International Journal of Electronic Commerce Studies
Vol.16, No.4, pp.27-58, 2025
doi: 10.7903/ijecs.2544

Understanding How Danmaku Platform Amplifies Emotional Responses of Users that Leads to Platform Engagement: Based on Social Presence Theory Combined with SOR Model

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ABSTRACT

This study investigates the emotional mechanisms that influence user engagement on Danmaku, a popular participatory video platform in China, by integrating social presence theory and the S-O-R framework. Survey data from 242 users were analyzed using partial least squares structural equation modeling. The results show that the amplification of surprise ($\beta = 0.215$*) and sadness ($\beta = 0.140$**) significantly enhances the interactive atmosphere, whereas happiness ($\beta = 0.019$, n.s.) and anger ($\beta = 0.089$, n.s.) have no significant effect, providing only partial support for the initial hypotheses. The interactive atmosphere subsequently increases the consciousness of copresence ($\beta = 0.453$***) and user engagement with Danmaku ($\beta = 0.340$***), with R^2 values of 0.139, 0.206, and 0.384, respectively. Moderation analysis reveals that long-term users are more influenced by anger amplification, while short-term users respond more to surprise and sadness. These findings highlight the asymmetric effects of discrete emotions on social engagement dynamics and offer practical implications for designing emotionally adaptive features in participatory media environments.

Keywords: Danmaku, Emotional amplification, Multidimensional social presence theory, SOR model

1. INTRODUCTION

In recent years, live chat systems have rapidly gained worldwide popularity, becoming crucial tools for customer service. Businesses are turning to live chat technology to enhance customer satisfaction and operational efficiency [1]. The utilization of real-time chat in e-commerce, social media, education, and healthcare sectors has significantly risen, showcasing its broad applicability and growth potential.┐ Social media video

[1] This research was supported by Hankuk University of Foreign Studies Research Fund.

platforms, such as YouTube Live, have also incorporated live chat features. YouTube Live viewers can send messages through the chat window next to the video, allowing real-time interaction via adjacent scrollable comments. The host can quickly review and act on these messages, creating a communal atmosphere among the audience [2].

In East Asia, a special form of live chat system called Danmaku has gained distinctive popularity (see Figure 1). Danmaku is a real-time commenting system where viewer-generated messages appear as continuously scrolling subtitles across the video screen [3]. It can be regarded as a reimagined version of the original content, blending informational and entertainment elements provided by both the video creator and its viewers [4]. Viewers can post on-screen comments through the Danmaku system, which are displayed in sync with designated moments in the video playback. This feature enables viewers to interact with the video and with each other by reading and quoting comments from other viewers simultaneously [5]. Danmaku-enabled videos foster a co-viewing experience, allowing viewers to feel connected and interact with peers, thereby enhancing community and engagement [3].

Figure 1. A screenshot of Danmaku's comments in a video ZOOTOPIA from

***Danmaku** comments from users are largely overlapped with the scenes*

www.bilibili.com

The significance of social presence on online Danmaku video platforms has been well acknowledged, yet the impact of Danmaku-generated social presence on consumers' intrinsic psychological states and behavior remains understudied. Compared with traditional video comments, which are usually placed in a comment box under the video, Danmaku comments display a higher proportion of emotional expressions [6]. When exposed to such synchronous overlaps, participants may experience a heightened sense of unity compared to using adjacent scrolling [7]. Given these differences, we suggest applying a three-dimensional model of social presence theory to comprehend the Danmaku system [8]. This model identifies three dimensions of social presence relevant to online communities: affective social presence, cognitive social presence, and awareness. These dimensions correspond to the three characteristics of Danmaku's comments: expression of emotion, interactive communication, and consciousness of copresence. Furthermore, to understand how Danmaku website features affect user behaviors, we employ the Stimulus-Organism-Response (SOR) framework as a

theoretical lens [9]. This framework postulates that external stimuli (i.e., website features) affect the internal state of an organism (i.e., consumer), which in turn generates a response (i.e., consumer actions).

The paper proceeds with the following structure. The following section presents a literature review covering Danmaku usage, the social present theory, the SOR model, and recent developments in related fields. Section three introduces a research model that explains how the emotional responses of the Danmaku users are led to platform engagement through the development of the atmosphere of interaction and copresence consciousness. Section four outlines the methodology used in this study. Section five presents the hypothesis test results. Finally, Section six discusses the summary of findings, academic contributions, and practical implications of the work.

2. THEORETICAL BACKGROUND

2.1 Motivations for Danmaku Participation

Researchers have investigated the factors motivating viewers to engage with Danmaku videos from various theoretical perspectives, notably including social presence theory and the stimulus-organism-response (SOR) model. For instance, Liu et al. (2016) integrated media synchronicity theory with the SOR framework to examine the media functionalities of Danmaku systems. Their study identified transmission speed, parallelism, symbol sets, rehearsability, and reprocessability as critical factors enhancing interactivity, which ultimately influenced users' immediate intentions to share and engage with Danmaku [10]. Similarly, Wang et al. (2019) applied the SOR model to explore the drivers of user participation in Danmaku on live streaming platforms [11]. Zhao et al. (2017), combining uses and gratifications theory with social presence theory, revealed that copresence serves as a primary motivation for viewers to watch Danmaku videos [12]. Based on uses and gratifications theory, Li and Guo (2021) employed online surveys to demonstrate that social presentation and information sharing are significant motivators influencing the frequency of Danmaku posting [13]. Yang et al. (2022) further showed that Danmaku's technological features enhance social presence through immersion, which positively affects consumer loyalty intentions [14]. Moreover, Liao et al. (2023), drawing on social presence theory, identified emotionality, fragmentation, entertainment, and media characteristics—such as interactivity, synchrony, anonymity, and supplementation—as key factors driving Danmaku viewership [15]. Xi and Choe (2023), utilizing uses and gratifications theory, found that cognitive needs, emotional gratification, individual integration, social cohesion, and stress alleviation significantly motivate Danmaku usage [16]. In a scenario-based quasi-experiment, Liu et al. (2023) demonstrated that communication behaviors enhance viewers' sense of presence, which in turn fosters value co-creation; this relationship is moderated by objective platform attributes [17].

Despite these advances, most existing studies predominantly employ unidimensional social presence theories and consequently fail to capture the complex, dynamic interactions between individual user characteristics and Danmaku usage behaviors. Danmaku represents a unique interactive system whereby user comments are displayed

in real time, scrolling horizontally across the video interface, thereby enabling dynamic and synchronous interactions among viewers [18]. This real-time overlay distinctly differs from traditional static or delayed feedback mechanisms, as well as from general impressions or retrospective comments [19]. However, few studies have effectively integrated the multidimensional conceptualization of social presence with the SOR model to systematically elucidate how Danmaku's technological affordances influence user behavior via underlying psychological processes.

To bridge this theoretical gap, the current study proposes an integrated approach combining the three-dimensional construct of social presence with the S-O-R framework. This integrated approach aims to offer a comprehensive understanding of the psychological mechanisms underpinning Danmaku interactions and their consequent effects on user behavioral outcomes.

