User Experience of Different Groups in Social VR Applications: An Empirical Study Based on User Reviews

Jiong Dong, *Member, IEEE*, Kaoru Ota, *Member, IEEE*, and Mianxiong Dong, *Member, IEEE*

***Abstract*—Social virtual reality (VR) applications provide a diverse and evolving ecosystem for different groups to socialize in VR. Understanding how people explore social VR applications is crucial for VR developers, such as designing social VR content. Previous work has focused on interviewing participants to study the user experience (UX) of social VR. However, the potential value of user reviews of social VR platforms is largely unexplored. In this article, we collect 105 757 user reviews of nine social VR applications from two digital distribution platforms (Steam and Oculus) to study the impact of social VR on people by in-depth analysis of reviews related to avatars, harassment, and physical reactions of different groups. We observe that players prefer avatar customization, and social VR applications are suitable places for some groups, such as lesbian, gay, bisexual, transgender, queer (LGBTQ). However, there are also many complaints from players about harassment and bullying in these social VR applications. Our findings highlight potential design implications of social VR applications for creating more friendly and fulfilling social VR experiences for users.**

***Index Terms*—Social VR, user experience (UX), user reviews, virtual reality (VR).**

I. Introduction

SOCIAL virtual reality (VR) is an emerging online social platform enabling players to interact in virtual space through head-mounted displays (HMDs). Social VR applications have attracted increasing numbers of users to join, especially during the COVID-19 pandemic when people could not do outdoor activities due to the strict lockdown measures. Many people use social VR applications to enjoy VR games, travel in virtual worlds, or communicate with others. Commercially available social VR applications include VRChat, Rec Room, Altspace VR, and PokerStars VR, to name a few.

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Jiong Dong is with the School of Information Engineering, Xuchang University, Xuchang 461000, China, and also with the Department of Sciences and Informatics, Muroran Institute of Technology, Muroran 050-8585, Japan.

Kaoru Ota and Mianxiong Dong are with the Department of Sciences and Informatics, Muroran Institute of Technology, Muroran 050-8585, Japan (e-mail: mx.dong@csse.muroran-it.ac.jp).

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A significant body of literature on social VR has resulted from the popularity of these commercial social VR applications. These studies have focused on design strategies [1], [2], [3], user experiences (UXs) of different age groups [4], [5], [6], [7], [8], [9], [10], self-presentation and avatars [11], [12], [13], [14], [15], and harassment in social VR platforms [16], [17], [18].

However, prior research has two limitations in studying the UX of social VR. First, most earlier studies are based on interviews [19], [20], [21]. Maloney et al. [19] recruited 30 interviewees to explore nonverbal communication in social VR. Piitulainen et al. [20] interviewed 17 participants to explore people's experiences with dancing in social VR. Maloney and Freeman [21] designed a research to investigate what made activities meaningful to users on social VR platforms and users' recommendations. Although research based on interviews has offered valuable insights into UX, the sample size could be easily extended by using reviews as data. Second, some prior social VR literature focused on specific groups, such as Baker and his colleagues paid attention to older adults in social VR [8], [9], [10], [13], Divine Maloney's team concentrated on the influence of social VR on children and teenagers [4], [5], [6]. There has been minimal exploration of a comprehensive study examining the social VR experience across various age groups.

To address the aforementioned gaps, we conduct a comprehensive empirical study grounded in extensive user reviews of social VR applications. In particular, we gather 105 757 English reviews of nine distinct social VR applications from two leading digital distribution platforms (Steam and Oculus), in pursuit of answering the following research questions (RQs).

- RQ1: *What do users think of avatar and self-presentation in social VR?*
- RQ2: *What are the harassment behaviors in social VR?*
- RQ3: *What is the impact of social VR on different groups of people?*
- RQ4: *What are the physical effects of social VR platforms?*
- RQ5: *What are the benefits of social VR during the COVID-19 pandemic?*

In summary, this article makes a number of contributions to UX research in social VR.

1) First, to the best of our knowledge, this is the first study to explore the UX of social VR based on large-scale user reviews from digital distribution platforms.

2) Second, we offer a large-scale dataset of user reviews collected from nine social VR applications, which could be used in future research about the UX of social VR.
3) Third, our study shows the valuable feedback of user reviews, which can help social VR developers better meet users' needs.

The rest of this article is organized as follows. Section II introduces the related work and the differences between our study and others. In Section III, we introduce the data collection, data preprocessing technologies, and topic modeling method. Section IV discusses our findings on research questions. The discussion and future work are presented in Section V. Our conclusion is presented in Section VI.

II. Related Work

A. Social VR Applications

The proliferation of commercial-grade HMDs such as Oculus Rift, Quest, and Vive Index, has catalyzed a surge in VR applications over the past 5 years. These applications span various fields, including gaming, tourism, education, and social interaction. Social VR platforms, in particular, offer an immersive virtual environment that enables multiple users to engage in activities such as chatting, gaming, movie watching, and other social activities, facilitated through VR HMDs. A few notable examples of popular Social VR applications are as follows.

1) *VRChat* was released on Steam on 1 February 2017. Players can design their own virtual worlds to interact with other players using virtual avatars. Players can also create or import character models for use in VRChat thanks to a software development kit for Unity.
2) *Rec Room* was released in June 2016, it consists of separate built-in multiplayer games, such as paint ball, co-op adventures games, 3-D charades, and various sports games. Therefore, the Rec Room attracts a lot of minors.
3) *Altspace VR* was released in May 2015. Users create their own worlds on the platform, which can be visited by other players. The platform also holds various live virtual events such as VR church, lesbian, gay, bisexual, transgender, queer (LGBTQ)+ meetups, magic shows, and large business conferences.
4) *PokerStars VR* is a free-play VR poker game that was released in November 2018. Players can play Texas Holdem, Blackjack, slots, roulette, and sports betting. It is popular on Meta Quest.

According to SteamDB,[1] the two most popular social VR applications on Steam are VRChat and Rec Room. Fig. 1 shows the average number of weekly online players of these two social VR platforms from January 2018 to April 2022. As Fig. 1 illustrates, before 2020, the number of players in VRChat has been hovering around 7500. Since 2020, the number of players has continued to grow. On the one hand, during the COVID-19 epidemic, people are locked down at home and cannot perform outdoor activities, social VR platforms can provide players with immersive virtual worlds where people can interact with friends, families, and strangers. On the other hand, the release of new affordable HMDs has also attracted a large number of players, such as the Oculus Quest 2, which was released on 13 October 2020.

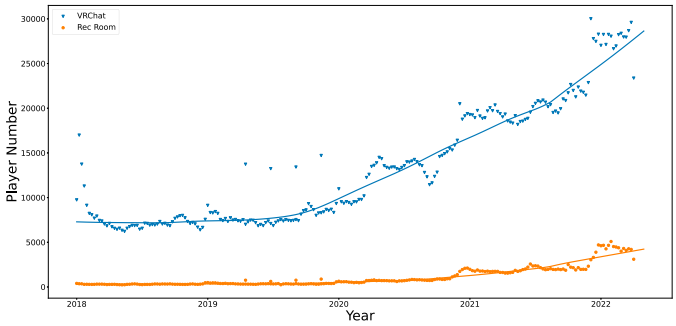

Fig. 1. Trends of average weekly online players of VRChat and Rec Room on Steam from January 2018 to April 2022.

With the popularity of social VR platforms, more and more researches focus on the UX of social VR. Such studies have focused on old adults' [8], [9], [10], [13], children and teenagers' experience in social VR [4], [5], [6], avatars [11], [12], [13], [14], [15], and harassment in VR platforms [16], [17], [18].

