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"Nice to Meet You in Masks": How Virtual Avatars Enhance User Experience on Random Video Chat Platforms

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Abstract: This study aims to understand how interaction design can enhance the user experience of random video chats using virtual avatars (RVC–VAs). We propose a framework to explain the mechanisms underlying changes in social anxiety and flow experiences. We applied analysis of variance (ANOVA), structural equation modeling (SEM), and fuzzy set qualitative comparative analysis (fsQCA) to data collected through surveys. Our findings indicate that a second-order construct, named mysterious interaction, comprising perceived interactivity, perceived vividness, and mystery, can reduce social anxiety and positively impact flow. Novelty experience enhances flow for female users but increases social anxiety for all users. Notably, social anxiety unexpectedly showed a positive effect on flow. Based on these findings, we propose interaction design strategies that could aid in the development and optimization of RVC-VA platforms, providing specific parameters to assist designers in prioritizing and planning actionable steps. This study makes a significant contribution to the advancing of online social services and addressing users' needs for online social interaction.

Keywords: human–computer interaction; user experience; virtual avatar; random video chat

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1. Introduction

In recent years, an increasing number of users have begun to engage in online social interactions. By leveraging human–computer interaction technologies and services, such as high-speed networks [1], mobile devices [2], and advanced applications [3], users are able to communicate with others anytime and anywhere, thereby expanding their social networks. Among them, platforms that cater to social needs beyond familiar circles have gained popularity. Unlike traditional social services, in this model, the system provides users with opportunities to make new friends through random matching [4]. The random video chat (RVC) discussed in this study is based on this concept and specifically refers to a social model in which users are provided with video as a means of communication after being randomly matched with strangers. RVC users are typically individuals rather than businesses, with a virtual social "playground" being created that allows users to express themselves and share their daily lives [5]. Therefore, it is essentially driven by social rather than commercial purposes. It is noteworthy that RVC is undergoing iterative upgrades, with designers integrating artificial intelligence technology and launching the

user-expression-driven virtual avatar function, which has injected new vitality into the activity. According to reports, a well-known platform that supports random video chats using virtual avatars (RVC–VAs) has seen its daily active users grow from 3.3 million to over 9.5 million over the past five years, with an average of nearly 30 million monthly active users [6]. Another platform offering virtual avatar social features saw its user base rapidly grow to over 100,000 within four months of its official launch [7]. These data partially reflect the potential of RVC–VAs in providing social services to users.

As noted by Shin et al. [8], chatting with strangers in online environments has become a very common behavior. The more comprehensive the information available, the more it can support the initiation and continuation of conversations between users. Information that may help convey social cues includes text, tone, facial expressions, and body language. Therefore, in conversations where strangers meet for the first time, face-to-face interactions typically yield more positive outcomes compared to text-based online interactions [9]. However, face-to-face communication also has its drawbacks. Users may experience varying degrees of social anxiety due to appearance-related factors, such as their looks, clothing, and mannerisms [10]. This can lead them to doubt their ability to make a positive impression on others [11] and, in turn, they may be less inclined to express their own viewpoints [12]. Some users have indicated that they are only willing to use cameras when the interaction is with friends who are familiar with their appearance, or when they have known the other person for a period of time and wish to maintain the friendship [13]. Under these conditions, RVC-VA appears to be an intriguing solution, as it provides an experience similar to face-to-face interaction while safeguarding users' privacy.

On the one hand, virtual avatars are considered to be able to help reduce the psychological burden during user interactions and facilitate self-expression [14]. Additionally, this technology may create a more inclusive online social environment for users with varying abilities, such as those with visual, auditory, or physical impairments, or autism [15,16]. When users feel they are immersed in their virtual avatar and can directly act through it, their flow experience is enhanced [17]. This finding is encouraging because flow is often seen as a positive and pleasurable state [18]. Low levels of social anxiety and high levels of flow experience may indicate successful design. Virtual avatars are used for various communication purposes, such as making new friends, disseminating knowledge, and seeking emotional support. Through virtual avatars, users can create personalized identities and imbue them with characteristics according to their desires, integrating themselves into the digital world [19]. However, theoretical research related to RVC-VA platforms remains insufficient. For instance, consensus has yet to be reached regarding the effectiveness of virtual avatars in fostering deeper user engagement, and design insights are lacking [20]. Furthermore, previous research has focused primarily on user experience within immersive interactive spaces, such as virtual reality and video games, while paying less attention to system design in video communication [21,22]. Human–computer interaction technologies applied in different social contexts or scenarios may lead to different user behaviors [4]. Currently, no study has evaluated the impact of virtual avatars in RVC on users' social anxiety and flow experience, or the specific mechanisms involved, which is the research gap we aim to fill. To advance online social services, we seek a better understanding of RVC-VA, including how to enhance user experience and propose effective interaction design strategies.

Overall, our research focuses on the human–computer interaction experience within the RVC-VA platform. For a long time, RVC has enjoyed widespread popularity globally, helping users meet their social needs and build appropriate interpersonal relationships. Computer vision technology provides more possibilities for its development. Scientifically designing and managing emerging interactive systems, addressing challenges and

opportunities, analyzing user behavior, and deriving theoretical foundations are especially important. On the one hand, many companies have begun exploring RVC–VAs in commercial applications to gain market advantages and share. For example, the Chinese platform "Soul" offers a feature called "Cute Avatar Matching", which allows users to select an avatar according to their preferences and synchronize their facial expressions with the virtual avatar in real-time through computer vision [4]. However, it is still unclear how users perceive this relatively innovative online social service. The main objectives of this study include two factors: first, we aim to measure the level of users' social anxiety on RVC platforms using real-person images and RVC-VA platforms using virtual avatars. This helps to understand the overall role of virtual avatar technology in improving online social experiences. Second, we aim to verify how interaction design elements influence users' social anxiety and flow experiences, analyze path relationships, and explain the impact of multiple concurrent conditions. This helps provide suggestions for the development of relevant products. We adopt a user-centered approach, drawing on key constructs from previous literature for evaluating human–computer interaction experiences to establish a theoretical framework and summarize effective strategies. Practically, this study will assist businesses and designers in reducing reliance on subjective experiences when making significant decisions, making it both timely and necessary in a rapidly evolving market.

2. Literature Review and Hypothesis Development

2.1. Virtual Avatar Technology in Human–Computer Interaction

Human-centered design can evoke positive emotions in users and create enjoyable experiences [23]. Since design thinking was systematized and widely adopted as a problem-solving methodology, understanding users' needs with empathy and exploring creative solutions have become core priorities in interaction design. The evolution of online social services exemplifies this trend. To enhance users' willingness to share [24], pay [25], and engage in continuous usage [26], designers have developed diverse systems and conducted iterative improvements. Media technology types can predict interactivity, thereby influencing users' cognition and emotions [27]. For online social platforms, the flexible integration of virtual technologies with various paradigms offers designers greater possibilities for constructing interactive social environments. Notably, users may express concerns about the degree of personal privacy protection in online services, with privacy perception closely tied to the use of real faces [28]. To address this issue, some designers have introduced optional virtual image features. Users can create customized text or images and visualize their application to themselves in a blend of virtual and real contexts [29]. This technique, referred to as "face-kini" when applied to online social platforms, aims to obscure users' appearance partially or entirely with traceable virtual images. However, face-kini systems typically support only static images or simple pre-designed animations. With the proliferation of 3D rendering and computer vision technologies, virtual avatars, as an advanced technology, now enable real-time synchronization of users' movements and expressions. Virtual avatars, digital representations with anthropomorphic appearances controlled by humans or software, play a vital role in enriching user experiences [30]. Prior research has evaluated the multifaceted value of virtual avatars in human–computer interaction experiences. Foster et al. [31] argued that virtual avatars can provide users with social-related enjoyment and practical task-related benefits. Additionally, Yao et al. [32] reported that the visual style and form of virtual avatars may influence users' perceptions. They found that users have higher expectations for humanoid virtual avatars, while cartoon-styled avatars help alleviate negative emotions potentially arising during human–computer interactions.

Based on practical applications in random chat platforms, some studies have conducted insightful evaluations of interaction design methods. Yu and Song [4] used the

Technology Acceptance Model framework to investigate users' willingness to use random chat platforms. They identified anonymity as a core feature of such platforms, mediating perceived risks and influencing users' intentions. The practice of obscuring appearances with virtual images protects users' anonymity and privacy while creating a sense of mystery. Song and Yu [5] employed qualitative research methods to analyze Soul, the most active random chat platform in China. They found that the platform meets user needs across social, consumer, and entertainment dimensions, forming a "attitude–intention–behavior–attitude" feedback loop, which suggests that virtual images may influence user behavior throughout the entire usage process. Hu [33] analyzed users' perceptions of algorithmic recommendation systems in random chat platforms from a dating perspective. They noted that, while such systems accelerate the process of finding compatible matches, they are criticized for potentially constraining the range of matches. This critical perception has a dual role, potentially reducing users' perceived value and indirectly decreasing compulsive usage behaviors, while also directly increasing such behaviors. These findings highlight the need for designers to adopt a dialectical perspective on technology's role. Overall, online platforms prioritize user needs and leverage data-driven decision making to create valuable interactive processes, thereby supporting the marketing industry [34]. This serves as the motivation for our study, which aims to propose interaction design strategies to optimize the user experience of the RVC-VA platform, provide scientific references for system iterations, and lay the groundwork for further exploration of its potential applications in marketing activities.

2.2. Theoretical Framework

This study establishes a quantitative model to evaluate the impact of interaction design factors on user experience within the RVC-VA platform. The theoretical framework is based on the Technology Incentive Model (TIM) proposed in prior research [35]. Originally applied in interactive education studies, the TIM assessed how human–computer interaction, as an external stimulus, enhances users' intrinsic experiences. Additionally, the framework was generalized in the subsequent Expanded Technology Incentive Model (ETIM) and demonstrated effectiveness in the field of interactive marketing [36]. Because the studies proposing these theories incorporated specific constructs tailored to their research contexts, we select only the core constructs related to human–computer interaction experiences, namely, perceived interactivity, perceived vividness, novelty experience, and flow. Furthermore, considering the characteristics of the RVC-VA platform, two new constructs—mystery and social anxiety—are added to update the theoretical model. On the one hand, mystery was selected because it is a fundamental feature of virtual avatars that enables users to conceal their identity and appearance [37]. On the other hand, social anxiety has garnered attention in studies of social experiences and represents a critical user sentiment that online social service providers should prioritize in mitigating [38].