2.2 Recent Developments in Related Fields

2.2.1 Temporal Dynamics of Danmaku

Recent studies have increasingly examined the temporal dynamics of Danmaku, highlighting its unique dual-time dimensions and their influence on user engagement. Chen et al. (2022) differentiate between video time, referring to the point in the video when Danmaku comments are displayed, and post time, indicating when users submit their remarks, highlighting the multi-layered temporal dynamics embedded in Danmaku interactions [20]. Building on this, Zhang et al. (2025) examine how temporal indicators influence narrative involvement on online video platforms [21]. They explore two aspects: time—represented by viewer metrics showing how many people have previously or are currently watching—and timing, which pertains to whether Danmaku comments appear at random moments or align with key story developments. The study concludes that highlighting previous viewer data, instead of real-time counts, and presenting Danmaku comments at unspecific moments rather than plot-relevant ones, significantly enhances users' sense of social presence, thereby promoting deeper engagement. Furthermore, Yuan et al. (2025) integrate social presence theory with information overload theory to demonstrate that the overall volume of Danmaku comments exerts a stronger effect on user engagement than the emotional valence of the comments themselves [22]. These outcomes reinforce the notion that the interplay between the timing and frequency of Danmaku comments plays a pivotal role in shaping users' sense of social presence and levels of engagement.

2.2.2 Social Presence in the Metaverse and Virtual Reality Environments

Insights from studies on metaverse and virtual reality (VR) environments offer valuable parallels for understanding the social presence fostered through Danmaku systems. The emotional and behavioral outcomes observed in immersive spaces provide evidence that social presence—comprising cognitive, affective, and behavioral dimensions—is a powerful driver of user engagement and social connection. For instance, higher levels of social presence within metaverse platforms correlate with increased supportive social

behaviors among users [23] and elevate customer engagement that translates into stronger purchase intentions in virtual retail contexts, moderated by individuals' sense of self-efficacy [24]. Emotional attachment fostered by these immersive environments also promotes repeated use and loyalty, suggesting that virtual spaces can effectively replicate real-world social habits [25].

Furthermore, immersive design elements such as vivid interaction, embodiment, and cues of co-presence are found to strengthen emotional bonds and a shared sense of "being with others" [26,27], dynamics that resonate closely with the real-time, participatory nature of Danmaku. Research in social VR platforms has additionally linked social and self-presence to perceived social support and subjective well-being, with gender differences observed in these perceptions [28]. The enhancement of mental imagery, immersive experience, and revisit intention through social presence has been evidenced in niche applications of VR, including virtual wine tourism [29], while affective touch in virtual interactions further promotes co-presence and alleviates isolation [30].

Collectively, these findings identify social presence as a dynamic, emotional catalyst, shaping perception, influencing behavior, satisfaction, and emotional connection. For Danmaku platforms, which similarly rely on immediate, shared textual expressions, this body of research reinforces the significance of real-time emotional interaction, participatory engagement, and identity expression in cultivating a vibrant sense of connectedness, comparable to that in VR and metaverse experiences.

2.2.3 AI-Mediated Emotion

The increasing prevalence of artificial intelligence in emotionally charged communication contexts has raised pressing questions about authenticity, affect regulation, and the evolving nature of interpersonal connection. Rather than merely facilitating message transmission, AI systems are now actively involved in shaping emotional content and mediating user perceptions. For instance, users tend to perceive limited or selective use of AI tools in sensitive communication—such as apologies—as more genuine, suggesting that technological restraint can enhance emotional authenticity [31]. This underscores a growing awareness that emotional resonance in AI-mediated communication is not only a matter of content but also of intention, control, and perceived human presence.

The emotional effects of interacting with AI also extend to domains such as education and mental well-being. Research on chatbot usage indicates that these tools can support users' emotion regulation processes and even contribute to psychological well-being, particularly when integrated into structured learning environments [32]. However, emotional engagement with AI systems is not uniformly positive. Teachers navigating AI-mediated classrooms, for instance, report complex emotional landscapes—experiencing both heightened motivation and pervasive anxiety [33]. This duality reflects the ambivalent emotional terrain that AI introduces into human-centered practices.

Concerns about emotional authenticity persist when AI-generated content attempts to simulate human subjectivity. AI-authored narratives, especially those mimicking personal experience, are often perceived as fundamentally inauthentic, challenging users' trust in

mediated emotional expression [34]. In response to these complexities, the AI-Mediated Intimacy Economy [35] offers a theoretical framework for understanding how AI technologies reshape affective labor, deepen or disrupt emotional ties, and necessitate regulatory safeguards for emotional data and digital identities.

This body of research reveals a shifting paradigm: emotion in digital spaces is no longer solely human-generated but increasingly co-constructed through AI mediation. For Danmaku platforms, which rely on the immediate broadcast of emotional reactions across users, this raises critical parallels. Just as AI systems amplify or shape emotional tone and perception, Danmaku's synchronous, emotionally charged messages contribute to a shared affective environment that influences engagement, presence, and communal interpretation. Understanding how these emotional dynamics unfold in both AI-mediated and user-generated environments is essential for capturing the full scope of digital emotion today.

2.3 Social Presence Theory for Danmaku Use

Social presence refers to the perceived salience of others within mediated environments and the interpersonal dynamics that emerge as a result [36]. It is considered an inherent characteristic of a communication medium. While most of the existing studies on social presence in Danmaku platforms use a single dimensional perspective and have primarily focused on either telepresence or social presence, emphasizing the sense of being surrounded by others [37], Shen and Khalifa (2008) proposed a three-dimensional framework of social presence specifically designed for online communities, aiming to offer a more nuanced understanding of user participation in such environments [38]. This model delineates three key aspects of social presence: awareness, affective social presence, and cognitive social presence. Awareness reflects a user's perception that others are present and capable of responding, which is cultivated through consistent engagement in online discussions, such as posting comments or messages [38][39]. Affective social presence captures the emotional resonance that emerges from virtual social interactions. Emotional engagement is considered fundamental to experiencing presence in digital settings. Lastly, cognitive social presence refers to a user's ability to interpret, construct, and confirm meaning within social exchanges, as well as to make sense of their relationships and the broader social environment [38].

2.4 Stimulus-Organism-Response (SOR) Model for Danmaku System

The S-O-R framework posits that environmental stimuli (S) affect individuals' internal psychological states (O), which in turn determine their behavioral responses (R)[40]. Several studies have applied the SOR framework to Danmaku video websites [40],[41],[42]. For instance, Fan et al. (2017) examined how Danmaku characteristics affect users' co-experience and content consumption [40], while Zhang and Sun (2018) explored differences between viewing and posting Danmaku behaviors [42]. In this study, emotions act as stimuli, significantly influencing user behavior. Basic emotions like happiness, anger, surprise, and sadness are fundamental drivers of behavior [43]. The

"organism" refers to internal processes mediating the influence of stimuli on responses [44], including perceptual, physiological, sensory, and cognitive activities [45]. This study explores viewers' cognitive states on the sense of presence in participatory video platforms through the atmosphere and conscious co-presence. The model characterizes response as the outcome of affective and cognitive processing, manifesting in subsequent choices and actions [46]. This study focuses on consumer attitudes and behaviors, particularly engagement and active Danmaku participation [5], validating the SOR model's interconnectedness and supporting this study's rationale.