Baker and colleagues conducted a broad research project on social VR experiences for older adults [8], [9], [10], [13], their studies demonstrated that social VR provides a promising avenue for supporting social connectedness in later life. For example, older adults could use social VR as a comfortable environment to communicate face-to-face [13], or as a reminiscence tool to stimulate memories [8]. Maloney and colleagues paid attention to children and teens in social VR. In [4], they focused on how people interact with young users across various social VR applications based on interviews with 30 adults. They also applied a participatory observation study to enhance this research [5]. In addition to the perspective of adults, the authors also interviewed 20 teenagers to explore why teenagers engage in social VR [6]. Freeman and Maloney [11] conducted interview-based research on 30 social VR users to explore self-presentation on commercial social VR platforms. They found that social VR users tend to construct platform-specific self-presentation. Based on eight interviews and 2 months of participatory observations, Acena and Freeman [12] explored how LGBTQ users participate in social VR and how social VR has the potential to support them by affording a range of inclusive interactions. In a 5-month study, Baker et al. [13] evaluated a social VR prototype with 16 older adults. Their findings showed that older adults are excited by the possibility of customizing their avatars to match various virtual environments.

However, these prior studies are usually based on interviews, and the number of interviewees is usually less than 50. The limitation is that the sample size is too small. User reviews of social VR platforms are also a considerable treasure, and little existing literature utilizes this resource. User reviews often display a greater spontaneity than feedback collected through surveys or interviews. These voluntarily submitted reviews encapsulate immediate reactions or sentiments, providing a direct insight into UX. The inherent openness of user reviews enables a broad discussion of thoughts and experiences. In contrast,

[1] https://steamdb.info/

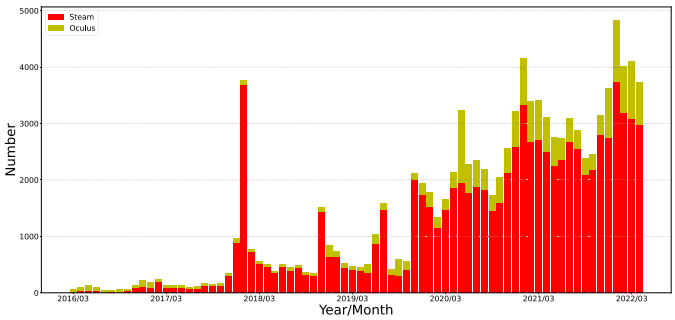

Fig. 2. Monthly distribution of English reviews of social VR platforms on Steam and Oculus.

surveys and interviews, driven by prearranged queries, guide respondents toward particular feedback. Thus, this study harnesses user reviews of nine social VR applications across two digital platforms to investigate social VR UX.

B. User Reviews

User reviews play a vital role for game developers as they provide valuable feedback, both positive and negative, which can be instrumental in ensuring the success of a game [22], [23], [24], [25], [26]. For instance, reviews from players could highlight well-received aspects that should be preserved, or pinpoint areas that need improvement or should be circumvented in future iterations. Hedegaard and Simonsen [23] conducted an analysis of online reviews of software and video games. They proposed that an enhanced understanding of users' concerns regarding various aspects of usability and UX could be derived from the substantial corpus of online self-reported experiences. Eberhard et al. [24] conducted a study of 64 games with 132 013 reviews on Steam and found that review length and time spent playing a game strongly influence the helpfulness of reviews. Lin et al. [25] studied the characteristics of 1182 early access games on Steam, including reviews, release notes, and discussions. They found that the smaller development studios mostly used the early access model, and 15% of games on Steam used the early access model as of that time. Jang and Park [26] explored how user groups (satisfied versus dissatisfied users) and domains (game versus nongame domain) affect the UX of mobile augmented reality based on analyzing user reviews.

With the popularity of VR games, a large body of reviews research has explored the sentiment of players, emotional tendency [27], and the enjoyment of VR games [28]. Epp et al. [29] conducted an empirical study of players' complaints about VR games on Steam. They analyzed 17 635 English reviews of 750 VR games on Steam to understand VR games and user complaints. Qian et al. [30] developed a topic model to identify the critical features of VR applications using 198 301 user reviews from the Oculus Quest Store.

However, there is still very little literature on social VR based on user reviews. Fig. 2 presents the monthly distribution of English reviews of social VR applications on Steam and Oculus platforms. It illustrates a significant volume of reviews published each month, which is a treasure to be unearthed. Compared with Fig. 1, as the number of players increases from 2020, the number of user reviews also increases. The Steam platform is more popular, and the number of reviews on Steam is much more than the Oculus platform. In this article, we study the UX of different groups regarding social VR applications from different aspects, including the virtual avatar, harassment in social VR, physical effects, and the benefits of social VR during the COVID-19 pandemic based on analyzing user reviews.

III. Methodology

In this section, the strategy employed for collecting user reviews from the Steam and Oculus platforms is delineated, along with the procedures adhered to for processing these reviews. Fig. 3 provides a visual representation of our overarching strategy. Subsequent sections elaborate on the specifics of our methodology.

A. Data Collection

We design two customized Python crawlers to collect user reviews from the Steam and Oculus digital distribution platforms as of 30 April 2022. On the Oculus platform, a "Social" category is present within the game genres, thereby facilitating direct acquisition of user reviews for social VR games. In contrast, Steam lacks a "Social" category for VR games. Therefore, after gathering data from Oculus and creating a list of games, we searched for them on Steam and extracted their reviews if available. Ultimately, nine social VR platforms/games were chosen based on the volume of reviews. The game details are as follows.

1) *Steam*: VRChat, Rec Room, PokerStars VR, Altspace VR, and Sansar.
2) *Oculus*: VRChat, Rec Room, Echo VR, PokerStars VR, Real VR Fishing, Poker VR, Altspace VR, and vTime VR.

In summary, we gathered 201 326 user reviews pertaining to nine social VR games, out of which 180 384 were sourced from Steam and 20 473 from Oculus. Furthermore, in adherence to data protection and privacy norms, we refrain from collecting personal information such as usernames and user IDs.

B. Keyword Selection

We construct a keyword bag to extract the most pertinent reviews pertaining to each topic from our dataset. Initially, a rudimentary set of keywords for each topic was curated based on the authors' experience. To enlarge the keyword bag and mitigate potential bias, we extract relevant reviews of each topic from the collected dataset using this initial keyword collection. Subsequently, we remove stop words from each review and employ the Word2vec [31], [32] technique to learn word associations. We calculate the similarity between initial keywords and words, and we choose the top 200 most analogous words for each initial keyword. Finally, the three authors read through the 200 words and select the most relevant keywords for each topic to supplement the keyword bag. Table I shows the keywords bag for each topic.

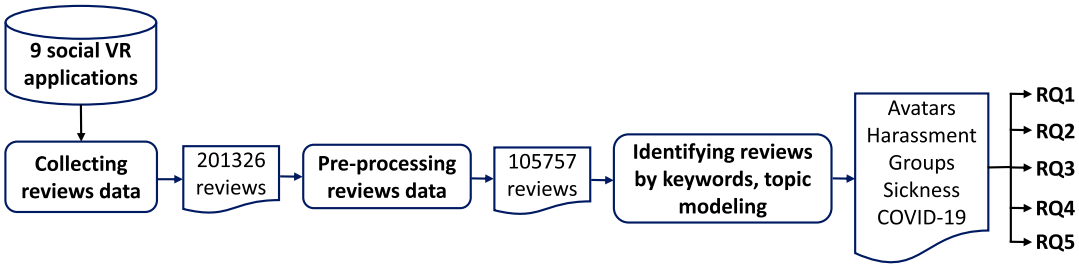

Fig. 3. Overview of review data collection and data processing steps.

