



Evaluating and eliciting design requirements for an improved user experience in live-streaming commerce interfaces

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ABSTRACT

Live-streaming commerce is emerging as a novel and interactive form of media commerce, allowing consumers to partake in live shows, purchase products, and engage with hosts in real time. Despite its substantial growth potential, there is a dearth of research on user interaction with live-streaming commerce in the context of user experience (UX). To comprehend user engagement with this technology and explore avenues for UX enhancement, we devised a three-stage user study. First, we conducted a UX assessment of leading live commerce platforms, employing both a self-report questionnaire and eye tracking. This enabled us to ascertain users' perceptions of user interface (UI) and live-streaming commerce components as well as identify the most user-friendly UI design. Second, we examined frequent users' experiences via online focus group interviews (FGIs). Through these, we observed that users employ chat and reaction features to convey empathy, enjoy themselves, or obtain rewards, ultimately driving sustained engagement and interaction with live-streaming commerce. Finally, we evaluated the visual effects designed to boost interactivity and pleasurable experiences through the development of a live-streaming commerce prototype. We determined that visual effects encompassing serendipitous elements augment users' enjoyable experiences considerably during live-streaming commerce. Our findings provide valuable insights for practitioners aiming to refine live-streaming commerce interfaces and components to enhance UX.

1. Introduction

The evolution of information and communication technology (ICT) has prompted significant transformations in the e-commerce industry, encompassing the expansion of e-commerce beyond traditional websites to social media platforms (Huang & Benyoucef, 2013) and the increased utilization of mobile devices for online transactions (Kim, Mirusmonov, & Lee, 2010). Moreover, since the advent of COVID-19, the shift toward contactless consumption has catalyzed further changes in the e-commerce landscape. Users can now access product information and make purchases via real-time video through live streaming, superseding the conventional method of obtaining product information through text and images. The burgeoning popularity of live-streaming commerce has prompted numerous businesses to integrate it into their marketing strategies to bolster profitability. The global live-streaming commerce market is witnessing exponential growth and has already left a

substantial imprint on the industry. This trend has seen particular success in Asian markets, such as China and South Korea, and is now proliferating across Europe and the United States (199IT, 2022; Activate, 2022; Arora et al., 2021; MezzoMedia, 2022). The South Korean live-streaming commerce market, valued at approximately 3 trillion won in 2020, has more than tripled to over 10 trillion won in 2023 (Ju, 2021; MezzoMedia, 2022).

Live-streaming commerce possesses a unique feature distinguishing it from traditional e-commerce: the capacity for real-time interaction between sellers and consumers via platforms (Sun, Shao, Li, Guo, & Nie, 2019). Show hosts can deliver more comprehensive and vivid product demonstrations and address customer inquiries instantaneously. Consumers can glean product information by watching live broadcasts and partake in real-time communication through chat windows on the platform. Consequently, numerous studies have examined the effects of several variables and their relationships on consumer purchase behavior

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(Chen, Wang, Rasool, & Wang, 2022; Dong, Zhao, & Li, 2022; Ho, Liu, & Chen, 2022; Lee & Chen, 2021; Li, Wang, & Cao, 2022; Lin, Tseng, Shirazi, Hajli, & Tsai, 2022; Ming, Jianqiu, Bilal, Akram, & Fan, 2021; Xu, Wu, & Li, 2020; Yang, Cao, Ye, & Shi, 2022a) as well as the impact of IT affordance on live-streaming platform users (Dong, Wang, & Benbasat, 2016; Dong & Wang, 2018; Joo, 2022; Saffanah, Handayani, & Sunarso, 2022; Sun et al., 2019; Tuncer, 2021). Additionally, researchers have investigated factors associated with show hosts who engage with users (Hu & Chaudhry, 2020; Kim & Heo, 2021; Lu & Chen, 2021; Wongkitrungrueng & Assarut, 2020; Wongkitrungrueng, Dehouche, & Assarut, 2020). Although a growing body of research exists on the platform interface and components (Fei, Tan, Peng, Wang, & Wang, 2021; Xu, Lv, & Cao, 2022; Yang et al., 2022a; Yang, Ye, Lv, & Cao, 2022b), which are crucial aspects of live-streaming commerce, existing studies have primarily investigated individual stakeholders—users, hosts, and platforms—separately and have focused solely on the functions or components offered by current interfaces. In other words, comprehensive research on live-streaming commerce interfaces remains scarce.

To fill this gap, we designed and executed three distinct yet interconnected studies. First, we evaluated three representative live-streaming commerce platforms dominating the market using eye trackers and a self-report questionnaire to examine IT affordance, intention to use, and engagement. Second, we investigated the perceptions and needs of frequent users of live-streaming commerce regarding the platform's interface. Third, we developed a prototype interface with specific components based on the findings of prior studies and assessed its impact on users. Through this, we were able to discern users' perceptions of user interface (UI) and live-streaming commerce components as well as identify the most user-friendly UI design. We also discovered that users employ chat and reaction features of the platforms to convey empathy, enjoy themselves, or obtain rewards, ultimately driving sustained engagement and interaction with live-streaming commerce. Furthermore, we determined that visual effects encompassing serendipitous elements significantly enhance users' enjoyable experiences during live-streaming commerce. Our research findings can offer practical suggestions for live-streaming commerce platforms to develop effective marketing plans and serve as a guide for designers to improve user experience (UX).

This paper is organized as follows: In Section 2, we review the relevant literature on live-streaming commerce interfaces and components, interactivity and enjoyable experiences, and IT affordance. In Section 3, we describe a comprehensive overview of the study with a figure. In Sections 4, 5, and 6, we present the specifics of the experiments, analytical results, and discussions of each study (Studies 1, 2, and 3, respectively). Finally, in Section 7, we summarize our findings, addressing the research implications, practical applications, and future directions for designing live-commerce platforms as well as limitations.

2. Related work

In this section, we delve into the related work, discussing three pivotal aspects of live-streaming commerce: the interface and components, the role of interactivity and enjoyable experiences, and the concept of IT affordance. By examining these topics, we aim to establish a comprehensive understanding of the current research landscape and lay the foundation for our investigation into enhancing UX in live-streaming commerce platforms.

2.1. Live-streaming commerce interface and components

A meticulously designed interface can bolster the overall UX and augment user engagement. The UI of a live-streaming commerce platform is pivotal, as it represents the initial point of contact for users. When a user-friendly interface and visually appealing components are offered, users are more inclined to remain on the platform, partake in

live streaming, and potentially make a purchase (Ming et al., 2021; Xu et al., 2022; Yang et al., 2022a; Yang et al., 2022b). Moreover, an esthetically pleasing interface can elicit positive emotional experiences for users, contributing to heightened satisfaction and enhancing the platform's brand image (Ho et al., 2022; Wang, Luo, Hua, & Benitez, 2022; Yang et al., 2022a).

UIs of live-streaming commerce platforms often share similar components that typically encompass content such as the program's title, vendor profile, promotional coupons, announcements, social sharing options, interactive chat, and interactive reaction buttons. Notably, elements like comments, reactions, and sharing options serve as vital indicators of user engagement in live-streaming commerce. Additionally, the emphasis on show hosts' unconventional, participatory activities, including contests, games, and artistic performances (Wongkitrungrueng et al., 2020), highlights the need for platform-level support to facilitate users' spontaneous involvement.

Within the live-streaming room, users encounter various visual stimuli, such as products, effects, and environments, that can contribute to the sensation of presence in a virtual space (Xu et al., 2022; Yang et al., 2022a). Prior studies have demonstrated that visual effects, like bullets, herding messages, pop-ups, and interactive animations, can enhance the social presence and telepresence of live-commerce platforms (Xu et al., 2022; Yang, Ye, et al., 2022). Incorporating diverse media or visual features on a platform can elevate its presence (Ma, 2021), thus stimulating users' emotional states and increasing their propensity to make purchases (Xu et al., 2022; Yang et al., 2022a).

While a thread of research has investigated each component of the UI of live-streaming commerce, there seems to be room for improvement in practice. Many services are currently attempting alterations by integrating several elements, but their design decisions often rely on hunches or may simply evolve into a complex interface added to their conventional UIs. These modifications lack a foundation in scientific research (Fei et al., 2021). Although intricate interface designs may reduce consumer attention, a convenient and intuitive interface can enhance the visual experience for consumers, fostering a sense of social presence and enabling users to concentrate more on the product itself (Yang et al., 2022b). The subsequent stage of live-streaming commerce does not demand substantial innovation but should instead concentrate on intensifying interactivity and capturing users' attention (Ruether, 2022).

2.2. Interactivity and an enjoyable experience in live-streaming commerce

Live streaming is a medium that facilitates real-time recording and broadcasting of content using communication technologies to transmit audio and visual data instantly, generating a sense of presence for viewers (Chen & Lin, 2018). The significance of interaction in live streaming is undeniable (Chen & Lin, 2018; Li & Peng, 2021) and is particularly crucial in the context of commerce (Cai, Wohn, Mittal, & Sureshbabu, 2018; Cai & Yvette Wohn, 2019; Kang, Lu, Guo, & Li, 2021; Lin et al., 2022; Lv, Zhang, Su, & Yang, 2022; Xue, Liang, Xie, & Wang, 2020). In live-streaming commerce, real-time interaction occurs through chat and reaction buttons, such as the Like button. These methods raise users' awareness of the presence of other users and allow show hosts to respond to chat content and reaction button effects, distinguishing live-streaming commerce from traditional online shopping. Interactivity is an essential aspect of live-streaming commerce, as it encourages users to actively engage in communication and transactions (Kang et al., 2021; Xue et al., 2020). This interactivity not found in traditional online shopping is the primary motivation for users to engage with the live platform (Cai et al., 2018; Cai & Yvette Wohn, 2019; Lv et al., 2022). The enjoyment derived from interactivity can increase user participation and immersion, ultimately influencing purchase behavior (Cai et al., 2018; Cai & Yvette Wohn, 2019; Lin et al., 2022).

The pleasurable experience during real-time interaction through chat and reaction buttons is another distinct feature of live-streaming

commerce. The amalgamation of a novel medium, a seamless purchase process, and social interaction enhances the user's shopping experience. Hedonic consumption, referring to positive experiences such as fun and playfulness during the shopping process regardless of the purchase (Alba & Williams, 2013; Babin, Darden, & Griffin, 1994; Falode, Amubode, Adegunwa, & Ogunduyile, 2016; Hirschman & Holbrook, 1982), can also apply to live-streaming shopping (Xu et al., 2020). This concept may be even more significant in live-streaming commerce, as users can experience a wider variety of content, leading to greater enjoyment of the shopping experience. Several studies have demonstrated that, even in the realm of live-streaming commerce, user enjoyment and fun influence purchase decisions (Cai et al., 2018; Cai & Yvette Wohn, 2019; Chen et al., 2022; Lee & Chen, 2021; Li et al., 2022; Lin et al., 2022; Lv et al., 2022; Yang et al., 2022a).

