of the live-streaming interface, the easier it is for consumers to generate arousal emotions, such as excitement.

Second, this paper confirms the significant and positive effect of a live atmosphere on consumers’ perceived arousal and engagement. In order to attract consumers to make purchases, merchants consciously create a shopping atmosphere, which leads to positive purchase emotions [91]. Researchers have found that offline store ambiance significantly affects consumer arousal [44,55]. Our study, further, indicates that the shopping atmosphere in live-streaming scenarios positively affects consumer arousal. In particular, the more pleasant the live-streaming atmosphere created by the merchant is, the more likely
the generation of arousal emotions among consumers. Thus, shopping atmosphere positively influences consumers’ perception of arousal, both offline and online. In addition, this study confirms the significant and positive effect of a live atmosphere on consumer engagement, which is similar to the findings of Choi and Kandampully [58]. The difference is that Choi and Kandampully [58] explored offline real engagement, while this paper explores online virtual engagement. This suggests that a live atmosphere not only has a positive effect on offline consumers’ engagement but also plays a positive role in online consumers’ engagement. In summary, a live atmosphere positively influences consumers’ positive emotions.

Finally, this paper supports the significant and positive relation between consumers’ positive emotions and impulse-purchase behaviour. This empirical study found that, with the live interface design and live atmosphere factors, consumers’ visual appeal, perceived arousal and engagement all have a positive impact on consumers’ impulse-buying behaviour. This corroborates the researchers’ findings that positive emotions help to promote consumer purchases [68,92]. The results of the data analysis indicate that three out of five visual-marketing elements play a significant role in influencing customers’ impulse-buying behaviour [93]. The visual appeal of the live room is equally important, as consumers are visually attracted to its diversity and brilliant colours, which creates a positive visual effect. This visual effect can further impact impulse-buying behaviour. Consumers can easily enter an excited and active arousal state under the influence of the many stimulating factors in the live room. This state of arousal can please consumers and make them eager to shop, which further increases the possibility of impulse-buying behaviour. In addition, consumers are prone to active participation in an interactive atmosphere [94], and the stronger the sense of participation is, the more likely the consumers are to make impulse purchases.

7. Discussion

This study aims to explore the mechanisms by which human–computer interaction in live-broadcast rooms affects consumers’ internal emotions and impulsive-buying behaviour as well as contribute to the study of impulsive-buying behaviour from a theoretical and practical perspective. All the original hypotheses presented in this paper were confirmed. This paper finds that interface design and a lively atmosphere are two important human–computer-interaction variables in live e-commerce rooms. These two variables significantly and positively influence consumer-impulsive-purchase behaviour, by affecting their internal states. Thus, the findings of this paper answer the two main research questions initially posed. The findings confirm the applicability of SOR theory to the live e-commerce scenario as well as enrich the research findings and research perspectives on impulse buying in the field of live e-commerce. In addition, based on the results, this paper makes recommendations for the multi-stakeholder groups of live e-commerce, which help promote the sustainable development of live e-commerce. Compared to the existing impulse-buying literature, this paper is innovative and timely. It takes a human–computer-interaction perspective within the field of live e-commerce, which researchers have explored less.

7.1. Implications

In terms of academic contributions, first, this study extends the field of research on impulse-buying behaviour. This paper examines irrational consumer behaviour starting from the lesser noticed context of live e-commerce, rather than the traditional offline and online-shopping-website environments. Although e-commerce live streaming has only emerged recently, it has already shown rapid development in China, with the market size exceeding trillions of RMB, and it is gradually becoming a new economic growth point. However, there are many problems in its development, such as impulse-buying behaviour, which makes consumers feel distressed [4]. Based on this, we argue that it is academically valuable to explore consumers’ impulse-buying behaviour in the context of live e-commerce. Second, this study broadens the research perspective on impulse-buying behaviour in e-commerce live streaming. The studies on impulse-buying behaviour in
live e-commerce have the limitation not only of being rare but also of a single research perspective. Most of the existing studies start from the perspective of the personal traits of the anchor or the live-broadcast environment and a lack a multi-perspective investigation of the factors influencing consumers’ non-rational behaviour. Since there are many human–computer-interaction stimuli in a live broadcast, it is a novel idea to explore the occurrence of impulse-buying behaviour, based on the perspective of human–computer interaction, which might be useful in revealing the inner mechanism of this behaviour. Again, the study results suggest that positive emotions have a positive impact on consumers’ impulse-buying behaviour. Existing studies have confirmed the positive role of positive emotions, such as perceived value [95, 96] and perceived trust [97, 98], in consumers’ impulse-buying behaviour. This study also reveals that when consumers are exposed to pleasurable external stimuli, they generate a range of positive emotions, such as good visual perceptions and high levels of arousal and engagement, which positively affect subsequent irrational purchase decisions. Finally, SOR theory is also applicable to the study of impulse purchases in live e-commerce. Although this theory has been applied extensively in the study of impulse-buying behaviour, most of these applications have focused on traditional venues, such as offline stores and online-shopping websites. Therefore, this paper confirms that the application of SOR theory in the context of live e-commerce has the same consistent applicability as that observed in traditional venues.

