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Understanding Social Interactions in Location-based Games as Hybrid Spaces: Coordination and Collaboration in Raiding in *Pokémon GO*

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The overlaying of physical spaces with digital information produces hybrid spaces, redefining people's experience of social interactions. Location-based games (LBGs) with social components are a good case. Yet, the impact LBGs have on sociability remains under-researched. In April 2020, the new in-person/remote raiding format in the LBG *Pokémon GO* provided a lens to explore people's social interactions in hybrid spaces. We interviewed 41 *Pokémon GO* players to understand how players coordinate and collaborate for in-person/remote raids and other social patterns. Our findings demonstrate that new social dynamics occurred: participants' social interactions highly rely on external social media groups bridging cyberspace and the physical world. In such external social media groups, spontaneously formed leadership roles and mentor-mentee relationships demonstrate autonomy among players in the hybrid space. However, we observed that the interoperability issue challenges people's experience. Overall, this work sheds light on the social interactions in LBGs as hybrid spaces.

1 INTRODUCTION

The integration of the mobile web and global position system (GPS) blends our physical environments with a digital layer of location-based information as a mobile interface [11], blurring the borders of traditional cyberspace and physical space. This advancement formed what de Souza e Silva [2017] termed "hybrid space," which enabled novel locative media to emerge. An important examples of locative media is the location-based game (LBG). LBGs (e.g., *Pokémon GO*, *Pikimin Bloom*, *Ingress*, etc.) support players with locative information through mobile devices and allow them to play across physical and digital spaces simultaneously [3]. This new format of locative gaming has attracted huge commercial attention. Indeed, it was valued at $3 billion in 2020 on the global market and is expected to expand to a worth of $30 Billion By 2028 [52]. At the same time, the area of LBGs as hybrid spaces has become a frequently discussed topic in academic literature [3, 13, 38]. As de Souza e Silva [2017] observed, new social possibilities and communication patterns occurred in the LBGs as hybrid spaces dramatically changed people's social interactions.

In the field of LBGs, extant research has tried to understand how LBGs influence people's interactions with their surroundings in the context of urban planning [34, 51, 54], mobility in municipal environments [12, 27, 65], and human territoriality [47, 48]. Overall, the majority of research has tended to focus on person-to-place interactions while

overlooking person-to-person interactions, which is a key aspect of social interaction as the process of "social exchange between individuals" by its definition [26].

In recent years, research has emerged that explores how LBGs affect people's social interactions against the social constraints during the Covid-19 pandemic [6, 20, 22, 40]. Related works have focused on understanding the relationship between LBG players and their social interactions from various aspects such as well-being [35, 41], safety [7], social connection [25, 53, 61], etc. Generally speaking, previous studies found that LBGs can both positively and negatively impact people's social life by strengthening their social ties [25], and supporting wellness and physical health [5, 35, 41] but might threaten their safety and privacy [7, 66]. Therefore, it is necessary to understand how LBGs as hybrid spaces could influence people's beliefs, perceptions, and behaviors in social interactions.

In *Pokémon GO*, the new in-person/remote raiding format (launched in April 2020) provides a lens for people's social interactions in a hybrid space. To be clear, raiding in *Pokémon GO* is a multi-player task where the goal is to defeat the NPC called "Raid Boss" in Raid Battles, which include complex social interactions (i.e., coordination and collaboration) [6]. The new in-person/remote raiding format allows players to join Raid Battles from any location, transforming the previously solely co-located in-person play format into large-scale international social interactions in the hybrid space. Thus we interviewed LBG *Pokémon GO* players (N=41) and analyzed their lived experiences in the new in-person/remote raiding format to understand people's social interactions in LBGs as hybrid spaces. We explore the following research questions: 1) How do players coordinate and collaborate in the new in-person/remote raiding format in LBG *Pokémon GO*? 2) What factors influence people's participation and social interactions in such a hybrid space?

As previous research (e.g., [6, 54]) suggests, findings in LBG-related studies are not only related to one specific LBG but can be applied to other LBGs. Additionally, we focus on social interactions, which are key for all hybrid spaces [11, 39]. Hence, we will discuss how to apply lessons learned from the social interactions of LBGs to broader contexts of hybrid spaces. To this end, our results are not only related to raiding in *Pokémon GO* but can be applied in the broader context of LBGs and even radiate to other hybrid spaces of non-gaming contexts. Overall, the main contributions of this paper include:

(1) An updated understanding of LBG *Pokémon GO* players' lived experience with an emphasis on person-to-person interactions in the new in-person/remote raiding format. Before the in-person/remote raiding format, raiding parties were small groups of less than 20 local players [2]. Still, hybrid social communities now embrace a larger number of players worldwide. We present newly identified social dynamics in the hybrid community.

(2) An understanding of the user experience issues occurred when players leveraged third-party applications to communicate in the *Pokémon GO*-created hybrid space. We affirmed that the lack of interoperability causes the issues, and the interoperability issues would cause more severe consequences in hybrid spaces than in purely virtual spaces.

(3) Design implications for the future design of LBGs and other hybrid spaces.

In the following section, we provide an overview of related literature on the social interactions of LBGs as hybrid spaces and provide a brief background of raiding in digital gaming. Following this, we describe our methodology, including participants' recruitment, interview protocol, and data analysis. We then present our findings, highlighting players' beliefs, perceptions, and behaviors while coordinating and collaborating in the LBGs. Finally, we discuss our findings and conclude the study with limitations and future research avenues.

2 BACKGROUND

2.1 The sociability of Location-based Games as Hybrid Spaces

LBGs are a type of gaming that allows players to play in physical places while players are supported by locative information via mobile devices in digital space [3]. As such, LBGs merge the physical and digital space into what has been termed "hybrid realities" [14]. With the nature of "hybrid reality," the rise of LBGs accompanied the convergence of the physical and cyber spaces to a "hybrid space" [11], enabled by nomadic technologies [11]. LBGs created "hybrid spaces" are "physical environments overlaid with digital and location information that can be accessed with suitable mobile devices" [46]. For instance, when playing traditional online gaming, such as World of Warcraft (WoW) [23] and League of Legends (LoL) [28], players mainly interact through online chat rooms and digital avatars. In contrast, LBGs such as *Pokémon GO* [43] enable players to interact with gaming narrations in digital space located in their physical surroundings (i.e., concrete places and other players in person).

As de Souza e Silva and Delacruz [2006] observe, through the convergence of the physical and digital spaces into a hybrid space, we are experiencing changes regarding social interactions. Importantly, sociability and communication patterns within these environments are under-explored. Echoing de Souza e Silva and Delarcruz's argument surrounding the "changes regarding sociability in hybrid spaces," Ulysses et al. [2020] observed a series of new opportunities for sociability occurred in hybrid space, such as the creation of additional social networks, external social media groups and physical gathering in the city. They reasoned that the new social opportunities took advantage of the location awareness of LBGs. Here, they focused on discussing how these new social possibilities might impact urban practices. To be specific, the emergence of hybrid spaces influenced how players interact with and perceive the city, and so is relevant to urban governance and managemen[51]. Besides the context of urban planning, as players' perception of urban space and mobility is hugely influenced by LBGs, "human territoriality" is expressed through their interactions with places [47]. Such "human territoriality" refers to the behavior in which humans claim space as their own with exclusiveness and state this claim to others [29].