3. HYPOTHESES DEVELOPMENT

3.1 Understanding Danmaku from a Three-dimensional Social Presence Theory Perspective

According to social presence theory, affective social presence refers to the degree to which a user's emotional connection is stimulated through virtual social interactions with others. Real-time comments can amplify users' emotions [47], which helps explain the emotional intensification observed in Danmaku. Emotions such as happiness, anger, and sadness easily evoke emotional resonance among Danmaku users, who may subsequently experience and express these emotions themselves [48]. Surprise is also a prevalent emotion in Danmaku, with substantial research indicating its significant impact on customer experience [49, 50].

To capture the core emotional responses conveyed through Danmaku, this study focuses on four representative emotions: happiness, sadness, anger, and surprise. These emotions were selected not only for their high frequency and psychological salience in online interactions but also for their distinct statistical characteristics in emotional anomaly detection. Specifically, in social media environments, while emotions such as happiness and sadness tend to follow normal distribution patterns, anger and surprise show significant deviations from normality, indicating greater emotional volatility and anomaly potential. This distinction between normative (statistically typical) and atypical (statistically deviant) emotional states enhances the sensitivity and explanatory power of sentiment analysis frameworks in dynamic, user-driven environments such as Danmaku [51].

Posting Danmaku comments is a common user behavior during significant video segments, such as turning points, climaxes, and finales. These comments serve various purposes, including preparing audiences for upcoming events, increasing suspense, highlighting significant moments, and encouraging collective participation in important aspects of the show [52]. Users communicate with each other to create a sense of tension, excitement, and other exciting feelings, finally forming an interactive atmosphere. It can be explained by cognitive social presence. Based on this characteristic of Danmaku, cognitive social presence is redefined as the atmosphere of interaction.

Danmaku comments on online platforms such as streaming sites bring a dynamic element to the viewing experience, with comments often flowing across the screen and disappearing, creating a sense of transience. This visuality of transience enhances the

interaction between users and the content, providing a unique and immersive experience [52]. At this time, the Danmaku can give people the feeling of watching it with other people [12]. It can be explained by awareness of social presence. We redefine the concept of awareness as the conscious copresence in social presence theory. The concept of Danmaku is shown in Table 1.

Table 1. Key concepts in Danmaku were developed from social presence theory

Social Presence Theory Dimensions	Experiences in the Danmaku System	Descriptions
Affective social presence	Amplifications of emotions	Various emotions, such as happiness, surprise, anger, and sadness, expressed by other users are shared and amplified through the Danmaku systems.
Cognitive social presence	Building an Interactive Atmosphere	The atmospheres of interactions are created and developed through communication among the Danmaku users.
Awareness of social presence	Conscious of Copresence	Danmaku users feel like they're watching videos together; hence, the feeling of copresence is created.

3.2 How Emotional Amplifications of Danmaku Users Lead to Platform Engagement

Emotional amplification during Danmaku viewing—particularly of emotions such as happiness, surprise, anger, and sadness—triggers affective resonance among users, which enhances their sense of social identification and intensifies the desire for emotional expression and interaction. This process fosters a lively atmosphere of interaction, characterized by reciprocal emotional feedback, synchronous affect, and emergent collective mood states. As emotional exchanges accumulate, users increasingly perceive a sense of copresence—the subjective feeling of watching and reacting "with others" in real time, which fulfills socio-relational needs such as belongingness and social connection. This perceived copresence, in turn, deepens users' emotional attachment to the platform and increases platform engagement. The specific mechanism is illustrated in Figure 2.

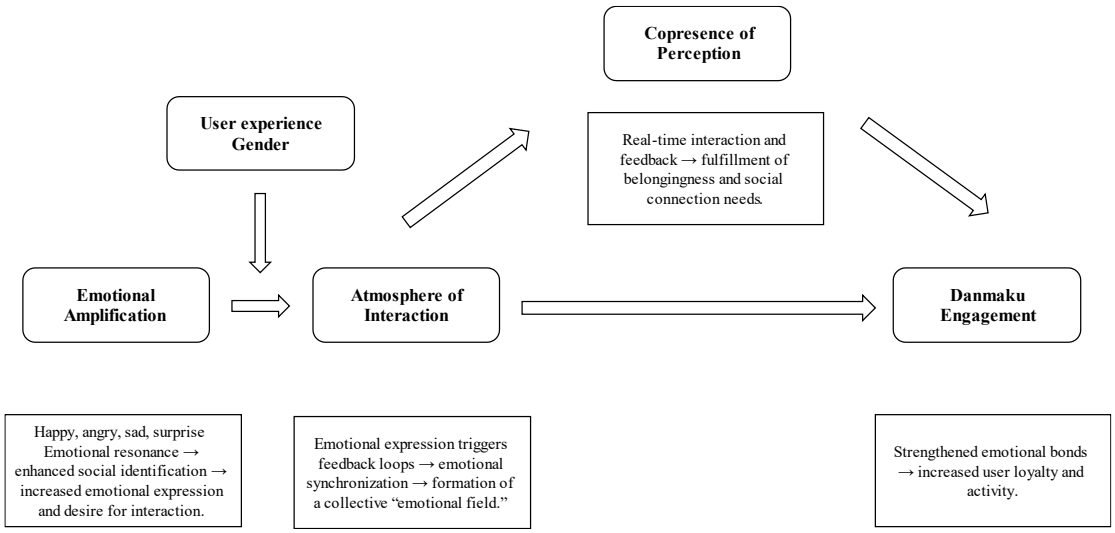

Figure 2. Mechanism of Emotional Amplification and Its Impact on Danmaku Engagement

The conceptual model depicted in Figure 3 illustrates the hypotheses, which are further elaborated in the subsequent section for testing and discussion. Individuals sharing emotional events with others tend to assess the emotional responses of others. If their emotions are validated by others, their emotional experience is intensified [53]. The dynamic nature of place evolves as shared attention synchronizes consumers' emotions and actions, giving rise to interactive displays of collective effervescence [54]. When people watch Danmaku, a form of interactive video content, they experience amplified emotions due to shared emotional experiences, leading to the creation of an interactive atmosphere [4]. Social connectedness has been recognized as a significant predictor of participants' attitudes and their frequency of watching Danmaku videos, with the enjoyment of an interactive atmosphere cited as the primary motivation for engaging with such content. As emotional responses intensify, individuals become more likely to interact with others via features like Danmaku, thereby enhancing perceived interactivity. Therefore, the study proposes the following hypotheses:

H1a: The amplification of the happiness emotion of a participatory video platform user positively affects the atmosphere of interaction in these platforms.

H1b: The amplification of the surprise emotion of a participatory video platform user positively affects the atmosphere of interaction in these platforms.

H1c: The amplification of the anger emotion of a participatory video platform user positively affects the atmosphere of interaction in these platforms.

H1d: The amplification of the sad emotion of a participatory video platform user positively affects the atmosphere of interaction in these platforms.

Danmaku offers viewers the opportunity to engage in real-time social interactions through IT features. Danmaku comments allow for a "pseudo-synchronic" co-viewing experience, where viewers can read comments from others who have watched the same video, creating distinct, fleeting, yet impactful interactions with fellow users through Danmaku

comments [4]. Users can post comments during specific moments in the video, which are then displayed at that exact time, enhancing the sense of 'liveness' [53] and strengthening the feeling of copresence with other 'live' audiences. Thus, we put forward the following hypothesis:

> **H2:** The atmosphere of interaction in a participatory video platform positively affects the consciousness of copresence perception in the platforms.