TABLE I
OVERVIEW OF KEYWORDS OF TOPICS

Topics		Keywords
Avatar		avatar, perception, presentation, disclosure, privacy, self-disclosure, anonymity
Harassment		sex, sexy, sexual, sexually explicit, sexist, sexism, attack, harassment, bullying, abuse, abusive, discomfort, violent, ableism, racism, racist, black people, color people
Different groups of people	Children & Teenagers	children, youth, adolescence, adolescent, kid, teenager, teens, pedophile
	Couples	couple, husband, wife, girl friend, e-couple boy friend
	Old adults	old adult, grandpa, grandma, grandfather, grandmother, granny, elderly
	LGBTQ	lesbian, gay, bisexual, transgender, queer, lgbtq
	Introvert	shy, introvert, introverted, anonymity, SAD, social phobia, social anxiety disorder, nervous
Motion sickness		nauseous, sickness, cybersickness, nausea, sick
COVID-19		covid, covid-19, pandemic

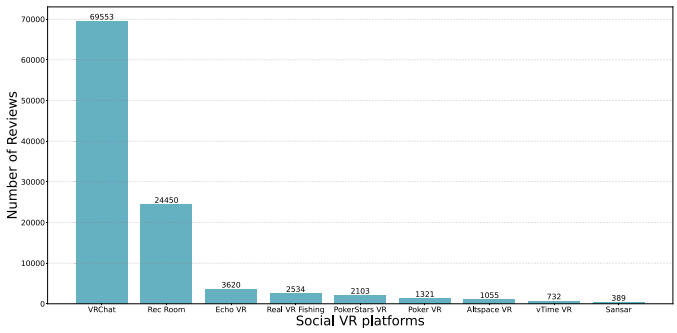

Fig. 4. Review numbers of each social VR platform.

C. Preprocessing Data

In this section, we present the preprocessing steps using natural language processing techniques.

1) Filtering English User Reviews: In this article, we aim to analyze the English reviews. We applied Lingua library to remove non-English reviews, and finally, we got 105 757 English reviews. Fig. 4 shows each social VR platform's total English review numbers.

2) Extracting Key Sentences: The 105 757 user reviews are a large amount of data, and it is impossible to obtain accurate information by directly clustering it. Therefore, we design a keywords bag for each RQ to extract key sentences from the collected review dataset. Fig. 5 illustrates the review numbers of each topic.

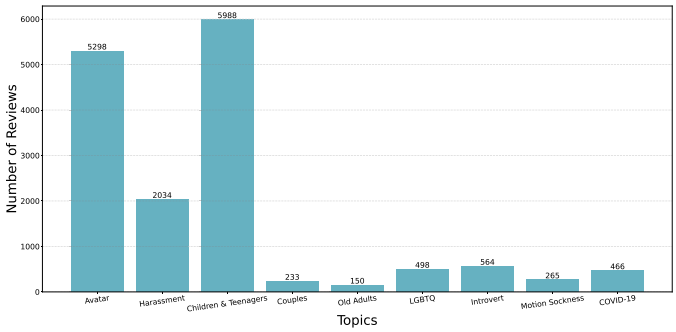

Fig. 5. Review numbers of each topic.

3) Cleaning Reviews: Stop words are frequently occurring words that hardly carry any information in user reviews, and some user reviews may contain distracting text, such as hyperlinks to advertisements. Therefore, it is necessary to clean the review data for more accurate topic clustering. The cleaning steps are as follows.

a) First, we remove the extra spaces and URLs in the reviews. Some reviews contain un URL to a video review, such as a YouTube link. And we also remove punctuation from each review and then convert the text to lowercase.
b) Second, we apply Python package nltk [33] to remove the stop words from each review text and then lemmatize the review text.

4) Topic Modeling: Upon cleansing the review data, we use the Python package BERTopic [34] to extract hot topics the players talk about for the RQs. BERTopic is designed to create dense clusters that make it simple to assign topics while maintaining essential keywords in the topic descriptions. In this step, each review was assigned to one topic.

After performing the BERTopic model on the reviews, the clustered topics were sorted according to the number of reviews assigned to each topic. Because BERTopic is nondeterministic, the results will vary from run to run. As a consequence, we ran the model five times for each research question and subquestion.

For each run, we set the topic parameter of the BERTopic model to 10. The first two authors sort the topics according to the keywords and the number of reviews. After five runs, the two

authors manually group the top 10 topics of all five runs. Then, the two authors discuss and select the top 5 topics. During the discussion, each author gives a rationale for every disagreement. Two authors adopt reasonable results for most of the disagreements. The third author participated in the discussion for the few remaining disagreements to obtain a final consensus.

IV. Findings

In this section, using user reviews of social VR applications, the following five themes are discussed. 1) how users think of avatars in social VR; 2) the harassment behaviors in social VR; 3) the influence of social VR on different age groups; 4) the physical effects of social VR; and 5) the benefits of social VR during COVID-19 pandemic. Note that a user review could be labeled to more than one theme [e.g., "there were some kids in the lobby who were just nasty in trying to do sexual things to my avatar" could be labeled as the themes (2) and (3)].

A. RQ1: What Do Users Think of Avatar and Self-Presentation in Social VR?

Self-presentation in online social platforms has been a long-standing research topic. Compared to other forms of media where users present themselves by creating online profiles using text, images, and videos, social VR introduces an entirely new form of self-presentation that combines a person's body and avatar. In these novel social VR platforms, how users experience and understand avatars and how to perceive the self-presentation of others is a topic worthy of research.

In this article, we collect 5298 avatar-related reviews by using keywords to filter user reviews. Then, we use TextBlob[2] tool to label the emotional sentiment of the reviews as positive, neutral, or negative. TextBlob tool indicates a sentence's attitude by calculating the score as a polarity in $[-1, 1]$. When the polarity of a review is less than -0.4, its sentiment is regarded as negative. The review is considered positive when it is more than 0.4. The polarity of neutral review lies in $[-0.4\ 0.4]$. After this process, the final distribution of the avatar-related reviews is positive (759,14.33%), negative (116, 2.19%), and neutral (4423, 83.48%).

We apply the BERTopic model to categorize the prevalent themes within both positive and negative reviews, thereby discerning what players care about most. In the positive reviews, most players expressed their love for the avatars that social VR applications provide. The second topic is avatar customization. The avatar customization impresses the social VR players, and they can design their avatar according to their liking and even make a great comedic situation. Players are generous with their compliments in reviews for avatar customization.

> "The avatar customization is surprisingly robust!;" "Especially the avatar custom system is wonderful.;" "Would be very willing to spend money for more avatar customization.;" "I love the new version it has more avatar customization."

[2]https://textblob.readthedocs.io/en/dev/

The number of avatar types is also a topic that players are more concerned about, some games have rich avatars for players to choose from: "There are so many avatars to choose to represent yourself;" but in some games, the number of avatars is limited, users require more avatars: "It's good but they need to make more avatars." Avatar diversity should be a concern for social VR developers in the future.

In the negative reviews, the most common complaint from users is the way avatars are displayed. Some users would like to see all avatars: "Cannot see all avatars, which is annoying;" "I have to go to the menu to show avatar, it's so annoying." On the other hand, compatibility is also an important issue: "the incompatibility of a lot of avatars with the PC version and the 'perf blocking' of avatars is highly annoying." In addition, the Not Safe For Work (NSFW) avatar also caught users' attention: "Be warned there are NSFW avatars on the game;" "banning NSFW avatars, please protect the kids."