As noted above, LBGs are distinguished from traditional online gaming by introducing physical place as a new layer besides digital space. Extant research, however, has mainly focused on the physical side of LBGs but has not thoroughly considered the interconnection of physical places and digital spaces. As its definition implies, hybrid space is not a simple addition of the physical place and digital space; instead, it is a product of "interrelations and entanglements between spaces" [54]. In other words, LBG as a hybrid space is a complicated whole formed by the collision of the two spaces, where the materials and information of the two spaces are mixed and presented with the interwoven effect. To this end, better understanding the sociability of LBGs requires equal attention to the two places and viewing them as an interconnected whole.

Additionally, extant research has tended to focus on person-to-place interaction in the context of LBGs. Yet, insufficient work has been done to understand person-to-person interactions. For instance, players' experiences of communicating in external social media groups and in physical gatherings are unknown regarding their behaviors, beliefs, and expectations. By definition, we argue that social interaction is the "social exchange between individuals" [26], where person-to-person interaction is an emphasis. To this end, our study demonstrates an understanding of social interactions with an emphasis on person-to-person interaction to expand the knowledge of sociability in LBGs as hybrid spaces.

2.2 Social Interactions of Location-based Games

Social interaction, considered one of the core elements in multiplayer gaming by definition [56], has long been discussed in the traditional online gaming context [18, 24, 33]. In online multiplayer games, however, without forming active social interactions and social capital among players [6], the limited interactions make players feel lonely being "alone together" [19, 60]. Unlike online digital gaming, location-based games (LBGs) introduce co-located play, allowing players to interact with each other face-to-face and online. To be specific, complex collaborative tasks in LBGs, such as raiding in *Pokémon GO* and forming teams in *Ingress*, facilitate social interactions among players both online and in real life (IRL). In addition, such social interactions are not only in the ludic environment, "external interactions" such as "hanging out" derive among players beyond the gaming context [6, 37].

Extant research has frequently discussed how LBG can influence their players and even people who do not play the games in the context of social interactions. Especially since the outbreak of the COVID-19 pandemic, an area of interest has emerged regarding how LBGs influence people's social interactions against situations that are socially constrained [6, 20, 22, 40]. Generally, previous studies focused on exploring the relationship between LBG players and their social interactions in LBGs from various aspects (e.g., well-being, safety, social connection, etc.). Specifically, the literature highlights the following phenomena:

(1) Social interactions in LBGs can support players' sense of social connections: help social withdrawal [61], maintain friendships, and strengthen relationships among family members [25].

(2) Social interactions in LBGs can support players' mental and physical health by encouraging them to go out and interact with people [35, 41].

(3) Social interactions in LBGs might threaten players' safety IRL (e.g., being stalked or harassed), especially when interacting with strangers [7].

The previous works demonstrated that LBGs could positively and negatively impact people's social life, highlighting the necessity to understand the mechanisms behind these phenomena. Nonetheless, due to the lack of in-depth observation of individual players' social interactions in and out of the ludic environment, understanding players' lived experiences of social interactions (such as behaviors, beliefs, and issues encountered) in LBGs remains nebulous. For instance, Eklund [2015] conducted a survey (N=2611) and mapped out the patterns of players with different co-players (i.e., family, friends, and strangers), but players' motivations and behaviors to interact with different groups have not been fully revealed. Additionally, some studies have reported the aforementioned externally derived social interactions of LBG (e.g., hanging out with in-game friends) [6, 37]. Yet, how players of LBG expand their social interactions beyond the gaming context remains under-explored. Consequently, in our study, we observe and analyze players' lived experiences of social interactions in and out of LBG *Pokémon GO* to reveal their motivations and beliefs behind the superficial phenomena.

2.3 Raiding in Digital Gaming

Raiding is a gaming format that requires two and more players to coordinate and collaborate for a common goal in the game [6]. This format exists in many traditional online digital gaming, such as *WoW* [23] and *Everquest* [36]. And some studies have been done regarding social interactions in raiding. Generally speaking, raiding is a collaborative organizing activity among multiple players and thus has long been an arena for observation of social interaction in the literature [62]. As mentioned above, social interaction is limited in traditional online gaming [19, 60] mainly due to the lack of synchronous communication. For instance, in *WoW*, players communicate through asynchronous chat

tools in guilds which challenges their active social interaction during raiding coordination and feeling "alone together" [19]. Additionally, how leadership activities emerge into social interaction has been discussed in the context of raiding. Leadership is crucial in team forming [10], decision-making [4], and raiding outcomes [49].

Unlike traditional online gaming, raiding in LBG *Pokémon GO* allows players to meet and play in physical locations, where social interactions also occur in the concrete world. Raiding in *Pokémon GO*, launched by Niantic in 2017, is a group of players (ranging from two to twenty) endeavoring to defeat and capture an NPC called Boss Pokémon. Raid Battles occur in Gyms (virtual infrastructures on the game map overlaid on landmarks of the real world) frequently every day and have four tiers of difficulty, with additional tiers available during special events. The higher the difficulty, the stronger the Boss Pokémon, and the more teammates are needed to win.

Completing a Raid Battle consists of the following steps (see Figure 1):

(1) Find a Raid Battle by searching the nearby in-game map or getting an invitation from in-game friends, no matter how far away you are from the Raid Battle.
(2) Enter the Lobby and prepare for the battle. A lobby is a virtual place where players wait for each other to get ready, invite more friends and pick six Pokémon to raid in the battle.
(3) Players can tap for Attack and swipe for Dodge on their mobile screens to fight against the Pokémon Boss. Attack damage by players in a team will work together to defeat the Pokémon Boss.