When viewers are exposed to a large number of floating Danmaku comments on the screen, they are often motivated to join in, especially if the content resonates with their beliefs or interests. This sense of community encourages users to either participate in or continuously engage with the Danmaku. Previous research demonstrates that interactive engagement contributes significantly to the sustained utilization of Danmaku services. The various features of the Danmaku system, such as its speed, ability to display multiple comments simultaneously, range of symbols, options for rehearsing, and flexibility, all contribute to increased interactivity. The enhanced level of interactivity subsequently affects users' propensity to share content and their intention to keep engaging with the Danmaku system [10]. Based on this reasoning, we propose the following hypothesis:

> **H3:** The atmosphere of interaction in a participatory video platform positively affects engagement in the platform.

A sense of copresence, defined as the subjective feeling of being together and interacting with others in a shared environment, fulfills fundamental relational needs and relates to increased life satisfaction [55]. In digital and immersive contexts, social presence indicators correlate positively with active, constructive, and interactive cognitive engagement [56]. Copresence also promotes cognitive empathy, enhancing understanding and connection among users [57]. In participatory video platforms featuring Danmaku, real-time comments, and live chats provide immediate social feedback, reinforcing users' perception of not watching alone. This interaction creates a shared viewing environment, amplifying the sense of copresence. Such shared presence increases emotional attachment and commitment to the platform, fostering higher engagement levels [12]. Based on these insights, we hypothesize:

> **H4:** The consciousness of copresence in a participatory video platform positively affects engagements in the platform.

3.3 The Moderating Effect of Danmaku Experience

The engagement duration with technology by an individual, commonly referred to as user experience [58], plays a vital role in shaping user beliefs. These beliefs are crucial perceptions that influence the utilization of information technology and may evolve as users gain more experience [59]. Prior studies have shown that firsthand experience promotes learning and gradually alters users' cognitive and emotional perceptions regarding the adoption and use of information technology [60-62]. The influence of user experience as a moderator has been explored in various research studies. Empirical studies indicate that familiarity with media use may boost users' confidence in their

capabilities [63], implying that increased experience or time spent using different social media platforms can boost users' inclination to interact with site functionalities.

Anger ranges from mild irritation to intense rage, involving distinct neural pathways and hormonal signals [64]. Its expression is shaped by genetic and environmental factors [65,66]. Longer exposure to digital content increases emotional processing and behavioral activation [67]. Users immersed in participatory platforms encounter more emotion-evoking content, raising the likelihood of emotional expression. Adolescents spending over three hours daily on games show higher addiction and stress (Rajab et al., 2020). Extended social media use during vulnerable periods heightens emotional instability and irritability [68,69]. Increased gaming addiction correlates with greater aggression and anger [70]. These patterns suggest that platform duration intensifies emotional expression, especially anger. Thus, longer usage may strengthen the link between anger amplification and perceived interaction atmosphere.

It would be valuable to investigate how the user experience on websites and the frequency of visits to Danmaku sites impact emotions and interaction dynamics, leading to the hypothesis:

> **H5a:** Longer usage of participatory video platforms strengthens the relationship between the amplification of the happiness emotion and the atmosphere of interaction.
>
> **H5b:** Longer usage of participatory video platforms strengthens the relationship between the amplification of the surprise emotion and the atmosphere of interaction.
>
> **H5c:** Longer usage of participatory video platforms strengthens the relationship between the amplification of the anger emotion and the atmosphere of interaction.
>
> **H5d:** Longer usage of participatory video platforms strengthens the relationship between the amplification of the sad emotion and the atmosphere of interaction.

3.4 The Moderating Effect of Gender

Demographic factors, particularly gender, significantly shape user behavior on social media platforms [71]. Men and women differ in emotional responsiveness: women are typically more influenced by affective stimuli, while men’s behaviors are more cognitively driven [63]. Women prioritize relational and emotional needs, whereas men are more achievement-oriented [72] and tend to experience greater positive emotions and benefit more from these experiences [73]. In emotional expression, men are more likely to express high-arousal emotions such as anger, while women more frequently express emotions linked to vulnerability, like sadness and fear [2]. Societal perceptions reinforce these patterns, associating happiness, surprise, sadness, and fear with women, and anger, contempt, and pride with men [74,75]. Neurobiological evidence also supports gendered differences: males exhibit stronger neural responses to anger-related stimuli, whereas females show higher levels of positive emotional experiences [76,77,78]. Women place

greater emphasis on maintaining social relationships, while men are more inclined to initiate new social ties [46].

Given that Danmaku is a participatory medium rich in emotional expression and social signaling, gender-based differences in emotional sensitivity, expression, and relational focus may influence how emotional amplification shapes users' perception of interactional atmosphere. Therefore, we propose:

H6: Gender moderates the relationship between emotional amplification and the atmosphere of interaction in a participatory video platform.

