Tell Me Before You Stream Me: Managing Information Disclosure in Video Game Live Streaming

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Live streaming is a new media format that simultaneously records and broadcasts in real time, in multiple channels including video, audio, and text. A new application area of live streaming is in the video game community, where players stream their gameplay. Since most of the streamed games are team-based, one's live streaming may involve other players' gameplay and disclosure. In the present paper, we aim to understand the attitudes and strategies of players who have been streamed by others in video game live streaming. From an interview study with 20 World of Warcraft (WoW) players, we found that participants had concerns about being streamed due to different factors, and adopted individual and collaborative strategies to cope with their concerns. We discuss privacy challenges in live streaming and present design implications for live streaming tools to improve privacy management.

CCS Concepts: • **Human-centered computing → Collaborative and social computing;** *Empirical studies in collaborative and social computing*

KEYWORDS

Live streaming; collective privacy management; video game; information disclosure; Twitch

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1 INTRODUCTION

Live streaming is a new form of social media where individuals simultaneously record and broadcast their activities to the public in real time [17]. It has become increasingly popular since 2009, due to improved network bandwidth and popularity of user-generated digital content. Market research has shown that the share of live-streaming audiences on all social media platforms has increased steadily in recent years [44]. Compared with traditional social media like Facebook and YouTube, where content production and consumption are asynchronous, live streaming platforms highlight real-time broadcast through video, audio, and text to viewers [16].

One popular live streaming scenario is video game players streaming their gameplay, with gameplay as the main element in their stream. Twitch is one of such video game live streaming sites, which has 15 million daily active viewers spending 106 minutes daily on average watching live streams, and over 2.2 million streamers live sharing their content monthly [45]. Many of the popular streamed games on Twitch are team-based, such as League of Legends, Playerunknown's

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Battlegrounds, World of Warcraft, and Dota 2. Thus, the teammates of streamers are often live streamed to Twitch audiences as well.

Previous privacy studies have shown the growing privacy concerns caused by one's personal information unexpectedly being revealed in contents shared by others [5,22,35]. Researchers thus call for attention to collective privacy management, which considers privacy management as a group responsibility in addition to actions by individuals [11,22,36]. Based on this framework, we are interested in exploring players' collective privacy management when they are live streamed by others in their teamplay.

In the present study, we aim to understand players' concerns and strategies regarding information disclosure when being streamed in others' live video game streaming. In this vein, we conducted 20 semi-structured interviews with World of Warcraft (WoW) players that focused on multiplayer interaction and team collaboration [26,46]. WoW is one of the most popular multiplayer online games in the world, and one of the most popular games streamed on Twitch [47]. We found that players have different attitudes, norms and strategies regarding being streamed by others. Privacy challenges are heightened in live streaming in comparison to traditional social media. We discuss collective privacy management in light of the distinctive sociotechnical characteristics of live streaming. Collective privacy management is situated in dynamic negotiation between individual values and multiple group norms. The design of privacy support in live streaming should be improved to meet users' privacy expectations. Our contributions are three-fold: 1) we analyze privacy issues in a novel context: users who are being streamed by others in live streaming; 2) we explore the distinct attitudes and strategies regarding information disclosure of users who are being streamed in a team-based setting, which contributes to a deeper understanding of collective privacy management; 3) we suggest design implications for privacy support in live streaming tools.

2 BACKGROUND

Live streaming enables users to broadcast their activities in real time to public viewers, which is different from traditional social media, such as Facebook and YouTube, where content production and consumption are asynchronous [16]. Compared with TV and other live video sharing services, live streaming allows user-generated content covering a variety of topics from outdoors sports, daily life to video games. For example, apps such as Facebook Live, Periscope, and Lifestreaming focus on real-life activities and big social events. Sites such as Twitch.tv and YouTube Gaming focus on watching people play video games.

A popular category on live streaming platforms is video games. Since the 2010s, the video game live streaming communities have grown rapidly, from broadcasting professional international championships to players streaming their own gameplay [7]. Twitch.tv, referred as "the ESPN of video games", is one of the most popular video-game live streaming platforms. In fact, live streaming is being considered as an important feature of today's video gaming culture [34,41].

In Twitch video game live streaming, the streamers aim to construct interesting and entertaining contents [34]. They are usually equipped with a webcam, a mic, and a computer running the games and the streaming platform. They broadcast live videos of their gameplay, while simultaneously engaging in the gameplay. Beside the gameplay videos, most of the time their audios and images are also broadcast. The webcams allow them to share their emotional reactions through facial expressions [17]. Through audio, they can explain the gameplay content and strategies, as well as chat with viewers [14].

The viewers watch the live videos and enjoy the entertainment created by the streamers as they play [34]. On Twitch, what viewers can see in a channel is the streamers' screen-capture, the webcam feed in the bottom-left corner, and a live chat box on the right side (Figure 1). They can also hear the streamers' audio at the same time. Mostly, viewers are motivated to watch a particular video game live streaming channel because of the unique content and the interactive chat [17]. Most live streaming platforms allow synchronous communication between broadcasters and their viewers through a chat room [32]. In the chat, they can send public or private text messages to the streamer or other audiences. Remote viewers can interact and socialize with each other in shared live experiences [17]. Although they may also be motivated by other purposes such as information seeking [14,32], socialization [14,32], tension release [32] and team-oriented performance [21], the interaction with streamers is the key element the viewers value in live streaming [16,17,20,21,23,33,34,40].