In human–computer interaction experiences, perceived interactivity, perceived vividness, and novel experience can form a second-order construct that technically motivates users and positively influences flow experiences [36]. These three constructs are regarded as important attributes of interactive media environments [39]. In this study, we examined the correlation coefficients among various independent variables. The results indicated that, on the RVC-VA platform, the correlations between novel experience and perceived interactivity ($r = 0.254$, $p < 0.05$) and perceived vividness ($r = 0.324$, $p < 0.05$) were relatively low, making it unsuitable to establish a second-order construct. On the other hand, we found that mystery exhibited a high correlation with perceived interactivity ($r = 0.585$, $p < 0.05$) and perceived vividness ($r = 0.666$, $p < 0.05$). According to Cohen [40], this meets the criterion for high correlation with $r > 0.5$. Furthermore, we referred to Edwards [41]

for guidance on constructing second-order constructs and considered mystery as a key attribute of the RVC-VA platform that holds similar importance to the other constructs, making it suitable for integration into a conceptual composite. Therefore, we combined perceived interactivity, perceived vividness, and mystery into a second-order construct named mysterious interaction.

2.2.1. Perceived Interactivity (PI)

Interactivity is defined as the degree to which users can influence the form and content of the media environment in real time [42]. Interactive experiences allow users to input information in specific ways and participate in the process of co-creating. In an interactive media environment, a synchronous bidirectional flow of information between the system and user exists [43], with the system providing timely feedback in response to user input. Interactivity is characterized by three main features: speed, mapping, and range. Here, speed represents how quickly the content within the media environment can be manipulated, mapping refers to the degree of similarity between virtual controls and controls in the real world, and range denotes the breadth of control [44]. Perceived interactivity reflects users' perceptions of processes or functionalities and indicates the psychological state experienced during interaction [45]. This perception does not necessarily reflect strictly the objective interactive attributes of the media environment, as it stems from users' subjective evaluations. As one of the important characteristics of the media environment, perceived interactivity may independently or synergistically influence users' emotional, behavioral, and cognitive responses [46], and its role in optimizing user experience and building effective systems is promising. It is important to note that, while perceived interactivity is often viewed as a positive design factor [47,48], its impact on RVC-VA platforms remains unclear. Fundamentally, the purpose of RVC-VA platforms is to facilitate social behaviors between individuals. However, interactivity can attract users' attention to technology [49], possibly even affecting user focus on social information [50]. Therefore, it is necessary to validate and analyze the effects of perceived interactivity.

2.2.2. Perceived Vividness (PV)

Perceived vividness is used to describe the ability of technology to create a sensory-rich media environment [51], and it can be explained by combining the concepts of breadth and depth. Breadth refers to the number of senses the medium excites (colors, sounds, etc.), while depth refers to how well the medium represents the sensory dimensions [52]. This combination corresponds to media environments with different characteristics. For example, the perceived vividness of a media environment tends to increase and become more engaging as it shifts from static to dynamic presentations [53]. Furthermore, this construct is not fixed based on the type of media environment; the richer the design details of the same system, the more likely it is to elicit a high level of perceived vividness among users [35]. In our study, perceived vividness refers to the multisensory experience that the RVC-VA platform provides to users; it is used to assess the extent to which external stimuli evoke relevant and clear images in users' minds [54]. However, it is uncertain whether this realistic experience meets the actual needs of users when using the RVC-VA platform. Specifically, when more vivid stimuli are provided, users may feel as if they are in the real world [55]. This suggests that a vivid social environment may, on the one hand, create a more complete media environment, while on the other hand, it may diverge from the users' original intention to choose online social interaction over face-to-face communication. Therefore, we chose to incorporate perceived vividness into the model to evaluate its specific impact.

2.2.3. Novelty Experience (NE)

In the field of human–computer interaction, novelty refers to the degree to which users perceive a service or function as new and exciting when considered as an alternative to existing solutions [56]. Novelty seems to be well reflected within the framework of creative thinking. For example, the uniqueness of physical attributes, the distinctiveness of layout, and the originality of stimulus presentation are all components of novelty [57]. Designers can draw insights and strategies for adjustment from these dimensions. By definition, novel experience is the evaluative outcome of users' assessment of the differences or similarities between new information and what they already know when encountering something different in their daily experiences [58]. In our study, this construct is used to describe the sentiment of freshness provided to users in random video chats by virtual avatars and additional features in online social platforms. Novel experiences may enhance users' interest [59], immersing them in the environment offered by technology [60]. Nonetheless, the impact of novel experiences on users may not always be positive for the RVC-VA platform. When a new technology appears to lack superior functionality or is difficult to use, users may be inclined to reject it [36]. Therefore, to understand the actual impact of novel experiences on user experience, we incorporated this into the research model.

2.2.4. Mystery (MY)

The sense of mystery arises from the unknown [61], with designers intentionally concealing aspects of functions from users, thereby enticing them to engage in deeper exploration [62]. This concept aims to create images that are both anticipated and aligned with expectations. Mystery can be generated by arranging and encoding symbols across temporal conditions, including the past, present, and future [63]. Carefully designed mystery may guide users to achieve positive experiences. Therefore, it is also regarded as a key component in creating product or service allure in order to captivate users [64]. In this study, mystery is viewed as the extent to which hidden information and services within virtual avatars and system functions provoke user expectations and stimulate their desire to explore the unknown. Mystery is often associated with experiences of surprise, which include elements of unpredictability and the promise of new information [65]. It is important to note that mystery can have complex effects on experiences, such as evoking emotional resonance in users [66]. Tan et al. [67] suggest that moderate levels of mystery tend to generate attraction, while high levels of mystery may cause users to feel resistance. For the RVC-VA platform, mystery is clearly a design factor worth assessing, as virtual avatars inherently involve concealment. Understanding the impact of mystery on preferences helps in providing better services to users.

2.2.5. Social Anxiety (SA)

Social anxiety manifests as the expectation that others will make negative evaluations or the concern that one's presence will make others uncomfortable [68]. A threshold exists for the level of social anxiety, characterized by the degree of difference between self-perception and the actual presence of this condition. Research by Jefferies and Ungar [69] shows that over 34% of individuals believe they meet the definition of social anxiety, but only about half actually exceed the standard. In contrast, 18% of individuals consider themselves free from social anxiety, while in fact they meet the criteria for social anxiety. This indicates that the impact of social anxiety is widespread, and many individuals do not accurately recognize their level of anxiety. In this study, we aim to discuss the levels of social anxiety among users on the RVC-VA platform. Previous research presents two differing perspectives on this issue. The positive viewpoint suggests that concealing one's face can help users reduce feelings of discomfort and being judged in public settings [70]; therefore,

users may conceal themselves to alleviate feelings of helplessness and social anxiety [71]. The negative viewpoint posits that concealing one's face may increase the difficulty in interpreting emotions, thereby exacerbating users' social anxiety [72]. When the other party is concealed, users may struggle to perceive subtle facial cues or, instead, see social interactions as having a higher level of threat [73]. Considering the media characteristics and operational methods of the RVC-VA platform, we seek to understand the trends in users' social anxiety when both parties conceal their faces, which can contribute to optimizing human–computer interaction experiences and potentially create a more inclusive online social environment for users with diverse social abilities, such as those with social anxiety disorders or autism.

Previous research has discussed the relationship between user representation and social anxiety. Kim et al. [74] argue that users adopting identities with low self-similarity may enhance their willingness to self-disclose and reduce social anxiety. Under this premise, users may choose to limit the disclosure of personal information and remain anonymous. As noted by Saint and Moscovitch [75], self-masking behaviors, such as obscuring the face, may increase comfort in social interactions and reduce anxiety. Allowing users to customize their representations in online social contexts is one of the features of the RVC-VA platform. From a semiotic perspective, using virtual avatars can place users in a position of mystery [76]. Mystery is considered one of the characteristics of virtual avatars, as users employing virtual images may attract attention and encourage others to engage in interaction [37]. Therefore, mysterious interaction may help alleviate users' social anxiety. Moreover, virtual technologies can create novel social opportunities. This mode of engagement may assist adolescents with high levels of social anxiety in adapting to changing social environments [73]. A study of virtual avatars indicates that users sometimes prefer not to acquire too much information, as they believe it may reduce the element of surprise [77]. This suggests that novelty may enhance online social interactions. Novelty is one of the key attributes of cutting-edge technology, closely related to the degree of digital innovation [78], and is considered to have a positive impact on users' perceptions [56,79]. Therefore, its effects on alleviating users' psychosocial problems are promising. Based on the literature, we proposed the hypotheses shown below.

Hypothesis 1 (H1). *In the RVC-VA platform, mysterious interaction has a negative influence on social anxiety.*

Hypothesis 2 (H2). *In the RVC-VA platform, novelty experience has a negative influence on social anxiety.*

2.2.6. Flow (FL)

Flow is defined as a state of optimal experience characterized by high pleasure that is triggered in users while performing tasks [80]. It is a positive feeling rooted in interactive behavior. In a state of flow, users experience rapid interaction and response with the system, feeling genuinely engaged, and they may lose track of time and space [81]. For the RVC-VA platform, understanding effective ways to trigger user flow is crucial for providing better services. Previous research indicates that the flow experience may be determined by the degree of fit between the virtual avatar and the user themselves [82]. Additionally, users are more likely to enter a state of flow when they have a sense of connection and identification with the virtual avatar [83]. In terms of formation, flow is influenced by both the media environment and user skills. The prerequisite for triggering a flow experience is that users perceive a balance between their own skills and the challenges they need to address [84]. Both skills and challenges should be at a high level. For example, low-level

balance does not always lead to positive feelings for users and may cause them to feel apathetic and bored [85]. However, there is currently a lack of systematic frameworks and targeted evidence to support system design for the RVC-VA platform. According to Csikszentmihalyi et al. [86], the conditions under which the RVC-VA platform induces flow experiences for users are illustrated in Figure 1.

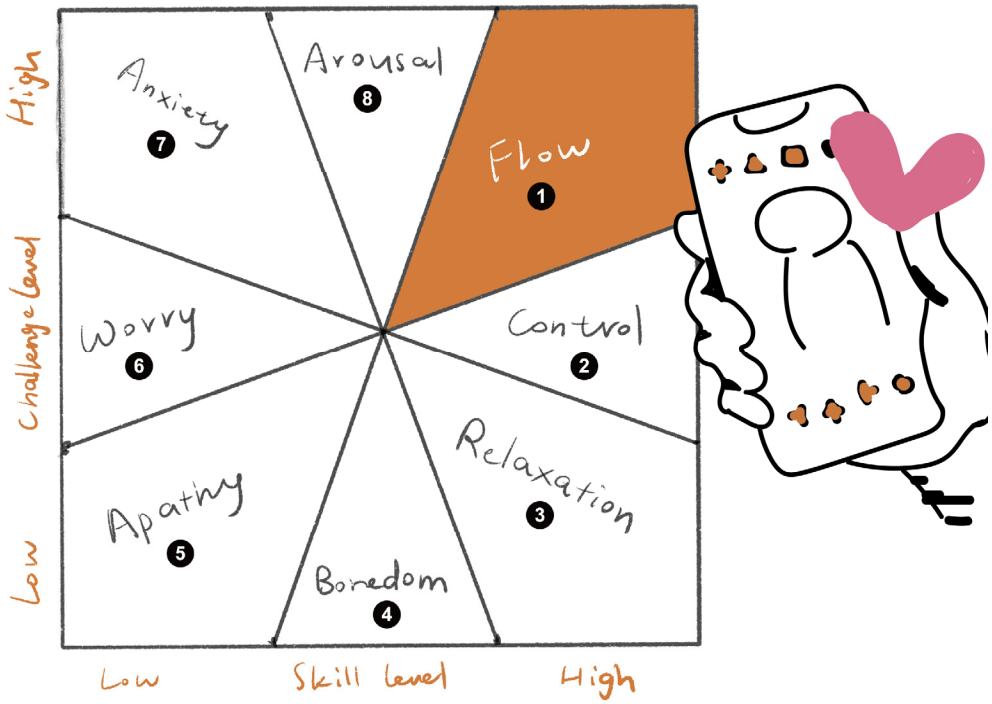

Figure 1. Psychological states triggered by skill–challenge alignment.