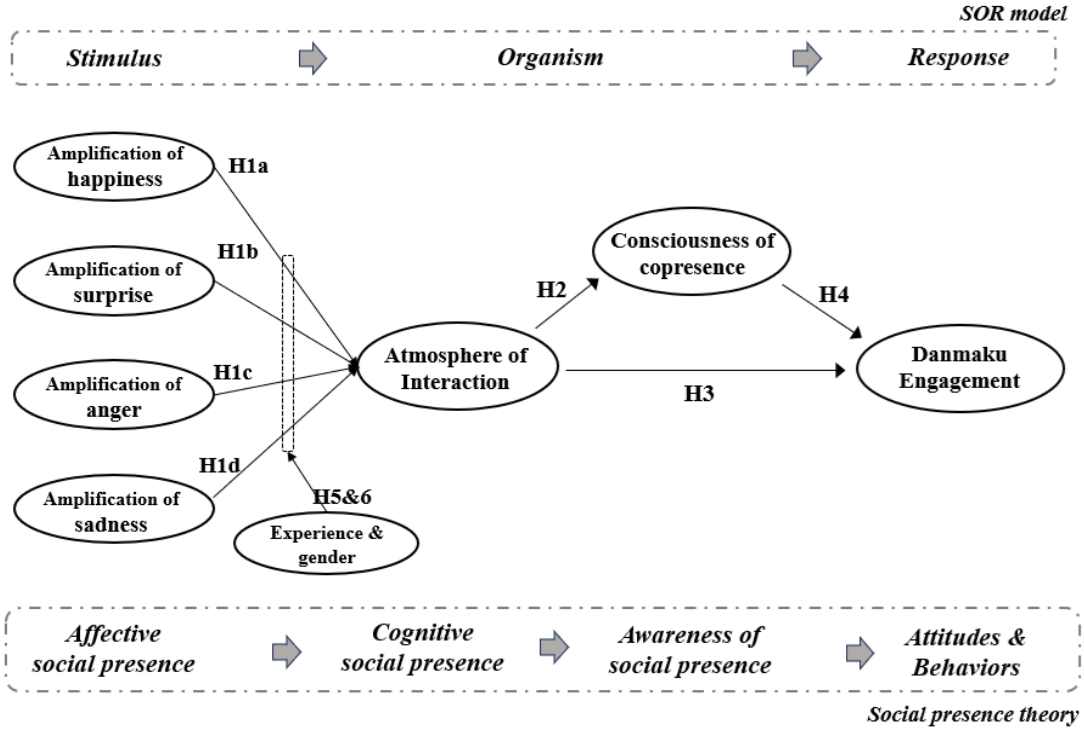

Figure 3. Research Model

4. Research Method

4.1 Measurement Development

All research constructs were assessed through the use of multi-item scales on a five-point Likert scale, which was based on existing studies but adjusted slightly to ensure they were more relevant to the specific context of this research. Emotional amplification was assessed through scale items adapted from previous research by Galanakis and colleagues (2016) and Hamilton et al. (2009) [79, 80]. The atmosphere of interaction was assessed using Paul and Gary's (2009) scale, which examines the impact of social interaction on the viewing of YouTube videos [1]. The items intended to ascertain consciousness of copresence were adapted from Bulu (2012) and Shen and Khalifa (2008) [43],[81]. The scale for measuring Danmaku engagement was adapted from Song et al. (2022) and Xiang and Chae (2022) [82],[83]. A detailed description of the items used to measure each construct of interest can be found in Table 1 in the Appendix A.

4.2 Data Collection

To examine reliability and validity, a preliminary test of the questionnaire was implemented from August 23 to August 30, 2023. A sample of 20 participants with prior experience using Danmaku video platforms was initially recruited to complete the survey. Drawing on both participant feedback and expert assessments, the questionnaire underwent refinement and optimization.

Then we published and conducted a formal questionnaire survey on China's Wenjuanxing website(https://www.wjx.cn) from September 1 to September 5, 2023. A total of 386 participants returned their questionnaires, for which precautions such as cross-referencing hyperlinks and IP addresses were taken to avoid duplicate submissions. Of the participants, 83 stated that they had not utilized Danmaku, leaving 303 eligible individuals. The exclusion of respondents who provided incomplete responses left a final sample of 242 valid questionnaires for analysis.

The questionnaire first asked whether they had used the Danmaku platform and how long they had used it. They were also required to provide demographic details, such as age and gender. Next, the respondents were prompted to evaluate their emotional states (e.g., happiness, surprise, anger, and sadness), the interactive environment in which they engaged with Danmaku, their consciousness of copresence, and their intention to continue using the platform. Table 2 presents the sample characteristics.

Table 2. Demographic Analysis

Gender		Age		Use of Danmaku	
Male	62 (25.6%)	18–24	78(33.2%)	Less than a year	26(10.7%)
Female	180 (74.4%)	25–34	135(55.8%)	1–2 years	32(13.2%)
Total	242 (100%)	35–44	16(6.6%)	2–3 years	41(16.9%)
		54–64	13(5.8%)	3–4 years	48(19.8%)
		Total	242(100%)	4 –5 years	25(10.3%)
				More than 5 years	70(28.9%)
				Total	242(100%)

5. Analysis Results

5.1 Measurement Model

We conducted an analysis using partial least squares (PLS), a form of structural equation modeling (SEM) that evaluates both the accuracy and credibility of construct measures while also determining the connections between these constructs [84]. PLS-SEM was selected for its capability to model latent constructs in non-normal conditions, as well as its effectiveness in handling categorical moderations across various relationships, including past experience moderation [84].

Although PLS-SEM does not require multivariate normality, univariate normality was assessed to enhance methodological transparency. Skewness and excess kurtosis values for all observed indicators were examined using SmartPLS. Skewness values ranged between −1.276 and 1.124, while excess kurtosis values varied from −1.205 to 2.082—both well within the commonly accepted thresholds (i.e., |skewness| < 3; |excess kurtosis| < 10) [85]. From these results, all variables were observed to have normally distributed data [86]. Kock (2015) suggests that VIFs ≤ 3.3 from a full collinearity test indicate no common method bias (CMB) [87]. Our VIFs ranged from 1.000 to 1.622, confirming CMB is not a concern in this study.

The collected data underwent a thorough statistical analysis, and the details are in Table 3. Upon closer examination, it was noted that the average value for each variable fell within a range of 2.921 to 3.959, with standard deviation values varying from 0.917 to 1.169. These results indicate a high level of concentration within the data, with minimal fluctuations, suggesting a strong level of reliability and adaptability. Furthermore, all item factor loadings ranged from 0.728 to 1.169, surpassing the standard threshold of 0.7 and thereby confirming the construct validity of the questionnaire items [86].

Table 3. Summary statistics

Variables	Items	Mean	SD	Excess kurtosis	Skewness	Factor loadings
Amplification of happiness (AHP)	AHP1	3.475	0.976	-0.461	-0.266	0.938
	AHP2	3.616	1.019	-0.622	-0.352	0.898
Amplification of surprise (ASP)	ASP1	3.264	0.969	-0.508	-0.140	0.969
	ASP2	3.198	1.045	-0.571	-0.143	1.045
Amplification of anger (AAG)	AAG1	2.921	0.935	-0.644	0.005	0.935
	AAG2	3.136	1.034	-0.822	0.130	1.034
Amplification of sadness (ASD)	ASD1	2.959	1.044	-0.679	-0.136	1.044
	ASD2	3.083	1.021	-0.656	-0.120	1.021
Atmosphere of Interaction (InAT)	InAT 1	3.252	1.040	-0.658	-0.054	1.040
	InAT 2	3.264	1.031	-0.551	-0.116	1.031
	InAT 3	3.186	1.115	-0.749	-0.157	1.115
	InAT 4	2.979	1.169	-0.856	0.025	1.169
Consciousness of copresence (CP)	CP1	3.876	0.975	0.758	-0.958	0.975
	CP2	3.959	0.917	2.082	-1.276	0.917
	CP3	3.583	1.054	0.073	-0.741	1.054
Danmaku engagement (DaEG)	DaEG1	3.657	1.133	-0.059	-0.772	1.133
	DaEG2	3.764	1.048	0.199	-0.775	1.048
	DaEG3	3.240	1.143	-0.564	-0.314	1.143

The study evaluated the measurement model's reliability using Cronbach's alpha, and its convergent validity through item loadings, CR, and AVE. Discriminant validity was confirmed by ensuring that the square root of each AVE exceeded the related inter-construct correlations. The results in Table 4 revealed Cronbach's α values falling within the range of 0.6 to 0.8, indicating acceptable reliability [88]. The CR values exceeded the threshold of 0.7, highlighting the substantial reliability of the variables and their ability to explain the model structure effectively [86]. All AVE values exceeded the

recommended cutoff of 0.5, indicating satisfactory explanatory power for each construct's measurement dimension [86]. The square root of the AVE for each variable exceeded its correlation coefficient with the other observed variables in the model, indicating strong discriminant validity for each variable. Overall, the analysis suggests that the questionnaire's design is highly valid and reliable, with an effective and logical measurement model that provides a solid foundation for further analyses of structural model fit.