To identify additional factors influencing purchase behavior, researchers have utilized the stimulus-organism-response (S-O-R) framework, suggesting that stimuli impact emotions and perceptions, ultimately leading to actions (Donovan, Rossiter, Marcolyn, & Nesdale, 1994; Mehrabian & Russell, 1974). Prior studies have identified multiple factors influencing users' buying behavior based on this framework (Chen et al., 2022; Dong et al., 2022; Ho et al., 2022; Lee & Chen, 2021; Li et al., 2022; Lin et al., 2022; Ming et al., 2021; Xu et al., 2020; Yang et al., 2022a), including user- (e.g., enjoyment, flow, immersion, arousal, engagement), show host- (e.g., social presence, bond, attractiveness, trust), product- (e.g., information, scarcity), content- (e.g., entertainment, atmosphere), and platform- (e.g., interface design, visual appeal, system, atmosphere, telepresence, convenience) related factors. The impact of these factors has been verified through research. The presence of the show host and platform stimulates emotional arousal in users and creates immersion (Li et al., 2022; Ming et al., 2021). The show host's attractiveness or connection with their audience can provide entertainment and encourage engagement in live-streaming commerce (Lee & Chen, 2021; Lin et al., 2022; Xu et al., 2020). Furthermore, product information, scarcity, and platform convenience can affect user attitudes, such as trust, while the broadcasting atmosphere can also contribute to increasing user participation and lead to pleasant emotions (Chen et al., 2022; Dong et al., 2022; Ho et al., 2022; Yang et al., 2022a).

Based on the findings of prior studies, it is crucial to prioritize evoking positive emotions in live commerce users as well. Consequently, it is evident that individuals who experience positive emotions are more likely to become engaged and make purchases. In particular, research findings indicating that serendipity, which is the unanticipated occurrence of beneficial experiences brought about by a person's valuable interaction with ideas, information, objects, or phenomena (McCay-Peet, Toms, & Kelloway, 2015; McCay-Peet & Toms, 2022), impacts user engagement and purchase behavior in online and live-streaming shopping support this claim (Bao & Yang, 2022; Grange, Benbasat, & Burton-Jones, 2019; Wang & Wu, 2019). Previous studies have proposed strategies such as creating a show host's image, events, and influencer promotions as well as enhancing the broadcasting studio environment to induce a positive emotional state among users (Chen et al., 2022; Ho et al., 2022; Lin et al., 2022).

2.3. IT affordance

Affordance, which refers to the potential action facilitated by a particular technology or object, may vary depending on the context (Majchrzak & Markus, 2013; Parchoma, 2014; Treem & Leonardi, 2013). In particular, IT affordance is defined as the symbiotic relationship between actor intentions and technological capabilities that potentially enables a specific action (Faraj & Azad, 2012; Majchrzak, Faraj, Kane, & Azad, 2013). Within the realm of live-streaming commerce, IT affordance comprises technical, design, and object features that captivate users' attention and promote engagement (Dong et al., 2016; Dong & Wang, 2018; Sun et al., 2019) with both show hosts and interface components.

Previous research has classified IT affordance into three primary categories: metavoicing, visibility, and shopping guidance. Metavoicing pertains to the live platform's capacity to facilitate product information gathering, providing customers with diverse means to express opinions and interact with sellers (Dong et al., 2016; Dong & Wang, 2018; Majchrzak et al., 2013; Sun et al., 2019). This attribute bolsters the interaction between show hosts and users, enhances presence, and fosters a sense of immersion, enabling users to concentrate on live shopping (Dong & Wang, 2018; Joo, 2022; Saffanah et al., 2022; Sun et al., 2019; Tuncer, 2021). Visibility denotes the extent to which product information is accessible to customers and the effectiveness of the product's visual presentation during live shopping (Dong et al., 2016; Dong & Wang, 2018; Sun et al., 2019; Treem & Leonardi, 2013). Rich visual information has been identified as a potent tool for engaging customers and boosting immersion in the content (Joo, 2022; Saffanah et al., 2022; Sun et al., 2019). Shopping guidance involves providing personalized services that aid customers in making purchasing decisions (Dong et al., 2016; Dong & Wang, 2018; Sun et al., 2019). A bidirectional communication process is established through direct interaction with sellers and the opportunity to ask questions, resulting in enhanced affordance (Dong & Wang, 2018; Joo, 2022). Personalized services also pique user interest, evoking a sense of immersion (Saffanah et al., 2022; Sun et al., 2019; Tuncer, 2021).

As illustrated by the definitions of the three IT affordance sub-dimensions, the show host's role in presenting products and communicating with users is paramount in live-streaming commerce, making their contribution to the IT affordance concept especially significant. Prior research has revealed that social bonds, physical resemblance, and shared values with show hosts can augment user trust and alleviate uncertainty in live-streaming shopping (Hu & Chaudhry, 2020; Lu & Chen, 2021; Wongkitrungrueng & Assarut, 2020). Indeed, show hosts actively strive to establish rapport with viewers and employ various methods, such as dancing, singing, and dressing, to convey product information and generate sales (Wongkitrungrueng et al., 2020). Nonetheless, UI components of existing live-streaming commerce services, which constitute the IT affordance alongside show hosts, can often hinder their endeavors.

In summary, prior research has examined the interface and components, the significance of interactivity and engaging experiences, and the concept of IT affordance in the context of live-streaming commerce, providing valuable insights into the crucial factors for various stakeholders and UI components. However, the majority of these investigations have focused on customer perceptions of the service. There remains a need for a deeper understanding of user interactions and experiences with live-streaming commerce services from the perspectives of human-computer interaction (HCI) and UX. This approach would yield more comprehensive, user-centric, and actionable design recommendations for the UIs of live-streaming commerce services.

3. Study overview

Our research comprises three interconnected studies designed to provide a comprehensive understanding of user interactions with live-streaming commerce services and to identify strategies for enhancing their overall UX (see Fig. 1 for more details).

- **Study 1:** This study uses a dual-method approach, utilizing both self-report questionnaires and eye-tracking devices, to evaluate the usability of three major live-streaming commerce platforms. Findings from this study will inform the UI structure of the prototype developed in Study 3.
- **Study 2:** We explore visual elements that engage users. Through online focus group interviews, we identify and develop innovative visual effects that will be incorporated into Study 3.
- **Study 3:** Building on the findings of Studies 1 and 2, we conduct experiments using a prototype to assess the impact of specific UI

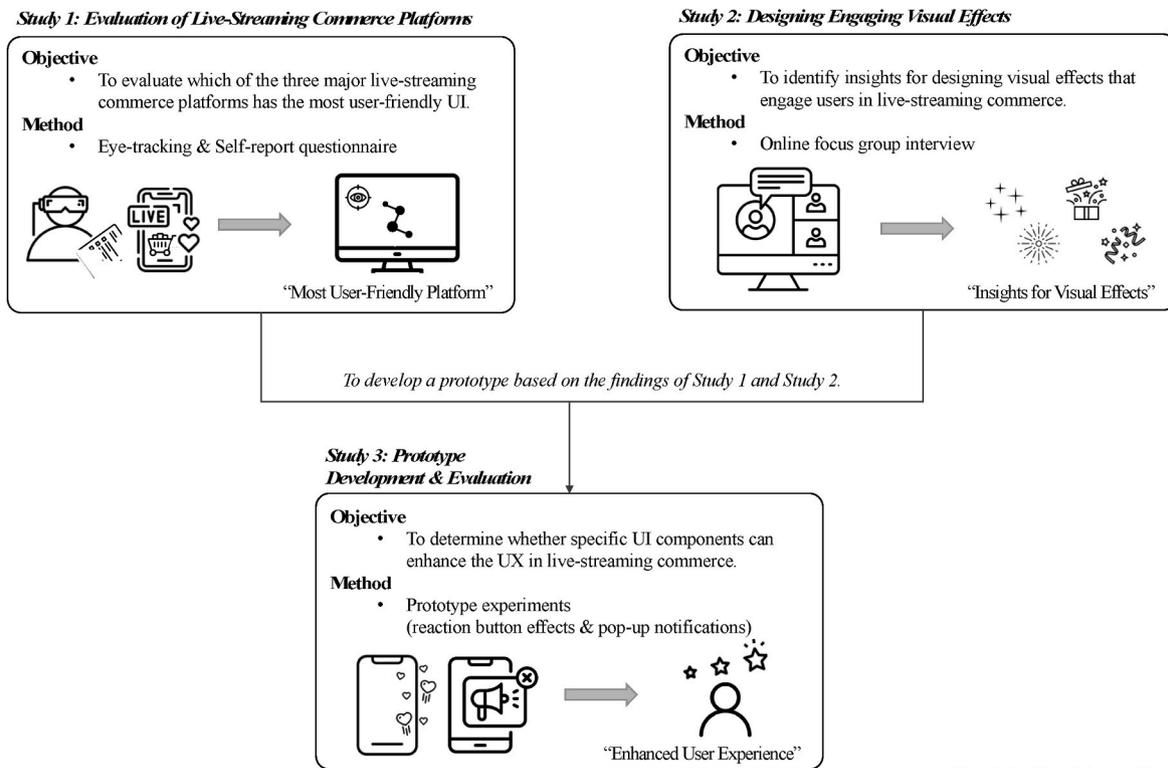


Fig. 1. Research process.

components on the overall user experience in live-streaming commerce.

All studies underwent rigorous ethical review and received approval from the Institutional Review Board (IRB) of the university (IRB No. 7001988-202211-HR-1650-04).

4. Study 1: comparative ui evaluation of live-streaming commerce platforms

The objective of Study 1 was to compare prominent live-streaming commerce platforms in the market, with the aim of determining which platform and specific features users perceive as user friendly. To accomplish this, we devised a user study that incorporated both objective (eye tracking) and subjective (self-report questionnaire) methods based on established research. The following sections provide further details on our approach.

4.1. Method

4.1.1. Participants

For our user study, we established the following participant recruitment criteria: individuals in their 20s and 30s who possessed prior knowledge of and experience with live-streaming commerce and faced no difficulties using the platforms in the experiment. After posting recruitment flyers on our institution’s bulletin board and online community, we enlisted 11 participants (six females and five males) with an average age of 29.87 ($SD = 8.728$). All participants had previous experience with live-streaming commerce, watching shows on average once a week for about 20 min. The participants used various live-streaming commerce platforms in South Korea, such as Naver and Coupang. As compensation for their participation, all participants received a gift certificate worth \$5 USD.

4.1.2. Live-streaming commerce platforms and shows

We needed to select representative live-streaming commerce platforms available in the Korean market, as the study was conducted in Korea (limitations related to this are discussed later in the paper). Based on a report by Nielsen Korea (Nielsen Korean Click, 2021) on live-streaming commerce platforms, we chose Naver (the largest portal site in South Korea, providing various services, including live-streaming commerce), Coupang (an e-commerce site akin to Amazon that also offers live-streaming services), and Grip (the first platform in South Korea specifically designed for live-streaming commerce) for our experiment.

Owing to the significance of real-time interaction between users and hosts in live-streaming commerce shows, we utilized live broadcasts for our experiment. All three platforms offer broadcasts from morning until evening, featuring products such as appliances, clothing, food, cosmetics, and furniture. To maintain consistency, we selected food, generally considered a low-involvement product, as the content for the shows. We reviewed the schedules for these shows beforehand and conducted the experiment on the same day and during a time slot when all three platforms were simultaneously broadcasting food-related content.

4.1.3. Procedure

The user study was conducted as an in-person lab study, with all participants visiting our laboratory to partake in the experiment. Prior to the experiment, participants were briefed on the study and signed a consent form. During the experiment, participants were instructed to use the three live-streaming commerce platforms described above while wearing an eye tracker. Participants underwent calibration for eye tracking before navigating each platform. The testing order of the live-streaming platforms was randomly assigned to each participant. They were then asked to use each platform, focusing on areas they found most useful for gathering information from the platforms’ UIs.