In virtual environments, users may experience different levels of flow depending on the design effects of virtual avatars [83]. Espinosa-Curiel et al. [87] suggest that the sense of mystery is related to the design effects of media environments and may influence user engagement. Cheung and Ng [88] also argue that incorporating both challenging and mysterious elements in media environment design helps enhance users' intrinsic motivation to participate. This indicates that there may be an association between mysterious interactive experiences and challenges, with the latter being an important antecedent for generating flow experiences. In system design, perceived interactivity, perceived vividness, and novelty experience are all key constructs that trigger users' flow experiences [89]. This effect has been found across various media environments, such as augmented reality [46] and first-person view drones [35]. Considering that interaction between users and anthropomorphic virtual avatars may lead to high levels of flow [90], we speculate that a sense of mystery and the second-order construct of mysterious interaction, comprising perceived interactivity, perceived vividness, and novelty experience, may all impact flow in the RVC-VA platform. Furthermore, Koehn [91] posits that users' anxiety levels are negatively correlated with their flow states. Beyrodt et al. [92] suggest that social interactions facilitated by virtual avatars may enhance users' flow experiences. Tokunaga [93] further points out that stronger feelings of social anxiety in virtual environments may make it more difficult for users to enter a flow state. Based on the literature, we further proposed the hypotheses shown below.

Hypothesis 3 (H3). *In the RVC-VA platform, mysterious interaction has a positive influence on flow.*

Hypothesis 4 (H4). *In the RVC-VA platform, novelty experience has a positive influence on flow.*

Hypothesis 5 (H5). *In the RVC-VA platform, social anxiety experience has a negative influence on flow.*

3. Research Method

3.1. Research Process

This research involved two studies focused on user experience within the RVC-VA platform, with the research process illustrated in Figure 2. In Study 1, we measured and compared users' social anxiety levels between RVCs and RVC–VAs. In Study 2, we established a structural equation model (SEM) for the RVC-VA platform to examine how perceived interactivity, perceived vividness, novelty experience, and mystery influence users' social anxiety and flow experience. Furthermore, we applied fuzzy set qualitative comparative analysis (fsQCA) to identify the necessary conditions and configurations that impact the dependent variables.

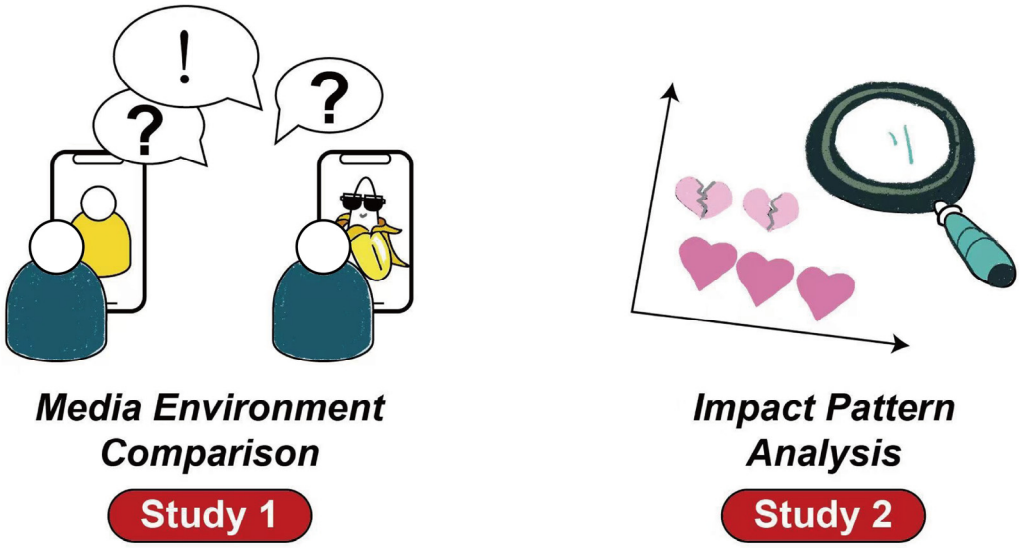

Figure 2. Schematic of research process.

This study progressively reveals how interaction design elements related to virtual avatars influence user behavior on random video chat platforms. As Wang [94] noted, a boring story without conflict or climax is unappealing, and research objectives should not be trivial or self-evident. In this study, we established a series of suspenseful research objectives based on the relatively cutting-edge and intriguing topic of virtual avatars. As the investigation progresses, these mysteries will be unraveled one by one. Specifically, we first aim to determine, at a macro level, whether the RVC-VA platform, as an emerging media environment, offers tangible advantages compared to existing online social experiences or whether it is merely a marketing gimmick derived from technological iterations. Second, we aspire to propose insightful interaction design strategies. All independent variables incorporated into our theoretical framework may exert effects on the dependent variables that are difficult to identify simply due to contextual variations. Third, we intend to explore the relationships between independent and dependent variables under more complex conditions, specifically how different combinations of conditions jointly influence outcomes. We aim to analyze the mechanisms behind various outcomes more flexibly, emphasizing the diversity of causal relationships and the asymmetry in triggering outcomes. Overall, we seek to provide designers with previously undefined information, substantively expanding the knowledge and perspectives related to human–computer interaction.

3.2. Questionnaire Design

This paper comprises two phases: Study 1 and Study 2. We conducted surveys among users using real-person images or virtual avatars when engaging in random video chats. Considering that some questions were used to investigate both platforms during different phases of the study, we did not include fields explicitly referring to "real-person images" or "virtual avatars" in the content, instead using "the platform" as a unified term of reference. On the one hand, this approach reduces redundancy, enabling participants to focus on the questions themselves. On the other hand, at the beginning of each questionnaire, we provided a statement defining the scope of the research subject under discussion (i.e., concerning real-person images or virtual avatars). Thus, the term "the platform" accurately refers to the type of technology we aimed to investigate.

We utilized previously validated scales from earlier research, and the questionnaire was designed using a five-point Likert scale, with scores ranging from 1 to 5 corresponding to "strongly disagree" and "strongly agree", respectively. We edited the questionnaire to align with the research context of this study without altering the original meaning of the text. Additionally, to ensure the fluency and clarity of the statements, we invited five participants to conduct a pilot test before the formal survey. They were asked to read each item individually, and then reflect upon and verbalize their understanding of the content expressed in the questionnaire. We compared the original meaning of the questionnaire with the participants' interpretations. If inconsistencies arose, we paused the pilot test to discuss the relevant items with the participant. Our goal was to identify keywords or phrases in the translation that could cause cross-cultural adaptation issues and, through collaboration with participants, revise the questionnaire to maintain consistency with the original content while minimizing misunderstandings. For example, some participants suggested that item FL2 could be misleading. While the phrase "I lose the sense of time" can be directly translated into Chinese, in the Chinese context, it can easily be confused with the psychological concept of "time perception". Therefore, we emphasized the meaning of "ignoring the passage of time" when revising the translation. This approach preserved the integrity of the original construct definition and helped participants to better understand the content. We also paid close attention to the selection of auxiliary words, prepositions, adverbs, and conjunctions, as well as changes in word order during translation. Overall, based on participants' feedback, we adjusted certain grammatical structures and vocabulary expressions to make the questionnaire content more consistent with the language logic habits of native Chinese speakers. Furthermore, we also invited three experts in interaction design and marketing to review the questionnaire to ensure that the content aligned with the definitions of the constructs and remained consistent with the inquiry objectives of the questionnaires referenced in the literature. The final questionnaire content is shown in Table 1.

Table 1. The questionnaire used in the study.

Construct	Item	Content	Source
Perceived interactivity	PI1	Overall, I believe the platform is highly interactive.	[95]
	PI2	I believe the platform is efficient and clear.	
	PI3	I believe using the platform fits well with my needs.	
Perceived vividness	PV1	Using the platform makes me feel dynamic.	[36]
	PV2	Using the platform provides me with a lot of vividness.	
	PV3	I enjoy using the platform.	

Table 1. *Cont.*

Construct	Item	Content	Source
Novel experience	NE1	Many aspects of the platform were novel to me.	[35]
	NE2	The platform provided a unique experience for me.	
	NE3	It was an adventurous experience.	
Mystery	MY1	Using the platform to socialize with others makes me feel there is something interesting to explore.	[96]
	MY2	I think using the platform to socialize with others will produce interesting things to invoke my curiosity.	
	MY3	I feel I will find interesting things if I use the platform to socialize with others more.	
Social anxiety	SA1	The platform will exacerbate the problem of having to interact with strangers.	[97]
	SA2	My anxiety about communicating in front of others is heightened by the platform.	
	SA3	My nervousness caused by others is intensified by the platform.	
Flow	FL1	I think while using the platform, I do not pay much attention to things around me.	[98]
	FL2	I think while using the platform I lose the sense of time and feel that time flies.	
	FL3	I think I will focus exclusively on using the platform.	

3.3. Data Collection

This paper aimed to understand the perspectives of Chinese users through a questionnaire survey. We collaborated with a professional data collection company to assist in gathering data, and the questionnaire was distributed online. We conducted broad sampling, with participants drawn from various regions of China, including the eastern, central, western, and northeastern areas, as well as the Hong Kong, Macau, and Taiwan regions. Basic information on the participants is shown in Table 2. In terms of gender, we referenced the survey report by iResearch [99], which indicated that female users of mainstream RVC-VA platforms in China slightly outnumbered male users. Regarding age, we referred to data provided in media interviews, which revealed that young users around the age of 25 constitute approximately 40% of the overall users on RVC-VA platforms [100]. Overall, the demographic characteristics of the participants we surveyed are consistent with the previous study by Song and Yu [5], which investigated the same statistical population.

Table 2. Demographic characteristics of the respondents.