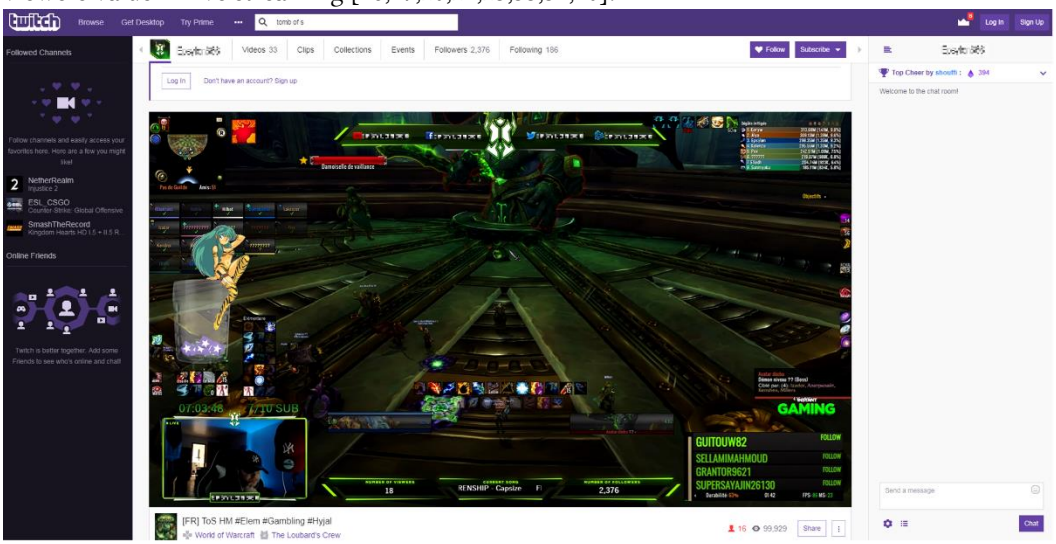

Figure 1. Screenshot of WoW live streaming on Twitch

3 RELATED WORK

3.1 From Individual to Collective Privacy Management on Social Media

Past research has shown that users disclose a large amount of information to other users in the use of social media [1], which can cause various privacy risks. For example, users' online profiles and information disclosures may be accessed by unwanted audiences [37]. Their personal information may be aggregated and thereby reveal more personal insights than they expect [24]. These may lead to unexpected consequences, such as online stalking, bullying, and identity theft [15]. Researchers and practitioners have designed various forms of privacy support to facilitate users' control over their personal information disclosure, such as audience control and visibility control. In addition to adopting privacy settings, users heavily rely on personal behavioral strategies to manage privacy [37]. Such strategies include self-censoring [10], managing contacts [43], multiple profiles [38], etc.

While most of the above mechanisms regard privacy management as an individual activity, recent studies find that managing privacy also requires collective efforts [8,11,25,36]. These studies [9,11,22] were inspired by Altman's boundary regulation theory [3] and Petronio's

Communication Privacy Management theory [30]. Both postulate that privacy is an interpersonal process and requires coordination between people. Researchers found that in social media, co-managed information disclosure commonly exists [22,35]. For example, Facebook users often post photos of others and link others' profile through tags [5]. Thus, users need to negotiate privacy rules with their friends, and expect everyone to follow the norms of co-sharing. Research has shown that norms indeed exist among groups of friends: users collaborate with their friends on managing boundaries of inappropriate content and on avoiding violations of each other's' expectations [22].

However, once the norms are violated, boundary turbulence happens. One's personal information can be unexpectedly revealed in contents shared by others. This raises a great amount of privacy concerns in people. Because privacy preferences vary from person to person, privacy conflicts can occur among the multiple content co-owners, resulting in lack of control over personal information [19,35]. For example, users do not want to be seen drunk in photos on Facebook, especially not by their employers [5]. But when others share such photos on social media, they are no longer in control of their own personal information. While users can untag themselves to avoid the linkage between the shared photo and their identities, the photo has already been disclosed and linked to others shown in the photo, thus remaining accessible from other profiles [5].

Following this conceptualization, we will analyze information disclosure in video game live streaming as a collective effort. This is because much streamed gameplay is team-based and involves interaction and communication between multiple users, including team collaboration, in-game text chat, audio team chat. and so on. The streamed players may not be capable of managing their streamed disclosure alone, but need to coordinate with their teams and the streamers in disclosure management. In addition, the real-time nature of live streaming may give rise to new issues in the disclosure of information about users who are live streamed.

3.2 Information Disclosure in Video Game Live Streaming

Previous literature on video-game live streaming focuses on the interaction between streamers and viewers, especially in interactive chats between streamers and viewers. The chat usually occurs in an informal setting, as "the experience of sitting on a couch with your friend and watching them play" [33]. Streamers focus on explaining their opinions and skills to build a comprehensive view of their personality [40]. Viewers mostly discuss about the stream content, but occasionally also exchange social information [23]. They find this helpful for understanding the streaming content [42] and for their communication with the community [16]. Viewers can also participate in the streamers' gameplay by helping the streamers, such as by offering suggestions and collaboration [31]. Some viewers may occasionally post harassing and offensive comments which are also broadcast in real time [16]. Streamers usually ignore or block these contents in live streaming [40], or rely on moderators, supportive viewers, and automated chat bots to censor the language [29]. Research has found that viewers' participation in the live streaming is affected by their goals and the game mechanisms [31], as well as the size of the viewership [12]. For example, in massive Twitch chats, viewers tend to use fewer unique lexical items so that it becomes easier to grasp the meaning of their chat [12]. Viewers' participation will impact streamers' gameplay, allowing streamers to advance their narrative and to perform in emotionally expressive ways [31].