In the practice session, participants were instructed to watch the broadcast and explore the interface freely. During the experiment,

participants performed eight tasks on each platform. These tasks were designed with three specific purposes in mind: to identify their viewing area (Task 1), to observe their interaction with show hosts (Tasks 3 and 4), and to assess their understanding of the screen layout (other tasks). The eight tasks were as follows: (1) Watch the live show for at least 30 s (2) Inform us about the discount rate after receiving a discount coupon. (3) Check the chat and type “annyeonghaseyo” (hello). (4) Locate the reaction button and press it at least six times. (5) Examine the Q&A and notice board. (6) State the name of the current live show in progress. (7) Return to the show after visiting the seller’s page. (8) Add the most expensive product from the show to the cart.

After each exploration session, participants completed a questionnaire (three times in total) about their overall experience using the platforms. Upon completing all experiment sessions, they filled out a demographic questionnaire and participated in brief interviews. The entire experiment lasted approximately 20 min. Tobii Pro Glasses 2 with Lab Pro and an Apple iPhone 12 Pro were employed as the eye tracker and mobile device, respectively.

4.2. Measures

4.2.1. Self-report questionnaire

The self-report questionnaire employed eight measurements, consisting of two control variables and six dependent variables adapted from prior studies to fit the context of live-streaming commerce shows. Since participants did not all watch the same show during the experiment, we used product involvement and show host involvement as control variables to account for the potential impact of the live-streaming commerce show on participants’ responses. For product involvement, we selected two items from a condensed version of the personal involvement inventory used in a previous study (Jang, 2014) that utilized a 7-point Likert scale ranging from strongly disagree (1) to strongly agree (7). To assess show host involvement, we adapted a 15-item scale with three factors (professionalism, credibility, and attractiveness) from Park and Kim (2018), selecting one item from each factor and using the original 5-point Likert scale ranging from strongly disagree (1) to strongly agree (5).

We measured 23 items for the dependent variables, presenting a 7-point Likert scale anchored by strongly disagree (1) and strongly agree (7). The six dependent variables were as follows: continuous intention to use, satisfaction, metavoicing, visibility, shopping guidance, and live-streaming commerce engagement. Continuous intention to use indicated a user’s likelihood of continuing to use new technologies and systems in the future (Hong & Tam, 2006; Jasperson & Zmud, 2005), while satisfaction represented an overall assessment of the experience of purchasing and consuming a good or service over time (Johnson & Fornell, 1991). We adapted and modified four items for continuous intention from Bhattacharjee (2001) and Lim, Kim, Hur, and Park (2019) and four items for satisfaction from Chen, Lu, and Zheng (2020) and Janda, Trocchia, and Gwinner (2002) to fit this study’s context. Furthermore, based on prior research, we selected three factors from the components of IT affordance, metavoicing, visibility, and shopping guidance, measuring each with four items. Metavoicing assessed customers’ ability to engage with product content and sellers (Dong et al., 2016; Dong & Wang, 2018; Majchrzak et al., 2013; Sun et al., 2019), visibility gauged the extent to which product information was made available to customers (Dong et al., 2016; Dong & Wang, 2018; Sun et al., 2019), and shopping guidance evaluated the potential to assist customers in making purchase decisions through personalized services (Dong et al., 2016; Dong & Wang, 2018; Sun et al., 2019). Lastly, we used live-streaming commerce engagement to measure consumers’ participation in events, interactions with show hosts, and experience sharing. We adapted and modified three items from previous studies (Hu & Chaudhry, 2020; Wongkitrungrueng & Assarut, 2020) to suit this study’s context.

4.2.2. Eye-tracking data

Two eye-tracking metrics, task completion time (TCT) and area of interest (AOI) fixation count (AFC), were analyzed using eye-tracking data to examine the interactive elements within the live-streaming commerce platforms, specifically focusing on the chat and response buttons. Among the eight experimental tasks, TCT and AFC were evaluated only for the chat participation and reaction button pressing tasks. TCT referred to the time elapsed from the moment the moderator announced the task to the participant’s completion of it, while AFC represented the number of times the participant’s gaze fixated on a predefined AOI, as determined by the researcher.

The AOI for the chat participation task encompassed the chat window, chat input box (or a button that brings up the chat input box), and keyboard. In contrast, the reaction button and its associated effects constituted the AOI for the reaction button pressing task. These AOIs were determined through continuous adjustments while tracking movements and screen activities, such as keyboard pop-ups, during task completion. Fig. 2 illustrates the specifics of these areas.

4.3. Data analysis

The reliability of the questionnaires was assessed using Cronbach’s alpha (α). The results indicated that the α values for all items, including product involvement ($\alpha = .94$), show host (seller) involvement ($\alpha = 0.90$), satisfaction ($\alpha = 0.86$), continuous intention to use ($\alpha = 0.97$), metavoicing ($\alpha = 0.85$), visibility ($\alpha = 0.90$), shopping guidance ($\alpha = 0.82$), and live-streaming commerce engagement ($\alpha = 0.89$), were above 0.7. For the eye-tracking data, specifically TCT and AFC, a one-way repeated measures ANOVA was conducted to determine the differences between the three live-streaming commerce platforms, followed by a Bonferroni post hoc test.

4.4. Results

4.4.1. Control variables

The results indicated no significant main effect for platform type, as the analysis of product involvement [$F(2, 20) = 0.29, p = .75$] and show host involvement [$F(2, 20) = 1.96, p = .17$] demonstrated. This finding suggests that neither the show host nor the product had a substantial impact on the participants. Detailed results can be found in Tables 1 and 3.

4.4.2. Dependent variables

In Study 1, a significant main effect was observed for TCT [$F(1.30, 13.01) = 4.36, p < .05, \eta_p^2 = 0.304$] and AFC [$F(2, 20) = 5.09, p < .05, \eta_p^2 = 0.337$] of the reaction button pressing task. However, no significant main effects were found for satisfaction [$F(1.27, 12.29) = 0.84, p = .45$], continuous intention to use [$F(2, 20) = 0.68, p = .52$], metavoicing [$F(2, 20) = 1.24, p = .31$], visibility [$F(1.28, 12.75) = 1.25, p = .30$], shopping guidance [$F(1.16, 11.57) = 0.95, p = .36$], live-streaming commerce engagement [$F(2, 20) = 0.69, p = .52$], TCT of the chat participation task [$F(2, 20) = 2.33, p = .14$], or AFC of the chat participation task [$F(2, 20) = 0.77, p = .48$]. We conducted Bonferroni post hoc tests for TCT and AFC of the reaction button pressing task. The former revealed differences between Grip and Naver (95% CI [0.41, 4.89], $p < .05$) and between Grip and Coupang (95% CI [0.16, 5.11], $p < .05$). Meanwhile, the latter confirmed a difference between Grip and Naver (95% CI [0.03, 4.67], $p < .05$). Tables 1, 2, 4 and 5 and Fig. 3 provide more details on these findings.

4.4.3. Fixation images

The eye-tracking data analysis revealed that, during the 30-s watching task, participants’ eye fixations were distributed broadly, but they tended to be concentrated on either the central region or the show host’s face. In contrast, for the chat participation and reaction

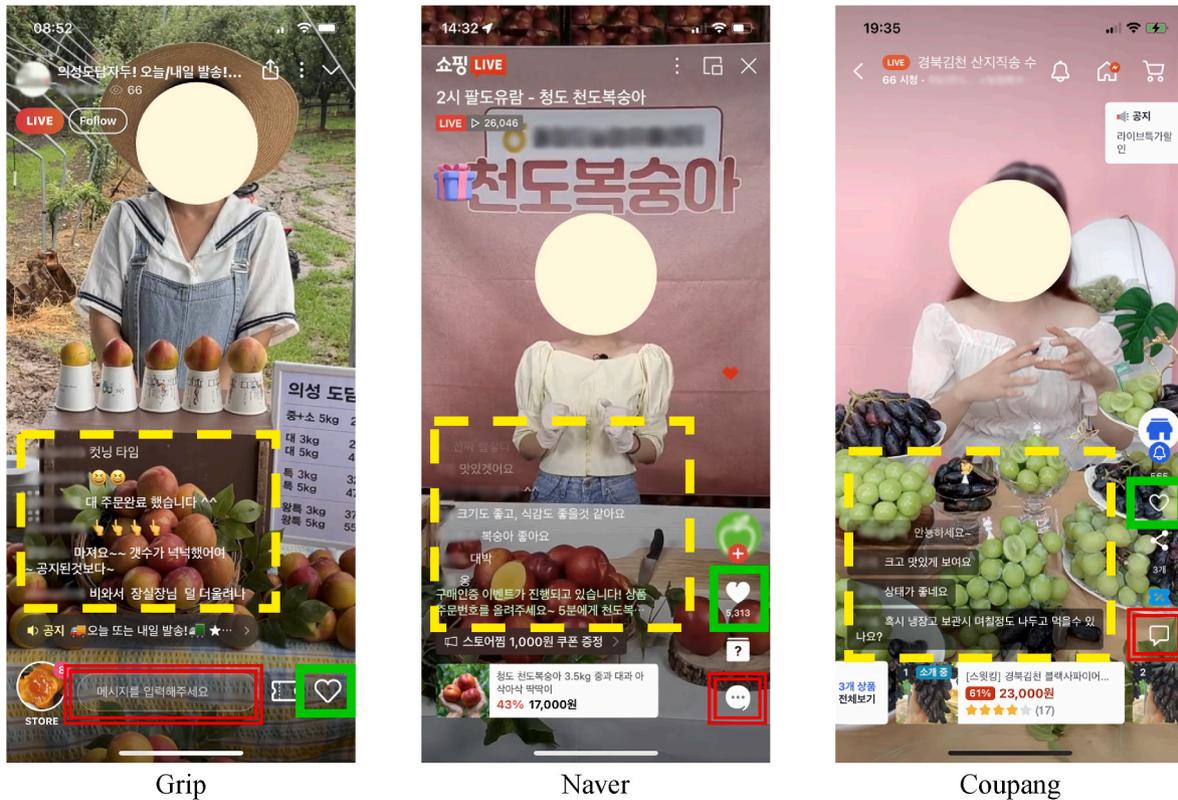


Fig. 2. Examples of AOIs' start points for live-streaming commerce platforms (The red box is the chat input box or a button that brings up the chat input box and keyboard, the yellow box is the chat window, and the green box is the reaction button.).

Table 1
Mean and standard deviation scores in Study 1.

Variables		Grip	Naver	Coupang
Dependent variables	Satisfaction	3.59 (1.020)	3.70 (1.077)	4.14 (1.357)
	Continuous intention to use	3.16 (1.073)	3.30 (1.378)	3.61 (1.610)
	Metavoicing	5.59 (1.286)	5.39 (1.153)	4.89 (1.514)
	Visibility	4.11 (1.411)	4.91 (1.905)	4.89 (1.485)
	Shopping guidance	3.39 (0.585)	3.68 (0.874)	3.89 (1.353)
	Live-streaming commerce engagement	5.82 (1.329)	5.52 (1.485)	5.58 (1.013)
Control variables	Product involvement	3.00 (1.817)	2.82 (1.328)	3.36 (1.762)
	Show host involvement	3.30 (0.875)	3.73 (0.917)	3.85 (1.004)

Table 2
Mean and standard deviation scores in Study 1: Eye-tracking data were measured in terms of seconds for TCT, and the AFC was measured in terms of the number of times.