Sample	Category	Survey 1		Survey 2	
		Number	Percentage (%)	Number	Percentage (%)
Gender	Male	47	40.171%	175	42.683%
	Female	70	59.829%	235	57.317%
Age	Under 22	4	3.419%	27	6.585%
	23–29	42	35.897%	124	30.244%
	30–39	59	50.427%	214	52.195%
	40–49	8	6.828%	34	8.293%
	Over 50	4	3.419%	11	2.683%

Table 2. *Cont.*

Sample	Category	Survey 1		Survey 2	
		Number	Percentage (%)	Number	Percentage (%)
Monthly income	Below 4000	6	5.128%	38	9.268%
	4001–6000	20	17.094%	74	18.049%
	6001–12,000	47	40.171%	181	44.146%
	12,001–18,000	36	30.769%	88	21.463%
	18,001 or more	8	6.838%	29	7.073%
Education	High school or below	6	5.128%	11	2.683%
	Bachelor's or associate degree	99	84.615%	351	85.610%
	Postgraduate or higher	12	10.256%	48	11.707%
Occupation	Government official	5	4.274%	37	9.024%
	Office worker	70	59.829%	214	52.195%
	Laborer	19	16.239%	56	13.659%
	Public institution employee	6	5.128%	26	6.341%
	Student	3	2.564%	32	7.805%
	Self-employed business owner	14	11.966%	45	10.976%
Area	Eastern China	81	69.231%	271	66.098%
	Central China	16	13.675%	75	18.293%
	Western China	13	11.111%	57	13.902%
	Northeast China	6	5.128%	6	1.463%
	Hong Kong, Macao and Taiwan	1	0.855%	1	0.244%

The survey period for Study 1 was from August to September 2024. To avoid potential influences from platform brand image on users, we did not limit the evaluation to any specific platform during the survey process. Instead, we described the technical parameters, service functions, and usage processes of the two media environments using images combined with explanatory descriptions. The visual materials used for the introduction are shown in Figure 3. All participants reported their levels of social anxiety on both platforms: the RVC platform (where users engage in random video chats using real-person images) and the RVC-VA platform (where users use virtual avatars for random video chats). Participants answered the questions after viewing the introduction we provided, rather than experiencing the platforms immediately. Nevertheless, there are already widely recognized real-world cases in China, so the characteristics of these two platforms are not entirely unfamiliar to the participants. For instance, the popular social platform Soul offers users similar functionalities [4], whereby users can freely choose to use real-person images or virtual avatars for random video chats. Currently, the platform has over 100 million users [5]. In this phase of the study, we distributed a total of 165 questionnaires. We implemented attention-check mechanisms and reverse-scored items to examine response times and logical consistency after collection, ultimately obtaining 117 valid samples, resulting in an effective rate of 70.91%.

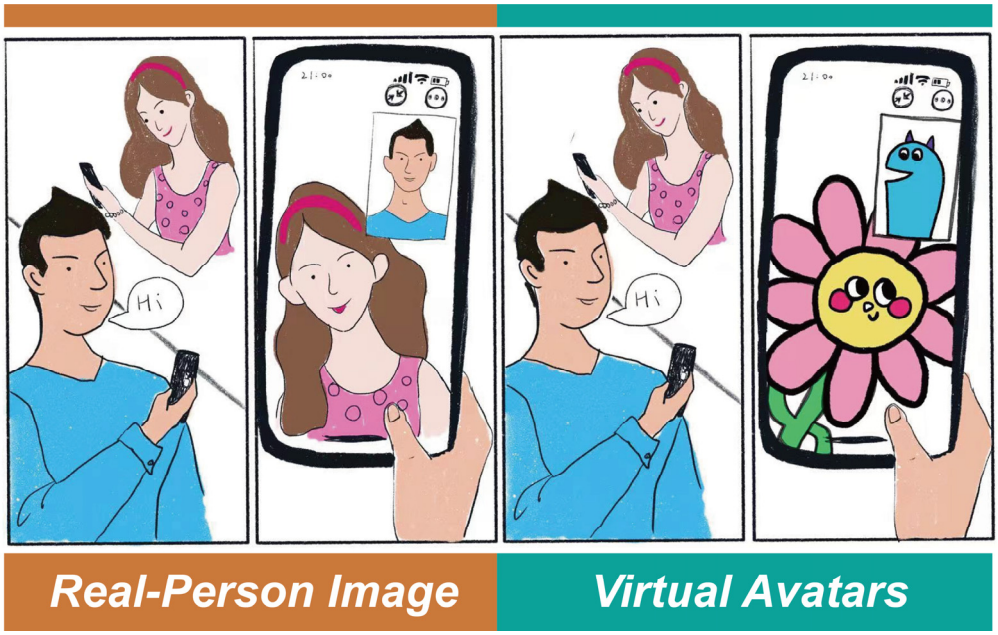

Figure 3. Visual material illustrating the media environment.

The survey period for Study 2 was from September to October 2024. Participants were required to complete a questionnaire after reading the introduction to the RVC-VA platform. In this phase of the study, we distributed a total of 610 questionnaires and implemented the same invalid sample detection mechanisms as in Study 1. After exclusion, 410 valid samples were obtained, resulting in an effective rate of 67.213%.

Finally, we conducted semi-structured interviews with four users to explore the underlying reasons and mechanisms behind changes in social anxiety and flow experience levels. The predefined interview prompts included the following:

1. Describe your thoughts, usage experiences, and feelings regarding the virtual-avatar-based random video chat platform.
2. Discuss your experience of social anxiety during the platform's use.
3. When perceived interactivity, perceived vividness, novelty experience, and mystery of the platform increased, did it affect your social anxiety? How do you think it influenced you?
4. Discuss your experience of flow during platform use.
5. When perceived interactivity, perceived vividness, novelty experience, and mystery of the platform increased, did it affect your flow experience? How do you think it influenced you?

3.4. Data Analysis

We evaluated the reliability and validity of the data collected in Studies 1 and 2. Corrected item–total correlation, Cronbach's alpha if item deleted, and Cronbach's alpha were calculated to analyze data consistency [101]. Additionally, exploratory factor analysis was used to calculate commonalities, factor loading, eigenvalue, and the total variation explained, in order to assess the unidimensionality of the constructs [102].

In Study 1, we conducted an analysis of variance (ANOVA) to compare whether there were significant differences in social anxiety among users of the RVC and RVC-VA platforms [103].

In Study 2, our primary goal was to analyze how design elements of the RVC-VA platform, such as perceived interactivity, perceived vividness, novelty experience, and mystery, influenced users' social anxiety and flow experience. We performed confirmatory

factor analysis to assess the convergent and discriminant validity of the constructs [104]. To examine common method bias, we constructed a control model using the common latent factor method [105]. Structural equation modeling was employed to calculate path coefficients and propose a validated theoretical framework [106], and the significance of the results was assessed through 2000 iterations of bootstrapping [107]. In addition, we conducted fuzzy-set qualitative comparative analysis (fsQCA) to analyze the necessity of independent variables and propose the configurational mechanisms driving the outcomes [108]. Overall, data analysis and model fitting processes were successfully executed without the removal of any questionnaire items. Furthermore, for the transcripts obtained from the semi-structured interviews, we examined the original texts to identify associations between independent and dependent variables. We then compared users' perspectives with the theoretical framework proposed in this study, providing supplementary evidence for explaining the path relationships.

4. Results

4.1. Study 1—Comparison of Social Anxiety Results

We grouped participants based on real-person image (RI) and virtual avatars (VAs) to compare differences in users' levels of social anxiety across the two platforms. The results of the reliability analysis showed that the Cronbach's alpha scores were 0.818 and 0.663 for the RI and VA groups, respectively, meeting the recommended standard, i.e., greater than 0.6 [109]. The results of the exploratory factor analysis indicated that both groups could only extract one new factor with an eigenvalue greater than 1. Specifically, in the RI group, the communalities of the three items were 0.665, 0.787, and 0.753, with an eigenvalue of 2.205, and the total variation explained was 73.492%. The factor loadings of the three items were 0.816, 0.887, and 0.868. In the VA group, the communalities of the three items were 0.444, 0.746, and 0.610, with an eigenvalue of 1.800, and the total variation explained was 60.002%. The factor loadings of the three items were 0.666, 0.864, and 0.781. The calculation results meet the standards recommended by prior research, which suggest that communalities should be greater than 0.4 and factor loadings should be greater than 0.6 [110]. These results indicate that the data have acceptable reliability and validity.

The results of the difference analysis are shown in Table 3. We found that the variance between groups was not significant, meeting the prerequisite for using ANOVA. A comparison of means indicated that the level of social anxiety was significantly lower in the virtual avatar group. According to the thresholds recommended by Richardson [111] for partial eta squared values, 0.0099 indicates a small effect, 0.0588 a medium effect, and 0.1379 a large effect. The test results in this study reached the threshold for a large effect, suggesting that the RVC-VA platform indeed corresponds to a lower level of social anxiety.

Table 3. Analysis of variance results.

Construct	Type III Sum of Squares	(RI) Mean	(VA) Mean	Mean Difference (RI-VA)	F	Sig.	Partial Eta Squared	Levene's Test	
								Leaven Statistic	Sig.
Social anxiety	30.154	3.558	2.840	0.718	42.923	0.000 *	0.156	0.256	0.613

* The level of significance is 0.05.

4.2. Study 2—Design Strategies for Enhancing User Experience

To propose interaction design strategies for the RVC-VA platform, we further analyzed the effects of independent variables on dependent variables. Descriptive statistics for the data are presented in Table 4. We found that skewness values for each item ranged from −0.744 to 0.233, while kurtosis values ranged from −0.490 to 1.193. According to

Byrne [112], data can be considered to meet univariate normality if the absolute value of skewness is less than 2 and the absolute value of kurtosis is less than 7; our findings align with this recommendation.

Table 4. Results of descriptive statistics.

Construct	Item	Skewness (Item)	Kurtosis (Item)	Skewness (Construct)	Kurtosis (Construct)	Mean	SD	Variance
Perceived interactivity	PI1	−0.621	0.996	−0.907	0.949	3.909	0.634	0.402
	PI2	−0.325	0.035					
	PI3	−0.361	−0.006					
Perceived vividness	PV1	−0.744	1.193	−1.101	1.277	3.846	0.686	0.470
	PV2	−0.572	0.453					
	PV3	−0.657	0.580					
Novel experience	NE1	−0.401	0.430	−0.681	0.685	3.810	0.631	0.398
	NE2	−0.562	0.973					
	NE3	−0.184	−0.084					
Mystery	MY1	−0.587	0.414	−1.111	1.195	3.929	0.676	0.457
	MY2	−0.693	0.555					
	MY3	−0.596	0.817					
Social anxiety	SA1	0.017	−0.325	0.198	−0.701	2.825	0.879	0.773
	SA2	0.232	−0.490					
	SA3	0.233	−0.491					
Flow	FL1	0.165	−0.189	−0.251	−0.277	3.321	0.723	0.523
	FL2	−0.276	−0.108					
	FL3	−0.407	0.269					

Table 5 displays the reliability calculations for each construct. We observed that the corrected item–total correlation values for each item ranged from 0.577 to 0.825. This indicator reflects the correlation between each item and the total construct score, which are used to diagnose the degree to which each item represents construct characteristics. Following the recommendation by Zijlmans et al. [113], corrected item–total correlations should exceed 0.4; therefore, the data in this study fall within an acceptable range. Additionally, Cronbach's alpha values for each construct ranged from 0.784 to 0.909, and removing any item resulted in lower values than the current results. Cronbach's alpha values above 0.6 indicate good construct reliability [109].