The first topic in the neutral reviews is avatar creation, as players like to create their own avatars. The second is anime avatars, females users usually like anime avatars, but some users do not like: "I love the virtual socialization idea but I hate the furry anime avatars." Privacy is also a topic that players are more concerned about. Some players discuss in the reviews that the developers do not pay attention to player privacy: "They do not do anything to protect user privacy." "the devs of this game should be ashamed, that my privacy and security was violated."

B. RQ2: What Are the Harassment Behaviors in Social VR?

Similar to traditional social media applications, harassment and other forms of abuse occur in social VR and received increasing attention from researchers. Shriram and Schwartz [17] conducted an interview study about 15 participants' experiences and behaviors in the social VR application VTime and found that females reported more harassment than males. Blackwell et al. [16] interviewed 25 VR users about their experiences with harassment, abuse, and discomfort in social VR and found that the harassment in social VR fell into three categories: *verbal harassment, physical harassment, and environmental harassment.* Many participants felt that particular groups of individuals were more likely to be harassed in VR than others, such as women, children, colored people, and persons with nontypical American accents.

Grounded in prior scholarships on harassment research in social VR, we conducted a study to explore what kind of harassment social VR users complain about more in reviews. We apply keywords to filter harassment-related reviews and get 2034 reviews. Among these reviews, the most common harassment is "sexual" (44.99%), the second is about "racism" (34.46%) and the others are about "abuse" (10.57%), "bullying" (7.82%), "attack"(6.24%), and "sexism"(2.36%).

Players frequently mentioned being sexually harassed by others in the reviews about "sexual." In addition, some users described the sexual content for kids and the sexual harassment from kids. Some example reviews are as follows.

> "I was shocked to see people attacking me sexually. The game could be really fun if it wasn't for nasty

> people sexually abusing me;" "Got on to this game and there were some kids in the lobby who were just nasty in trying to do sexual things to my avatar."

Racism is also the main problem on social VR platforms. Typically, racism is harassment of colored people.

> "Rec Room is full of little white supremacist kids and racism, homophobia is the main problems of this game;" "This is a racist app! whites only;" "There were several white people around us calling us "Niggers," so we both told them to stop being F**ing racist;" "too many racist players so there should be some more moderators."

Bullying is another type of harassment, in general, bullying is bilateral between adults and children: "The thing that bothers me is the bullying how so many people and I mean adults and kids, turn to bully." In addition, as mentioned in [16], sexism also exists in social VR: "There is ton of racial, sexist and rude behavior on the platform." Some players complain about more than one kind of harassment: "I have seen many accounts of sexual harassment, racism, and bullying, all in the same time playing the game I was even bullied."

Harassment is a widespread problem in social media. Despite implementing video game content rating systems and the requirement for parental guidance, many children remain active on these platforms. As a potential solution, social VR platforms could establish distinct environments segregating adults and children and enhance surveillance by increasing the number of moderators. This could contribute to minimizing instances of harassment between adults and children.

C. RQ3: What Is the Impact of Social VR on Different Groups of People?

Social VR has attracted users from different groups, and in this section, we discuss its impact on children, old adults, couples, LGBTQ, and introverts.

1) Children and Teenagers: In our study, we collect 5988 reviews about children (5208) and teenagers (780) of social VR applications. The majority of these reviews are from adults and are almost negative.

We cluster the topic of these reviews using model BERTopic. The most discussed topic in the 5988 reviews is the annoying behaviors of kids. Many mature users complained about annoying kids, such as "Kids really made me hate the game because of how annoying they are, and they are very toxic." "However, the game is pretty much unplayable because there are too many kids and frankly just hearing their voices is extremely annoying. And then if a kid sneaks in we could vote unanimously to remove them." These quotes well explained the distress annoying kids bring to adult players, the co-existence of adults and minors on the same social VR platform leads to potential tensions. The minors often try to get attention from others by yelling or screaming, but this is disturbing for adults. Creating separate spaces or adding moderators could better cater to different age groups in this situation.

The second topic in these reviews is bullying: kids bullying and bullying kids. On the one hand, children or teenagers bully other players and get disgusted by them: "Kids bullying and cursing and not letting anyone play!" "I was playing paintball then this random kid just starts bullying me for no reason." One user gave advise to avoid kids bullying, "I know lots of people complain about kids bullying so just mute all nonfriends it's simple it's what I do."

On the other hand, our findings also reveal that adults bully kids on social VR platforms compared to traditional media platforms. Some players even showed off in reviews and taught others to bully children: "I like bullying children." "Is bullying these small children in Rec Room funny? yes!" "Play this if you like bullying children." "Incredibly boring if you do not like bullying kids." Moreover, one parent commented that his child would commit suicide after being bullied: "My child tried to commit suicide because of the bullying going on in [social VR platform]. It's a total hangout for bully's and aholes that have nothing better to do then spew hate toward others and especially children." Some players warning to children and their parents: "a lot of bullying, do not recommend for 13 or younger."

In addition, the social VR platforms can potentially be a grooming platform for pedophiles as kids and adults seem to mix freely, and there's no way to control what goes on. Some players have pointed out the phenomenon and expressed their concern: "Too many little kids and pedophiles on the game it's actually quite concerning." "The game is literally filled with pedophiles that expose children to adult avatars."

2) Couples: How VR technology supports long distance relationships (LDRs) is also a topic worthy of study. Zamanifard and Freeman [7] used 650 social media posts and comments to explore the influence of social VR in LDRs. In our study, we filter out 233 user comments about LDRs from the social VR dataset. We find that the first hot topic is that players find their other half through VR games. Some are couples only in social VR games, and others meet in person and even get married.

> "I have met some of the best people on here and my current boyfriend;" "VRChat is an amazing game! I've made a lovely friend group on here and have also met my boyfriend on here! We recently met in person and I had an amazing time;" "I met my current wife on this game, thanks VRChat!"

The second hot topic is that social VR platform offers opportunities for remote interaction between LDRs and boost relationships between couples.

> "Since my girlfriend doesn't live near me, I mainly use VRChat to still spend time with her;" "Being in a long-distance relationship, it's also where I can get close to my boyfriend and emulate close-to-real dates and hangouts."

3) Older Adults: In our study, we extract 150 user reviews about older adults using keywords in Table I. Many older adults have reported that they have had more opportunities to communicate with their children through the social VR platform.

For example, the Real VR Fishing game provides a good opportunity for parent-child activities: "I'm older and got this to play with my son;" "Fishing was something my dad I did a lot growing up, now that he's older this VR experience is a great way for my dad and I to spend time together." And for some older adults, the VR technology might be a little different to learn: "Big learning curve for me as an older adult." Social VR has also become a way for older adults to make friends: "I'm in the older crowd, and this game still changed my life! For the past 2 years, I've met people who have become cornerstones in my social circle."

However, in the VR game PokerStars VR, some younger players complained that they did not want to play with older and vice versa: "At very least, the game should have an all age area and an adult area and possibly a 30+ area to make it easier for older people to find each other." That means it's better to create different rooms to separate users of different age groups.

Harassment is a common topic in different age groups, and some reviews report harassment from older adults.

> "I entered and the first room I walked into some older guy was trying to groom some children;" "I have entered lobby's/instances where older men/women actively try to invite children to engage in sexual or other actions with them."

4) LGBTQ: In the past 5 years, social VR has become increasingly popular with the LGBTQ community, and some researchers have taken notice to study how social VR supports LGBTQ users. Freeman and Maloney [11] studied self-presentation in social VR by conducting an in-depth interview of 30 participants, including four trans-women participants. In [12], the authors recruited eight LGBTQ participants to explore LGBTQ users' engagement in social VR and how social VR supports them. Corboz [35] conducted a study on the formulation of queerphobic discourse within the video game "The Last of Us Part II." This involved analyzing discourses related to queer slurs as well as neutral queer terminologies.