Find a Raid Battle─────→Enter the Lobby and prepare for the Battle─────→Begin Battle
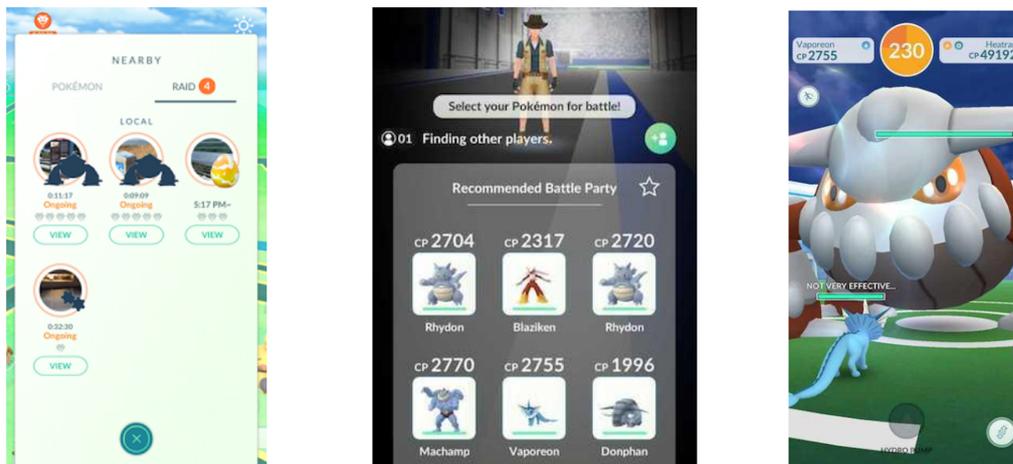
Fig. 1. Steps to complete a Raid Battle (interfaces from [45])

Originally, all players had to gather near the Gym's physical locations where Raid Battles occur to raid. However, to alleviate the impact of the COVID-19 pandemic, Niantic introduced remote raid passes in *Pokémon GO* on April 15th, 2020 [44]. With a remote raid pass (which can be purchased in-game), players can access Raid Battles from wherever they are physically located. To be noted, at least one player battling in person is required to launch the raid,

and only in-person players at a Raid Battle are able to invite friends to join them. This new feature created the new in-person/remote raiding play mode: besides raiding in-person, players can raid remotely, making remote raid (i.e., a raid containing players joining remotely from separated physical locations) a new option besides in-person raid (i.e., a raid with players all gathering in the Gym). For instance, in Figure 2, three players raided in person and waited for more remote teammates to join them. The *Pokémon GO* raiding environment creates a "complex, fluid, large-scale" experience for millions of all-age grouped players across multicultural communities around the world [6].

Fig. 2. Three players raiding in person teamed up with other remote players

Compared to the raiding in traditional online gaming, social interaction is differentiated in LBGs as hybrid spaces. More specifically, the aforementioned "hybrid reality" raiding in LBGs formed complex environments for social interactions [6]. For instance, in online gaming, players coordinate and participate in raiding in digital space "online together." But in LBGs, such as the in-person/remote raiding in *Pokémon GO*, players interact in a hybrid space: they communicate with remote players online and in-person players in the real world. In other words, raiding in LBGs is an environment that merges social interaction into a hybrid space. Thus, it could be an arena to observe the social interactions in hybrid spaces by observing LBG players' lived experiences. Unfortunately, because raiding in LBGs is relatively recent, little work has been done to understand its person-to-person social interactions in-depth. In 2019, Bhattacharya et al. [2019] conducted an online survey (N=510) and interview (N=25) in gamic environments using *Pokémon GO* as a case study. They gained an empirical understanding of how people coordinated and collaborated in small groups (less than twenty people) for raiding in *Pokémon GO*. However, their study was conducted before the

introduction of remote raiding, and the in-person/remote raiding format significantly changed how people engage in the raiding and interact with others. When raiding was solely in-person, in most cases, players' social interactions were sequentially independent in two spaces (i.e., digital space and physical place) or did not happen in digital space. That is to say, they coordinate in digital space first and then meet IRL to raid; otherwise, they do not pre-organize online but meet IRL directly [6]. However, in the new in-person/remote raiding format, face-to-face communications IRL and online communications are entirely interwoven in the hybrid space. This evolution means the boundary of physical place and digital space is becoming more blurred, and how that might influence peoples' social interactions is unknown yet. Nevertheless, Bhattacharya et al.[2019] scaffold our study in several ways. First, they examined raiding in *Pokémon GO* as a reasonable arena to observe people's social interactions, including coordination and collaboration. Next, they revealed the existence of social media groups on third-party applications for raiding coordination, such as WhatsApp and Discord. After this, they showed that the findings in *Pokémon GO* could be applied to other LBGs[6]. Thus, we work on the in-person/remote raiding format in *Pokémon GO* to gain an updated understanding of people's social interactions, including coordination and collaboration in the hybrid space.

In sum, this literature review demonstrates that in the context of LBGs, new social possibilities can dramatically influence people's social behaviors when interacting with places and other individuals [54]. But there are insufficient studies that explore this area. The majority of studies focus on either 1) demonstrating the phenomena of how LBGs can influence people's social interactions while not analyzing the mechanisms behind them (e.g., how do players make decisions in social behaviors such as teaming up?) or 2) person-to-place interactions and rarely touch the person-to-person interactions. To this end, people's perceptions and behaviors during social interactions in hybrid spaces remain nebulous. Our study aims to address this lacuna by examining the new player interactions using *Pokémon GO* raids. The reason is twofold: 1) *Pokémon GO* as an LBG with the aforementioned large-scale community, it is necessary to update the knowledge of players' experience. 2) a thorough understanding of person-to-person interactions in the *Pokémon GO* raiding format could apply to other LBGs, so we can advance the knowledge of social interactions in hybrid spaces and make implications for other LBGs and hybrid spaces design.

3 METHODOLOGY

3.1 Participants

After obtaining IRB approval in January 2022, we began recruiting via the subreddit r/Pokémongo. People interested in sharing their experiences in the new in-person/remote raiding format were invited to book an interview slot via the online scheduling website [1]. We allocated 60 one-hour slots for interview appointments that participants filled within a day of posting the recruitment information to Reddit. Participants were rewarded with a *Pokémon GO* gift code valued at $10 upon the completion of the interview. In the end, 41 participants (14 female and 27 male) aged from 20 to 65 and residents in eight countries on multiple continents, with the majority living in the US (see Appendix A, Table 1 for demographic details), completed the interview. All our participants (41/41) are veteran players of *Pokémon GO*, reaching the game level of 39 and higher, and seven were at Level 50 (the maximum level to the interview date). In addition, all participants began to raid before the release of the remote raiding experience in 2020 and engaged in both in-person and remote raids, which means they experienced the evolution of the game from solely in-person mode raiding to the in-person/remote raiding format.

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[1]youcanbook.me

3.2 Interviews

All interviews were conducted online via Zoom, and all sessions were audio-recorded by the first author for transcription purposes. Before recording, we obtained permission from the participants after precisely informing them of the study context and interview topics. We supplied a participation reward in the form of a *Pokémon GO* gift code valued at $10.