Table 5. Results of Cronbach's alpha test.

Construct	Item	Corrected Item-Total Correlation	Cronbach's Alpha If Item Deleted	Cronbach's Alpha
Perceived interactivity	PI1	0.625	0.709	0.784
	PI2	0.577	0.759	
	PI3	0.672	0.651	
Perceived vividness	PV1	0.736	0.742	0.839
	PV2	0.660	0.816	
	PV3	0.712	0.767	

Table 5. *Cont.*

Construct	Item	Corrected Item-Total Correlation	Cronbach's Alpha If Item Deleted	Cronbach's Alpha
Novel experience	NE1	0.696	0.763	0.832
	NE2	0.694	0.765	
	NE3	0.685	0.775	
Mystery	MY1	0.676	0.727	0.812
	MY2	0.665	0.740	
	MY3	0.646	0.758	
Social anxiety	SA1	0.814	0.875	0.909
	SA2	0.825	0.865	
	SA3	0.820	0.868	
Flow	FL1	0.762	0.820	0.874
	FL2	0.761	0.820	
	FL3	0.752	0.828	

The results of the exploratory factor analysis are shown in Table 6. The Kaiser–Meyer–Olkin (KMO) test results were above 0.5, and Bartlett's Sphericity test reached significance, indicating the presence of common factors in the data and sufficient inter-item correlations, justifying the use of exploratory factor analysis. We found that only one new factor with an eigenvalue greater than 1 could be extracted for each construct. Under this condition, and following the recommendation by Fabrigar and Wegener [110], commonalities should exceed 0.4 and factor loadings should exceed 0.6. In this study, commonalities ranged from 0.644 to 0.852, and factor loadings ranged from 0.803 to 0.923, meeting acceptable standards. These results indicate that the items within each construct cluster on a single dimension and reflect similar characteristics, demonstrating the unidimensionality of constructs [114].

Table 6. Results of exploratory factor analysis.

Construct	Item	KMO	Bartlett's Sphere Test	Commonalities	Factor Loading	Eigenvalue	Total Variation Explained
Perceived interactivity	PI1	0.691	0.000 *	0.703	0.838	2.101	70.021%
	PI2			0.644	0.803		
	PI3			0.753	0.868		
Perceived vividness	PV1	0.718	0.000 *	0.790	0.889	2.269	75.646%
	PV2			0.712	0.844		
	PV3			0.767	0.876		
Novel experience	NE1	0.725	0.000 *	0.754	0.868	2.247	74.900%
	NE2			0.752	0.867		
	NE3			0.741	0.861		
Mystery	MY1	0.715	0.000 *	0.742	0.861	2.181	72.702%
	MY2			0.730	0.854		
	MY3			0.710	0.842		

Table 6. *Cont.*

Construct	Item	KMO	Bartlett's Sphere Test	Commonalities	Factor Loading	Eigenvalue	Total Variation Explained
Social anxiety	SA1	0.758	0.000 *	0.842	0.918	2.542	84.742%
	SA2			0.852	0.923		
	SA3			0.848	0.921		
Flow	FL1	0.742	0.000 *	0.803	0.896	2.398	79.921%
	FL2			0.802	0.896		
	FL3			0.793	0.890		

* The level of significance is 0.05.

We employed two methods to assess the model: a first-order confirmatory factor analysis (CFA) and the common latent factor (CLF) method. By comparing the fit indices of these two models, we evaluated potential common method bias. The model fit results are presented in Table 7. We found that the fit indices for the first-order CFA model met the recommended standards from previous studies, with no significant changes in the indices compared to those from the CLF model. This suggests that the model fit is adequate and that common method bias is not present [115].

Table 7. Model fit indices of the CFA and CLF models.

Common Indices	χ^2/df	RMSEA	GFI	AGFI	NFI	CFI	SRMR
Judgment criteria	<3	<0.08	>0.9	>0.9	>0.9	>0.9	<0.08
CFA Value	1.616	0.039	0.951	0.930	0.953	0.981	0.041
CLF Value	1.581	0.038	0.951	0.930	0.954	0.982	0.042

Detailed results for the first-order CFA are shown in Table 8. According to the recommendations of Norhayati et al. [116], factor loadings should be greater than 0.6. In this study, the calculated factor loadings ranged from 0.675 to 0.883, with all meeting significance standards. The squared multiple correlation (SMC) values were above 0.4 [117], indicating that the items effectively measured the characteristics of the constructs. Furthermore, the calculated average variance extracted (AVE) for each construct in this study was greater than 0.4, and the composite reliability (CR) exceeded 0.6, indicating good convergent validity [115].

Table 8. Convergence validity of confirmatory factor analysis.

Construct	Items	Factor Loading	t Value	SE	Sig.	SMC	AVE	CR
Perceived interactivity	PI1	0.763	16.860	0.026	0.002 *	0.582	0.557	0.789
	PI2	0.675	14.348	0.031	0.001 *	0.455		
	PI3	0.795	17.795	0.025	0.002 *	0.631		
Perceived vividness	PV1	0.810	18.919	0.023	0.001 *	0.656	0.637	0.840
	PV2	0.756	17.157	0.026	0.001 *	0.572		
	PV3	0.827	19.484	0.023	0.001 *	0.684		
Novel experience	NE1	0.804	17.891	0.025	0.001 *	0.647	0.622	0.831
	NE2	0.808	17.999	0.027	0.001 *	0.653		
	NE3	0.753	16.481	0.026	0.001 *	0.568		

Table 8. *Cont.*

Construct	Items	Factor Loading	t Value	SE	Sig.	SMC	AVE	CR
Mystery	MY1	0.820	18.938	0.022	0.002 *	0.673	0.590	0.811
	MY2	0.742	16.486	0.029	0.001 *	0.550		
	MY3	0.739	16.412	0.025	0.001 *	0.547		
Social anxiety	SA1	0.872	21.567	0.014	0.001 *	0.760	0.771	0.910
	SA2	0.883	21.983	0.012	0.002 *	0.780		
	SA3	0.880	21.858	0.014	0.001 *	0.774		
Flow	FL1	0.826	19.396	0.018	0.001 *	0.683	0.698	0.874
	FL2	0.837	19.747	0.019	0.001 *	0.701		
	FL3	0.844	19.969	0.020	0.002 *	0.712		

* The level of significance is 0.05.

We applied the Fornell–Larcker criterion to assess discriminant validity, with results shown in Table 9. We found that the correlation coefficients between constructs ranged from −0.165 to 0.666, with all reaching significance. This indicates the presence of linear relationships suitable for establishing a structural equation model with an oblique model. The correlation coefficients were below 0.8, suggesting that multicollinearity is not a concern [118]. Additionally, we found that the square root of each construct's AVE was greater than its correlation with any other construct, indicating good discriminant validity [119].

Table 9. Results of Fornell–Larcker criterion.

	PI	PV	NE	MY	SA	FL
Perceived interactivity	0.746					
Perceived vividness	0.664 *	0.798				
Novel experience	0.254 *	0.324 *	0.789			
Mystery	0.585 *	0.666 *	0.374 *	0.768		
Social anxiety	−0.165 *	−0.102 *	0.130 *	−0.102 *	0.878	
Flow	0.330 *	0.372 *	0.282 *	0.416 *	0.154 *	0.835

* The level of significance is 0.05.

To further assess discriminant validity, we employed the heterotrait–monotrait ratio (HTMT). This method involves pairwise comparisons by calculating the ratio of correlations within constructs and correlations between constructs. Following the recommendation of Peralta and Rubalcaba [120], HTMT values should be below 0.85. The calculated HTMT values in this study ranged from 0.118 to 0.819, indicating acceptable discriminant validity. HTMT results are presented in Table 10.

Table 10. Results of the heterotrait–monotrait ratio.

	PI	PV	NE	MY	SA	FL
Perceived interactivity						
Perceived vividness	0.819					
Novel experience	0.321	0.393				
Mystery	0.735	0.807	0.460			

Table 10. *Cont.*

	PI	PV	NE	MY	SA	FL
Social anxiety	0.197	0.118	0.148	0.121		
Flow	0.398	0.433	0.331	0.494	0.172	

We also constructed a second-order CFA model to determine whether the first-order constructs were suitable for measuring the second-order construct. The model fit results are shown in Table 11. The results indicate that all fit indices met the recommended standards from prior studies, demonstrating good model fit [115].

Table 11. Model fit indices of the second-order CFA model.

Common Indices	χ^2/df	RMSEA	GFI	AGFI	NFI	CFI	SRMR
Judgment criteria	<3	<0.08	>0.9	>0.9	>0.9	>0.9	<0.08
SEM Value	1.409	0.032	0.982	0.967	0.981	0.994	0.021

The second-order CFA model is illustrated in Figure 4. We found that the factor loadings for the first-order constructs on the second-order construct mysterious interaction (MI) met acceptable standards, i.e., perceived interactivity, perceived vividness, and mystery [115]. This indicates that the first-order constructs effectively reflect the overall characteristics of the second-order construct, demonstrating the good explanatory power of the model.