Variables		Grip	Naver	Coupang
Eye-tracking data	TCT_Chat	10.29 (1.822)	12.65 (2.792)	11.12 (2.471)
	AFC_Chat	7.29 (2.259)	7.31 (2.164)	6.35 (2.740)
	TCT_Reaction button	7.25 (2.295)	9.89 (3.886)	9.88 (4.066)
	AFC_Reaction button	2.89 (1.817)	5.25 (2.501)	5.58 (3.633)

Table 3
Results of one-way repeated measures ANOVA of control variables.

Control variables	Type III sum of squares	F	η_p^2	Bonferroni post hoc test
Product involvement	1.70	.29	.028	–
Show host involvement	1.80	1.96	.164	–

Table 4
Results of one-way repeated measures ANOVA of dependent variables from self-report questionnaire.

Dependent variables	Type III sum of squares	F	η_p^2	Bonferroni post hoc test
Satisfaction	1.82	.84	.078	–
Continuous intention to use	1.20	.68	.063	–
Metavoicing	2.89	1.24	.111	–
Visibility	4.51	1.25	.111	–
Shopping guidance	1.39	.95	.087	–
Live-streaming commerce engagement	.56	.69	.064	–

button pressing tasks, participants' eye fixations were specifically focused on each respective component location. These findings are presented in further detail in Figs. 4–6.

4.5. Discussion

Although no statistical differences were found in subjective measures, all three platforms received low scores for satisfaction and continuous intention to use, indicating an overall unsatisfactory UX.

Table 5
Results of one-way repeated measures ANOVA of dependent variables from eye tracker.

Dependent variables	Type III sum of squares	F	η_p^2	Bonferroni post hoc test
TCT_Chat	31.64	2.33	.189	–
AFC_Chat	6.59	.77	.072	–
TCT_Reaction button	51.04	4.36*	.304	Grip < Naver Grip < Coupang
AFC_Reaction button	47.01	5.09*	.337	Grip < Naver

* $p < .05$.

Additionally, the low IT affordance scores suggest that users encountered challenges while navigating the system, meaning that IT affordance did not effectively facilitate the behaviors users needed (Tuncer,

2021). However, the low scores for shopping guidance affordance may be due to the unavailability of personalized services in live-streaming commerce, and users might prefer interaction through other means for such services (Saffanah et al., 2022). The above-average metavoicing affordance scores for the three platforms may be partly attributed to the influence of the experiment setting, making it difficult to interpret these scores as indicative of efficient buyer–seller interaction. While visibility affordance in live-streaming commerce refers to the ability to present product images and information clearly, there are other visual elements on the screen, which can distract users (Fei et al., 2021). Increasing the number of components on the screen may negatively impact the overall visual experience, reducing user interest. It is crucial for designers to enhance the IT affordance of live-streaming commerce (Dong & Wang, 2018; Saffanah et al., 2022; Sun et al., 2019; Tuncer, 2021) and improve the UI.

Meanwhile, the objective data collected through the eye tracker

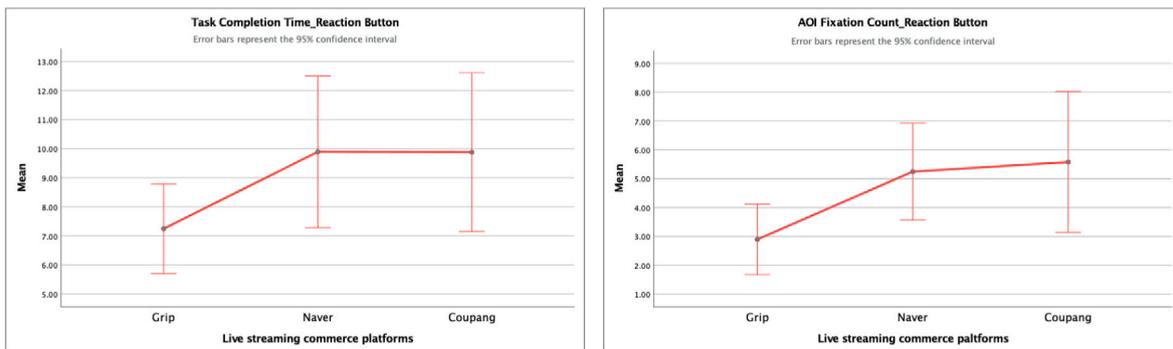


Fig. 3. TCT and AFC results of reaction button pressing task (In TCT, participants using Grip performed the task faster than those using Naver and Coupang. In AFC, Grip received fewer fixations than Naver. The smaller number meant that participants did not have to move their eyes very much to find the reaction button. In other words, Grip showed better usability than the other platforms.).

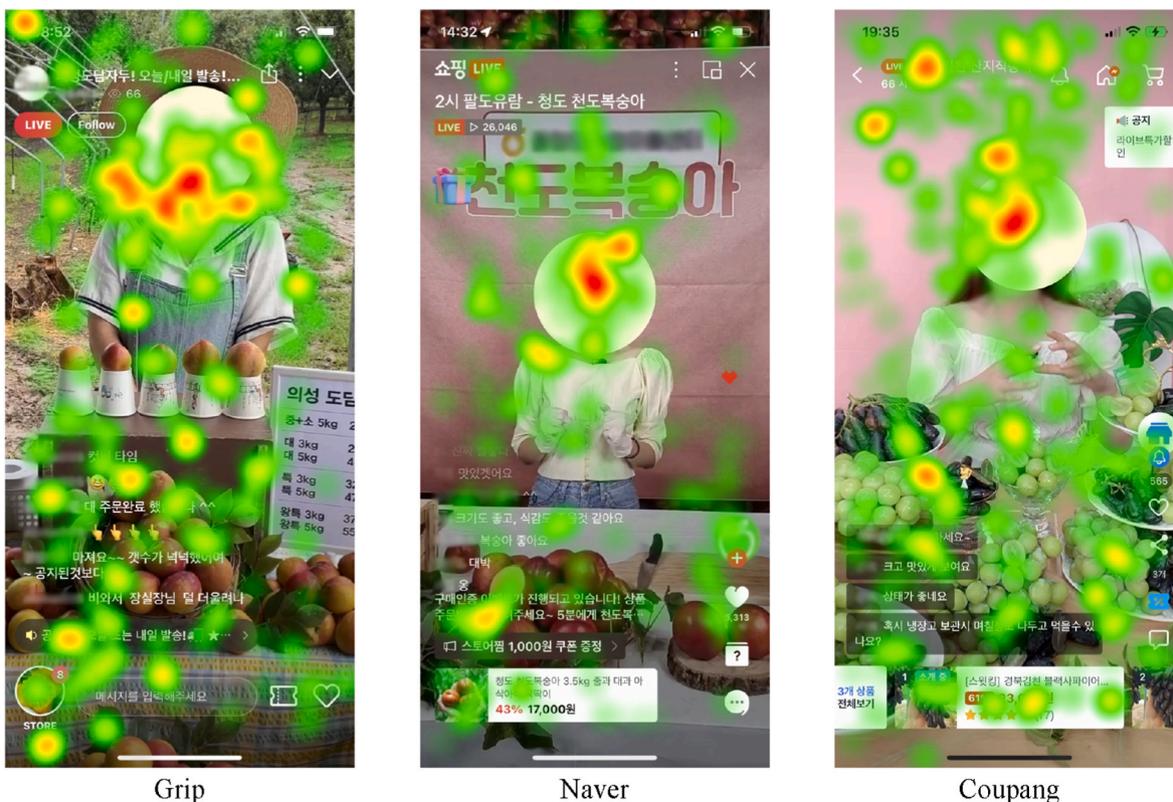


Fig. 4. Heat map of 30-s watching task.

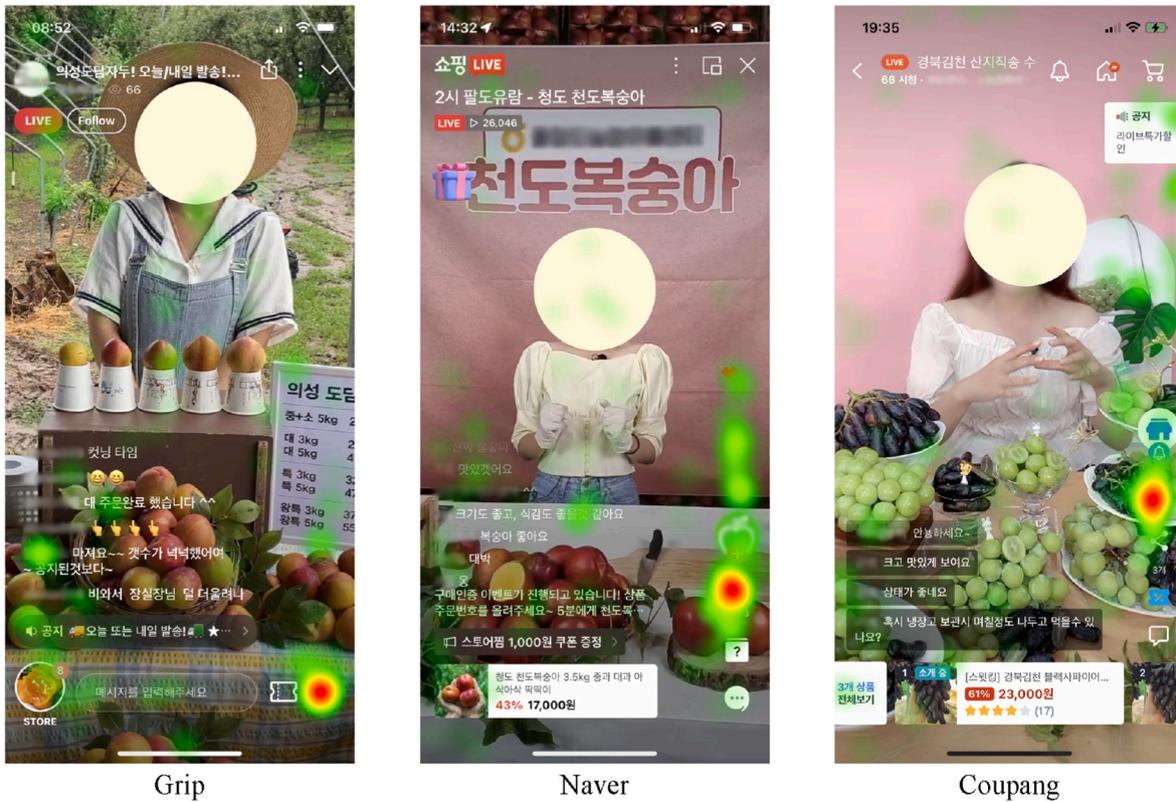


Fig. 5. Heat map of reaction button pressing task.