In our study, we extracted 498 LGBTQ-related reviews and found that social VR has become a popular communication platform for the LGBTQ community, breaking geographical barriers, especially during the COVID-19 pandemic. One user praised that "If you are part of LGBTQIA++, you will feel super supported and hardly any racists." In a sense, LGBTQ users can use social VR to find other LGBTQ users or supportive people, especially if their gender, sexual identity, and lifestyle are less or unsupported in their natural social world.

> "It has an extremely large presence of LGBTQ+ individuals (including myself) and lends itself to being a space for people to freely express themselves exactly as they see fit, or in whichever way they feel most comfortable."

However, the social VR platforms flood of LGBTQ users has also caused disgust among other players. They also complained about this phenomenon in their reviews.

> "90% of people in VRChat are either a guy or transgender and also gay (somehow, VRChat turns everyone gay);" "It was fun back in 2017, but now it is overrun by gay furries."

On the other hand, LGBTQ users are more concerned about privacy and rarely identify themselves in the reviews, only 117 users indicated they were LGBTQ among the 105 757 reviews. Some users are careful to reveal their identities in the reviews, fearing that others will know he is gay: "I'm pretty sure nobody ever reads these things, so I just want to say that I'm gay," "Nobody reads the reviews for sure, so I'll say I'm gay." A valuable finding is that some players stated that they only became LGBTQ after playing a specific social VR game like VRChat: "After 600h, I've now become bisexual," "This game made me a Transgender," "I was a straight male then this game turned me into a gay furry." Therefore, some players issued a warning in the reviews: "Do not play it, my son is gay now," "This game will turn you gay," "It has a tendency to make people gay if you play for 5+ h."

LGBTQ-related harassment is also a topic of concern, which can be divided into two categories, one is LGBTQ harassment of other users.

> "I have never felt more uncomfortable while playing a video game, the constant harassment from gay males who make it their goal to make you as uncomfortable as possible is disgusting;" "Just after 5 min of playtime, I was sexually harassed by gay men with anime avatars."

and the other is harassment of LGBTQ users.

> "bullying gay people very nice;" "it's fun to make fun of gays and furries;" "this game is really fun but if you are LGTBQ+ you get bullied a lot, I'm bisexual and transgender and I get harassed a lot....."

5) Introverts: As Baker et al. [13] indicated in their research, social VR platforms support a level of anonymity that allows users to blend into group communities. This feature has a huge positive impact on shy and introverted users. We apply keywords bag, including "shy, introvert, introverted, anonymity, social phobia, social anxiety disorder, SAD, nervous," to extract related reviews from the collected review dataset for studying the social VR influences on antisocial people. Among the 564 reviews, 80% of users said that they were shy, introverted, or antisocial and were nervous to talk to strangers face-to-face in real society. Fortunately, social VR platforms gave them a chance to become more social and make new friends. These players were timid at the beginning, then gradually overcame their social anxiety, participated in virtual bars, clubs, and lounges, talked to others, hung out, danced, roleplayed, and became more and more outgoing.

> "It's also helpful for people who really have serious anxiety because of the level of anonymity it provides." "This is one of my favorite games, it is awesome and can make an introvert an extrovert." "I love

> this game, if you are shy or introverted like me then this game will bring you out of your comfort zone and help you make friends and just enjoy yourself."

However, some users were still shy and nervous about communicating with others, even when they were anonymous. Moreover, some users complained that social VR platforms are full of introverted players and that it was easy to meet unsavory characters who take advantage of their anonymity.

> "If I wasn't so f**king shy, It might be more fun for me." "Game is filled with antisocial introverted kids." "Please be careful! There's a lot of manipulative people who enjoy the anonymity of the internet." "The anonymity that VRchat gives can allow users to be mean and bully others without repercussions."

D. RQ4: What Are the Physical Effects of Social VR Platforms?

Motion sickness will influence UXs in the VR environment, and a large body of VR research has investigated the phenomenon [36], [37], [38]. In our study, we extracted 265 (0.25%) reviews related to motion sickness issues using the keywords "sick, sickness, cybersickness" from the collected review dataset. The first author read through these reviews and classified them into three categories: *sickness, no sickness,* and *warning*. Among the 265 reviews, 166 users indicated that they suffered motion sickness. The reasons include 1) the influence of locomotion methods: "If I move my head around, it's instant motion sickness;" 2) poor performance: like the participant (P10) in [20], some users complained about that "low FPS in VR is very worse for VR sickness," "considering that poor performance can lead to motion sickness, headaches, and other discomfort;" 3) new VR user or at the beginning of a game: "Can get pretty motion sickness inducing if you are new to VR," "For beginners this can make them motion sickness;" and 4) specific game: "This is the only game that gives me motion sickness."

And 50 users cleared that they did not get motion sickness like others: "For me, I got used to the movement quick so I didn't get motion sickness, but there is a good possibility that you might," "Didn't get motion sick like I expected." Moreover, 49 users expressed a warning for other users who may have motion sickness problems and gave some advice: "WARNING!! Not a good game for someone with motion sickness," "If you suffer from anything like motion sickness, epilepsy or headaches, stay well away from this game."

E. RQ5: What Are the Benefits of Social VR During the COVID-19 Pandemic?

In the past 2 years, the coronavirus has raged worldwide, people were obliged to stay home, and public spaces (parks, gyms, etc.) were closed to combat the COVID-19 pandemic. Therefore, social VR platforms are popular among people during the COVID-19 pandemic. People can do sports with families, communicate with distant friends, play games, attend online concerts, company meetings, church activities, and so forth. Take the VRChat game on the Steam platform as an example, As Fig. 1 shows that before the COVID-19 pandemic, the number of players of VRChat per day was around 7000, after the outbreak of COVID-19, the number of players has continued to grow.

Previous research has investigated the benefits of using social VR platforms during the COVID-19 pandemic. Kelley analyzed 259 user reviews of VRChat on Steam to explore the uses and satisfactions of social VR [39]. Barreda-Ángeles and Hartmann [40] surveyed 220 participants to study the psychological benefits of using social VR platforms. In [20], the authors focused on the dance experience in social VR, and some of their participants emphasized that the VR club provided them with a safe space for socializing and physical activity during the COVID-19 pandemic.

In our study, we extract 466 user reviews containing the keywords (e.g., covid, pandemic) from the collected review dataset. We find that 90% of the reviews emphasized that social VR platforms freed them from restrictions imposed by COVID-19. And users could talk to friends and play games or sports together with friends in the immersive environment.

> "Love it! I and my friend live far from each other and especially in these crazy COVID-19 times, this is a perfect way for us to hang out, catch up and catch some fish at the same time."

Social VR platforms are also crucial for psychological building during the COVID-19 epidemic. Some users have also mentioned that they help them overcome loneliness and stay sane.

> "Good to pass the time during the pandemic and take social distancing seriously while also helping my mental health and possibly killing it at the same time." "This game has allowed me to stay sane through this pandemic and has allowed me to make some amazing friends from around the world."

V. Discussion

UX is a significant aspect of social VR application design. To better understand UX in social VR platforms, we set out to analyze user reviews. Our work directly addresses the limitations of previous interview-based research on UX in social VR. We can now offer deeper insights into the UX in commercial social VR applications.

A. Key Insights

This article aims to answer five research questions (RQ1 ∼ RQ5, see Section I). Table II shows the summary of key points for each theme. The specific analysis of each RQ is as follows.