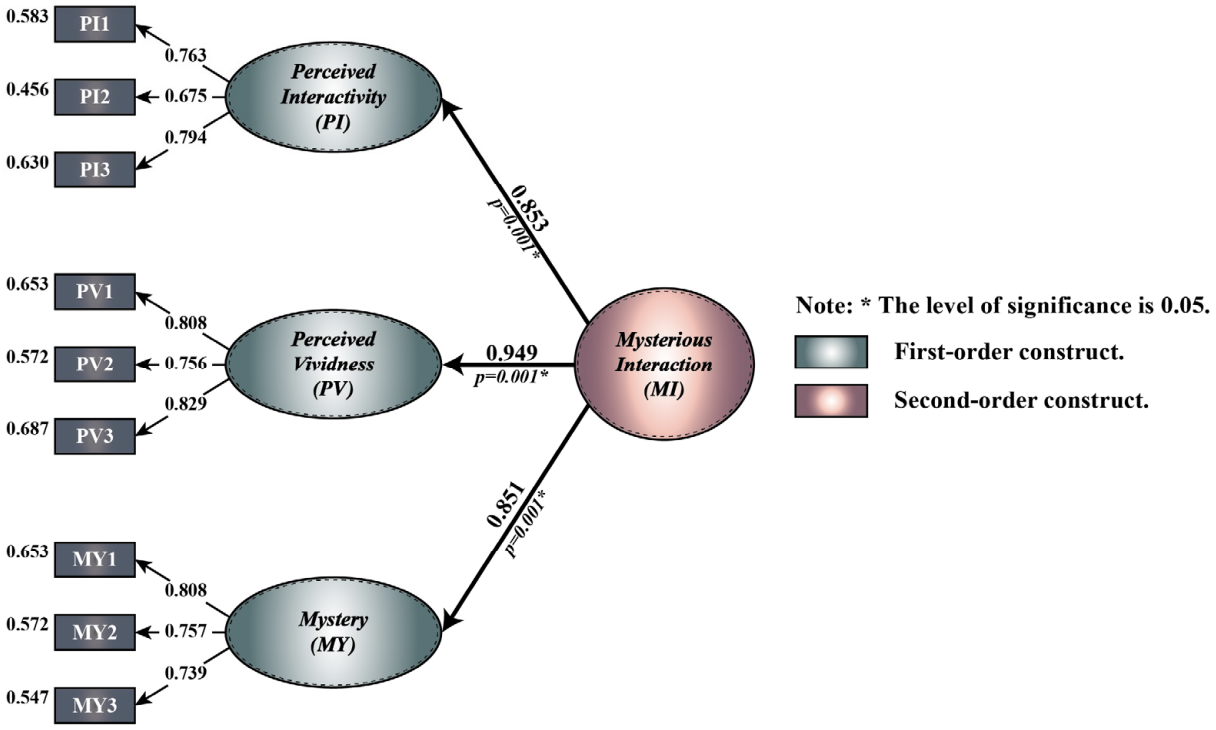

Figure 4. The second-order CFA model.

We constructed a structural model to confirm the hypothesis paths. The model fit indices, shown in Table 12, reached acceptable standards [115]. We used the maximum likelihood method for calculation and performed 2000 bootstrapping iterations to assess the significance of coefficients.

Table 12. Model fit indices of the structural equation model.

Common Indices	χ^2/df	RMSEA	GFI	AGFI	NFI	CFI	SRMR
Judgment criteria	<3	<0.08	>0.9	>0.9	>0.9	>0.9	<0.08
SEM Value	1.684	0.041	0.946	0.927	0.948	0.978	0.046

The structural model is illustrated in Figure 5, where bidirectional arrows represent correlation coefficients between constructs, and unidirectional arrows represent path coefficients indicating the impact of independent variables on dependent variables. Following the recommendations of Owusu et al. [121], the effect size was classified into three levels: weak (0.1–0.3), neutral (0.3–0.5), and strong (greater than 0.5). We identified three paths within the weak level range: the effect of mysterious interaction on social anxiety, the effect of novelty experience on social anxiety, and the effect of social anxiety on flow. Additionally, the effect of mysterious interaction on flow reached a strong level, while the effect of novelty experience on flow did not meet the weak level threshold.

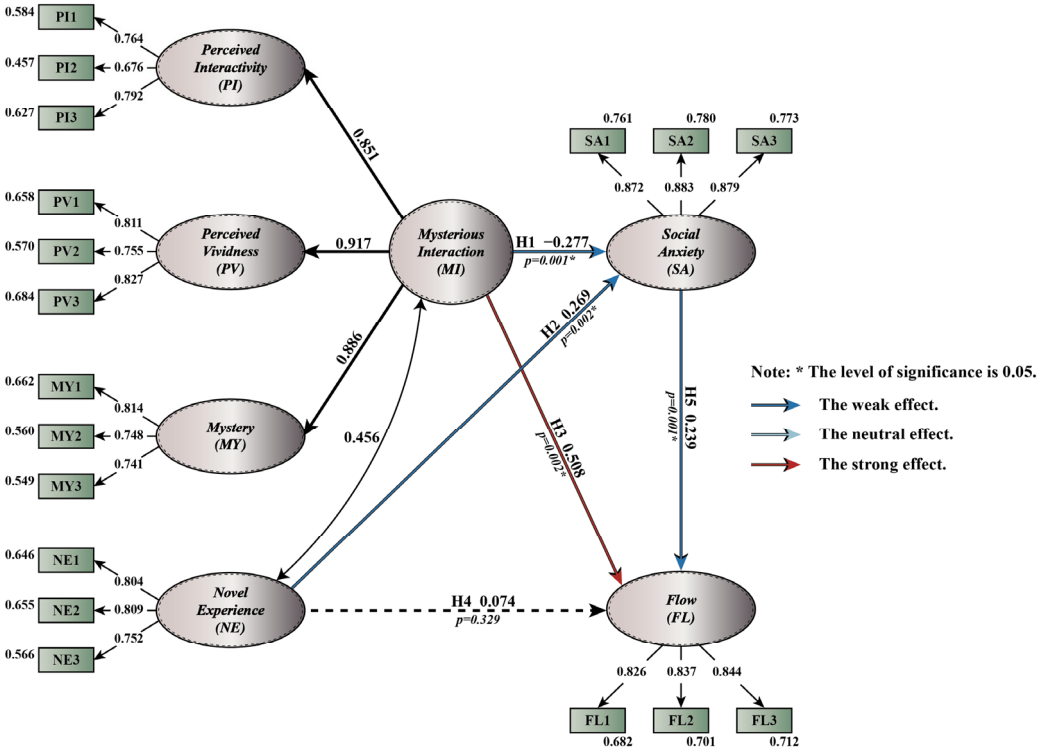

Figure 5. The structural model.

We conducted a detailed examination of the direct, indirect, and total effects of each path, as shown in Table 13. Results indicated that mysterious interaction had a significant negative effect on social anxiety, supporting H1. Conversely, novelty experience had a significant positive impact on social anxiety, which contradicted our hypothesis. Thus, H2 was rejected. On the other hand, we found that mysterious interaction had a significant positive effect on flow, and its indirect effect via social anxiety reached significance, indicating a partial mediation relationship. However, given that the path coefficient was below 0.1, the practical significance of this mediation effect is limited, and we do not consider it to represent a robust or valuable relationship [40]. Similarly, in the path from novelty experience to flow, the direct effect was not significant, while the indirect effect was. Although a full mediation relationship was formed, it did not meet the acceptable influence standards. Therefore, H3 is supported, while H4 is not. Finally, contrary to our hypothesis, social anxiety had a significant positive effect on flow, leading to the rejection of H5.

Table 13. Paths affect results.

Hypothesis	Path	Direct Effect		Indirect Effect		Total Effect		Results
		β	Sig.	β	Sig.	β	Sig.	
H1	MI → SA	−0.277	0.001 *	/	/	−0.277	0.001 *	Supported
H2	NE → SA	0.269	0.002 *	/	/	0.269	0.002 *	Not Supported
H3	MI → FL	0.508	0.002 *	−0.066	0.001 *	0.442	0.001 *	Supported
H4	NE → FL	0.074	0.329	0.064	0.001 *	0.138	0.062	Not Supported
H5	SA → FL	0.239	0.001 *	/	/	0.239	0.001 *	Not Supported

* The level of significance is 0.05.

We tested the moderating effect of gender on each path, with results shown in Table 14. Gender had a significant moderating effect on the path from novelty experience to flow, indicating that the null hypothesis of equal path coefficients across genders was rejected.

Table 14. Results of moderating effect.

Path	Gender	
	CMIN	Sig.
MI → SA	1.463	0.227
NE → SA	0.002	0.965
MI → FL	1.117	0.290
NE → FL	10.379	0.001 *
SA → FL	2.657	0.103

* The level of significance is 0.05.

The specific moderating effect of gender on the path from novelty experience to flow is detailed in Table 15. For male users, changes in novelty experience did not significantly impact flow. However, for female users, the effect of novelty experience on flow reached significance. This result partially supports our proposed hypothesis.

Table 15. Comparison results of path coefficients.

Moderating Variable	Group	Path	β	Sig.
Gender	Male	NE → FL	−0.142	0.224
	Female		0.261	0.007 *

* The level of significance is 0.05.

We employed fsQCA to examine necessary conditions for the presence or absence of the dependent variable. The data calibration process calculated three qualitative breakpoints for each variable's mean: 0.050, 0.500, and 0.950 [122]. These values are interpreted as non-membership, the crossover point, and full membership, respectively [123]. Following Fiss [124], we added a constant of 0.001 to the calibrated data to ensure accurate recognition and calculation. The results of the necessity test are shown in Table 16. We observed that all consistency scores were below 0.900; therefore, they did not meet the threshold proposed in previous studies [125]. This indicates that none of the independent variables can be regarded as necessary conditions for the presence or absence of social anxiety or flow.

We selected configurations with a raw consistency above 0.750, setting the threshold frequency to 1 [126]. Additionally, we referred to the proportional reduction in inconsistency (PRI) for further preliminary screening. Sharma et al. [127] argue that this metric avoids simultaneous subset relations of configurations in both the outcome and its absence. The PRI score should approximate the consistency score, with values below 0.500 indicating

significant inconsistency. We computed complex, parsimonious, and intermediate solutions. The complex solution presents all possible combinations of conditions when traditional logical operations are applied, the parsimonious solution identifies the essential conditions that cannot be ignored in any solution, and the intermediate solution is a partial simplification that considers combinations of simplified conditions without excluding significant, relevant conditions [127]. We primarily report the intermediate solution, while referring to the parsimonious solution in determining core and peripheral conditions.

Table 16. Results of necessary condition analysis.

Construct	Social Anxiety (Absence)		Flow (Absence)	
	Consistency	Coverage	Consistency	Coverage
Perceived interactivity	0.613 (0.732)	0.576 (0.666)	0.728 (0.636)	0.708 (0.558)
Absence of perceived interactivity	0.645 (0.535)	0.713 (0.573)	0.546 (0.668)	0.624 (0.689)
Perceived vividness	0.630 (0.724)	0.603 (0.672)	0.739 (0.633)	0.732 (0.566)
Absence of perceived vividness	0.657 (0.572)	0.711 (0.600)	0.562 (0.700)	0.629 (0.707)
Novel experience	0.621 (0.609)	0.663 (0.629)	0.682 (0.571)	0.752 (0.568)
Absence of novel experience	0.652 (0.674)	0.633 (0.633)	0.608 (0.750)	0.611 (0.680)
Mystery	0.642 (0.740)	0.577 (0.644)	0.775 (0.631)	0.721 (0.529)
Absence of mystery	0.605 (0.514)	0.706 (0.581)	0.494 (0.667)	0.597 (0.728)
Social anxiety	/	/	0.671 (0.619)	0.694 (0.578)
Absence of social anxiety	/	/	0.592 (0.672)	0.633 (0.648)

Table 17 presents the configurational analysis results for social anxiety. We found that consistency scores ranged from 0.812 to 0.836, while raw coverage values ranged from 0.284 to 0.434. Sukhov et al. [128] consider raw coverage values above 0.200 to be acceptable, as this metric indicates the percentage of cases explained by the corresponding solution. Additionally, solution consistency exceeded 0.750, meeting the acceptable standard [129]. Four causal configurations contributed to high levels of social anxiety. Based on Configuration 1, we found that, in the absence of perceived interactivity, the presence of perceived vividness still leads to high levels of social anxiety. Based on Configuration 2, we found that, in the absence of mystery, the presence of novelty experience leads to high levels of social anxiety. Based on Configuration 3, we found that, in the absence of perceived vividness, the presence of novelty experience leads to high levels of social anxiety. Based on Configuration 4, we found that, in the absence of both perceived vividness and mystery, the presence of perceived interactivity still leads to high levels of social anxiety.