However, most of the above literature focuses on the information disclosure between the streamers and viewers. No study pays attention to players who are being streamed by others in

video game live streaming, and how their information disclosure is accessed. In this study, we will thus explore the privacy issues in this setting in light of the literature on collective privacy management.

4 METHODOLOGY

We conducted 20 semi-structured open-ended interviews in WoW in August 2017. We chose WoW as the context of our interview study because it is one of the games that highlight multiplayers' interaction and team-based collaboration [26,46], and is one of the most popular games streamed on Twitch [47]. In WoW, dungeon, raid, battleground, arena and guild are major team-based interactions. Dungeons and raids refer to activities that 5-20 players team up to adventure and kill monsters in the same designed scenarios. Battlegrounds and arenas are competitions between two teams with 2-40 players per team. Guilds are relatively long-term communities of players that band together to go on adventures. Because these team-based interactions require intense coordination among the members, WoW players often adopt communication tools besides in-game text chat to facilitate teamplay. Such tools include external audio chat applications, such as Discord, Teamspeak, Curse, and Ventrilo. Teamplay with in-team communication via these tools is often streamed on Twitch.

We recruited interviewees in one large realm (game server), which had a full population. WoW hosts 238 realms located in the United States. Players in one realm can communicate and play with those in another realm. We advertised our study recruitment information in the trade channel and in the cross-realm "looking for raid" feature. The trade channel is a public chat channel where players look for in-game trading information. The cross-realm "looking for raid" feature allows players to post messages to players in all realms. Combining these two channels enabled our announcement to reach as many players as possible. Our recruitment message indicated our affiliation and mentioned that we were looking for interviewees for a study about players' attitude towards WoW live streaming on Twitch. We did not offer compensation to interviewees.

We stopped recruitment after 23 players responded to us. All were Level 110 players (max level), indicating that they had a comparatively high experience with WoW. All of them had used Twitch and had watched video-game live streaming. 20 had been streamed by others, and 2 had been streamers themselves. The interviews were conducted through in-game textual chat or Discord, as the participants preferred. Each interview lasted between 30 minutes and one hour. We started an interview with general questions, such as whether they had watched Twitch live streaming and which channels they preferred. We also asked what they normally did and talked about with others in the game. We then proceeded to probe how they changed their attitudes and behaviors when they found that they were being streamed by others, and whether they encountered any issues and felt comfortable or rather not. We particularly asked them to describe their experiences when being streamed by others. All the interviews were conducted in English. The three participants who had never been streamed also shared their opinions about this issue, which to some degree confirmed our findings. But we did not include their quotes in our findings.

To analyze our interview data, we employed an inductive approach using open and axial coding [13]. All three researchers involved in data analysis were familiar with video games and streaming. At the beginning of the data analysis process, they familiarized themselves with and developed an initial understanding of the data. In several rounds of discussion, the researchers jointly identified various privacy concerns and strategies as the prominent themes throughout the dataset. With this general idea in mind, the researchers went back to the data and conducted

open coding. This process was conducted in several rounds of discussions, to build mutual understanding and to consolidate ideas. The researchers first analyzed five interviews, then another set of ten, and then the rest. Thereafter we used axial coding to connect concepts and themes, using both inductive and deductive reasoning. After generating the final theoretical map, we returned to the interviews to select representative quotes for each code (when reporting quotes from interviews, we retained the original spelling and punctuation).

5 FINDINGS

The 20 interviewees who had already been streamed by others reported that they were generally fine with being streamed by others in the teamplay. The streamed teamplay took place in dungeons and raids (n=17), or battlegrounds and arenas (n=3). The streamers were friends or guild members of the participants, and occasionally strangers in random teams. Two participants reported that they happened to be on a team with famous streamers, and thus were streamed.

One reason for their positive attitude was that they considered live streaming as beneficial for their groups and as compatible with the community norms. Participants suggested that a great benefit of streaming was that team members could review their teamplay by replaying the recorded video. This was an effective approach to figure out why they had failed and how to tune their strategies and coordination accordingly. Additionally, large teams usually had "bench," a group of players waiting to substitute the members in the teams for better coordination or in case of emergency. If the teamplay was streamed, the bench could learn about the strategies before they substituted. Two participants explicitly mentioned that this was a well-accepted norm in the game community. For example, P13 mentioned:

I've been in many guilds and streaming has never been off limits. We streamed our normal raids for the parts where we can look over our kills and wipes and fine tune in on our mistakes and try to not make them again. It is also for the bench usually to watch something. It's something accepted in the wow community. WoW is not that type of game where you worry about people watching.

This participant accepted being streamed as a norm in teamwork in WoW: if one played as a part of a team, he or she should agree to be streamed by other team members for the good of the team.