The interviews were semi-structured to gain in-depth data on participants' lived experiences of social interactions in the in-person/remote raiding format. Each interview took between 45 minutes to one hour to complete. According to the research aims, we listed initial and open-ended questions (See Appendix B) from several aspects: 1) social demographic questions including gender, age, and citizenship; 2) general information regarding raiding in *Pokémon GO* such as game level, first time to raid, raiding frequency, and so on; 3) raiding experiences in the new in-person/remote raiding format, including but not limited to their coordination and collaboration experiences. Specifically, we asked questions such as "In your opinion, what is the difference between the two kinds of raiding format (i.e., pure in-person raiding format vs. in-person/remote raiding format) regarding the raiding coordination?" and "When you do remote raids how do you communicate with the players that raid in person? And if you raid in person and how do you communicate with co-located/remote players?" Additionally, we asked questions like "Have you made any new friends while raiding? Do you hang out with people you met during raiding outside raiding?" and "Have you had people that you raid with remotely becoming friends and discussing things beyond the game?" During the interview, participants were asked follow-up questions like "Why" to explain their statements and "How/what" to raise examples to articulate their opinions. For instance, when participants mentioned their preference for which raiding mode, they were asked, "Why do you prefer in-person raids (or remote raids) more?" "What do you dislike about in-person raids (or remote raids)?" and "what issues did you encounter during raiding remotely/in person?" As such, semi-structured interviews allowed our participants to share their experiences and perceptions freely [9]. At the same time, we took notes for each interview to reinforce the analysis.

3.3 Analysis

While conducting interviews, we began an initial analysis, reviewing audio recordings and interview notes. After completing forty-one interviews, we elected not to recruit more participants as we achieved thematic saturation. After the completion of 41 interviews, audio recordings have been automatically transcribed by the transcription service Otter.ai. Following this, all transcriptions were manually corrected by the first author. This was done by listening to recordings while reading through concomitant transcriptions. During this process, we anonymized the names of places mentioned and pseudonymized participants' names while retaining non-verbal information such as laughter and hesitation. Transcripts and notes were then uploaded to the professional qualitative analysis software Nvivo 12 [50].

Moving forward, We utilized inductive thematic analysis [8]. This process involves three main stages:

- Data Familiarization. In the data familiarization phase, we read and corrected all interview transcripts adding memos where appropriate.
- Create codes. We coded phrases and sentences related to our research aims as initial codes in each transcript. In the first cycle of coding, we used in vivo coding. We generated a list of codes during this phase: "coordination and collaboration," "I changed my raiding time," "I prefer in-person raids," etc. We used the pattern coding method in the second cycle to categorize and refine codes. We collated codes generated in the first cycle into relevant topics. And we also generated new codes (e.g., "familiar people") around players' preference for raiding collaboration.

- Find and refine themes. Constructing potential themes inductively and collocating relevant codes into these potential themes. To search for themes, we built an initial theme map (See Appendix C) with potential themes and sub-themes. Then they were revisited and refined by the first author through discussions with the second and third authors. We removed the "social activities go beyond the raiding context" in the final themes because it is not directly related to the new in-person/remote raiding format but acts as a result of the extended social groups in LBGs. The finalized themes are the titles of the Finding section (See Figure 3).
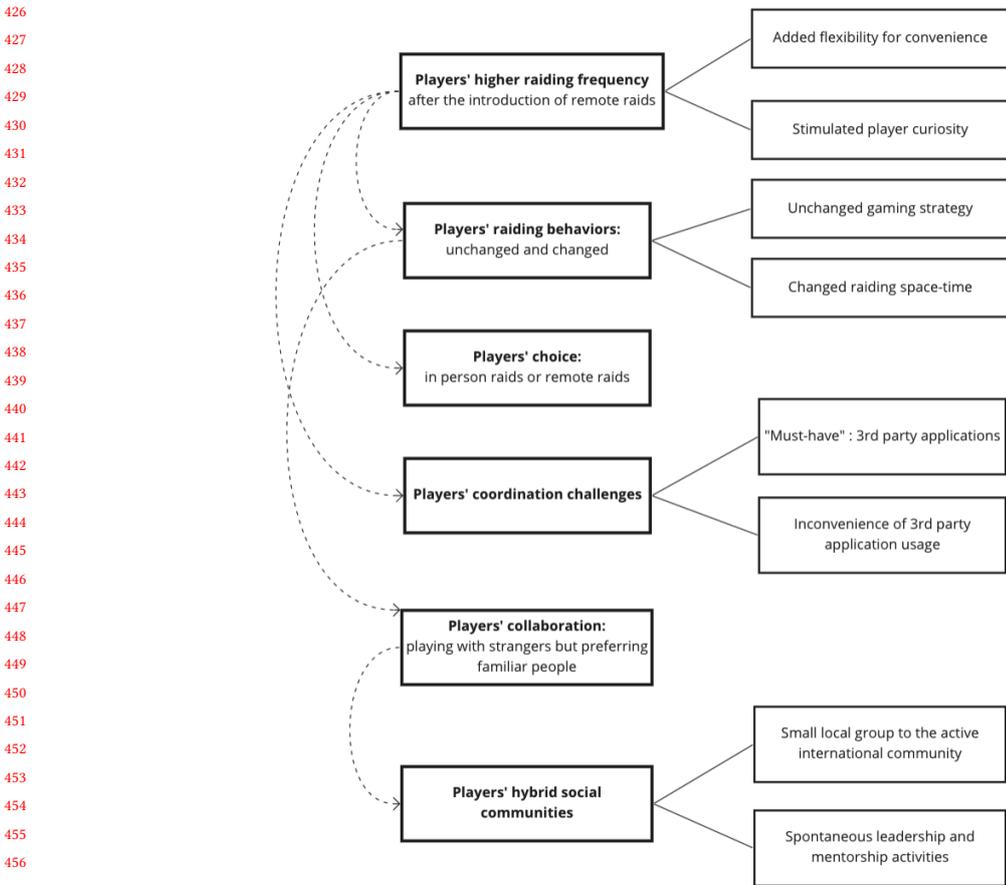

Fig. 3. Theme map

4 FINDINGS

4.1 Players' higher raiding frequency after the introduction of remote raids

4.1.1 Added flexibility for convenience. Before the introduction of remote raids in response to the COVID-19 pandemic, all players (41/41) who experienced pre-pandemic in-person raiding reported they played much fewer Raid Battles

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compared to the pre-pandemic stage. However, soon after Niantic released the remote raiding option months later, most players (32/41) began to engage in Raid Battles more frequently. Arthur and Dara said the following after they experienced raiding remotely during the pandemic:

> "Before COVID-19, I raided every day. [...] Our city was locked down for several weeks, so I couldn't go out to do in-person (raids). After we had remote raids, I did a lot of remote raids at home. [...] I would say my raid participation probably went up during the COVID-19 in terms of remote raids because it makes it (raiding) more accessible." (Arthur, level 44)

> "I started raiding around 2018, and I raided so hard [laugh]. [...](Compared to the pre-pandemic stage), I'd say I raid may be about the same or even more, but it is slightly different because I do raid in person less, but more remotely. [...] I'm not getting out as much as I used to, but I'm probably raiding about the same amount or even more." (Dara, level 43)

Arthur and Dara show a consistent passion for raiding, but sadly the impact of the pandemic restricted them from engaging with this aspect of the game in person. Therefore, the introduction of remote raids provided players with opportunities to raid at home, allowing players like Arthur and Dara to raid more.