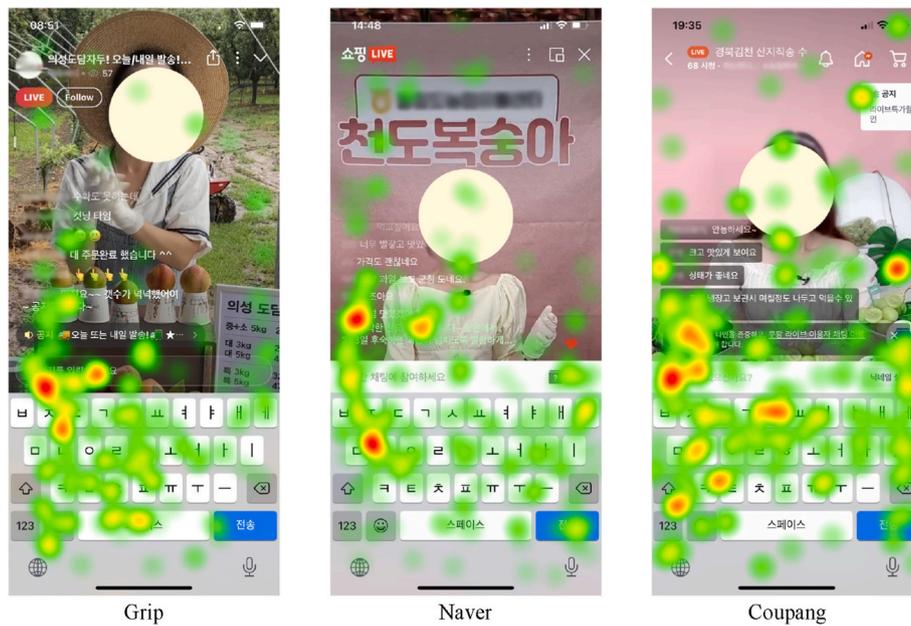


Fig. 6. Heat map of chat participation task.

showed different statistical differences depending on the task. The chat participation task did not yield significant differences due to variations in user preferences. P6 in Study 1 expressed a preference for a chat input box resembling that in Grip, which is easy to use and intuitive with the mental model of another app, stating, “It’s intuitive to have a chat input box like the one in Grip, and it is not difficult because it is similar to Instagram.” In contrast, participants who prioritize a clean interface or use chat less frequently tended to prefer a chat button that can be accessed

on demand. For instance, P12 in Study 1 noted, “I don’t see the need for a chat input box. Simply pressing a button to bring it up is straightforward.”

However, for the reaction button pressing task, there was a noticeable difference between the three platforms. A higher eye fixation frequency indicates greater difficulty or lower efficiency (Cooke, 2006; Wang et al., 2019). Thus, Grip, with a lower AFC and shorter TCT, can be considered more user friendly and convenient than the other two platforms. The ease of finding and pressing Grip’s reaction button seems to

be due to its separation from the other components. Conversely, the reaction buttons in Naver and Coupang are often grouped with or sandwiched between other components, with P2 in Study 1 noting, “I can press the Grip icon right away, whereas Coupang is intuitive but the icon is too small to see well, and Naver is complicated due to the number of components.”

In summary, the overall UX for live-streaming commerce with the most representative platforms in the market received a negative evaluation, indicating potential usability issues that can be improved (Altin Gumussoy, Pekpazar, Esengun, Bayraktaroglu, & Ince, 2022). Among the platforms, while Grip received low ratings in user self-report evaluations, it was most effective in behavioral assessments. Based on the findings and previous research, Grip was chosen as a reference standard for creating a prototype for use in Study 3.

5. Study 2: investigating user engagement strategies through visual effects in live-streaming commerce

Study 1 focused on evaluating the overall UX of widely used live-streaming commerce services, while Study 2 aimed to obtain detailed insights for designing visual effects that could engage users in the context of live-streaming commerce interfaces. To achieve this, online focus group interviews (FGIs) were conducted with frequent users of live-streaming commerce services. By examining their experiences, we sought approaches to encourage increased user participation in live-streaming commerce platforms.

5.1. Method

5.1.1. Participants

For Study 2, we aimed to recruit heavy users of live-streaming commerce, specifically defined as those who had made at least three purchases through live-streaming commerce platforms or watched live-streaming commerce shows more than 15 times. To secure participants who met the recruitment criteria, we posted a recruitment flyer on our institution's bulletin board and utilized snowball sampling simultaneously.

Eight female participants were recruited, with ages ranging from 22 to 31 years ($M = 26.75$, $SD = 2.905$). These participants reported watching live-streaming commerce shows more than once a week. Only one participant did not have any purchase experience, while the others had made purchases more than five times, with three of them having made more than 15 purchases. The participants stated that they often wait for live-streaming commerce shows to make purchases due to the discounts offered and that they had also been receiving notifications about their favorite items. As compensation for their participation, all participants received goods worth \$20.

5.1.2. Procedure

Study 2 utilized online FGIs through Zoom, as it offered enhanced flexibility and accessibility for participants, regardless of their geographical location or time constraints (Janghorban, Roudsari, & Taghipour, 2014). Before conducting the online FGIs, participants were assigned preliminary tasks to familiarize themselves with the three live-streaming commerce platforms (Grip, Naver, and Coupang), which included the chat participation task and reaction button pressing task.

Participants were organized into groups of four, with two researchers participating in each group interview. We explained the experiment and obtained signed consent forms from the participants. The online FGIs were conducted as semi-structured interviews, during which participants shared their experiences and proposed suggestions for enhancing live-streaming commerce services. Each group interview lasted

approximately 60 min and was recorded with the participants' consent.

5.2. Data analysis

A qualitative content analysis approach was applied to analyze the transcripts from the online FGIs (Mayring, 2014). The collected data consisted of 483 responses (Group 1: 274; Group 2: 209), which were recorded in a Google spreadsheet. We divided the transcripts into sentence units and extracted keywords by grouping similar answers. The extracted keywords were combined into more specific categories, focusing on live-streaming commerce interaction and UX. Afterward, we grouped and merged similar keywords to produce three new categories until we reached an agreement.

To ensure the validity of the findings, a data source triangulation process was employed, which involved verifying the analyzed data with multiple sources, such as news articles, online postings, and existing services (Carter, Bryant-Lukosius, DiCenso, Blythe, & Neville, 2014; Flick, 2004). This process helped to strengthen the credibility of the findings and provide a more comprehensive understanding of the participants' experiences and suggestions for enhancing live-streaming commerce services.

5.3. Results

As a result of the FGIs, we were able to discern participants' actions (what they were doing on the platforms), motivations (why they used the platforms), and suggestions (what they desired from the platforms) while engaging with live-streaming commerce. Participants employed various components, such as chat and reaction buttons, to actively participate in the live commerce events. Their primary action involved responding to the show hosts by either conversing with them or pressing the reaction button to generate visual effects. Although they reported using reaction buttons more frequently than the chat feature to convey their responses to the show hosts, they relied on chat to ask questions and engage in events. Despite the chat feature offering opportunities for diverse activities, participants reported using it less frequently than expected. This might be attributed to several factors, including a lack of motivation, wariness about sharing in a public forum, and the absence of direct personal benefits.

Simultaneously, we identified various motivating factors that fostered user engagement with live-streaming commerce. Participants were driven by a desire to express empathy, have fun, or receive rewards, which ultimately led them to continually engage and interact with live-streaming commerce. The chat and reaction buttons allowed participants to spontaneously convey their empathy toward the show hosts. Additionally, show hosts deliberately encouraged audience participation in chat events, which sometimes resulted in rewards for participants. Several individuals utilized the reaction button to amuse themselves by persistently pressing it and creating visual effects.

Furthermore, participants offered suggestions for enhancing the live-streaming commerce experience. They shared their perspectives on the challenges they encountered and proposed modifications they would like to see implemented in live-streaming commerce. Their suggestions were classified into two aspects: business and design. From a business standpoint, participants recommended that live-streaming commerce offer additional incentives, such as discount coupons, complimentary gifts, and raffles, rather than focusing exclusively on entertainment when using chat or reaction buttons. Conversely, from a design perspective, participants suggested integrating more unexpected and captivating elements into the chat and reaction buttons to bolster engagement. These findings are detailed in Table 6.

Table 6

Results of FGIs: ○ indicates that the participants used the component in relation to the theme and keyword, while × indicates that they did not.

Category	Function	Used Interaction Component		Example quote
		Chat	Reaction Button	
Action	Respond to show host	○	○	“The advantage of live-streaming commerce is being able to communicate with the show host.” (P5 in Study 2)
	Ask a question	○	×	“The show host answers questions from viewers posed through chat in real time.” (P3 in Study 2)
	Participate in event	○	×	“I became interested in chat participation after witnessing someone else win an event.” (P2 in Study 2)
Motivation	Empathy	○	○	“I press the reaction button when I empathize with the show host.” (P1 in Study 2) “When another user in the chat asked a question I was interested in, I told them I was curious as well.” (P6 in Study 2)
	Fun	×	○	“I enjoyed the experience because the host responded to the effect of the reaction button I pressed.” (P1 in Study 2)
	Reward	○	×	“I participated in a live-streaming commerce show hosted by a small business owner because it appeared to offer a high chance of winning an event.” (P8 in Study 2)
Suggestion	Serendipity	×	×	“When watching a clothing live-streaming commerce show, it would be more enjoyable if pressing the reaction button produced clothing-shaped instead of heart-shaped visual effects.” (P1 in Study 2) “Currently, the show host only encourages participation (in the chat) through verbal means, but if there was a visual effect, it would be more noticeable.” (P4 in Study 2)
	Benefit	○	×	“I believe I would participate in the chat if there was a definite reward.” (P7 in Study 2) “I do not participate because there is no reward for pressing the reaction button.” (P8 in Study 2)

5.4. Discussion

In Study 2, we assessed users’ awareness and utilization of interactive components in live-streaming commerce via FGIs. The results indicated that although the chat function had high potential for utilization, its actual usage frequency was relatively low. In contrast, the reaction button exhibited low utilization rates but a high frequency of actual use. This suggests that chat and reaction buttons, which are vital elements of interaction in live-streaming commerce, may not be optimally utilized by users. Consequently, it appears that interactivity, a fundamental characteristic of live-streaming commerce, is not being effectively leveraged, and its impact on users’ purchase intention (Lin et al., 2022; Xu et al., 2020) and engagement (Kang et al., 2021) has not been demonstrated as prominently as anticipated.

Currently, the affordance encouraging users to engage in chat within live-streaming commerce relies on show hosts mentioning the chat feature or the presence of chat windows. Sole dependence on these elements may have limitations and could also be burdensome for show hosts. P4 remarked, “If there were visual effects in the chat, wouldn’t it make you want to participate more?” Prior research has demonstrated that pop-up messages in live-streaming commerce are effective in terms of visual affordance among various interface designs and that frequent exposure can be advantageous (Xu et al., 2022). Moreover, the pop-up interface design fosters interaction between the anchor and consumer, enhancing their social engagement (Yang, Ye, et al., 2022). Based on these findings, we decided to develop a pop-up effect to encourage chat participation for use in Study 3. However, as the ideal proportion of on-screen pop-ups remains undetermined, we aimed to investigate this aspect in Study 3.

Simultaneously, the FGI findings revealed the need to incorporate serendipity into interactive elements to cater to participants’ desire for fun and enjoyment, significant motivators for using and engaging with live-streaming commerce. Previous studies have also emphasized the importance of eliciting positive emotions in users, such as happiness and joy, for live-streaming commerce (Cai & Yvette Wohn, 2019; Ho et al., 2022; Lee & Chen, 2021; Li et al., 2022; Lin et al., 2022; Lv et al., 2022; Xue et al., 2020). Typically, the reaction button in live-streaming commerce platforms generates a heart-shaped effect, a familiar visual across social media platforms like Instagram, YouTube, and Twitter (Bucher & Helmond, 2018). While the familiarity of this effect may provide an advantage (Yablonski, 2020), it needs to incorporate serendipity, as users find it too ordinary and uninteresting. P1 stated, “The heart is too predictable. I need something new.” Previous research has also

demonstrated that positive emotions like happiness and joy can significantly influence purchase behavior during live-streaming commerce (Li et al., 2022; Lin et al., 2022). Furthermore, when products align closely with the live commerce platform’s scene style, consumers may experience an enhanced sense of presence, increasing the likelihood of product purchases (Yang, Ye, et al., 2022). In light of these findings, we devised unique effects that correspond with the commerce context and appeal to users, considering various elements. As part of our designed effects in Study 3, we implemented product-related effects that reflected participants’ suggestions and were relevant to commerce.