Another reason was that since it was the streamer's point of view in the streamed gameplay, viewers would pay less attention to other people who were being streamed. Thus, they did not care about it. For example, P9 said:

I didn't think much of it (being streamed by others) because I wouldn't think people were focusing on me because it was in his (the streamer) point of view. It just looked like another person running around like they do now in cities. You don't tend to give them much focus. I guess if I'm going to watch someone's stream, I'm going to focus on what they (the streamers) are doing in the raid rather than what other people are doing.

18 participants reported that their audio chat communication was also streamed in addition to gameplay, while 2 reported that in-game text chat was streamed. Normally, the topics of players' communications ranged from game mechanics, tips and skills to personal life, jokes and opinions. Participants also mentioned talking about things unrelated to their teams and guilds. P23 mentioned:

We usually explain encounter, strategies, control group during it, for better coordination. and we just talking random while clearing trash (easy monsters in raids), like jokes, events, you know cheap chats.

Three interviewees did not receive explicit notification ahead. P11 mentioned that he found it out by seeing the streaming link posted by the streamer in the text chat. P13 already knew that one of his guild members was a famous streamer. P17 learned from others in the same streamed gameplay:

I think I got into a random battleground with a streamer one time but that's the only time it was brought up. Someone recognized his name and started freaking out, saying they were a huge fan. I didn't bother looking him up though but he claimed to be some multi season gladiator (an honored title for players who excel at arena).

These interviewees were not concerned that they had not received explicit notification because they accepted streaming as a norm. Most interviewees (n=17) got explicit notifications before being streamed. The notification was through either audio chat or in-game text chat. For example:

We have organized guild runs on certain days that he streams. He sent a few messages to the guild chat (which is in-game text chat) so everyone that was online at the time knew about it.

In this case, the streamer took the responsibility to notify the guild before streaming. It seemed that notification was a self-developed strategy accepted well in the WoW community to protect everyone's privacy, as it was not specifically required by Twitch or WoW.

When we asked whether participants regarded notification as necessary before someone streamed their teamplay, 17 participants found it important because they had privacy concerns about being streamed on Twitch, though they agreed nevertheless to be streamed by their teammates. In the next section, we describe the concerns participants reported when being streamed by others.

5.1 Privacy Concerns

We asked participants why they agreed to be streamed and whether they had any problems with it. We summarize and categorize their concerns in the following subsections.

5.1.1 Concern about Personal Information Privacy.

Six participants reported that they were concerned about the privacy of their personal information when being live streamed. They were worried about the risk of disclosing identifiable information to unknown viewers in the streamed chat. For example, P10 had played with a couple of people who streamed their Rated Battlegrounds and Arenas. He did not find it worrisome because he thought the viewers would focus on the streamers rather than him. But he expressed concerns in terms of what he would talk about in the streamed gameplay, as he usually used audio chat with his teams:

I sometimes talk about family issues, relationship, or school issues with my friends in game when we play together. I might mention the names of my family members, or my school name. But I would avoid that if I know someone I'm playing with is streaming because there could potentially be a lot of people viewing. I wouldn't want a bunch of strangers hearing me talk about my personal life. They could do something with that info and do something bad with it like swat my school or house.

This participant felt more cautious about the personal information disclosure of family and school name, because he knew that he was being watched by random people, not just the people he was playing with. He perceived of potential threats once this sensitive personal information was streamed, namely that the unknown viewers would use this information for malicious purposes, such as SWATing the participant's school or house (a harassment tactic of deceiving an emergency service into sending a police and emergency service response team to another person's address). Such concern wasn't groundless, as recent years have witnessed a rise of gamers raided by SWAT due to information leak through streaming [18]. P20 expressed similar concerns about

the disclosure of identifiable information such as address, full name, and credit card information, because "*what's once on the streams stays there forever and you can't take it back. Identity theft and fraud is pretty common. I work at a bank so I try to be pretty careful about those things.*" The participant realized that disclosures in streams could not be undone since streams were broadcast in real time. Such disclosures might however facilitate identity theft and fraud.

Another two participants even expressed concern about the privacy of people who were physically around them. Participants might have their families or friends around when they played games. If they were talking with their teams in the game through streamed audio chat, their family's or friends' voices would also be broadcast to Twitch viewers. Family and friends usually would not even know that their talking was broadcast, and thus not be aware that their information was disclosed. P8 mentioned:

There was actually a brief period that my baby was talking with my cat while we were going over the raid mechanics because I forgot to mute my mic. (Was it streamed?) Yes…I found it funny because it lightened the mood. But maybe a bit of invasion to privacy.

In this case, the participant accidentally disclosed his personal information about his baby and cat. His baby was not even part of the gameplay, and probably had no idea what gameplay or streaming are. But due to audio chat streaming, the baby's voice was inadvertently leaked to lots of viewers.

5.1.2 Concern about Self-presentation.

Five participants were concerned because they cared about their self-presentation when being streamed. Specifically, they were concerned with the way they talked and played in the streamed gameplay. They reported feeling uncomfortable if their talk and gameplay left a bad impression on viewers. For example, P5 said:

Don't want someone watching me or recording me in secret. If someone sees my character and starts making fun of it for low damage or anything else, it could be detrimental to my time on the game…. (if someone is streaming) I might be a little bit more cautious, not want to make mistakes cuz I would want to make a good impression to viewers. (What mistakes?) Step on shit lol. You know, I stand in shit and die and he (raid leader) yells at me then ya, viewers would be like he sucks.