4.1.2 Stimulated player curiosity. However, some players (6/41) did not show a consistent passion for raiding, but the introduction of remote raids attracted them back to Raid Battles. Take Chris (level 50), for example. He said that he started raiding from the day it was released in 2017; however, he began to be "on and off" after the first year of raiding because he was getting bored of the game format. But when remote raids came out, he began to raid again "out of curiosity" and engage in Raid Battles more frequently:

> "During the pandemic, my friend told me the remote raid was out. Then I re-downloaded the game for the new thing (i.e., remote raids). I have never tried raiding remotely. I heard that we could raid with people in another country. That would be incredibly cool. I was curious about the new mechanism. Then I had my first remote raiding experience and raided more and more." (Chris, level 50)

4.2 Players' raiding behaviors: unchanged and changed

4.2.1 Unchanged gaming strategy. Given that all players experienced in-person raids and remote raids, we asked players to describe how their raiding experiences changed following the introduction of remote raids. Jacob (level 37) described his experiences through a series of behaviors:

> "I watch youtube videos and read Niantic blogs to check the information about the Pokémon boss I will meet. [...] So I can decide which types of Pokémons. For example, if we face Rayquaza (a dragon/flying-type Pokémon boss), I need to use ice-type Pokémons. [...] Though attack damage is reduced when raiding remotely, it does not matter much. I still dodge and tap on my screen, whether (raiding) in person or remotely. The raid itself did not change much (upon introducing the remote raids) to me." (Jacob, level 37)

Jacob used "raid itself" to describe his behaviors of attacking the raid Pokémon bosses (i.e., getting information about the opponent, choosing the proper Pokémons, and operating on the screen), which was barely influenced by the introduction of remote raids. Most players in our study (35/40) reported their "raid itself" behaviors barely changed.

4.2.2 Changed raiding environments and time. However, except for the "raid itself," we observed that players' raiding experience did change considerably regarding playing environments. Once raiding remotely became an option, players did not have to be physically located near gyms where Raid Battles occur. Instead, they could stay far away from the physical gyms and join the Raid Battles with remote passes. In our study, all players raided remotely more frequently than in-person; most (38/41) players joined Raid Battles at home alone, and the rest raided in their workplaces (other than home). In other words, players' raiding environment shifted from outdoors to mainly indoors in terms of the physical locations. Reacting to this, Alice (level 44), who worked from home during the lockdowns, felt it was "so quiet" when raiding remotely at home:

> "I used to raid with a group of friends, we high five when we won the battle. [...] We raided in the parks and were a bit noisy sometimes. [laugh] When remote raids came out, fewer and fewer people went out, and we stayed at home. [...] When I raid remotely, I stay at home alone. It is just too quiet." (Alice, level 44)

For Alice, besides the outdoor to indoor alteration, her raiding environment changed in terms of the atmosphere. Remote raids separate co-located player groups into single players in different physical locations, which moved the raiding environment from "loud" as a group to "quiet" alone. Unlike Alice, Nick still got some opportunities to raid in person and also felt the "cool down" in his raiding environment:

> "Now, I still do some in-person raids, but things are different. [...] Only a few people raid in person as frequently as before. They played more remotely. Usually, only two or three players, including me, raid in person. Others join remotely. [...] I do kind of miss being able to raid in a big group in person. We were excited about being together, running from this gym to another, (and we were) very active. I can not say I have less fun now, but my feeling cools down a bit." (Nick, level 50)

In addition, we observed that the mechanism of remote raids changed some players' raiding time. As mentioned in the background, Raid Battles appear in gyms around 8-9 a.m. and stop around 9 p.m. local time. However, when given access to remote passes, players can join a Raid Battle in additional time zones. As such, remote raids allow players more opportunities to raid, especially for "night owls" and people doing night shift jobs. In other words, remote raids extended the playing time, just as Melody (level 42) and Joanne (level 50) said:

> "I work at night. [...] It was difficult for me (to raid) because most raids happened while I was sleeping. [...] Now, if the raids are no longer available in my time zone, I will remotely join it from someone else in another region." (Melody, level 42)

> "With the remote raids, I would say the biggest change to my schedule is that I probably do more raids. I would raid more at night or in the morning because I've got international people I can raid with." (Joanne, level 50)

4.3 Players' choice: in-person raids or remote raids

As mentioned, most players in our study joined raids remotely from their homes and did so more frequently than in person. However, this does not necessarily mean players prefer raiding remotely over in-person raiding. We observed that preferences between the two raiding modes were evenly distributed among individuals: nearly half (19/41) of participants in our study preferred raiding in person, while a similar number of participants (16/41) preferred raiding remotely; the rest of them (6/41) were not able to decide.

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Interestingly, these players usually started with "it is hard to choose because I like both of them" or "I like both, but I prefer…" when we asked players to discuss how they like and dislike both modes while making decisions about their preferences. This stance implies that players valued the benefits of both raiding modes. Take Sara (level 50) and Nick (level 50), for example. Sara preferred raiding in person for its "real-life interaction with places and other players." Still, she also appreciated the time flexibility of raiding remotely, which allows her to raid 24/7 without raiding time restrictions of her local place. And Timmy, who preferred to raid remotely because it supported him in collecting Pokémon bosses he wanted globally, still believed raiding in person with others in the physical gyms is exciting.

For players who preferred raiding remotely, we observed that they mentioned their eagerness to win the battles in the game extensively. Timmy (level 49) highlighted his goal is to collect "useful Pokémons" so he could "do well in the Raid Battles." He explained how raiding remotely helped him reach the goal:

> "My main goal is to collect useful Pokémons. [...] A useful Pokémon can help me do well in the Raid Battles. People in the community would discuss which Pokémons were powerful and which were not. And some useful Pokémons are not available in my region but are available in another country. So raiding remotely definitely helped a lot in this case." (Timmy, level 49)

Other players frequently described remote raiding as "more convenient" when rationalizing their raiding preference for remote raids. Players who prefer raiding remotely enjoyed the feeling of staying at home:

> "Raiding remotely means you do not have to walk to the gyms, can comfortably stay in your apartment, and can play in your coach. You have worries about the bad weather because you do not need to go outside. It is convenient to me." (Oleguer, level 43)

> "I prefer to raid remotely at home. Raiding remotely is much more convenient. I do not need to walk to the gym and stand there waiting for others. To start a new Raid Battle, I do not have to move to the next gym." (Jacob, level 37)

Quite the opposite of Jacob and Oleguer's opinions, Dave and Stacy preferred raiding in person because they could go out and explore their physical surroundings by moving around the gyms, as they mentioned:

> "I mean, I traveled a lot. When I go to a (new) city, I will raid nearby. That is sort of my way to know new places." (Dave, level 45)

> "It is always fun to see what is happening around me. Though I have been to the parks hundreds of times, looking at them at different weathers, seasons, with different people is still interesting." (Stacy, level 50)

Besides being able to interact with outdoor physical surroundings, raiding in person could provide opportunities for face-to-face interaction, especially in pre-pandemic stages. Alicia and Adam preferred raiding in person because they like interacting with people and had many good memories of raiding in person:

> "I like interacting with people, so I prefer raiding in person. [...] I have many good memories of going to fests of raid days and being in person. [...] And those are a lot of fun when you're with a group of friends or a family." (Alicia, level 45)

> "Very few things would have ever been as fun as driving around all day and doing the raids together with other players." (Adam, level 50)

4.4 Players' coordination and communication challenges

4.4.1 "Must-have": 3rd party applications. When talking about raiding coordination, our study found that all participants (41/41) mentioned it became "more complicated," but they "still can handle it." All of them were using third-party applications to assist this process. Third-party applications are a "must-have" for coordinating remote raids because there are no in-game communication features (e.g., messaging and chats). Co-located communications are hindered when players are separated in different locations.