Additionally, our results align with previous research indicating that live-streaming commerce users feel close to show hosts and are influenced by their engagement in the show (Kim & Heo, 2021; Lu & Chen, 2021; Wongkitrungrueng & Assarut, 2020). The virtual space provided by live-streaming platforms also plays a crucial role in enhancing user engagement (Yang, Ye, et al., 2022). The design of this space has the potential to impact the platform’s brand image and improve users’ brand experience (Wang et al., 2022). Specifically, the visual and interactive features of live streaming have been identified as factors contributing to the establishment of a positive brand image for the platform (Ho et al., 2022; Wang et al., 2022).

Based on the aforementioned research, we hypothesized that visually exposing users to the platform’s branding could enhance user participation and positively impact the platform’s image. Moreover, we theorized that incorporating a serendipitous aspect could provide users with unexpected experiences beyond the traditional heart symbol, so we included a brand-related effect in our visual effects design for Study 3.

In conclusion, Study 2 revealed the importance of optimizing interactive components, such as chat and reaction buttons, to better engage users in live-streaming commerce. Our findings highlighted the need to incorporate serendipitous and visually engaging elements that not only pique users’ interest but also encourage participation. In Study 3, we aimed to further investigate the ideal proportion of on-screen pop-ups and implement unique product and brand-related effects to enhance users’ experiences and interactions within live-streaming commerce platforms.

6. Study 3: evaluating the impact of ui components for enhanced ux in live-streaming commerce

Drawing on insights from Studies 1 and 2, Study 3 aimed to determine whether specific UI components could improve the UX of live-streaming commerce. To achieve this goal, we developed a live-

streaming commerce prototype featuring visual effects derived from the findings of Studies 1 and 2. We then designed a user study in which participants engaged in a series of tasks involving interaction with the reaction button and chat area.

6.1. Method

6.1.1. Participants

For Study 3, we recruited participants with prior experience in using live commerce, as we had done in Studies 1 and 2. Following the same recruitment procedures, we enrolled 46 participants (30 females and 16 males), aged between 23 and 37 years ($M = 28.43, SD = 7.258$). Five of these participants participated in a pilot test, where they evaluated questionnaires and prototypes. All participants reported typically watching live-streaming commerce shows for approximately 10 min per week and using various platforms available in South Korea, such as Naver, Coupang, and Grip. Each participant received goods worth \$5 as compensation for their involvement.

6.1.2. Experiment design

In Study 3, we devised two experiments based on the findings from Studies 1 and 2. The first experiment centered on the impact of the reaction button, while the second aimed to encourage users' chat participation. To facilitate these experiments, we designed a live-commerce prototype using ProtoPie, largely adhering to the UI of Grip, which was deemed the most user-friendly platform in Study 1. For the prototype, we created a fictitious brand called Honeybee Commerce, which simulated selling *tteokbokki*, a popular Korean dish.

Drawing from the findings of Studies 1 and 2, as well as previous research on live commerce, we designed Experiment 1 as a mixed-subject design with two factors: the shape of the visual effects (heart vs. product vs. brand) and the number of visual effects (one vs. six) associated with the reaction button (Fig. 7). As the brand we designed for the experiment was called Honeybee Commerce, the brand shape resembled a honeybee. Before evaluating the brand effects, we introduced Honeybee's concept and brand images to participants. The product-related effect incorporated images of foods commonly consumed with *tteokbokki* in South Korea (Fig. 7). We also varied the number of visual effects (one vs. six). To determine the number of effects displayed on screen, we continuously referenced various live-streaming platforms and graphic effects used on social media, such as YouTube, Instagram, and TikTok, with a minimum of one and a maximum of six. By combining these factors, we created six experimental conditions: OH (one heart effect), OP (one product effect), OB (one brand effect), SH (six heart effects), SP (six product effects), and SB (six brand effects). Further details can be found in Fig. 8.

Experiment 2 was designed as a within-subjects study, consisting of four conditions concerning the visual effect size of pop-up notifications: 0% (no effect), 20%, 50%, and 80% of the prototype screen's width. It was based on AOIs identified by participants during the 30-s viewing task in Study 1. The effect size was expressed as a percentage of the area where the user's attention was focused, with 0% signifying no effect and 20%, 50%, and 80% representing the proportion of the visual effect relative to the area. Although no absolute criterion exists for the ratio of

the pop-up window to the mobile screen, we set the minimum pop-up size to 20% by referring to Google's 2016 guidelines and the maximum size to 80% (Phan, 2016). Based on the findings of Study 2, we created and employed pop-up effects consisting of GIF (graphics interchange format) animations that depicted a gift box opening and a message popping out. The details are presented in Fig. 9.

6.1.3. Procedure

Before participating, participants were provided with information about the experiment and asked to sign a consent form. They were informed that they would partake in two separate experiments and were introduced to a fictitious brand named Honeybee Commerce. We assigned 25 participants to each of the six conditions of the reaction button experiment based on the number of effects. In Experiment 1, participants were exposed to all three conditions of effect shape, with the exposure order randomly assigned to each participant. Similarly, each participant was randomly exposed to all four conditions for effect size in Experiment 2. We randomized the order of conducting the reaction button pressing and chat participation experiments to minimize the impact of live-streaming commerce content on participants.

In the reaction button pressing experiment, participants were required to press the reaction button at least five times while watching the live-streaming commerce show. In the chat participation experiment, participants were asked to engage in events through chat whenever requested during the live-streaming commerce show. After experiencing each experimental condition, participants completed a questionnaire. Following each experiment, they were asked to choose their most and least preferred conditions and provide a reason for their choices as an open-ended question. After completing both experiments, participants filled out a demographic questionnaire. The entire procedure took approximately 30 min to complete.

6.2. Measures

In the questionnaires, four measurements were used to examine the effectiveness of the visual components, which included pop-up notifications and interactive animations: serendipity, satisfaction, arousal, and hedonic consumption. A 7-point Likert scale was presented, anchored by strongly disagree (1) and strongly agree (7), and a total of 14 items were measured.

Serendipity is defined as a positive and unexpected experience arising from valuable interactions with ideas, information, objects, or phenomena (McCay-Peet et al., 2015). To measure serendipity, three items from previous studies were adjusted to suit the study context (McCay-Peet et al., 2015; McCay-Peet & Toms, 2022). Satisfaction was defined as a comprehensive evaluation of the experience of purchasing and consuming a product or service over time (Johnson & Fornell, 1991). Three items from previous research were adapted for this study to evaluate satisfaction (Chen et al., 2020; Janda et al., 2002). Arousal was defined as the degree of stimulation and activity experienced by users during live-streaming commerce (Mehrabian & Russell, 1974; Xu et al., 2020). Hedonic consumption referred to the pleasure and enjoyment users experienced while shopping via live-streaming commerce (Alba & Williams, 2013; Hirschman & Holbrook, 1982; Xu et al., 2020). Four

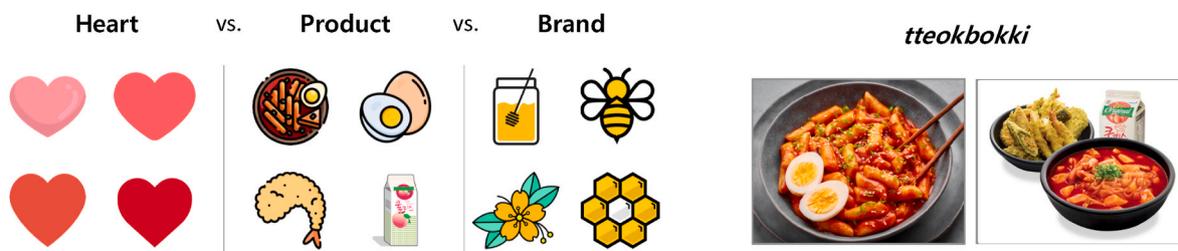


Fig. 7. The left shows the shape of the visual effects. The right image is *tteokbokki* that is a popular Korean dish.

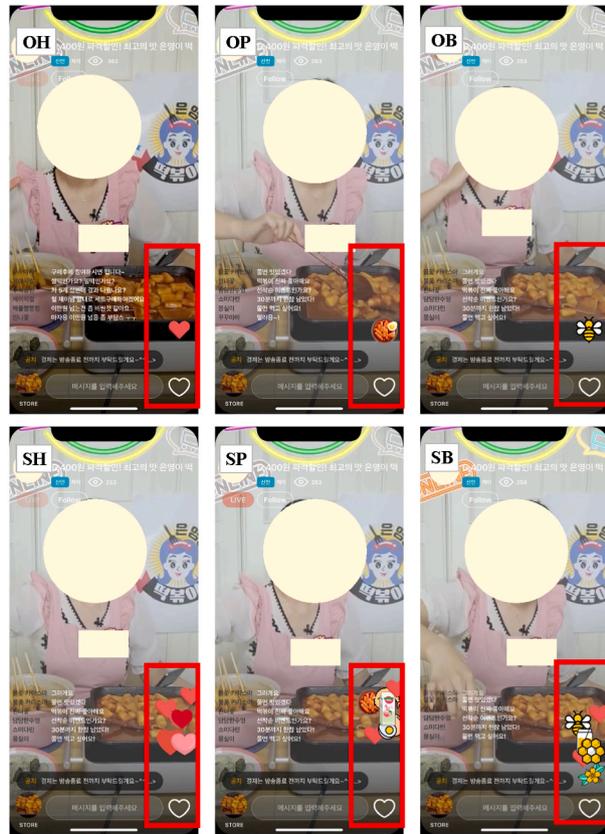


Fig. 8. Experiment 1 in Study 3 (The left image depicts our fictitious brand and its brand images. The right image shows the six possible effect combinations when a participant presses the reaction button.).