In this case, the participant wanted to be notified before he was streamed by others because he was concerned about his self-presentation to viewers. He believed that "low damage" and "stand on shit and die" would be seen by the viewers and cause a bad self-presentation. "Damage" in WoW referred to the amount of reduction in the target's health made by a player through his/her weapon or spell attack. Players who are damage dealers pursue "high damage" rather than "low damage". In WoW raids, bosses (difficult monsters) sometimes highlight an area inside of which anyone would get damage. "Step on shit" referred to the situation that the player forgot to move out of the damage area, which was often considered as a mistake. This participant believed that if he did not know he was streamed, his low damage and high number of mistakes would be inadvertently broadcast to viewers, which would hurt his self-presentation as the viewers would judge him negatively. Thus, he wanted to be notified of game streaming beforehand, so that he could do something to improve his damage and avoid mistakes.

5.1.3 Concern about Collective Impression.

Collective impression refers to the impression of a team in front of viewers. Three participants were concerned about the collective impression when being streamed. Specifically, they were concerned if internal matters of the teams or guilds were broadcast to viewers because this might hurt their collective impression and reputation. For example, P7 mentioned:

The main problem I have with people streaming raids is that people are unpredictable. Guild drama can start with a turn of a switch. Yes, this might be entertaining to watch from a viewer's view. But it brings un-needed pressure to the guild, if people aren't comfortable with it.

When we asked P7 to elaborate on what guild drama means, and why it is problematic to broadcast. He said:

Once someone streamed our raid in Mythic Nighthold ("Nighthold" is the name of the raid and "Mythic" is the highest level of the difficulty of a boss). We wiped for hours on the last boss ("wipe" means failing to defeat a boss). Two people just started to yell at each other through mic on Discord because one of them had low damage. The whole thing was streamed on Twitch. What was even worse was that someone spread it out to other guilds. It was like almost everyone in the realm came to the streams, watched and laughed. I felt bad because people were not just talking about the Mages. They were mocking our guild, saying things like "stupid guild", "the guild is bad", "the guild leaders suck". It could have been just about the two players, just within the guild. But now everyone in our realm knew it. Many people left the guild after that. So did I.

This participant described how the streamed guild drama violated guild privacy and hurt the guild reputation. Guilds are stable communities for WoW players, in which players bond, help each other, organize large-scale collaborations, and share identities and understandings [26]. Players usually make great efforts to construct their communities, especially in those guilds with a high WoW guild rank and a comparatively long history. Guild drama is considered as common in WoW [26]. In the described case, the participant believed that the guild drama, i.e. the conflicts between two raid members and the hours of "wiping", was supposed to be a private matter within the guild. But the streamer and those who spread out the drama made it public, which amplified the negative consequences: unknown viewers of the streams judged and laughed at the guild and the guild leaders; the guild reputation got damaged; and this participant and some other guild members left the guild due to this wide-spread drama.

5.1.4 Concern about Norm Conflicts.

Participants also described how they tended to consider privacy issues against the backdrop of perceived norms in their groups or the larger gaming community. Group norms and community norms were sometimes aligned, but were at odds or in conflict at other times. This norm conflict may put group privacy at risk. Eight participants admitted that they often used inappropriate language, such as foul words and vulgar language in teamplay, but that this was accepted behavior in their team. But the use of inappropriate language in public or in front of children was against the norm of the Twitch community or society at large, as it might offend others and cast a negative impact on children. Thus, participants became concerned that if their group talk was streamed to the public, it would violate the community norms. For example, P2 mentioned:

I sort've feel restricted with what I can say sometimes. My friends and I are used to using vulgar language with each other and when we're streamed sometimes, I feel like I'm restricted as to what I can say. Well, just to give you an example that's not too bad. We always call each other "faggots" jokingly and on Twitch I feel like we can't really say that in fear of offending someone. We're a clique of friends. Nothing we can say to each other can really offend one another because we all know each other personally. But on Twitch, you never know who's watching

In this case, the participant mentioned two types of norms: one was the group norm between him and his friends that they used to call each other jokingly; the other was the norm of the Twitch community that users should not say something that offends others. As the participant described, behaving under the group norm was common for him, and would be fine if kept private within this group of friends. But when their interactions were streamed on Twitch, they conflicted

with the community norms. Comments that were considered appropriate in one group would be inappropriate, and raise privacy concerns in the group, if inadvertently streamed to another group.

5.2 Privacy Strategies

Participants described various strategies they employed to cope with the privacy concerns that they developed due to teammates' live streaming. Because all participants received either implicit or explicit notifications before being streamed, the strategies they reported were under the situation that they were aware of the live streams.

5.2.1 Restrict Personal Information Disclosure.

Participants indicated they would pay attention to the disclosure of their personal information when being streamed. They would withhold sensitive information and rather favor talking about non-sensitive content. For example, P11 said:

Don't bring it up. If we talk about school, don't say what school you go to, just like what year you are and grades, maybe how hard classes were. Just not exact information.

They would also avoid contents that don't conform with the community norms. P5 said:

A real strategy would just be more thoughtful in my words, like what words are appropriate what are not. I would say a lot of cuss words or saying crude things like body parts or slang words for those body parts. Those shouldn't be used while streamed.