The Discord server was the most common choice of third-party application by most players (34/41). Compared to other messenger applications mentioned, such as Telegram and Whatsapp, Discord is designed to build larger online communities and protect users' privacy without sharing contact details such as phone numbers. Besides messenger applications, some participants (8/41) mentioned using automatic raid coordinators such as Poke Genie and Poke Raids. These applications match players randomly into a remote raid. For Kelly, without forming a community, raids coordinated by Poke Genie and Poke Raids are "one-time businesses" and became a backup option. Similarly, Sara wishes she could "build up that relationship" with people who raided together so they may raid together again:

> "I first tried Discord to reach out to people in the community before using Poke Genie... Because I can never know whom I was raiding with (in a raid coordinated through Poke Genie). It is a one-time business. Raid and leave. That is weird. I wish I could send gifts to my teammates and connect. So you see, Poke Genie is my backup option." (Kelly, level 39)

> "Some of the other apps like Poke Raid, Poke Genie, some of them have you can join a raid but they don't have the communication component, [...] it would be nice to be able to keep those relationships with those people that you're doing a raid with to build up that friendship, knowing that, you're interested in raiding, I am too. I will continue to invite you to raids and have people that are kind of on standby." (Sara, level 50)

Though third-party applications compensated for the lack of communication features in-game, players encountered some issues. The typical process for players to join a raid through third-party applications includes four steps: add friends in *Pokémon GO* by sending/receiving friend codes, sending/receiving raid invitations, joining the lobby, and waiting for the battle begins. For example, Alicia uses the Discord server to coordinate raids, and she has to complete the following actions to get ready for a remote raid:

> "With Discord, if you have the person already [as] friends, awesome. They just sent the invitation. If not, they'll add you and then send over the invitations." (Alicia, level 45)

4.4.2 Inconvenience of 3rd party application usage. As mentioned by more than half of the players (27/41) in our study, it is inconvenient to swap between applications (i.e., third-party applications and *Pokémon GO*) to complete the coordination. This could be an extra operation burden for players like Melody (level 42) and Martin (level 50) complained:

> "I am really bad at multitasking. Copying and pasting players' handles, swapping between apps is difficult for me." (Melody, level 42)

> "Because you need to swap and switch back and forth between different apps because you need to copy some codes and paste them. I think it's inconvenient." (Martin, level 50)

Still, the delay in loading the game after swapping between applications can interrupt their experience, as Neil described:

"I do find that inconvenient, especially because the *Pokémon GO* app where if I back out, switch over to

another app and then switch back into *Pokémon GO*. It'll essentially reset the app, and I have to wait

through the loading screen to enter up. Sometimes it does get frustrating." (Neil, level 48)

Some players mentioned the accessibility issue. Dhan mentioned he was unaware of any third-party applications and joined the Discord group after a friend told him:

"I don't think most people who play the game would be in Discord at the very beginning. They won't

even know about it. It's only the people who really search to like to join the communities and know

about it. And only the minority of them in Discord and (other third party applications like that) have

the benefits of that." (Dhan, level 50)

Because there is no guide in the game for users to download any third-party applications, it was a secret and hidden path. Joining a community on a third-party application means a player can connect to more local and international players and access more raids. This fact makes players who have not joined communities on third-party applications less prioritized, which causes the accessibility issue.

Furthermore, all players mentioned that they communicate with in-person and remote teammates in different ways. Specifically, in-person players usually talk to each other rather than text in social media groups. This way, remote players can only get involved in very limited conversations. As Joel mentioned, he felt talking is much more convenient than typing during raids and so he and his friends do not communicate with remote players:

"Usually, we don't communicate with them because it is inconvenient during raiding. Let's say, 10 of us

jump into the raid (in person), then, you know, ten more people will jump in remotely and we don't

communicate with them at all. We just chat with the in-person friends." (Joel, level 44)

4.5 Players' collaboration: playing with strangers but preferring familiar people

During raiding coordination, teaming up is an indispensable step for all players. Before the introduction of the remote raids, all players raided with "local" players, including families, friends, people in the neighborhood, and strangers. It is worth noting that, for players, "strangers" referred to people who show up in the lobby without pre-organization and raiding together for the first time. When players raid in person, "strangers" can easily transform into friends in-game. Just as Caenin mentioned, "it's super easy to add friends, just scan a QR code and go."

When remote raids came out, most players noticed the expansion in team member options: with a remote pass, players can join raids with "local" players or/and "non-local" (i.e., remote) players. Remote players include families and friends in other locations and strangers whom players may never be acquainted with in real life (IRL).

We observed that all players did not mind having remote players in raids, including strangers. As Kelly explains follows:

"We don't mind people joining remotely from anywhere else in the world because we know that some

people can't come out. So we don't mind people joining in remotely [...] you know, it helps us out as

well because there's quite a big group if more people join. So it's easier for us to win. And it gets Raid

Battles done quicker as well." (Kelly, level 39)

But the majority of participants (37/41) in this study claimed that they preferred to raid with "familiar people" rather than "strangers." Liz joined two Discord groups that contain both "local" and "non-local players," but she still tends to raid with friends and families:

"Ever since remote raiding has come out, I usually raid with family who has joined, with friends who live far away from me. It's able to keep us kind of connected through that, which is nice. Also, we have raided together so many times, we work very well together [...] I guess I sometimes avoid raiding with a whole group of strangers. I don't know who they are, what levels they are at, or which Pokémons they will use. [...] I am not sure I can win that battle, so I will not take the risk of wasting a remote pass." (Liz, level 50)

Other players commonly agree with Liz's opinion. Raiding with friends and families remotely is a good way to maintain connections. Also, players know about each other's game profiles (e.g., game levels and strategies) which could guarantee good collaboration in Raid Battles.

4.6 Players' hybrid social communities

4.6.1 Small local group to the active international community. Our data shows that players' online communities in third-party applications are expanding from a local scale to a global scale, and the number of members has increased dramatically. Before the introduction of remote raiding, players only had chatting groups with familiar players. As Liz (level 50) mentioned, she only had "around twenty people in a local WhatsApp group, and only half of them are active members." After remote raids came out, she was moderating a discord group with nearly 200 players worldwide.