Table 17. Results of configurational analysis for social anxiety.

Configurations	Solution					
Model: SA = f (PI, PV, NE, MY)	High Social Anxiety			Not High Social Anxiety		
	M1	M2	M3	M4	M1	M2
Perceived interactivity	⊗			●	●	●
Perceived vividness	●		⊗	⊗	●	⊗
Novel experience		●	●		⊗	⊗
Mystery		⊗		⊗	⊗	●

Table 17. *Cont.*

Configurations	Solution					
Raw coverage	0.396	0.390	0.434	0.318	0.284	0.301
Unique coverage	0.070	0.020	0.042	0.026	0.056	0.073
Consistency	0.812	0.836	0.832	0.824	0.833	0.831
Solution coverage	0.595				0.357	
Solution consistency	0.763				0.812	

Note: Black circles indicate the presence of a condition, while the crossed-out circle indicates its absence. Large circles indicate core conditions, whereas small circles indicate peripheral conditions.

The low levels of social anxiety are caused by two causal configurations. Based on Configuration 1, we found that, in the absence of novelty experience and mystery, the presence of perceived interactivity and perceived vividness leads to low levels of social anxiety. Based on Configuration 2, we found that, in the absence of perceived vividness and novelty experience, the presence of perceived interactivity and mystery leads to low levels of social anxiety.

Table 18 presents the configurational analysis results for flow. We found that consistency scores ranged from 0.820 to 0.896, with raw coverage values between 0.349 and 0.600. Solution consistency also exceeded the previously recommended threshold of 0.750, meeting acceptable standards [129]. Five causal configurations contributed to high levels of flow. Based on Configuration 1, we found that the presence of novelty experience and mystery leads to high levels of flow. Based on Configuration 2, we found that the presence of perceived vividness and social anxiety leads to high levels of flow. Based on Configuration 3, we found that the presence of mystery and social anxiety leads to high levels of flow. Based on Configuration 4, we found that the presence of perceived interactivity, perceived vividness, and novelty experience leads to high levels of flow. Based on Configuration 5, we found that the presence of perceived interactivity, novelty experience, and social anxiety leads to high levels of flow.

Table 18. Results of configurational analysis for flow.

Configurations	Solution								
Model: FL = f (PI, PV, NE, MY, SA)	High Flow					Not high Flow			
	M1	M2	M3	M4	M5	M1	M2	M3	M4
Perceived interactivity				●	●		⊗	⊗	⊗
Perceived vividness		●		●		⊗		⊗	⊗
Novel experience	●			●	●	⊗	⊗		⊗
Mystery	●		●			⊗	⊗	⊗	⊗
Social anxiety		●	●		●	⊗	⊗	⊗	
Raw coverage	0.600	0.510	0.526	0.531	0.411	0.369	0.349	0.354	0.447
Unique coverage	0.026	0.031	0.025	0.003	0.009	0.037	0.022	0.027	0.120
Consistency	0.832	0.838	0.848	0.841	0.896	0.869	0.871	0.870	0.820
Solution coverage	0.756					0.534			
Solution consistency	0.779					0.810			

Note: Black circles indicate the presence of a condition, while the crossed-out circle indicates its absence. Large circles indicate core conditions, whereas small circles indicate peripheral conditions.

In contrast, low levels of flow are caused by four causal configurations. Based on Configuration 1, we found that the absence of perceived vividness, novelty experience, mystery, and social anxiety leads to low levels of flow. Based on Configuration 2, we found that the absence of perceived interactivity, novelty experience, mystery, and social anxiety leads to low levels of flow. Based on Configuration 3, we found that the absence of perceived interactivity, perceived vividness, mystery, and social anxiety leads to low levels of flow. Based on Configuration 4, we found that the absence of perceived interactivity, perceived vividness, novelty experience, and mystery leads to low levels of flow.

In this study, we conducted semi-structured interviews with four users recruited offline, inviting them to experience the core features of the RVC-VA platform, and discussed how design elements, such as perceived interactivity, perceived vividness, novelty experience, and mystery, may influence social anxiety and flow, as well as the specific mechanisms involved. The average interview time for each user was 45 min, and the content was recorded as text, totaling 30,591 words. The users were aged between 20 and 30, with 2 males and 2 females, who were students or engaged in the education, publishing, or music industries. These user characteristics were similar to those in previous research on the same platform [5]. As shown in Table 19, we selected representative viewpoints and summarized the mechanisms through which various design elements affect social anxiety.

Table 19. Mechanisms through which each design factor influences social anxiety.

Design Factor	Dependent Variable	Interview Transcript
Perceived interactivity	Social anxiety	User A, 19:28: "If I feel social anxiety while communicating with someone, I would hope for interactivity as a guide, helping me quickly exit the conversation, or for interactivity to serve as a means to ease some of the awkwardness in the exchange". User C, 19:04: "I think it would be better if perceived interactivity were increased, as it would reduce social anxiety because it would attract both parties' attention. Whether it's pressing a button or clicking something that causes a corresponding effect, it would distract both parties' attention".
Perceived vividness		User A, 18:14: "I think if the platform could be more vivid and immerse me in the scenario, I wouldn't be aware that I am communicating with a stranger, but instead would become more integrated into the conversation itself, which would significantly improve my social anxiety". User D, 14:29: "I think if more senses could be stimulated, such as some background music, it would reduce social anxiety. Having some music while speaking would make things more relaxed, whereas in a quiet setting, if you speak and the other person doesn't respond immediately, it would feel awkward".
Mystery		User B, 26:22: "I think mystery should suppress social anxiety, because not showing your face... means the anxiety isn't as intense... It doesn't need to be too real, really... Otherwise, it would be very anxiety-inducing". User D, 21:05: "The more mysterious it is, the less information can be exposed. For example, my scene could be hidden... and my voice could also be altered. In such a case, it's like being in a protected state... reducing the exposure of my true identity, so I think it would reduce anxiety".
Novelty experience		User B, 16:53: "The first time I used it, I actually wasn't sure if, after clicking this thing, it would show what information about me or my face could be seen. I did experience social anxiety". User C, 35:14: "During my first use... I spent some time on the image issue... This process itself is a reflection of social anxiety because you always want to present the best version of yourself".

By organizing the interview results, we identified the mechanisms through which each design factor influences social anxiety, as shown in Table 20. It is noteworthy that the users' views on the path relationship between novelty experience and flow were not unanimous. Some users believed there was a positive impact, while others held a negative view. To some extent, this debate seems to explain the results of the structural equation model, which suggests that novelty experience does not have a significant direct effect on flow from a linear relationship perspective.

Table 20. Mechanisms through which each design factor influences flow.

Design Factor	Dependent Variable	Interview Transcript
Perceived interactivity	Flow	User B, 35:53: "Interactivity can provide more features... with more options... creating a sense of happiness, and without realizing it, the experience feels particularly smooth and efficient, and time just passes by". User D, 25:29: "If interactivity is enhanced... there could be some customization options, such as different spaces and styles of outfits. Being able to use various accessories to dress up would make the process conducive to flow".
Perceived vividness		User A, 27:13: "Vividness makes it easier for me to immerse myself in the conversation... I can ignore external distractions and focus on the current conversation, thus facilitating my entry into a flow state". User D, 27:22: "I think if it's more vivid, it would be easier to experience flow, as it stimulates more of your senses. For example, with sound and better colors, it would definitely attract you to maintain focus".
Mystery		User A, 33:26: "I now feel that mystery more often promotes flow... When you're curious about what the other person is like... it increases the willingness to chat... becoming more engaged... wanting to learn more about the other person's information". User B, 41:40: "The more mysterious it is, the more it triggers curiosity. But I think it's a social app, so users need to be curious enough to immerse themselves in the process of getting to know each other".
Novelty experience		User A, 31:54: "At first, I might get distracted because I'm not very familiar with it. When trying something new, I would focus some attention on understanding the system... so this would also inhibit flow to some extent (negative)". User B, 49:09: "From my personal experience, because I really wanted to know what updates had been made and was eager to try it, I felt very excited and positive... In fact, from that moment on, my mood was already deeply immersed in the experience (positive)". User C, 51:45: "I think novelty diminishes flow because novelty means unfamiliarity... there's a sense of strangeness... and many things to consider, which leads to an inability to enter a flow state (negative)". User D, 30:36: "If it stays the same... playing for a long time might get boring. But if there are different outfits and new content updates... it would be like shopping for clothes... trying out new combinations would promote flow (positive)".

5. Discussion

In this paper, we analyze how interactive design supports online social services based on the RVC-VA platform. Virtual avatars create digital self-representations for users through technologies such as recognition, tracking, motion capture, and expression mapping, which are based on computer vision [130]. This technology plays an important role in social activities and has become a hot topic in the fields of systems and communications [131].

Based on the results of a quantitative survey, we propose validated design strategies, with specific findings detailed below.

Comparatively, we found that users exhibited lower levels of social anxiety when using the RVC-VA platform than when using real-person images. Here, social anxiety refers to the dynamic level of anxiety experienced by users while using the platform, rather than their individual characteristics. In other words, we observed differences in social anxiety levels for the same users when using the two platforms, but our conclusions do not suggest that users' platform preferences are related to their inherent levels of social anxiety. As noted by Rogers et al. [132], virtual avatars can provide users with social interactions similar to face-to-face interactions. This technology may also enhance users' experiences in media environments [133]. The RVC-VA platform retains necessary social information while allowing users to hide their identities and characteristics. Recent studies indicate that levels of social anxiety may be rising, particularly affecting young people [69]. Many users choose to meet new friends through the RVC-VA platform to expand their social networks. Their intentions are not limited to forming same-gender friendships but may also include establishing emotional connections with the opposite gender. A well-designed media environment can help users reduce negative interpretations or biases regarding social activities. Our research confirms the advantages of the RVC-VA platform for real-time information transmission and support for audio and visual communication, corresponding to lower levels of social anxiety.