For RQ1, we found that the users would like to create their avatars and want more avatar choices. Social VR platform developers should give players more choices of avatars or allow players to design their avatars. The compatibility of avatar models and NSFW avatars are two pain points that players complain about the most. NSFW avatars may have a negative impact on child players, and social VR game developers should pay attention to this issue. Some social VR platforms support users in importing an avatar model created by any other 3-D software.

TABLE II
OVERVIEW OF KEY POINTS OF EACH TOPIC

Topics		Summary of Key Points
Avatar		Players prefer avatar customization, and require more avatar choices, the compatibility is another pivotal consideration for players. Moreover, some players express discontent with the presence of NSFW avatars.
Harassment		The comment harassment behaviors in social VR are sexual, racism, abuse, and bullying. Some players described the sexual content for kids and the sexual harassment from kids. Racism harassment is typical to color people, bullying is bilateral between adults and children.
Different groups of people	Children & Teenagers	Many mature users complained about annoying kids, the bullying behaviors between kids and other players.
	Couples	Social VR platform offers opportunities for remote interaction between LDRs and boost relationships between couples.
	Old adults	Older adults have more opportunities to communicate with their children through the social VR platform. Some younger players complained that they did not want to play with olders.
	LGBTQ	Social VR has become a popular communication platform for the LGBTQ community. However, the social VR platforms flood of LGBTQ users has also caused disgust among other players. LGBTQ-related harassment is also a topic of concern.
	Introvert	Social VR platforms gave them a chance to become more social and make new friends.
Motion sickness		Motion sickness is physical effect for players, the reasons for sickness in VR games include: the influence of locomotion methods, poor performance of VR display, VR games beginners, and playing specific game.
COVID-19		90% of the reviews emphasized that social VR platforms freed them from restrictions imposed by COVID-19. Social VR platforms are also crucial for psychological building during the COVID-19 epidemic.

but it sometimes brings compatibility issues. Moreover, the VR community should ban sexual suggestiveness avatars. In Fig. 6(a), the solid blue line shows that the frequency of avatar-related reviews has increased from 2016 to 2022, which shows that users are very concerned about their avatar display in social VR applications. Social VR application developers should pay more attention to avatars.

For RQ2, sexual harassment, and racism are two of the most widespread types of harassment behaviors on social VR platforms. Sexual harassment is a common form of harassment that exists in different groups. Although players can be shunted to different rooms, not all players abide by the game's rules. Players should have certain psychological expectations that others may harass them. Parents should guide their children well, as virtual social networking is a double-edged sword for them. In Fig. 6(a), the solid orange line shows that such reviews are increasing, especially after 2020, the rate of increase is faster. Social VR application developers should establish a complete user feedback mechanism and a harassment identification system and issue some punitive measures to prevent harassment among users, such as freezing accounts.

For RQ3, social VR platforms benefit these five different groups of people, but it is easy to influence and bullying between different groups of people. The best way is to divide different groups of people into different rooms or increase each room's number of moderators. In Fig. 6(a), the solid green line shows the frequency of Children and Teenagers reviews increased slowly from 2016 to 2020. It increased sharply after 2020, indicating that more children and teenagers are pouring into social VR platforms. The reason may be that children are confined at home during COVID-19 and flocking to social VR applications for entertainment. Fig. 6(b) shows the trends in the number of reviews related to couples, old adults, and LGBTQ. The monthly number of reviews related to these three groups is not very high. The number of reviews related to couples has stabilized since 2021, and that related to LGBTQ and old adults has increased significantly from 2020, indicating that 2020 is a watershed, possibly due to the impact of the

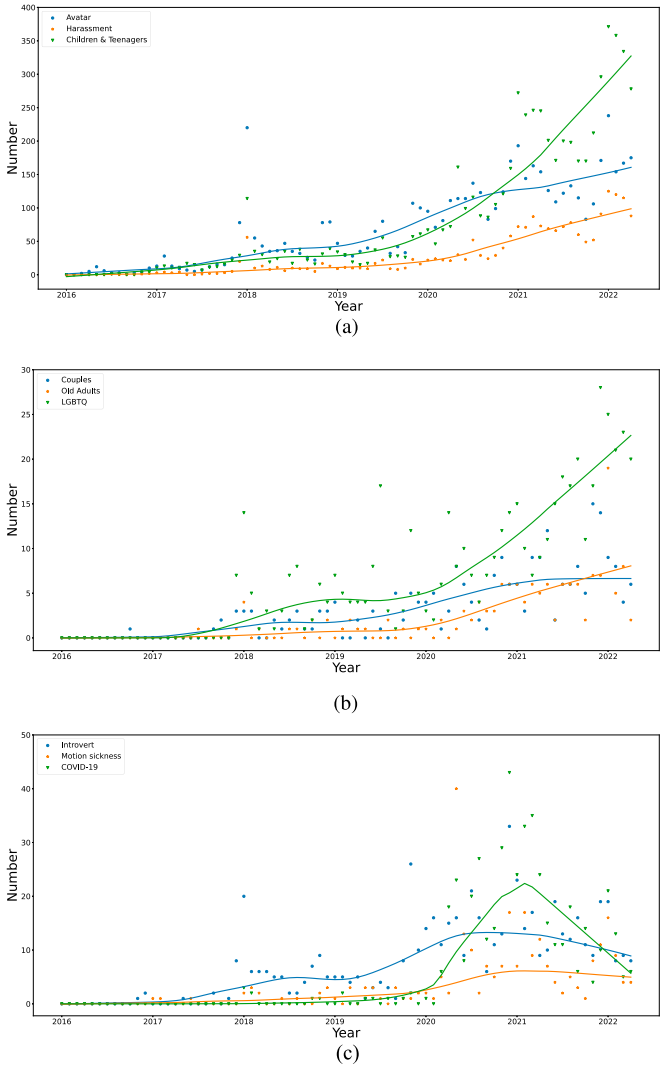

Fig. 6. Monthly distribution of the number of reviews of each category. Solid lines are trend lines, providing a smoothed estimate of the trends over time. (a) Avatar, harassment, children, and teenagers. (b) Couples, old adults, and LGBTQ. (c) Introvert, motion sickness, and COVID-19.

TABLE III
FREQUENCY DISTRIBUTION OF REVIEWS BEING TAGGED AS ''HELPFUL''

No. of Times a Review is Tagged as "Helpful"	Frequency (No. of Reviews)									
	All	**Avatar**	**Harassment**	**Children & Teenagers**	**Couples**	**Old Adults**	**LGBTQ**	**Introverts**	**Motion Sickness**	**COVID-19**
0	75 503	2996	1033	3203	551	85	387	383	218	312
1∼25	28 942	2109	871	2229	482	33	301	186	191	139
26∼50	539	74	48	111	12	2	4	6	9	6
51∼75	230	35	25	58	13	0	3	3	3	2
76∼100	117	14	11	23	2	0	0	3	1	1
>100	426	70	60	105	27	4	9	11	9	6
Total	250 887	37 211	25 048	**51 040**	10 656	1134	3124	5569	4297	2818
Maximum	2912	**2912**	1697	1800	1039	618	672	1929	1039	727
Mean	2.37	7.02	**12.23**	8.91	9.80	9.15	4.44	9.41	9.97	6.05
Standard Deviation	29.85	64.93	66.76	56.50	60.21	58.99	**32.64**	87.73	64.30	45.37

COVID-19 epidemic, these two groups prefer online social VR activities. The solid blue line in Fig. 6(c) shows that the number of introvert-related reviews increased from 2016 to mid-2020, after which began to decline. In RQ3, we found that although each group can find its circle in social VR applications, different groups often cannot live peacefully, such as bullying against children and discrimination against LGBTQ groups. Avoiding conflicts between different groups of users is also a problem that developers should consider.