We also observed that players became more active in communicating with players from other regions to gain information, such as Pokémon bosses and raid invitations. Take Alasdair (level 47), a player from the UK, for example. Before the introduction of remote raids, he only discussed the game with friends in his town, which was "enough." After remote raids came out, however, he began actively connecting with players in other countries through Discord servers, Reddit, Facebook messenger, etc. Because he wanted to be invited to remote raids and get some rare Pokémon unavailable in his country, such international interactions in cyberspace made the players' community expand rapidly.

In addition, we observed that the social interactions among players went far beyond raiding together. To be specific, online communities such as telegram groups, Reddit subthreads, and Discord servers became places not only for raiding coordination but also for social topics like pets, food, and music, to name but a few:

"We have several discord channels about pets, music, food, etc." (Neil, level 48)

"Each one of my Discord groups has an off-topic chat. Some have specific chats like pets and food and that kind of stuff. And some just have a regular off-topic." (Hermes, level 50)

4.6.2 Spontaneous leadership and mentorship activities. In such a large-scale online community, players either send out invitations to others and other or join the lobby through invitations. For players who invite others, they need to 1) post raid information and user ID on social media or chat groups, waiting for responses; 2) add people who want to join as friends in the game and send raid invitations to friends on the list; 3) wait in the lobby for everyone to be ready. Other players joining a raid by invitation only need to add the host as a friend, accept the invitation, and enter the lobby, waiting for the raid to start. As Sara said:

"The person sending out invitations usually means they need to take responsibility, to take care of other raids, to make sure the raid would go smoothly. Others follow their guides, who can join the lobby now, who should wait for another team, etc. And suppose someone has trouble joining the lobby or encounters bugs. In that case, the organizer is the one who usually comes to help." (Sara, level 50)

From Sara's point of view, she believed the person who sends out raiding invitations would be the one to take responsibility for taking care of the team. Others who get invitations should follow the organizer's instructions. Similarly, David (level 45) mentioned that he tended to follow organizers' instructions during the raids, including the Pokémon choices and attack actions, because he believed he should "show respect to the organizers" because organizers are usually "very experienced players."

Organizing a raid is not easy for most players, and not every player is willing to do so. For Nicole (level 50) and Alasdair (level 47), though reaching very high levels in-game, still felt it was hard to organize a raid:

> "I only organized (the raid) once, which was not a good one. I made a mistake, and some people on the list could not join. I felt I ruined their experience. After that, I never tried to invite others anymore. " (Nicole, level 50)

> "I prefer to join other people's (raids) just because I found it quite difficult to invite them to attend. I would join other people's (raids) unless I know there are already two to three who would join. It is very likely that you can not invite anyone." (Alasdair, level 47)

In addition, to maintain communities' orders and lead the cohort, a small group of players spontaneously became moderators of the social media groups. The other members, to build a friendly online space, need to obey the rules of the community. According to Jared, most people in her raiding community are "peaceful and friendly," and conflicts are very rare to see:

> "We've had some small conflicts, but it hasn't been anything too crazy. It's been more like, Hey, I got kicked out of the lobby. Okay, cool, we'll all back out to you, you know, so we can all do it together. So I'm assuming it's in person, or even if it's remote, you know, somebody says, Hey, I got kicked out, you know, in the group chat, and then we just all back out so that they can get back in and we can do it." (Jared, level 50)

The main task for moderators is supporting remote raids, organizing social topics, and avoiding conflicts and bullying behaviors among players. Besides, supporting new players is a meaningful thing to do for high-level players. For instance, Kevin (level 50) spends a lot of time teaching lower-level players to raid and making sure no one is left behind:

> "I'm an admin on all these servers, and that's my job. I just help out to make sure that everyone's experience is as good as possible and that as our group, there's no one left behind." (Kevin, level 50)

5 DISCUSSION

In our study, all participants had been raiding in *Pokémon GO* for several years and experienced the new in-person/remote raiding format and social interactions with other players. Our findings demonstrate that new social dynamics occurred in the hybrid space of this LBG. Due to the lack of an in-game communication feature, the participants' social interactions, including coordination and collaboration in such a hybrid space, highly rely on external social media groups bridging cyberspace and the physical world. In such external social media groups, spontaneously formed leadership roles (i.e., Raid Battle organizers and social group moderators) and mentor-mentee relationships demonstrate autonomy among players in the hybrid space. However, we observed that the interoperability issues negatively influence people's experience of social interactions, which supports the extant but limited literature that interoperability issues are the main challenge in hybrid spaces [17, 42, 67]. Moving forward, we will use the remainder of this discussion to distill our

findings while contextualizing them against extant literature. Further, we discuss design implications for future LBGs and hybrid spaces.

5.1 Making LBGs more inclusive by adding remote gaming options

Upon the introduction of the remote raiding option, players engaged in Raid Battles more frequently, demonstrating the success of the new in-person/remote raiding format. From our observation, the reasons for an increase in Raid Battle participation are twofold: first, play place, and playtime of the new raiding format are more flexible. This new in-person/remote raiding allows players to join Raid Battles remotely rather than must be physically located near specified outdoor places, which is more convenient and accessible than ever, especially under the constraining situations of the COVID-19 pandemic [40]. In addition, players can join Raid Battles near their physical locations and join ones in remote places without the restriction of in-game curfew according to their local time, increasing their opportunities to raid. Second, this novel feature triggered players' curiosity to explore it [58] and brought back players who quit the game earlier. Players in our study believe the game strategy of "attack the Pokémon boss" did not change in the new in-person/remote raiding format, and the new remote raiding feature did not increase the game's challenge to an extreme level; thus, the new feature could enhance players' engagement and generate high values of entertainment [68].

Due to the social constraints present due to Covid-19, it is understandable that our participants raided more remotely than in-person during the study period. However, about half of the participants prefer raiding in person due to the "active atmosphere" of interacting with places and other people IRL. Some are nostalgic about the "old days" when raids were solely in-person. While people who prefer raiding remotely believe it is more efficient and can better support their game goals (e.g., level-up, rewards). As evidenced in the literature [59], players' behaviors can be influenced by their game traits. Here, socially-oriented players prefer in-game raids, while goal-oriented players prefer remote raids. However, we argue participants' preference for in-person or remote forms also depends on the context. For instance, when players are at the workplace, they would prefer raiding remotely because it is more convenient. And in-person raiding would be the choice when they are co-located with a group of friends. In such a new in-person/remote raiding format, people with different game traits and in different contexts can enjoy together, collaborate and create new social dynamics in this hybrid space.