Table 4. Reliability and Validity of Constructs

Construct	Cronbach's Alpha	CR	AVE	AHP	ASP	AAG	ASD	InAT	CP	DaEG
AHP	0.817	0.915	0.844	0.919						
ASP	0.654	0.852	0.742	0.442	0.861					
AAG	0.682	0.863	0.759	0.365	0.443	0.871				
ASD	0.706	0.868	0.767	0.388	0.458	0.559	0.876			
InAT	0.822	0.880	0.648	0.199	0.325	0.268	0.293	0.805		
CP	0.863	0.917	0.786	0.324	0.328	0.217	0.405	0.452	0.887	
DaEG	0.835	0.902	0.755	0.194	0.268	0.173	0.215	0.484	0.545	0.869

Note: *Diagonal elements (bold) are the square root of the AVE of each construct.
Below the diagonal elements are the correlations of the factors.

5.2 Base Model Test: from H1 to H4

The SRMR value was 0.079, comfortably under the 0.08 threshold, thus adhering to acceptable standards [89]. Tenenhaus et al. (2005) addressed the unique complexities associated with PLS-SEM by introducing a specific goodness-of-fit (GoF) index, which has since received widespread approval [89],[90],[91]. According to established guidelines, a GoF value of more than 0.25 signifies a well-fitting model. The GoF value is calculated using the formula [GoF =√ (average AVE * average R2)]. In our case, the GoF value was 0.37, confirming that the model is well-fitted.

The hypotheses on the amplification of surprise and sadness (i.e., H1b and H1d) affecting the atmosphere of interaction were supported, with path coefficients of 0.215 ($p < 0.05$) and 0.140 ($p < 0.1$), respectively. However, the suppositions regarding the amplification of happiness and anger (i.e., H1a and H1c) as influencing the atmosphere of interaction were not supported with path coefficients of 0.019 ($p = 0.789$) and 0.089 ($p = 0.265$). The atmosphere of interaction influenced the consciousness of copresence ($\beta = 0.453$, $p < 0.001$) and Danmaku engagement ($\beta = 0.340$, $p < 0.001$), supporting H2 and H3, respectively. The consciousness of copresence significantly influenced Danmaku engagement ($\beta = 0.386$, $p < 0.001$), supporting H4. The R^2 values for atmosphere of interaction, consciousness of copresence, and Danmaku engagement were 0.139, 0.206, and 0.384, respectively. All values surpassed the minimum acceptable threshold of 0.10 commonly cited in empirical social science research [92], demonstrating that the model

exhibits moderate explanatory power. Consequently, the hypotheses proposed in this study are supported.

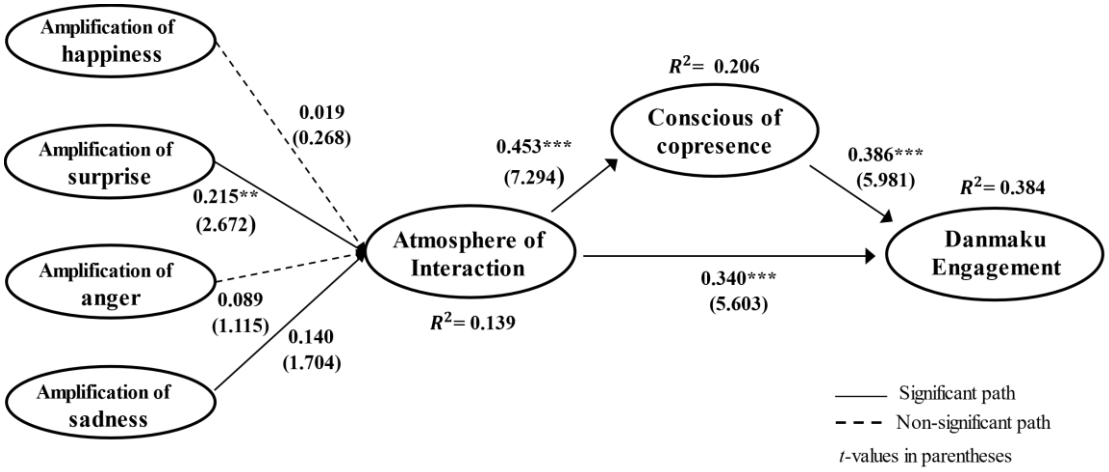

Figure 4. Structural model test result

5.3 Testing of H5: Moderating Effect of Danmaku Experience

To assess potential differences in path coefficients, a multi-group analysis (PLS-MGA) was performed comparing long-term Danmaku users (over 3 years) with those having shorter usage experience (3 years or less). The findings indicated that the disparities in user experience moderated the correlation between anger amplification and the interactive environment (β dif. = –0.357, p = 0.015). No substantial differences were observed in the path coefficients of other relationships between long-term and recent users, thus confirming the support for H5c.

Table 5. Experience Effect Test Results

Paths	More than 3 years of experience (a)	Up to 3 years of experience (b)	Group Difference (a-b)		Results
			MGA β Dif.	p-values	
AHP → InAT	0.060 (0.470)	-0.111 (0.151)	0.171	0.102	Not Supported
ASP → InAT	0.277 (0.005**)	0.143 (0.081)	0.133	0.183	Not Supported
AAG → InAT	–0.045 (0.346)	0.313 (0.003**)	-0.357	0.015*	Supported
ASAD → InAT	0.136 (0.124)	0.225 (0.014*)	-0.089	0.286	Not Supported

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

5.4 Testing of H6: Gender Differences

We investigated whether the path coefficients differed significantly between male and female groups. The multiple group analysis results show that gender moderated the following relationship: the amplification of anger → the atmosphere of interaction (βdif. = –0.034, p = 0.025). No significant gender-based differences were observed in the remaining path relationships, indicating that H6 received partial support. The detailed results of the PLS-MGA are reported in Tables 5 and 6, while a summary of all hypothesis testing outcomes is provided in Table 7 and Figure 3.

Table 6. Results on Gender Differences Effect Tests

Paths	Male group (a)	Female group (b)	MGA β Dif. (b - a)	p-values	Results
AHP → InAT	–0.122 (0.216)	0.066 (0.207)	0.188	0.135	Not Supported
ASP → InAT	0.184 (0.165)	0.242 (0.003**)	0.058	0.402	Not Supported
AAG → InAT	0.307(0.005**)	0.002 (0.490)	-0.034	0.025	Supported
ASD → InAT	0.137 (0.204)	0.146 (0.065)	0.009	0.484	Not Supported

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

Table 7. Results of hypothesis testing

Hs	Hypothesis	Results
H1a	The amplification of the happiness emotion of a participatory video platform user positively affects the atmosphere of interaction in these platforms.	Not Supported
H1b	The amplification of the surprise emotion of a participatory video platform user positively affects the atmosphere of interaction in these platforms.	Supported
H1c	The amplification of the anger emotion of a participatory video platform user positively affects the atmosphere of interaction in these platforms.	Not Supported
H1d	The amplification of the sad emotion of a participatory video platform user positively affects the atmosphere of interaction in these platforms.	Supported
H2	The atmosphere of interaction in a participatory video platform positively affects the consciousness of copresence perception in the platforms.	Supported
H3	The atmosphere of interaction in a participatory video platform positively affects engagement in the platform.	Supported
H4	The consciousness of copresence in a participatory video platform positively affects engagement in the platform.	Supported
H5a	A longer usage of the participatory video platform strengthens the relationship between the amplification of the happiness emotion and the atmosphere of interaction.	Not Supported
H5b	A longer usage of participatory video platform strengthens the relationship between the amplification of the surprise emotion and the atmosphere of interaction.	Not Supported
H5c	A longer usage of participatory video platform strengthens the relationship between the amplification of the anger emotion and the atmosphere of interaction.	Supported
H5d	A longer usage of participatory video platform strengthens the relationship between the amplification of the sad emotion and the atmosphere of interaction.	Not Supported
H6	Gender moderates the relationship between the emotional amplification and the atmosphere of interaction in a participatory video platform.	Partially Supported

6. Discussion

6.1. Summary of Findings

This study highlights three key findings.