In a practical sense, the study findings have certain implications for different interest groups. Consumers should be alerted to the influence of the richness of the live-streaming interface and the pleasure of the live-streaming atmosphere on their irrational purchasing behaviour. Given the rich and colourful interface design and interactive atmosphere of live streaming, consumers should reasonably examine their shopping desires and establish the concept of sustainable consumption, to reduce the possibility of irrational purchase decisions. The live-streaming platform and live-streaming practitioners should have a certain understanding of the live-streaming stimulus factors that influence consumers’ irrational purchasing behaviour. In addition, live-streaming platforms and practitioners should focus more on the importance of human–computer interaction in live streaming, for consumers’ positive emotions. For example, by building a more attractive human–computer-interaction interface and shaping a more pleasant live atmosphere to improve consumers’ positive emotions, consumers can be attracted to stay in the live broadcast room and contribute to the sustainable development of the live economy. Given the significant positive effects of human–computer interaction and positive consumer emotions on impulse-purchase behaviour, this paper suggests that live-streaming platforms can provide guidance to prevent impulse purchases in the live-streaming interface. Irrational purchasing behaviour not only damages consumers’ rights and interests as well as affects their shopping experience but also causes different degrees of negative impacts on merchants, such as subsequent consumer returns and brand-reputation damage [9]. This paper also suggests that regulatory platforms and industry organisations should encourage merchants to create a comfortable shopping interface and shopping atmosphere for consumers. In addition, these supervisory authorities should strengthen their supervision of merchants, such as live-streaming platforms, to prevent their abuse of rights to the detriment of consumers.

7.2. Limitations and Future Research

This paper deepens and extends the research on human–computer-interaction stimuli, consumers’ intrinsic emotional states and impulse-buying behaviour in e-commerce live streaming. It has some implications for e-commerce live-streaming platforms, for carrying out marketing and management practices, but there are also some shortcomings. First, because of the numerous live e-commerce platforms, this study fails to consider the possible differences between various live e-commerce platforms. The e-commerce live-streaming platforms developed based on traditional e-commerce platforms, and those developed based on short video platforms, have differences in form and experience, which might have different effects on respondents’ information processing. Therefore, future research
should consider the effects of different types of live e-commerce platforms on consumers’ impulse-buying behaviour, to develop marketing programs for platforms that are more in line with their live-streaming characteristics. Second, due to limited time and resources, the 339 samples in this study were mainly collected from the Asia-Pacific region, such as China, Singapore, Australia and New Zealand, where e-commerce live streaming is well developed. With the gradual launch of live streaming with goods on major social and e-commerce platforms, live-streaming e-commerce is expected to become a new trend in global online consumption. Therefore, future research should explore the international and cultural differences in impulse-buying behaviour in e-commerce live streaming as well as make the findings more representative, by expanding the collection scope and sample size. Third, the respondents might have recalled incomplete information when answering the questionnaire. Some respondents might have been biased towards emotional perception and environmental perception when recalling their live-shopping experiences, resulting in the low precision of their answers. Therefore, a follow-up study should attempt to combine the questionnaire survey with the operational data of the live-streaming e-commerce enterprises as well as use big-data analysis to explore the formation mechanism underlying consumers’ impulse-purchase behaviour.