However, restricting disclosure might be effortful for players because the WoW gameplay alone is already cognitively demanding. Disclosure restrictions would impose an additional cognitive burden on them.

5.2.2 Impression Management.

Participants believed that their self-presentation would improve if they put more efforts into playing. For example, P3 said:

I might play better. I might be a little bit more cautious not want to make mistakes. I mean sometimes you're playing like sleep, play without thinking a whole lot. But if I knew I was like being streamed and I would definitely think about it you know. Sometimes I eat a sandwich and watch live stream or something while I'm playing you know. If I knew I was being streamed, I will probably you know focus on only doing that.

Another example is what P14 said:

I would spend more time on it. I don't usually spend that much time on this game, but if the viewers that are watching me like my gameplay and what I'm doing in the game then I would play it more often to improve my skills.

The former participant would invest more cognitive resources to improve his in-game performance, and the latter would invest more time to improve his gameplay skills, so that the viewers would be pleased by their gameplay and have a good impression of them. This strategy would be effective to improve their self-presentation, but would also cost them more efforts as they did not play like this normally.

5.2.3 Group Collaboration.

Most participants reportedly collaborated with each other to manage their disclosures. For example, they would collaboratively put more efforts into coordination and progression to improve the group impression. P22 said:

(When being streamed,) we would be a bit more composed, more serious, because we want to show other people we are serious. We will be more set on progression and less casual.

In this case, the participant believed that his team members would work together to build a good collective impression. "Progression" in WoW usually means defeating bosses in the raids

fast and efficiently, while "casual" usually indicates less efficiency and stress in the raid progress. To build the group impression, the team would focus more on efficiency in the raids. While P22's description was about the general guidelines that the team would follow, P2 offered more detailed actions of his responsibility in the team collaboration:

We would get into that mood there's a certain sense of kinda professionalism where we don't really want to say anything irrelevant. I am an officer (a managerial position in a guild). The raid leader talked about mechanics. I talked about talents (the ability or power of a WoW class) but mainly to the healers (as this interviewee played as healer in the raid). I also called out inc (incoming boss skills or other events) from DBM or BigWigs (DBM and BigWigs are two addons to facilitate raiding) like any raid assistant in other streams. I also threw in my strat ideas (ideas of strategies to defeat the boss) for better team coordination.

In this case, when being streamed, the team would like to maintain a professional impression of the group. The participant took an amount of responsibility to contribute to the team. The team was like an organization, in that each member and the leader had their own responsibilities, but the goal was to collaboratively achieve the boss defeat and at the same time maintain professionalism for viewers.

Participants also collaboratively developed group norms and worked together with the streamers to protect the private conversations within the group. For example, P13 said:

If it's something controversial, we would use text chat. What's a raid without unrelated conversation? You'll notice that most streams have text covered. That's the norm. It's very rare you find one where you can read the text. Text is where the shit talk happens. We can't have that shown or some private convos (conversations) going on. (Can you give an example?) 'This fucking guy dies every pull' I said that last night in officer chat or private conversations. Or 'xx is so annoying.' Or 'this guild is bad.'

In this case, the participant and his team put inappropriate content into the text chat rather than the audio broadcast, which the streamer hid in the live streaming. The raid members collaborated well to manage their group privacy by following the group norm.

6 DISCUSSION

In this paper, we analyzed the interplay between the privacy concerns and strategies of players who were streamed by others in video-game live streaming. Our paper is among the first to look into privacy issues in streaming. While much previous work focuses on streamers' [40] and viewers' [42] attitudes and behaviors in video-game live streaming, our study points to the importance of considering the streamers' teammates who are also involved when their teamplay is streamed. We documented various privacy concerns that participants expressed despite having agreed to be streamed, and privacy strategies that participants devised to address their concerns. Next, we discuss how privacy concerns and strategies in streaming intersect in complex ways with individual attitudes, group interests, and community norms.

6.1 Unpacking Individual and Collective Privacy Management in Live Streaming

Players expressed various concerns about personal and group privacy, even though they might not explicitly object to being streamed by their teammates. Previous research on privacy in social media has reported that users are concerned when their personal information, especially identifiable information, is disclosed by others to unwanted audiences [2,36], since this conflicts with their privacy preferences and hurts their self-presentation [22]. Building upon this body of research, our study further showed how gameplay was also viewed as a type of personal

information that people related to their self-presentation and wanted to have control over. For example, participants reported that they did not want viewers to secretly watch them play and to make fun of them. Undesired disclosure of gameplay would raise privacy concerns.

Our findings contribute to the literature on collective privacy management [5,22,35] by highlighting two critical dimensions of group privacy in streaming. The first concerns whom the information is about. For example, the information could be about a single person, such as a player's personal information, or about a group, such as its gameplay strategies or in-group conflicts. The second finding concerns actual actors in exercising control. For example, the information flow could be in the control of an individual, several individuals, or a group. We use Table 1 to illustrate the various collective privacy scenarios along these two dimensions.

Table 1. Two Dimensions of Collective Privacy Management in Live Streaming.