First, the amplification of emotions such as sadness and surprise significantly enhances the interactive atmosphere. Users experiencing these emotions are more likely to trigger resonance and responses from others, leading to increased community interaction. This emotional exchange strengthens user connections and promotes greater engagement and

social activity. In contrast, happiness had a limited effect on fostering interaction. This may be due to the way happiness is typically expressed on Danmaku platforms—through simple, reactive phrases such as "hahaha" or "hhhh." While these indicate positive affect, they tend to lack emotional or cognitive depth, making them less likely to spark meaningful dialogue. According to the Emotion-as-Social-Information (EASI) model [93], emotional expressions rich in informational or social value are more likely to elicit interaction. Hence, happiness on these platforms may function more as a passive acknowledgment than as a catalyst for engagement.

Moreover, to better contextualize these emotional dynamics, it is important to consider the unique interface design of Danmaku platforms. Prior research comparing Danmaku's synchronous overlay (SO) comments with traditional adjacent scrollable (AS) comments found that SO formats enhance users' sense of togetherness but reduce memory of comment content [7]. This suggests that Danmaku promotes emotional immersion and shared presence rather than detailed content processing. Such interface affordances likely amplify emotions like sadness and surprise more effectively, fostering rapid emotional contagion and interaction. In contrast, happiness expressions, often brief and surface-level, may not benefit similarly from this design. Therefore, the emotional amplification observed in our study may be closely tied to how the Danmaku interface channels and synchronizes user emotions in real time.

Second, we found mediating the effects of the atmosphere of interaction and the consciousness of copresence in the relationship between heightened emotions and the intention to continue using Danmaku. This suggests that intensified emotions contribute to the development of an interactive atmosphere. Such an atmosphere, in turn, promotes the perception of copresence, ultimately influencing the intention to engage with Danmaku.

Finally, user experience moderates the emotional effect on engagement. Specifically, individuals with longer Danmaku usage histories showed greater responsiveness to anger. While anger is often perceived as a disruptive emotion, experienced users may express it in performative or socially meaningful ways, such as sarcasm, critique, or collective dissent. These uses of anger can provoke discussion, reinforce group identity, and thus foster interaction rather than suppress it. This aligns with the EASI model, which emphasizes that the impact of emotional expression depends on context and interpretation. In contrast, users with shorter usage durations were more responsive to positive or surprising emotional experiences. This suggests that emotional engagement patterns evolve as users become more embedded in platform-specific communication norms.

6.2. Theoretical Contributions

This study offers several important theoretical contributions to the literature on social presence, affective computing, and participatory media systems.

First, we propose the Emotional Amplification Framework (EAF) as a cohesive theoretical lens that synthesizes how emotional intensity and co-experienced affect emerge in real-time, user-driven media environments. The framework explains how spatial-temporal synchronization and collective visibility of user-generated content in

Danmaku systems amplify emotional salience, fostering a shared emotional field that fundamentally alters users' perception of social presence. In doing so, the EAF contributes a novel account of emotion as a socially co-constructed and media-mediated phenomenon, extending affective theories in human-computer interaction (HCI).

Second, we advance social presence theory by validating a three-dimensional structure—awareness, affective presence, and cognitive presence—within the Danmaku context. This multidimensional operationalization moves beyond the traditional unidimensional view and demonstrates how these layered presences interact dynamically in media-rich, socially synchronized environments. Our findings highlight that social presence is not merely a cognitive recognition of others, but an affectively charged, temporally situated, and socially co-constructed experience.

Third, we integrate social presence theory into the stimulus–organism–response (SOR) paradigm, offering a revised conceptual model that positions co-experienced affect as a central mediating mechanism between system features and participatory outcomes. This integration extends the SOR framework to accommodate socially immersive and emotionally synchronized interaction patterns, enriching its applicability in contemporary digital environments.

Finally, our findings reveal that emotional amplification is not homogeneous; it is moderated by individual prior experience and gender. This insight contributes to the emerging discourse on personalized affective computing, suggesting the need for adaptive interaction systems that are sensitive to differential emotional responsiveness. Taken together, our theoretical contributions pave the way for paradigm-shifting implications in HCI, particularly in designing emotionally resonant, socially embedded, and cognitively engaging participatory platforms.

6.3. Managerial Implications

First, by examining the amplification of four types of emotions and their impacts on Danmaku engagement, this study offers valuable insights to both platform developers and content creators. Investigating how emotions such as happiness, surprise, anger, and sadness influence users' intentions to engage with Danmaku offers a more nuanced understanding of emotional drivers of consumer behavior and enables content creators and platform managers to better tailor their services to users' affective preferences.

Furthermore, the investigation of how emotion amplification affects users' intention to continue using Danmaku sheds light on the importance of integrating emotion-enhancing features into Danmaku platforms to elevate user engagement and retention. By incorporating features that amplify emotions such as happiness, surprise, anger, and sadness, developers can create a more dynamic and immersive user experience, ultimately leading to increased user satisfaction and loyalty. To support this, Appendix B presents three concrete feature mockups that translate the study's findings into actionable platform design strategies.

Second, the development of a model that incorporates the mediating roles of interactive

atmosphere and copresence offers practical guidance for platform optimization. This model can be leveraged by other video website administrators to enrich the interactive features of streaming platforms, cultivating a more engaging and immersive environment for the users. By prioritizing factors such as interactive atmosphere and copresence, platforms can increase user satisfaction and retention.

Finally, the recognition of differences in emotions depending on experience and gender highlights the importance of personalized marketing strategies. This understanding can serve as a reference for content creators and platform administrators in tailoring content and promotional campaigns to different demographic groups. By catering to the unique emotional preferences and behaviors of users based on experience and gender, platforms can effectively attract and retain a diverse audience.

6.4. Limitations and future studies

Although this study offers valuable insights, several limitations warrant attention in future work. First, the research was confined to participatory video platforms featuring Danmaku, leaving open the question of whether the results can be generalized to other platforms like YouTube. Second, the analysis focused solely on four emotional categories, highlighting the importance of exploring a wider range of emotions to better understand the drivers behind Danmaku participation. Third, the study relied on data collected through a questionnaire-based survey. Future research could enhance the depth of analysis by incorporating multiple methodologies, such as large-scale data analytics or behavioral tracking, to capture more nuanced user interactions and emotional dynamics.