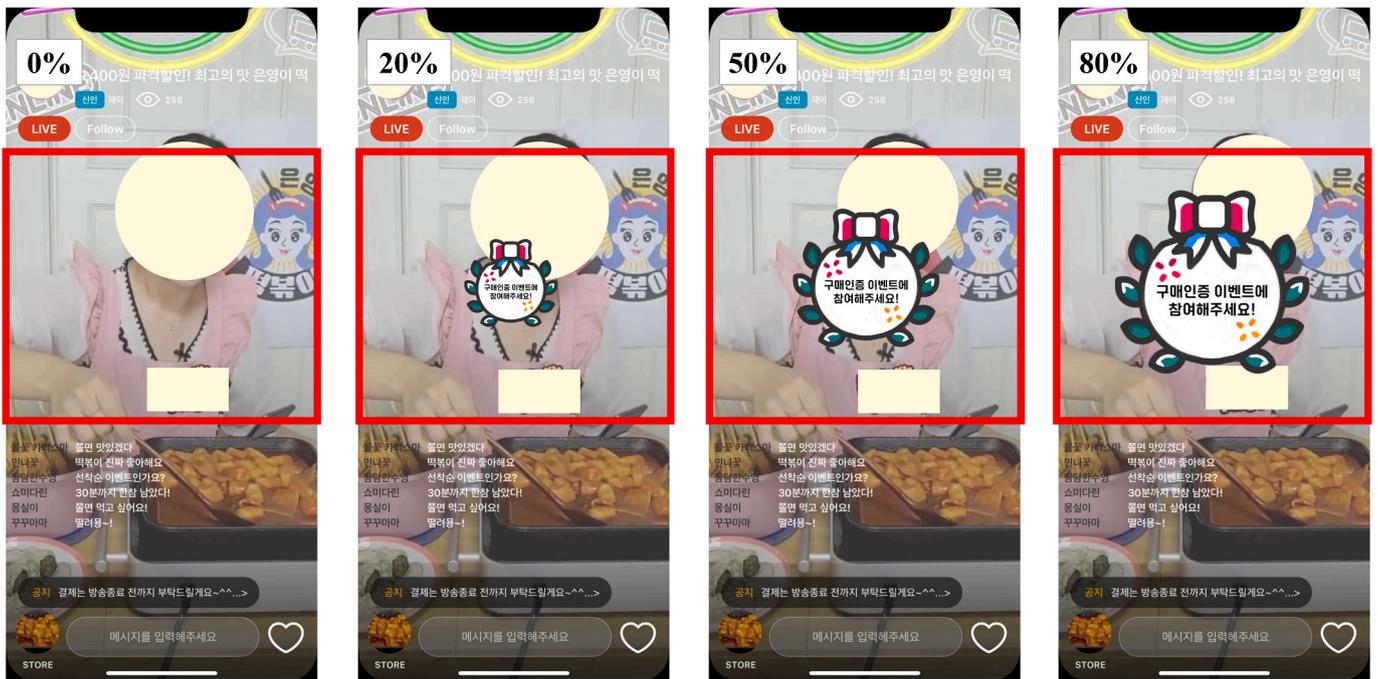


Fig. 9. Experiment 2 in Study 3 (The image shows the four possible sizes of pop-up notifications encouraging users to participate in an event. The red box is the area where the users' attention was concentrated in the 30-s watching task of Study 1. In Experiment 2, a GIF image containing the sentence "Please participate in the purchase event!" was used as the effect.).

items each from a previous study were adjusted to fit the study context for measuring arousal and hedonic consumption (Xu et al., 2020).

6.3. Data analysis

To evaluate the reliability of the questionnaires, Cronbach’s α was calculated for each of the four measurements: serendipity, satisfaction, arousal, and hedonic consumption. All items demonstrated high reliability, with Cronbach’s α values above 0.7: serendipity ($\alpha = 0.86$), satisfaction ($\alpha = 0.92$), arousal ($\alpha = 0.94$), and hedonic consumption ($\alpha = 0.95$).

For data analysis, in Experiment 1, a two-way repeated measures ANOVA was employed, followed by a Bonferroni post hoc test to determine any significant differences between the conditions. In Experiment 2, a one-way repeated measures ANOVA was used for data analysis, followed by a Bonferroni post hoc test to identify significant differences between the conditions.

6.4. Results

6.4.1. Experiment 1 Reaction button

The results of the two-way repeated measures ANOVA in Experiment 1 showed that the effect shape and the number of effects influenced participants differently. The main effect of effect shape was significant for all scales: serendipity [$F(2, 88) = 40.66, p < .001, \eta_p^2 = 0.480$], satisfaction [$F(2, 88) = 4.72, p < .05, \eta_p^2 = 0.097$], arousal [$F(2, 88) = 6.47, p < .01, \eta_p^2 = 0.128$], and hedonic consumption [$F(1.82, 80.24) = 10.63, p < .001, \eta_p^2 = 0.195$]. Similarly, the main effect of the number of effects was significant for all scales: serendipity [$F(1, 44) = 7.13, p < .05, \eta_p^2 = 0.139$], satisfaction [$F(1, 44) = 4.42, p < .05, \eta_p^2 = 0.091$], arousal [$F(1, 44) = 7.96, p < .01, \eta_p^2 = 0.153$], and hedonic consumption [$F(1, 44) = 5.06, p < .05, \eta_p^2 = 0.103$].

A significant interaction effect between the effect shape and the number of effects was observed only for serendipity [$F(2, 88) = 3.11, p < .05, \eta_p^2 = 0.066$]. A Bonferroni post hoc test showed that the one-product shape produced significantly higher serendipity scores than the one-heart shape (95% CI [1.29, 2.77], $p < .001$) and the one-brand shape produced significantly higher serendipity scores than the one-heart shape (95% CI [1.06, 2.33], $p < .001$). Moreover, the six-product shape produced significantly higher serendipity scores than the six-heart shape (95% CI [0.62, 2.11], $p < .001$), and the six-brand shape produced significantly higher serendipity scores than the six-heart shape (95% CI [0.12, 1.39], $p < .05$). These results suggest that participants experienced more feelings of serendipity with the product and brand shapes compared to the heart shape when there were six effects instead of one. The mean and standard deviation of the scores for each dependent variable can be found in Table 7, while ANOVA details are presented in Table 8 and Fig. 10.

6.4.2. Experiment 2 Chat participation

In Experiment 2, a one-way repeated measures ANOVA showed that the effect size had a significant main effect on all scales: serendipity [$F(2.14, 96.46) = 88.61, p < .001, \eta_p^2 = 0.663$], satisfaction [$F(2.19, 98.35) = 51.37, p < .001, \eta_p^2 = 0.533$], arousal [$F(1.99, 89.66) = 41.35,$

Table 7
Mean and standard deviation scores in Experiment 1.

Dependent variable	One effect			Six effects		
	Heart	Product	Brand	Heart	Product	Brand
Serendipity	3.59 (1.105)	5.62 (1.156)	5.29 (.950)	4.67 (.969)	6.03 (.910)	5.42 (1.011)
Satisfaction	4.42 (1.505)	5.41 (1.015)	4.35 (1.297)	5.00 (1.078)	5.42 (1.334)	5.01 (1.237)
Arousal	4.00 (1.236)	4.86 (1.175)	4.32 (1.317)	4.63 (.932)	5.33 (1.010)	5.02 (.953)
Hedonic consumption	3.95 (1.174)	3.95 (1.175)	4.587 (1.217)	4.60 (1.212)	4.60 (1.212)	5.15 (1.179)

Table 8
Results of two-way repeated measures ANOVA in Experiment 1.

	Dependent variable	Type III sum of squares	F	η_p^2
Effect shape	Serendipity	70.48	40.66***	.480
	Satisfaction	15.80	4.72*	.097
	Arousal	13.930	6.47**	.128
	Hedonic consumption	24.24	10.64***	.195
Number of effects	Serendipity	9.92	7.13*	.139
	Satisfaction	6.09	4.43*	.091
	Arousal	12.48	7.96**	.153
Effect shape * Number of effects	Hedonic consumption	9.39	5.06*	.103
	Serendipity	5.40	3.11*	.066
	Satisfaction	2.88	.86	.019
Number of effects	Arousal	.34	.16	.004
	Hedonic consumption	.56	.25	.006

*** $p < .001$, ** $p < .01$, * $p < .05$.

$p < .001, \eta_p^2 = 0.479$], and hedonic consumption [$F(1.93, 86.91) = 41.60, p < .001, \eta_p^2 = 0.480$].

Further analysis using the Bonferroni post hoc test for each dependent variable revealed significant differences between all conditions for serendipity and hedonic consumption. However, for arousal, significant differences were observed between all conditions except for 0% vs. 20% and 50% vs. 80%. For hedonic consumption, significant differences were found between all conditions except for 50% vs. 80%. The mean and standard deviation of the scores for each dependent variable can be found in Table 9, while ANOVA details are available in Table 10 and Fig. 11.

6.5. Discussion

The results of Study 3 showed that both pop-up notifications and interactive animations positively impacted users in the context of live-streaming commerce. In particular, the study found that visual effects with serendipity can be highly appealing to users. When compared to the traditional heart effects, product and brand effects were perceived as unexpected discoveries and were more attractive.

In Experiment 1, we found that multiple product effects on the reaction button provided users with the highest level of emotional stimulation and satisfaction. Participants in Study 3 expressed that unexpected effects and product effects increased their desire to press the reaction button. Serendipity appears to be high with product effects since they can offer a variety of visual effects depending on the product being sold, making them expect something new to appear if they press the reaction button. Moreover, participants stated that the product-related effects increased their purchase intention: “Effects related to the product I am currently looking at make me want to buy it” (P25 in Study 3). These findings suggest that interactive animations with serendipity can encourage users to stay engaged with live-streaming commerce shows by providing product information reminders and potentially eliciting purchase intention. The study also confirmed that brand effects were more effective for users than heart effects, highlighting the potential of

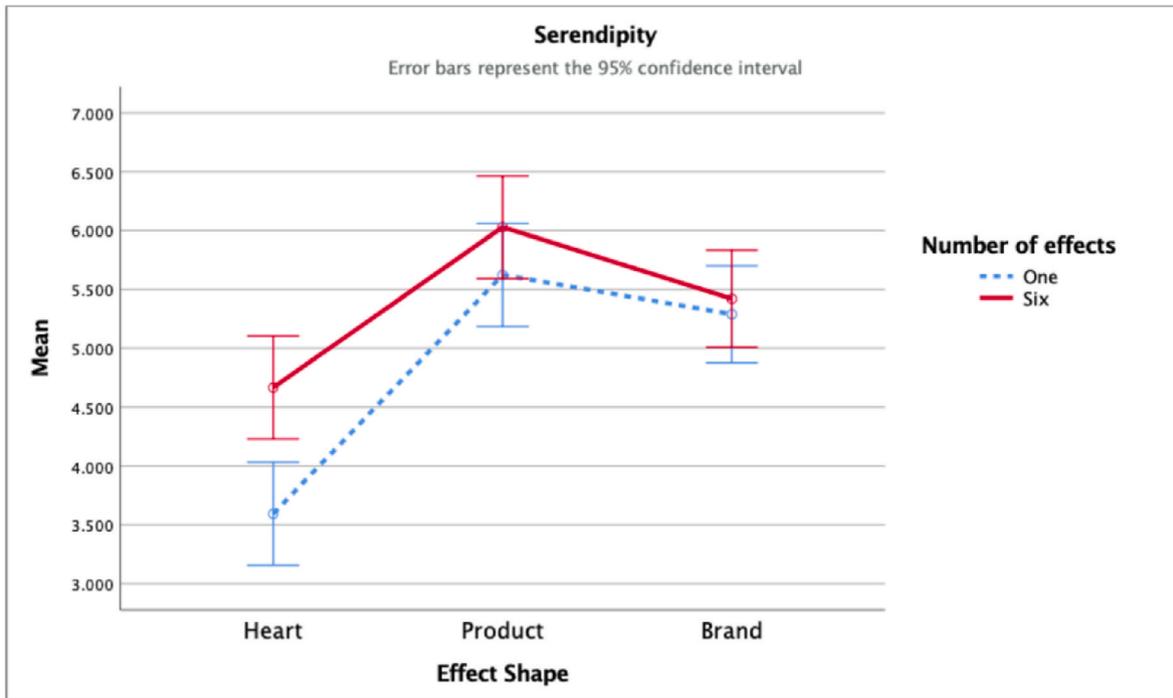


Fig. 10. Interaction effect of serendipity in Experiment 1.

Table 9
Mean and standard deviation scores in Experiment 2.