2nd / 1st	Individual A	Individual B	A group
Individual A	*A is in full control of information about himself.*	B controls whether to disclose about A.	A group controls whether to disclose about A.
Individual B	A controls whether to disclose about B.	*B is in full control of information about herself.*	A group controls whether to disclose about B.
A group	A controls whether to disclose about the group.	B controls whether to disclose about the group.	*The group controls whether to disclose about itself.*

As Table 1 shows, various situations in each of the two dimensions lead to a wide range of collective privacy scenarios. For example, one's personal information is disclosed by a second person, and the disclosure can only be managed by this second person. This scenario is common in participants' concerns about unwanted disclosure of their personal information (e.g., the voice of a participant's baby was streamed). In this scenario, participants' personal privacy was the most vulnerable as streamers might not share similar levels of privacy concerns as participants. As a result, the task of privacy protection falls on the individual who needs to engage in privacy management strategies such as restricting personal information disclosure and impression management. This is similar to prior privacy research in social media, where researchers found that people were concerned about unwanted disclosure of their personal information by a second person, such as photos of their inappropriate behavior being shared by others on Facebook [22].

One's personal information could be co-determined by a group of people. In this scenario, the information owner and the sender have shared control over the owner's personal information disclosure. An example is that many groups already have developed norms to send out notifications before starting to stream. In this case, notifications are a way of control that was a developed norm agreed upon by group members. However, such control might not be effective as a social mechanism, as streamers might forget to notify their teammates. This scenario thus points to the necessity of technical solutions that can complement or enhance the current social way of control.

Group information could be disclosed by a person in the group, and the disclosure can only be managed by this person. For example, a guild drama was streamed by the streamer in the guild, but it was the group's privacy that was violated. No one in the guild but the streamer could control the disclosure. The streamer may or may not care about the group's privacy, as he was part of the group. Similar to the discussion of scenario 2, technical control (i.e., through a vote) might be

built in to decide and manage the disclosure collectively. Group information can also be jointly managed by the group. For example, participants had their small group norm of jokingly calling each other names. But when one of them streamed their conversations, they choose to restrict their disclosure to protect the group's privacy. In this case, group privacy was collectively managed by all its members.

Importantly, beneath the wide range of possible scenarios illustrated in Table 1 is the uneven terrain of social reality and technical feasibility. For example, our participants reached certain levels of mutual understanding about whether and how a player should disclose their own personal information, but not so much about how a group should manage an individual player's information. In terms of technical feasibility, much technical control lies with individual players, not their teammates or their groups.

6.2 Heightened Challenges to Privacy in Live Streaming

Our study reveals several privacy challenges for users when being streamed by other members of their team. First, streamers' teammates lacked awareness mechanisms and relied entirely upon streamers' verbal notification. In our study, most participants found out they were being streamed through the notifications from the streamers. Such notifications were important, because after being notified, players need to apply strategies to cope with their privacy concerns, such as restricting game chat, improving gaming performance, and moving controversial conversations to text chat. However, such notification was also imperfect, because there was no way to be aware of being streamed if the streamers did not provide notifications, or team members did not receive or pay attention to the audio or text chat. Neither Twitch nor WoW provides explicit notification features for play streaming.

Second, live streaming can be viewed as synchronous communication where any disclosed information is broadcast to viewers in real time. In contrast, most social media sites such as Facebook and YouTube are asynchronous, and users can still negotiate and untag when their personal information is unexpectedly disclosed in others' contents before it reaches a broader audience [22]. According to cognitive load theory [39], synchronous communication induces more cognitive load on humans than asynchronous communication. In live streaming, players need to manage the disclosure of numerous pieces of information (such as sensitive information, inappropriate words, low gaming performance, and guild drama) simultaneously, while also being busy playing games.

Third, real-time live streaming also captures information about players' local contexts. For example, participants mentioned that the voices of bystanding family members and friends were also captured and streamed. These people were completely unrelated to the gameplay, and might not even know that they were being streamed. Family members and friends were thus unknowingly exposed and their privacy jeopardized. This suggests that we should extend our understanding of the stakeholders in privacy management, especially when live-streaming of real-life activities is nowadays becoming increasingly popular [4].

6.3 Interplay between Multiple Group Norms in Video Game Live Streaming

Our study extends the understanding of "norms" in privacy research by highlighting that users' information disclosure is influenced by multiple group norms. Previous studies only showed that one's privacy attitude and behavior are significantly influenced by perceived social norms in one's social networks [27]. For example, users adjust privacy settings of social network profiles based on others' profiles they have seen [37]. Our participants mentioned that their disclosure was

simultaneously influenced by the norms of their small group of friends (e.g., it is o.k. to use vulgar words), the guild norms (weekly raids are streamed), the WoW norms (live streaming is necessary for gameplay), the Twitch community norms (code of conduct), and even the social norms (avoid language that offends others and children). Multiple norms jointly influence their disclosure. For example, participants agreed to be streamed in accordance with the WoW norm, and restricted their disclosure due to the Twitch norms and broader social norms. Their amount of disclosure reflected the effects of both norms.

Norms might conflict. For instance, participants' group norms sometimes conflicted with the Twitch community norms and the societal norms. When different norms conflict with each other, they will choose to conform with the norms at large. This is related to "norms collision" in Burnett's work [6], where the intersection of multiple groups in a community results in conflict due to different norms. Thus, future research should consider privacy decisions as an outcome of multiple norms rather than a single norm.