Our research results provide design suggestions for the RVC-VA platform to alleviate users' social anxiety, primarily including increasing mysterious interaction and reducing users' novelty experience. First, consistent with our expectations, the second-order construct of mysterious interaction, composed of perceived interactivity, perceived vividness, and mystery, has a significant negative impact on social anxiety. Users with higher levels of social anxiety may interpret social events as negative evaluations or rejections from others, and some users may catastrophize minor negative social incidents [134]. Designers can enhance the system's mysterious interaction attributes to help improve this situation. For example, users in a chat can be guided to participate in specific activities. These activities should feature high levels of interactivity, such as fast feedback, realistic controls, and multiple methods of interaction [44], as well as high levels of vividness characterized by stimulating multiple senses and strong expression of sensory dimensions [52], and high levels of mystery that are unknown, deliberately concealed, and engaging [62]. As Hong and Cho [135] state, technology is not merely an assistant to human activities; it is also a powerful force that reshapes human activities and their meanings. Finding topics of mutual interest after random matching is key to reducing social anxiety and successfully establishing friendships. The system's mysterious interaction attributes may enrich user experiences by providing sufficient information to create sustained conversations [8]. Users can naturally get to know each other during activities rather than blindly probing each other's interests in a state of ignorance.

Secondly, we found that novelty experience is related to users' social anxiety. In situations of high social anxiety, users may feel discomfort in social relationships and anticipate embarrassment or humiliation from being evaluated by others [136]. One possible explanation is that users experience additional worries due to the system's novelty. For instance, uncertainties may arise about whether the virtual avatar fully represents them, whether the image becomes distorted or loses quality during communication, or whether their voice is altered by the system's stylization. These concerns can further evolve into insecurity and anxiety regarding social relationships. This result resonates with the viewpoint of Miguel-Alonso et al. [137], who suggest that a novel media environment may impose additional cognitive load on users due to new, unfamiliar, and unexpected

modes of interaction. Although novelty may be associated with pleasure [138], and has positively influenced user attitudes in other specific systems [139], enhancing novelty experience in the RVC-VA platform may trigger high levels of social anxiety. An effective coping strategy may be to provide adequate functionality explanations and appropriate onboarding guidance. Furthermore, users may become more familiar with the system over time, leading to a decline in perceptions of novelty [93]. Therefore, designers may also consider reducing major updates and try to maintain the basic logic of system usage to avoid a sudden increase in users' novelty experience.

On the other hand, we confirm the antecedent variables that positively impact flow. First, mysterious interaction demonstrates its importance in the RVC-VA platform. It can effectively enhance flow, resulting in positive effects on user experience. Previous practical research has also reported design concepts similar to mysterious interaction. For example, Klopfer et al. [140] developed an application called "Museum Mystery", where users explored cultural and educational spaces using handheld interactive devices. Freitas et al. [141] designed an interactive narrative themed "Mystery of the Ecological Park", allowing users to unravel a mystery through digital nonlinear exploration. These cases utilized a combination of real and virtual elements in their designs, with functionalities and patterns reflecting the first-order constructs of mysterious interaction, such as perceived interactivity, perceived vividness, and mystery, receiving positive feedback in testing. Our research confirms the positive impact of mysterious interaction on user experience and extends its effectiveness to fully virtual media environments.

Secondly, we verify that novelty experience does not enhance flow experiences for male users of the RVC-VA platform but can have a positive impact on female users. It is noteworthy that novelty experience increases users' levels of social anxiety. The concomitant negative effects limit the practical significance of this conclusion. One possible explanation is that triggering flow requires users to perceive a balance between their abilities and the challenges they face, both being at a high level [84]. Under this premise, users may view the novelty of the media environment as a challenge, providing objective conditions for the emergence of flow experiences. Miguel-Alonso et al. [142] argue that novelty in virtual environments can diminish enjoyment during user experiences. Our research results challenge this viewpoint, as flow experiences are considered a pleasurable psychological state [143]. We believe that the impact of novelty experience should be dual-faceted—neither completely positive nor negative. When the media environment possesses social attributes, it may induce social anxiety in users while simultaneously fostering a high level of engagement and concentration, leading to a sense of losing track of time and space [144].

Additionally, we find that higher social anxiety levels correlate with an increased likelihood of experiencing flow. This seems counterintuitive, as social anxiety is often regarded as a negative feeling [145,146]. Wang et al. [97] noted that users' levels of social anxiety had a slightly positive impact on flow experience in their study on interactive experiences with automatic ordering machines; however, their results did not reach statistical significance. Our study further finds that this intriguing effect is statistically significant in the context of the RVC-VA platform. Previous research has indicated that users with higher levels of social anxiety tend to perceive digital technology as more attractive [147]. They may believe that human–computer interaction experiences are feasible, acceptable, and safe [68]. Yuan et al. [148] also argue that social anxiety can promote user acceptance of such tools by modulating the advantages of the media environment. Nevertheless, our research findings can only confirm that a relationship exists between them, while the specific motivations of users warrant further qualitative analysis.

The configuration analysis results demonstrate the presence and absence of various design elements when users exhibit different levels of social anxiety and flow. It is noteworthy that we found that low levels of social anxiety must meet the condition of nonexistence of novelty experience. This further validates the impact of novelty experience on users' social anxiety within the RVC-VA platform. We discovered that all five configurations corresponding to high levels of flow included at least one of either novelty experience or social anxiety. While novelty experience can be directly controlled through design, its close relationship with social anxiety suggests that enhancing it for the sake of achieving flow may be risky. Furthermore, social anxiety is not entirely dependent on system design but is also related to user traits [149]. For users with higher levels of social anxiety, the design of the RVC-VA platform can stimulate high levels of flow when it satisfies either perceived vividness or mystery, allowing them to gain positive experiences. This finding seems to imply that the RVC-VA platform has the potential to serve as an intervention for users with social anxiety and, even more broadly, for users with diverse social abilities, such as those with autism, helping them to be exposed to social environments and reducing potential avoidance behaviors. As noted in the research by Kellems et al. [150], autistic users look forward to interacting with virtual avatars and can understand the basic emotions represented by humanoid virtual avatars. It must be emphasized that existing evidence is insufficient to support any medical inferences, and we can only provide referrals for colleagues in psychotherapy or related fields. Notably, we found that mystery is the only condition that must be absent in the four configurations of low flow. This concept has long seemed to receive insufficient attention in human–computer interaction research, and our findings emphasize the importance of mystery and provide compelling evidence.

6. Conclusions

6.1. Research Conclusions

This study validated the application effects of virtual avatars on the RVC-VA platform through two questionnaire surveys. Specifically, in Study 1, we found that users experienced lower levels of social anxiety when using the RVC-VA platform compared to using real-person images. This finding indicates that virtual avatar technology helps to provide a more positive user experience in human–computer interaction environments. In Study 2, we discovered that second-order construct mysterious interaction, composed of perceived interactivity, perceived vividness, and mystery, reduced social anxiety and enhanced flow experience. This pathway aligns with our expectations and successfully explains the potential of the RVC-VA platform to promote online social behavior, as well as the essential functionalities that need to be considered when applied in commercial activities. Unlike the conclusions of many previous studies, we found that perceived novelty heightened social anxiety, and female users perceived that novelty positively influenced their flow experience. In this context, we argue that perceived novelty should not be simply regarded as a positive factor; rather, its potential effects should be analyzed dialectically based on user characteristics, and it should be cautiously employed as a design element. Surprisingly, social anxiety had a positive effect on flow experience. Generally, social anxiety is perceived as a negative feeling, whereas flow experience is considered a pleasant state of full engagement. We believe this pathway might be related to the fulfillment of users' social needs. In other words, a high level of social anxiety may not necessarily indicate a lack of desire to engage in conversations with others. Instead, it may represent an unmet social need, suggesting that higher levels of social anxiety could correspond to a greater gap in unmet social needs and, once social services are obtained, the likelihood of achieving a flow experience increases. It must be emphasized that this interpretation, as one way of explaining the data, requires further evidence to substantiate. Furthermore, from the perspective of

configurational analysis, we found that low levels of social anxiety necessarily require the absence of perceived novelty. On the other hand, low levels of flow experience only occur in the absence of mystery. These findings provide design recommendations for applying virtual avatar technology in online social services and contribute to the advancement of human–computer interaction systems.

6.2. Theoretical Contributions

This study successfully constructs the concept of "mysterious interaction", a second-order construct that includes perceived interactivity, perceived vividness, and mystery, and demonstrates its effectiveness in reducing users' social anxiety and enhancing their flow experience. According to our theoretical model, novelty experience should not be regarded merely as a positive construct, as it may elicit higher levels of anxiety. Furthermore, gender serves as an effective moderating variable between novelty experience and flow. This path relationship is ineffective for male users but shows a positive impact among female users. Additionally, it is noteworthy that social anxiety can positively influence users' flow, a phenomenon that has been less frequently mentioned in previous studies. From the perspective of theoretical development, this study provides a deeper explanation of users' online social behavior. We have verified the potential of design elements, such as perceived interactivity and perceived vividness, in interactive social environments, which is of significant importance for enhancing user experience. The results also indicate that novelty experience exerts a complex influence on users, which may be related to the context of technology use. Compared to entertainment activities, users in social contexts are more inclined toward technology that provides familiarity and controllability. Virtual avatars, combining technologies such as computer vision and deep learning, have gained widespread attention amid the rapid development of artificial intelligence. Based on innovative concepts, such as human-centeredness, natural interaction, intelligence, and sustainability, we have expanded the existing theoretical framework and contributed to future design topics from the perspective of human–computer interaction.

6.3. Managerial Implications

This study offers practical design suggestions for RVC-VA platforms. We suggest that designers consider incorporating activities that exhibit perceived interactivity, perceived vividness, and mystery into services. These activities should be challenging and dynamically adjusted in real-time according to users' individual abilities, achieving a balance between challenge and ability. The system can frequently acknowledge users' abilities during interactions, for example, by providing specific percentages that indicate that their current ability level is high. However, we argue that it is not advisable to risk enhancing novelty experience in pursuit of flow experience. A more prudent strategy is to focus on ensuring the presence of perceived interactivity, perceived vividness, and mystery within the system, thereby ensuring that low levels of flow do not occur. Furthermore, the RVC-VA platform appears to have the potential to provide a positive media environment for users with high levels of social anxiety, meeting their social needs and offering a space to practice social skills.

6.4. Research Limitations and Future Studies

This study has three main limitations that warrant further exploration and validation in future research. First, our sample was concentrated in China, without investigation of a broader range of countries or regions, nor among users raised in cross-cultural contexts. The social environment in which users exist may influence their preferences or subconscious behaviors, suggesting that future research should conduct comparisons across a more diverse user base to enhance the robustness of our proposed theory. Second, our focus is on

user experience, which means that variables related to usage or purchase intention were not included in the model. Future commercial studies could consider expanding the model's scope, which would enhance the marketing and operational value of the findings. Third, our analysis does not differentiate between users' purposes for use, such as for romantic or social purposes. We also did not consider users' self-perception of their appearance or their popularity due to their appearance as moderating variables. Future research could consider further analyzing whether these variables influence users' willingness to adopt virtual avatars in order to expand the conclusions drawn from this study and improve the completeness and rigor of the theory.

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