For RQ4, we found that motion sickness is no longer a significant issue for VR players. The solid orange line in Fig. 6(c) shows that the number of motion sickness-related reviews is less than ten between 2016 and 2022, and there is a downward trend from 2021. Motion sickness only exists in new VR players, and certain games can cause players to experience motion sickness. Although motion sickness is no longer a common phenomenon, developers should also pay attention to player feedback and solve problems timely.

For RQ5, social VR platforms provide the opportunity to interact with others in virtual worlds for lockdown people during the COVID-19 pandemic and help people overcome loneliness. In Fig. 6(c), the solid green line shows the trends of players discussed COVID-19 in reviews. From 2020 to the beginning of 2021, there was an upward trend in COVID-19-related comments. In April 2020, the novel coronavirus (COVID-19) outbreak escalated into a global pandemic, confining most people to their homes. Consequently, several individuals explored VR gaming as a new avenue for entertainment. Initial interactions were scant, with an average of 20 reviews monthly, but they gradually increased throughout the year. At its peak toward the end of 2020, the discourse reached a monthly average exceeding 40 posts. However, with the relaxation of pandemic restrictions and the resumption of outdoor activities in 2021, the frequency of COVID-19-related discussions in VR gaming spheres began to decline. By April 2022, there were fewer than 10 relevant posts per month.

B. Quantitative Analysis

Although these online reviews are not in the form of conversation, the platform provides users with an interactive mechanism. For example, on the Oculus platform, if one player feels that a review is helpful to him, he can click the "Helpful" button. On the Steam platform, the player can click the "Yes" button to indicate that the review is helpful to him. Therefore, considering the review interaction between players, we first counted the number of "Helpful" tags for all the reviews collected, as well as the number of "Helpful" tags received by the relevant reviews for each topic.

Table III shows the frequency distribution of reviews marked as "Helpful." The table counts the number of times comments were marked as "Helpful" under various topics. 105 757 reviews received a total of 250 887 "Helpful" tags. Among them, 75 503 (71.39%) reviews did not receive a "Helpful" tag. On average, each review received 2.37 "Helpful" tags. The review with the most "Helpful" tags received a total of 2912 tags, this review is about avatars. Reviews on topics related to "Avatar," "Harassment," "Children and Teenagers," and "Couples" have received more than 10 000 "Helpful" tags. Reviews related to "Children and Teenagers" received the most "Helpful" tags, and reviews related to "Old Adults" received the least. Reviews related to "Harassment" received the highest average "Helpful" tags, and reviews related to "LGBTQ" received the lowest average "Helpful" tags.

The data in Table III can indirectly provide insights into user interactions. Reviews marked as "Helpful" generally mean that they have had a positive impact on the user community, perhaps because they provided useful information, answered other users' questions, or shared valuable personal experiences. This marking behavior itself is an interaction between users, indicating that there is a certain degree of communication and collaboration between users.

As illustrated in Fig. 7, we conducted the percentage of user reviews for each application in each topic. Across almost all themes, the highest number of reviews originated from VRChat, except the "Children and Teenagers" category, where Rec Room dominated. This could be attributed to the plethora of multiplayer games Rec Room offers, which tend to attract a younger demographic. Reviews associated with avatar, harassment, LGBTQ, and introverts were predominantly from VRChat and Rec Room, the two platforms with the highest user volumes currently.

Echo VR, a multiplayer VR game themed around zero-gravity space scenarios, accounted for 27.15% of reviews

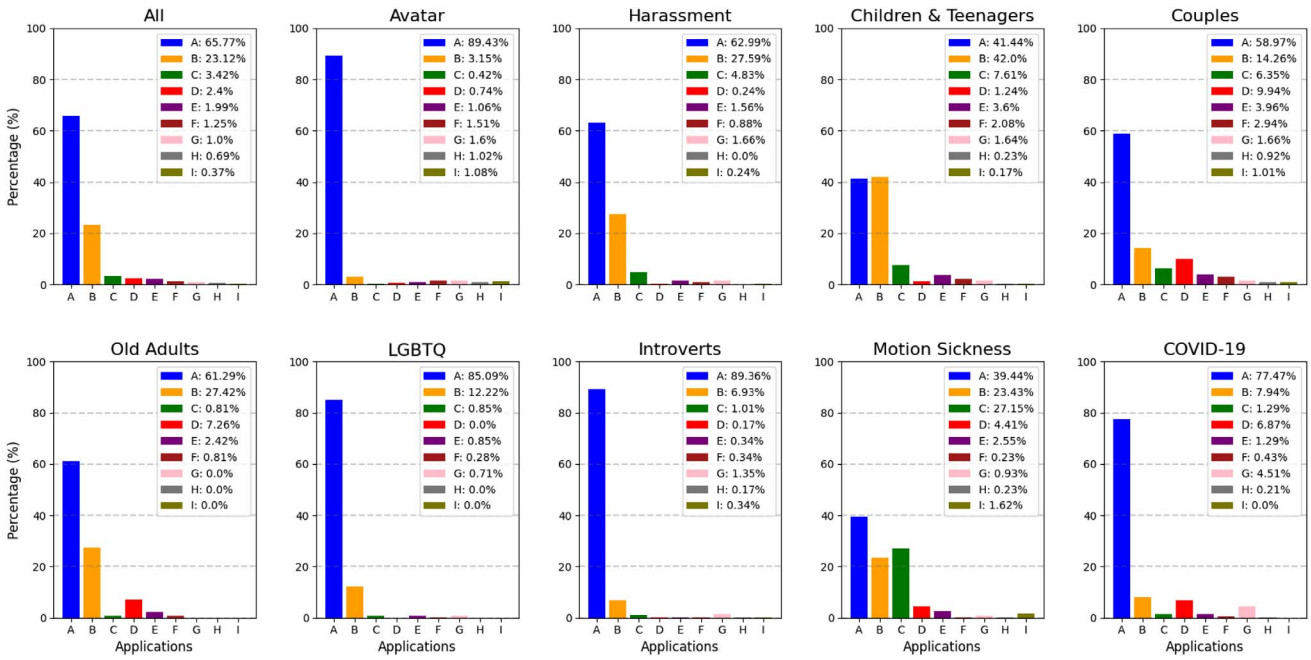

Fig. 7. Percentage of user reviews for each application in each topic. (a) VRChat. (b) Rec Room. (c) Echo VR. (d) Real VR Fishing. (e) Pokerstars VR. (f) Poker VR. (g) Altspace VR. (h) vTime VR. (i) Sansar.

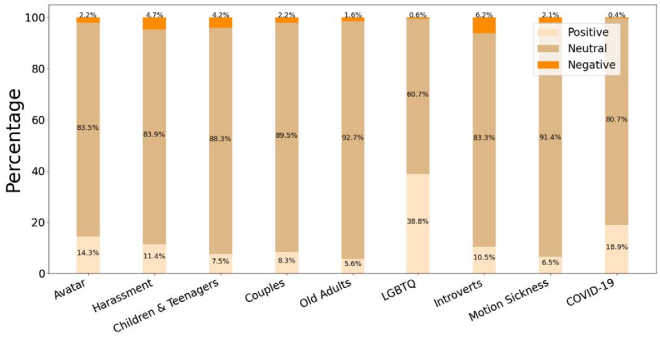

Fig. 8. Sentiment distribution across each topic in social VR user reviews.

related to motion sickness, reinforcing the premise discussed in [38] that game content significantly influences the incidence of sickness. Elderly players rarely engage with stimulating games like Echo VR, preferring simpler interaction environments like fishing or poker.

Reviews associated with couples were diverse in origin, stemming from various applications, including chat, gaming, fishing, and poker. Reviews related to COVID-19 were also found across multiple games, indicating that players experimented with various games for self-regulation during the COVID-19 pandemic.