The pressure to conform to norms may override players' personal concerns and drive them to accept being streamed at the risk of unwanted disclosure. For example, despite the concerns they had about privacy and impression, participants agreed to be streamed to comply with the norms in the WoW community. They were affected by what others do and what others expect them to do in their disclosure decisions, regardless of the actual concern and comfort they may feel. Conformity biased their privacy decisions.

7 DESIGN IMPLICATIONS

Future design in video game live streaming should facilitate players' collaboration in collective privacy management. As we discussed in the 4 scenarios of collective privacy management, users' privacy needs and strategies differ in these scenarios, which calls for customized technical support. For example, when a user's information is disclosed and managed by a second person, the system should allow this user to explicitly express privacy concerns to the second person. When a group's information is disclosed and managed by one group member, the system should enforce the group norms of privacy management. When members in a group collaborate to manage their privacy, the game should allow them to assign tasks and communicate with each other about their privacy needs. The live streaming platform should enable the group leaders to control the teamplay streams.

Future design of live streaming tools should grant players more control over their information disclosure while avoiding additional cognitive cost. In our interviews, players can only control their disclosure through their own behavioral strategies, which requires much cognitive effort and may influence the gaming performance or experience. Future design should assist their behavioral strategies. For example, teammates could blur their voices in a broadcast when talking about sensitive matters in the audio chat. Their actual utterances can still be delivered to their teammates, but will not be heard by the unwanted viewers. And if the team members do not want to be involved in the live streaming, they should have the option to anonymize their characters or not be streamed.

Future design should enhance notifications to players when being streamed, so that they are aware of being streamed by others and of the changing group norms. In the current design, sending notifications is external to the live streaming tool and the game. Players rely on streamers' effort to get notified, and they have no clue about the viewers. A design that incorporates the notification of live streaming into the gameplay is helpful for team members to be aware of the different norms. As one interviewee suggested:

Maybe it's just the UI. If you're in a party with somebody, you know you can see their icon. Maybe just right next to their icon there is like a little movie camera. I think that could probably be pretty well implemented. If they are streaming, or recording the play, then you would know.

In addition to this type of persistent notification of streaming, the different levels of conspicuousness should also be considered. For example, notifications can be initiated in the audio chat, in the game, and even on Twitch. These three systems should coordinate to achieve this, so that players will be notified even if they can only access one of these settings. Also, notifications should mention who on the team is streaming, whether the text chat and audio chat are being streamed, how many viewers are watching, and what the viewers' feedback will be. This information can help the streamed teammates adjust their privacy strategies accordingly, to protect their personal privacy and/or group privacy.

8 LIMITATIONS AND FUTURE WORK

Our study has some limitations. First, we only interviewed 20 Twitch users from the WoW community. They may not represent the whole spectrum of information disclosure behaviors in the WoW community that has tens of millions of players across the world. Nor can our findings represent other genres of games, or other live streaming platforms. However, as our study is among the first to explore privacy issues in the context of video-game live streaming, it yielded insightful results that warrant future research into privacy and group privacy management in live streaming. Future work can consider large-scale survey studies to capture broader demographics, or design privacy techniques to support players' privacy management in live streaming.

Second, our study focuses on live streaming in WoW. The privacy violations of live streaming in WoW may be different from those in other genres of games. In WoW, players who team up may have frequent communication and maintain a friendly relationship with each other. The privacy issues may be different in other games where players usually play with random matches, such as LOL, Dota 2, and Overwatch. Previous work has suggested that the genre of games, including game mechanisms, affect how people participate in video-game live streaming [31]. Such genre effects may also apply to information disclosure by people who are streamed by others. We suggest future work sample players from multiple game genres to examine possible differences in their privacy management during live streaming.

Third, we did not include the perspectives of Twitch streamers and viewers in this paper. These people are important parts of the Twitch community, and play key roles in the community norm development. Their culture and expectations may influence players' disclosure and performance in live streaming. For example, one study has shown that audience chat in video-game live streaming may be influenced by the size of the audience [12]. It may also partly influence the information disclosure and gameplay of players when they are being streamed. We suggest this as an interesting future research direction, as integrating the perspectives of streamers, viewers, and players' who are in the live streams, as well as the contextual factors of video-game live streaming, will give us a more comprehensive understanding of privacy management in video game live streaming.

Fourth, many of our interviews were conducted through in-game text chat as the interviewees preferred. While this interview approach has advantages, such as offering a degree of anonymity to interviewees, it also has several possible downsides, such as the lack of social cues, of contextual information about the interviewees, and of details in interviewees' description of past experiences [28]. We suggest future work apply richer data collection methods to gather users' perceptions towards video-game live streaming.

Last, we believe that a detailed analysis of video recordings of live streams can yield many insights into real-time privacy practices of streamers and their teammates. However, such analysis is beyond the scope of this paper. In future work, both manual and computational ways of video analysis might be considered for exploring privacy issues in live streaming.

9 CONCLUSION

In this paper, we report an interview study with 20 World of Warcraft players, to explore privacy issue in video-game live streaming. The unique characteristics of live streaming entail disclosure of new types of private information, heightened privacy challenges in comparison to traditional social media platforms such as Facebook and YouTube, and new forms of collective privacy management. More research needs to be conducted to fully understand the privacy challenges in live streaming and to find effective ways for supporting collective privacy management.

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