Dependent variable	Effect size			
	0%	20%	50%	80%
Serendipity	2.70 (1.421)	4.17 (1.321)	5.48 (.893)	6.03 (.924)
Satisfaction	2.69 (1.383)	3.29 (1.310)	5.10 (.953)	5.36 (1.192)
Arousal	2.99 (1.412)	3.79 (1.338)	4.85 (1.101)	4.93 (.990)
Hedonic consumption	2.94 (1.574)	4.00 (1.417)	5.00 (1.055)	5.36 (.915)

Table 10
Results of two-way repeated measures ANOVA in Experiment 2.

Dependent variable	Type III sum of squares	F	η_p^2	Bonferroni post hoc test
Serendipity	303.60	88.61***	.663	0% < 20% < 50% < 80%
Satisfaction	229.93	51.37***	.533	0% < 50%, 80% < 20% < 50%, 80%
Arousal	117.76	41.35***	.479	0% < 20%, 50%, 80% < 20% < 50%, 80%
Hedonic consumption	163.18	41.60***	.480	0% < 20% < 50% < 80%

***p < .001.

interactive effects to influence platform brand image and enhance users' brand experience.

Experiment 2 revealed a significant difference between no/smaller pop-up notifications (0% and 20%) and larger ones (50% and 80%). Notifications that occupied 50% or more of the available screen space elicited emotional stimulation and significant satisfaction among users. Additionally, the study found that as the size of pop-up notifications increased, both serendipity and hedonic consumption also increased, indicating a potential alignment between user needs and the usefulness

of pop-up notifications. These findings corroborate prior research indicating the advantages of interacting with bullet information, such as pop-up messages (Wang et al., 2022; Xu et al., 2022). However, users preferred no pop-up notifications to ones that occupied only 20% of the screen since the latter were considered too small, making the information provided difficult to see or read. The satisfaction variable supported these findings, suggesting that while pop-up notifications can be effective in inducing positive emotions in users as visual stimuli, they must occupy more than 50% of the screen to have a significant positive impact on user satisfaction.

In summary, the findings from Study 3 provide valuable insights into the design of visual elements in live-streaming commerce platforms. The study highlights the importance of incorporating serendipity into interactive animations, such as product and brand effects, to enhance user engagement, satisfaction, and potential purchase intention. For pop-up notifications, the study emphasizes the need to balance their size to ensure optimal visibility and legibility without obstructing the user's view of the live-streaming content. Designers should consider pop-up notifications that occupy at least 50% of the screen space to provide users with a satisfactory experience while also conveying essential information effectively.

Moving forward, it would be beneficial for future research to explore other visual elements and their impact on UX in live-streaming commerce as well as the potential long-term effects of these design features on user engagement and purchase behavior. By continuing to investigate the impact of visual components in live-streaming commerce, designers and platform developers can create more effective and engaging experiences for users, ultimately leading to increased platform success and consumer satisfaction.

7. Implications

The results of this research indeed provide interesting insights into interface design and components on live-streaming commerce platforms for researchers.

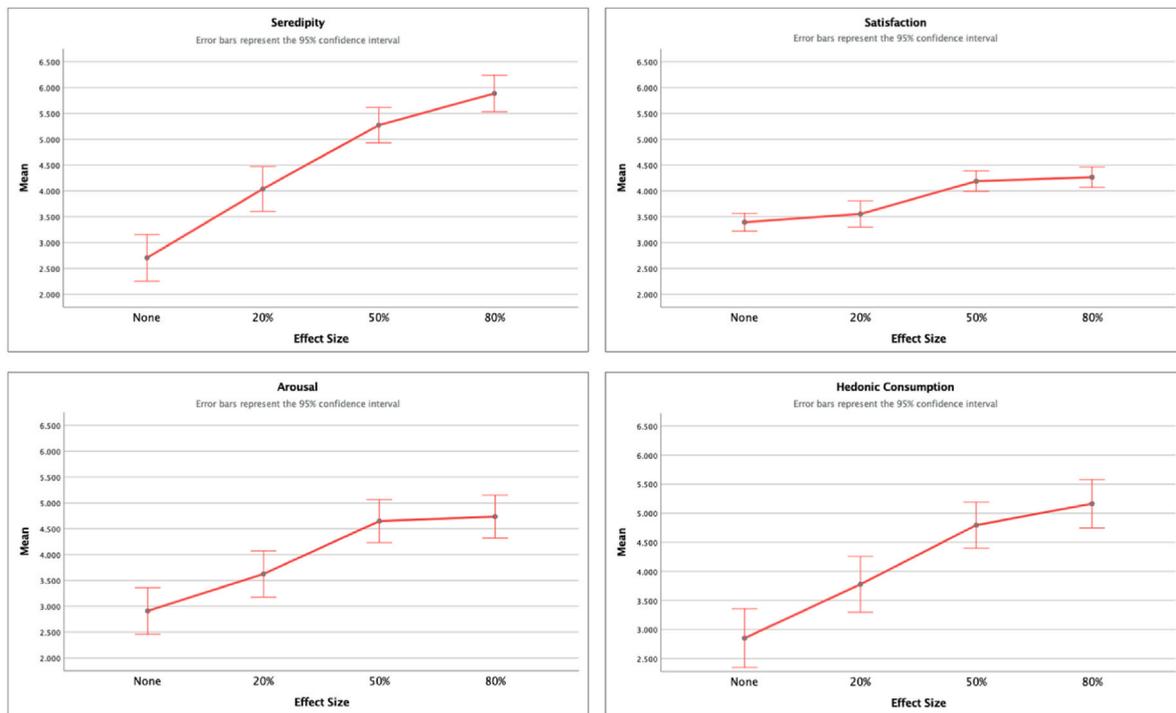


Fig. 11. Results of experiment 2.

7.1. Research implications

The academic contributions of this research can be summarized as follows:

Serendipity in live-streaming commerce: The study highlights the importance of serendipity in live-streaming commerce and supports prior research on creating emotionally positive experiences during consumption (Cai et al., 2018; Cai & Yvette Wohn, 2019; Ho et al., 2022; Lee & Chen, 2021; Li et al., 2022; Lin et al., 2022; Lv et al., 2022; Wang & Wu, 2019; Xu et al., 2020; Xue et al., 2020; Yang et al., 2022a). It demonstrates that serendipity can lead to increased satisfaction, user engagement, and interactivity, ultimately affecting purchase decisions. Therefore, it suggests it can boost users' immersion in the shows and interaction with the hosts as a result.

Appealing interface design and atmosphere: The research underscores the value of an appealing interface design and atmosphere in enhancing users' positive emotions and motivation to engage in live-streaming commerce. It builds upon and supports the conclusions of previous research (Xu et al., 2022; Yang, Ye, et al., 2022) by investigating the positive effects of pop-up notifications and visual effects (brand- and product-related) on UX. These findings provide a foundation for future investigations in this area.

Combination of subjective and objective methods: The study evaluated three live-streaming platforms using both subjective and objective methods, such as IT affordance and eye tracking, demonstrating the importance of combining these approaches for a comprehensive understanding of UX. Our findings support the notion that subjective and objective measures of UX can complement each other to provide a more comprehensive understanding (Altin Gumussoy et al., 2022; Wang et al., 2019), emphasizing the need for integrating objective measures in UX evaluations to accurately identify user behaviors and preferences.

Overall, this research offers valuable insights for academics and practitioners alike, contributing to the understanding of live-streaming commerce interface design, UX, and the role of serendipity in enhancing user engagement and satisfaction.

7.2. Practical implications

This research provides valuable and practical guidance for live-streaming commerce platform companies and designers, offering strategies to enhance UX, brand promotion, and product sales. Key recommendations include the following:

Novel visual effects on reaction buttons: Implementing product- and brand-related effects can foster positive UX, stimulate curiosity and interest, and increase engagement with the reaction button. This can add considerable appeal to users' visual experiences, while varying alterations can stimulate and encourage users to use the reaction button, depending on the product being sold. Displaying multiple effects simultaneously can be more attention-grabbing than showing just one effect.

Brand promotion through reaction buttons: The growing live commerce market has led to the emergence of various platforms, making it crucial for service providers to establish and promote their brand image to users. Platforms can utilize brand-related effects to promote their brand, enhance interactivity, and increase users' sense of immersion and brand experience. However, they should ensure that the exposure is maintained at an appropriate frequency to avoid adverse effects.

Simplification of the live-streaming commerce interface: Too many elements on a screen can frustrate users (Fei et al., 2021) and make using the service difficult. Platforms should reduce the number of components on the screen to create a more user-friendly, convenient, and intuitive interface. They should arrange components so they do not overlap with the middle area or the show's host face, where users' gaze is primarily focused.

Effective use of pop-up notifications: Platforms should employ pop-up notifications to attract users' attention and encourage participation. They should ensure that pop-ups occupy a minimum size of 50% of the screen for a more satisfying UX. The use of visual stimuli along with verbal prompts by show hosts may be more effective at encouraging user participation. This approach is crucial for promoting engagement and ensuring accessibility for all users.

By following these recommendations, live-streaming commerce

platforms can create more engaging and enjoyable experiences for users, ultimately leading to increased interactivity, brand recognition, and sales.

7.3. Limitations and future directions

This study has several limitations that should be considered. Firstly, the research was confined to live commerce platforms in South Korea, limiting the generalizability of the findings to other countries. Future research should examine UX in live-streaming commerce across a more diverse range of nations. Secondly, the interaction design experiment was conducted using our prototype rather than an actual commerce show, which did not provide a natural context for users to engage in genuine live-streaming commerce. Thus, further research is required to ascertain the effectiveness of actual shows' interaction design. Collaborating with live-streaming commerce platforms may enable such practical evaluations. Thirdly, the study focused only on interaction-related elements among the various components of live-streaming commerce, warranting further exploration of other aspects. Additionally, although this research concentrated on users already familiar with live-streaming commerce, users unfamiliar with this new type of commerce must be studied to enhance the service.

8. Conclusions

This research delved into the UX in live-streaming commerce by evaluating pertinent platforms and discerning user needs through online FGIs. Furthermore, we developed a prototype incorporating visually engaging effects based on these insights and assessed its impact on UX. Our investigations demonstrated that serendipitous visual effects can significantly augment the consumption experience for users in the live-streaming commerce context. In doing so, we bolstered the domain of interface design research within live-streaming commerce, offering valuable insights to academics and researchers. These findings provide essential guidance for developers and designers of live-streaming commerce platforms, ultimately fostering enriched UX.

Credit author statement

All authors contributed equally to various aspects of the research, including Conceptualization, Methodology, Investigation, and Formal Analysis. We also jointly interpreted the results and approved the final manuscript. While we collaborated closely on all aspects, specific contributions of each author were particularly notable in the areas mentioned below: **Hyorim Shin**: Writing - Original Draft, Writing - Review & Editing, Data Curation, Visualization, Funding Acquisition. **Changhoon Oh**: Writing - Review & Editing, Resources, Visualization. **Na Young Kim**: Software, Resources, Funding Acquisition. **Hobin Choi**: Data Curation, Validation, Funding Acquisition. **Boyoung Kim**: Validation, Data Curation, Funding Acquisition. **Yong Gu Ji**: Supervision, Project Administration.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Hyorim Shin, Nayoung Kim, Hobin Choi, Boyoung Kim reports financial support was provided by the Institute of Convergence Science (ICONS) at Yonsei University.

Data availability

Data will be made available on request.

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