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APPENDIX A: Construct items

Table A1. Construct items

Construct	Items	Based on
Amplification of happiness	When I see Danmaku chats expressing happiness, such as “23333,” “hhhhhh,” and “Hahahahaha,” I begin to feel happy.	[79],[80]
	I experience an increase in happiness when I come across Danmaku comments that express joy, such as “23333,” “hhhhhh,” and “hahahahaha.”	
Amplification of surprise	When I see Danmaku chats discussing surprises, I too find myself feeling surprised. For instance, while I may not have initially been surprised, witnessing someone send a Danmaku chat conveying surprise, such as “stunned” or “666666,” can suddenly elicit a sense of surprise in me.	
	When I see Danmaku chats discussing surprises, I become even more astonished. For instance, my initial pleasant surprise is heightened upon encountering Danmaku messages conveying astonishment, such as “stunned” or “666666.”	
Amplification of anger	Upon observing Danmaku chats discussing anger, I find myself unexpectedly experiencing anger.	
	When I encounter Danmaku chats discussing expressions of anger, it tends to escalate my feelings of anger.	

Construct	Items	Based on
Amplification of sadness	Upon viewing Danmaku chats expressing sadness, I experience a sudden onset of sadness. Before this, I did not feel sad; however, after witnessing messages such as “55555,” “crying,” and “crying to death,” my emotional state shifted toward a more melancholic mood.	[79],[80]
	When I come across Danmaku chats discussing sadness, it tends to amplify my feelings of sadness. For instance, if I am already feeling down, seeing Danmaku chats about sadness, such as “55555,” “crying,” or “crying to death,” can further intensify my emotions.	
Atmosphere of interaction	I also want to participate in a chat when I see Danmaku chats floating by.	[1]
	The Danmaku I send can get responses from others.	
	I can meet other interesting viewers.	
	I can communicate freely and pleasantly with other people.	
Consciousness of copresence	When I access Danmaku, I feel I’m not alone.	[43],[81]
	When I access Danmaku, I feel like I’m watching with other people.	
	When I access Danmaku, it can reduce my loneliness.	
Danmaku engagement	I often read Danmaku.	[82],[83]
	I will access Danmaku in the future.	
	I will send Danmaku in the future.	

APPENDIX B: Emotion-Responsive Danmaku Features for Participatory Video Platforms

This appendix presents three emotion-sensitive features designed to enhance affective engagement and foster shared emotional experiences on Danmaku-enabled participatory video platforms. These features translate our design implications into practical applications, supported by illustrative mockups (see Figure 1-3).

B1. Emotion Density Heatmap

Description: A real-time visual overlay on the video timeline that highlights emotionally intense segments, based on aggregated Danmaku tags (e.g., spikes in “anger” or “surprise”).

Design Rationale: This feature allows users to quickly locate and revisit emotionally charged moments, thereby enhancing emotional resonance and encouraging rewatch behavior.

User Benefit: Supports emotional memory, facilitates content curation around affective peaks, and deepens personal engagement.

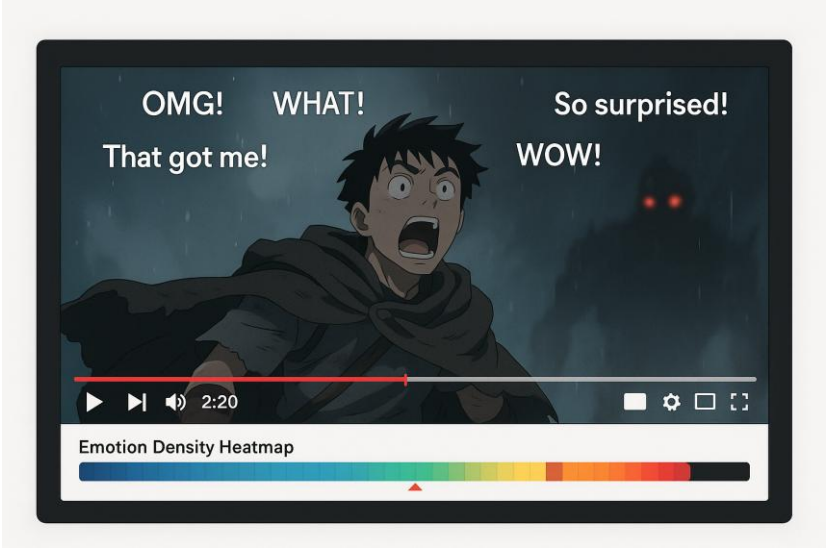

Figure 1. Emotion density heatmap

B2. Emotion Synchronization Prompt

Description: When a critical mass of viewers (e.g., over 500) express the same emotion (e.g., “surprise”), the system generates an ephemeral on-screen prompt such as: “Join 500+ others shocked at this moment!”

Design Rationale: The prompt amplifies the real-time co-experience of emotion and reduces expressive inhibition by signaling social consensus.

User Benefit: Enhances the sense of presence, encourages spontaneous participation, and strengthens communal affective response.

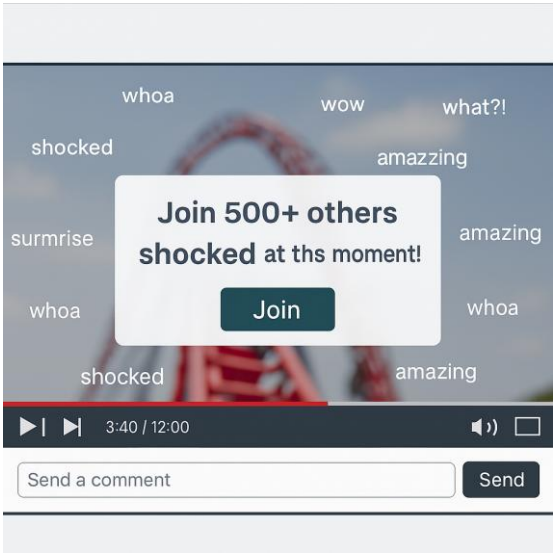

Figure 2. Emotion Synchronization Prompt

B3. Post-Viewing Emotional Summary

Description: Upon video completion, the platform displays a summary dashboard that visualizes dominant emotions across the timeline.

Design Rationale: This retrospective view facilitates emotional reflection and encourages post-viewing sharing behavior centered on collective experiences.

User Benefit: Promotes emotional awareness, fosters group identity, and invites further engagement through reflection and discussion.

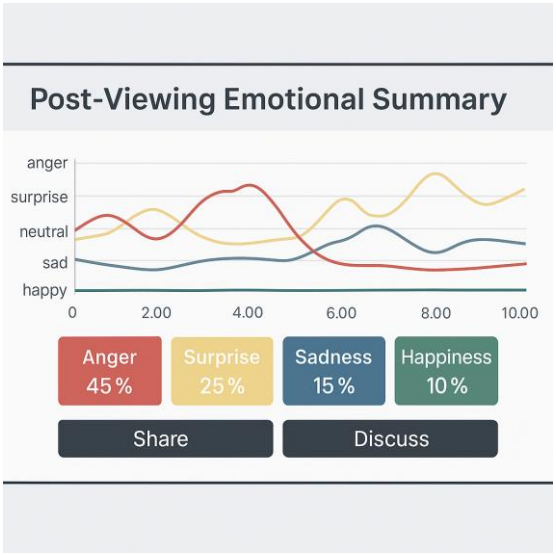

Figure 3. Post-Viewing Emotional Summary