We apply the TextBlob tool to label the emotional sentiment of the reviews as positive, neutral, and negative. Fig. 8 presents a comprehensive sentiment analysis distribution across different topics within the user reviews of social VR applications.

The "LGBTQ" category shows the highest percentage of positive sentiment, reflecting the supportive and inclusive environment that social VR can offer to the LGBTQ community. The "COVID-19" category exhibits a high percentage of positive sentiment, which indicates that social VR has served as a vital platform for maintaining social connections during the pandemic. The "Avatar" category also exhibits a high percentage of positive sentiment, indicating that users generally have favorable experiences with avatar customization and selection.

The "Introverts" category shows the highest percentage of negative sentiment, indicating some users complained that social VR platforms are full of introverted players. The "Harassment" category shows a significant portion of negative sentiment, highlighting the prevalence of negative interactions and the need for improved moderation and user safety measures within social VR platforms. The "Children and Teenagers" category exhibits a mixed sentiment distribution, suggesting that while social VR provides a platform for engagement and socialization, there are also challenges related to age-appropriate content and interactions. The "Couples" and "Old Adults" categories lean more toward positive sentiment, indicating that social VR is a useful tool for fostering relationships and providing social engagement opportunities for these demographics.

C. The Recommendations for Different Groups

1) Developers: Social VR platform developers should prioritize avatar customization and diversify the range of avatar choices. Given the prevalence of harassment among groups, developers should consider preventive measures such as allocating different groups to separate rooms, enhancing moderation, and establishing punitive mechanisms. Moreover, developers must also address the motion sickness caused by VR to improve UX.

2) Children and Teenagers: While certain platforms mandate a minimum age of 13 for players, some children circumvent this restriction, often by utilizing their parents'

accounts. The substantial presence of harassment and bullying directed at children in social VR platforms necessitates the vigilance of developers.

3) Couples: Social VR platforms serve as effective instruments, offering an immersive communication platform for couples separated by distance.

4) Older Adults: Social VR platforms present a remarkable opportunity for the elderly to expand their activity range and enrich their lives. However, it is crucial to note the presence of unfriendly players on these platforms.

5) LGBTQ: Social VR platforms facilitate their communication; however, their operation should also diligently ensure privacy protection and minimize adverse impacts on other players.

6) Introverts: Social VR platforms have the potential to provide a secure and nonintimidating environment for introverted individuals to socialize. They can selectively determine the time, location, and companions for interaction, thereby gaining substantial autonomy over their social encounters.

D. Limitations and Future Work

In this section, we discuss some of our work's limitations and future work. Our study is based on user reviews. We cannot guarantee the authenticity of reviews. Fake reviews are a concerning problem. Specifically, within LGBTQ-related reviews, several users allege either being or becoming gay as a result of their engagement with social VR games. While certain players might merely be imitating others or making jests, our analysis is based on the assumption of the reviews' genuineness. In the future, we will strive to adopt a more nuanced approach to analyzing online reviews, considering the broader cultural and conversational context.

Despite their utility, user reviews also exhibit inherent limitations. They may not encompass detailed information usually elicited through surveys or interviews, such as user demographics or the context of use. Additionally, user reviews may reflect an extreme score bias, where people who had extremely positive or negative experiences are more likely to leave a review.

We cannot obtain players' personal information from the platforms, such as age, gender, geographical location, and previous experience with VR, due to the privacy policies of the Steam platform and Oculus platform. As indicated in [17], female players reportedly experience more harassment than their male counterparts. However, the absence of gender data in our collected reviews restricts our ability to investigate potential gender-based differences in harassment experiences. How personal factors such as player gender, age, and geographical location affect the player's VR experience is also an issue worth exploring and requires research by relevant scholars.

This article only focuses on English reviews, and in future research, we will analyze multilingual reviews to explore players' social VR experiences in different cultural backgrounds. Additionally, a potential area of exploration could involve investigating how the themes we have identified might differ across these cultures, providing a more comprehensive understanding of the UX in social VR. Our collected dataset has 52.53% (105 757 of 201 326) English reviews. The languages that account for more of the remaining reviews are Simplified Chinese, French, Russian, and German. It is also meaningful to research UX in these language regions.

VI. Conclusion

Social VR has become an appealing online social space for people to interact, socialize, and connect in an immersive way. In this article, we have engaged in a reviews-driven study of UX on social VR platforms. Our findings show that players prefer avatar customization and want more avatar choices. Social VR platforms provide a suitable place for some groups, such as LGBTQ, introverts, and the elderly, to communicate and interact. However, social VR platforms are also full of harassment. Sexual harassment and racial discrimination are the most common forms of harassment. In addition, developers also need to pay attention to bullying between children and adults. Furthermore, social VR also helps people overcome loneliness and remain connected with friends during the COVID-19 epidemic. We hope our findings contribute to a better understanding of the UXs of different groups in social VR and guide developers to design more friendly and fulfilling experiences in social VR applications for users. In a bid to spur continued research in this field, we have made our dataset publicly accessible. Interested researchers can access this resource through the following link: http://doi.org/10.5281/zenodo.8005440. We believe this will serve as a valuable foundation for future explorations and developments in studying UXs in social VR applications.

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Jiong Dong (Member, IEEE) received the B.Eng. degree in computer science from Dalian Maritime University (DMU), Dalian, China, in 2015, the M.Eng. degree in computer science from Ecole d'ingénieurs Polytechnique de l'université de Tours, Tours, France, in 2017, and the Ph.D. degree in advanced information and electronic engineering from Muroran Institute of Technology, Muroran, Japan, in 2023.

He is currently a Lecturer with Xuchang University, Xuchang, China. His main fields of research interest include virtual reality, data mining, and natural language processing.

Kaoru Ota (Member, IEEE) received the B.S. degree from The University of Aizu, Aizuwakamatsu, Japan, in 2006, the M.S. degree from Oklahoma State University, Stillwater, USA, in 2008, and the Ph.D. degree from The University of Aizu, Japan, in 2012, respectively, all in computer science.

She is a Professor and a MEXT Excellent Young Researcher with Muroran Institute of Technology, Muroran, Japan. She is Clarivate Analytics 2019, 2021, and 2022 highly cited Researcher. She is selected as JST-PRESTO researcher in 2021 and Fellow of EAJ in 2022.

Mianxiong Dong (Member, IEEE) received the B.S., M.S., and Ph.D. degrees in computer science and engineering from The University of Aizu, Aizuwakamatsu, Japan, in 2006, 2008 and 2013.

He is the Vice President and a Professor with Muroran Institute of Technology, Muroran, Japan. He was a JSPS Research Fellow with the School of Computer Science and Engineering, The University of Aizu, Japan, and was a Visiting Scholar with BBCR Group, the University of Waterloo, Waterloo, Canada, supported by JSPS Excellent Young Researcher Overseas Visit Program from April 2010 to August 2011.

Dr. Dong was selected as a Foreigner Research Fellow (a total of 3 recipients all over Japan) by NEC C&C Foundation, in 2011. He was the recipient of the 12th IEEE ComSoc Asia–Pacific Young Researcher Award 2017, Funai Research Award 2018, NISTEP Researcher 2018 (one of only 11 people in Japan) in recognition of significant contributions in science and technology, the Young Scientists' Award from MEXT in 2021, SUEMATSU-Yasuharu Award from IEICE in 2021, and IEEE TCSC Middle Career Award in 2021. He is a Clarivate Analytics 2019, 2021, 2022, 2023 highly cited Researcher (Web of Science) and a Foreign Fellow of EAJ.