8. Conclusions

In conclusion, guided by SOR theory, this paper constructs a model of consumers’ impulse-purchase behaviour under live e-commerce broadcasting from the perspective of human–computer interaction. The mechanism underlying the influence of the interface design and live-streaming atmosphere on consumers’ intrinsic emotion and impulse-purchase behaviour is explored. This paper uses the PLS-SEM method to quantitatively analyse the 339 valid questionnaires collected. The results show that interface design and live atmosphere have a significant and positive impact on consumers’ internal emotions. Colourful interface design and pleasant live atmosphere can provide high visual appeal, perceptual arousal and engagement to consumers. These positive internal emotions positively affect consumers’ subsequent impulse-purchase behaviour. In terms of theory, this paper enriches the research results on impulse-buying behaviour in the context of live e-commerce and expands the research perspective on this behaviour, from the viewpoint of human–computer interaction. In addition, this paper confirms the applicability of SOR theory in the live e-commerce scenario, which is consistent with other scenarios. In addition, the research results contribute to consumers’ and e-commerce live-streaming platforms’ understanding of the mechanism of irrational behaviour, in the e-commerce live-streaming environment. It also provides new ideas for the decision-making and management of consumers, e-commerce hosts and e-commerce platforms, at the practical level.

This paper’s findings help reduce unsustainable impulse purchases and promote the sustainability of live e-commerce. Consumers of live e-commerce can gain insights into the impact of interface design and lively atmosphere on their irrational shopping behaviour, thereby developing a sustainable-consumption mindset and reducing the likelihood of impulsive purchases. E-commerce anchors and practitioners can attract more consumers to live-streaming through a carefully designed interface and atmosphere, promoting a sustainable and thriving live economy. At the same time, they can understand the mechanism of human–computer interaction and positive consumer emotions in the formation of impulsive-buying behaviour as well as provide proper guidance to customers to reduce the occurrence of irrational shopping behaviour, thus promoting the sustainable and healthy development of the live-streaming economy. For regulators, an in-depth understanding of the factors influencing impulsive-buying behaviour in live-streaming can also help them carry out reasonable regulations, create an excellent live-streaming environment and promote the sustainable prosperity of the live-streaming economy.

Author Contributions: Conceptualisation, J.Y. and C.C.; data curation, J.Y.; formal analysis, Y.S.; investigation, J.Y. and C.Y.; methodology, J.Y., C.C. and Y.S.; resources, C.C.; writing—original draft,
J.Y.; writing—review and editing, C.C. All authors have read and agreed to the published version of the manuscript.

**Funding:** This research was funded by the Zhejiang University of Technology Subject Reform Project, grant number SKY-ZX-20210175.

**Institutional Review Board Statement:** Ethical review and approval was not required for this study on human participants, in accordance with local legislation and institutional requirements.

**Informed Consent Statement:** Informed consent was obtained from all subjects involved in the study. Written informed consent from the participants was not required to participate in this study, in accordance with national legislation and institutional requirements.

**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 restrictions.

**Conflicts of Interest:** The authors declare no conflict of interest.

**References**

11. Liang, C.-C.; Yu, A.P.-I.; Le, T.H. Customers focus and impulse buying at night markets. *J. Retail. Consum. Serv.* 2021, 60, 1012434. [CrossRef]
17. Clover, V.T. Relative Importance of Impulse-Buying in Retail Stores. *J. Mark.* 1950, 15, 66–70. [CrossRef]
42. Zhang, Z.; Zhang, N.; Wang, J. The Influencing Factors on Impulse Buying Behavior of Consumers under the Mode of Hunger Marketing in Live Commerce. *Sustainability* 2022, 14, 2122. [CrossRef]
44. Donovan, R.J.; Rossiter, J.R.; Marcocyn, G.; Nesdaale, A. Store atmosphere and purchasing behavior. *J. Retail.* 1994, 70, 283–294. [CrossRef]


64. Hou, F.; Guan, Z.; Li, B.; Chong, A.Y.L. Factors influencing people’s continuous watching intention and consumption intention in live streaming. *Internet Res.* 2020, 30, 141–163. [CrossRef]


95. Patterson, P.G.; Spreng, R.A. Modelling the relationship between perceived value, satisfaction and repurchase intentions in a business-to-business context: An empirical examination. *Int. J. Serv. Ind.* 1997, 8, 414–434. [CrossRef]