5.2 Attention to the communication needs and interoperability in LBGs

As there are no in-game features such as a chat box that could support communications among players at the time of our study, players must leverage third-party applications (e.g., Discord, Facebook, Telegram) to coordinate their Raid Battles. In the new in-person/remote raiding format, players embraced a larger social circle to team up with. Specifically, they were no longer playing with local players only. Teaming up with remote players became an option. Differing from group interactions in small groups as complex systems [2] (less than twenty people) described in the previous literature [6] when Raid Battles were solely in-person, now those social media groups are international and large-scale (many with nearly 200 people, reported by participants in our study). As a result, players have opportunities to interact with more "strangers" than ever.

Although we observed that players do not mind having strangers in their teams, they prefer to team up with familiar people (i.e., friends and families) for Raid Battles. After excluding safety and privacy concerns, the main reason would be: people believe that playing with familiar people guarantees good collaboration and a successful outcome. Because they have mutual awareness of each other's game level and strategies which can build "team trust" [32]. However, not everyone has enough friends and families to play together, so playing with "strangers" is unavoidable for many players.

Besides coordinating Raid Battles, most players expect to have more interactions with teammates (especially remote ones) to transform "strangers" into "friends" [63]. But this requires some communication features, without which it seems impossible to remain in touch with remote players after Raid Battles. Overall, the lack of in-game communication features in the in-person/remote raiding format set barriers for players to a) find enough teammates and coordinate the raids and b) transform "stranger" players into "familiar" players. So they transcended privacy boundaries and built external social media groups spontaneously via third-party applications.

However, participants encountered issues that challenged their social interactions in the hybrid space when using third-party applications for communications. Chiefly, most participants reported their experience of being interrupted during swapping between the game application and third-party applications to complete the coordination and collaboration. The diaspora of players between discrete apps results in extra operational burden and cognitive load [55, 57]. Players are forced to 1) complete extra steps (e.g., create new tags, copy and paste codes) to manually exchange information between applications, 2) wait for reloading in the applications after swapping, and 3) try to adapt to different applications' user interface designs back and forth. Particularly for in-person players in LBGs, they have to pay attention to the physical surroundings while interacting with the virtual space, and safety risks have always been a concern [31]. Such extra operational burden and cognitive load might put them in danger. In addition, some participants reported that not all players were aware of these third-party applications and external social media groups. This caused unfairness because those who used third-party applications and joined social media groups were privileged in information gaining and teammate matching. Also, players complained that communication between in-person and remote players is blocked since texting during raiding is inconvenient. In-person players can talk smoothly in the physical world, meaning remote players have less information available to them.

The above issues can be summarized as the"interoperability" issue. Interoperability was first coined to describe the information exchangeability of two or more software components in virtual spaces [64]. With the emergence of the hybrid space concept, we argue that interoperability should be unrestricted to purely virtual spaces. Before this work, the interoperability in hybrid spaces has been discussed in the relevant but limited literature without specific examples [17, 42, 67]. Our study first supports the relevant literature by instantiating that the lack of interoperability would harm people's experience in the virtual world. Second, we expand the extant literature by reporting that the interoperability issue would influence users' experience across the virtual and physical worlds (i.e., in hybrid spaces). To some extent, the interoperability issue in hybrid spaces can cause more severe consequences than in purely virtual spaces. As mentioned above, users may encounter safety risks in the physical world due to attention distraction.

5.3 Players' autonomy among the hybrid social communities

Our study illustrates players' spontaneously formed leadership activities after introducing the remote raiding option. We argue that the leadership emerged since the in-person/remote raiding format is more complicated than the purely in-person format regarding coordination and collaboration. Our participants reported that proper self-organization is a prerequisite for a successful Raid Battle. This aligns with the relevant literature [30], leadership can emerge during self-organizations in a leaderless group without designation. Specifically, although no "leader" role is set in-game, some high-level and experienced players volunteer to lead the team and organize the Raid Battles. Under the newly formed convention, other players in the Raid Battle team respect their "leaders" and follow their instructions in pre-raiding coordination and in-raiding collaborations. Supporting the previous work [49], leadership activities also emerged beyond the gaming context, i.e., in the external social media groups. Social media group moderators played similar leadership roles in organizing events but were not necessarily limited to raiding, for example, creating channels for

other social purposes, avoiding cyberbullying, and solving conflicts. In addition, besides the leadership activities, we also observed the new relationship "mentor-mentee" between higher-level and lower-level players. Some higher-level players want to ensure "no one is left behind" in their community, so they volunteer to tutor lower-level players to help them perform better through either online or in-person meetings. We believe that spontaneous leadership and mentor-mentee activities demonstrate autonomy among players during social interactions in the hybrid space, though their motivation needs to be further stimulated.

5.4 Design implications for hybrid space LBGs

Based on the findings we discussed above, we made three design implications which are not only for *Pokémon GO* but for all LBGs. Also, as gamified elements are widely used in non-gaming contexts [16], the lessons we learned could apply to other non-gaming hybrid spaces.

First, in future LBG designs, we suggest adding new features to support in-person/remote gaming. The addition of a remote gaming feature should not change the key mechanics (e.g., rules, storyline, etc.) of the previous pure in-person gaming format but only open up a new option: playing the game online when needed. To emphasize the co-located gaming mechanism of LBGs, designers could differentiate the details of in-person and remote formats to stimulate people to play in person. For instance, in-person players will get a higher value of rewards than remote players after completing the same task in LBGs. We believe the remote gaming format would not weaken the co-located play nature of LBGs. In contrast, the remote gaming feature will be an extra option for people who prefer online gaming or can not do it in person for reasons such as social distancing and time limitations. In addition, as we mentioned above, the new feature could also stimulate players' curiosity to explore the game. More importantly, the in-person/remote gaming feature can make the game more inclusive by supporting various play styles and player contexts.

Second, designers should pay attention to players' communication needs and the interoperability in LBGs. The goal is two-fold: 1) supporting players' coordination and collaboration and 2) minimizing players' operational burden and cognitive load to do so in the hybrid spaces. We suggest building a new communication platform, which plays a similar role as third-party applications but has consistent design standards with the LBG and can support seamless information exchange. The entrance of the communication platform should be easy to find. And communication notifications should be accessible within the game interface so users do not have to swap between pages frequently. Also, to ensure fairness in the hybrid space, we suggest keeping the information symmetry among all remote and in-person users. Specifically, new communication features are needed to support remote users getting involved in communication with in-person users seamlessly.

Lastly, to support players' autonomy among the hybrid social communities, we suggest LBGs could create new roles related to leadership and mentor-mentee activities. Furthermore, we can imagine a feature to reward these roles with badges (both virtual and physical versions) for helping other players or organizing activities. Players can ask for help from nearby/online roles with such badges embodied or have badge icons after their handles. Resonating the related literature, gamified elements can be applied in non-gaming contexts to motivate users' certain behaviors [1, 15]. Thus, in other non-gaming hybrid spaces such as hybrid learning, aforementioned role-play and rewarding gamified elements can also be added to motivate users' interpersonal interactions. This way, it could lead to a more reciprocal hybrid social community.

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6 LIMITATIONS AND FUTURE WORK

All participants in our study are very experienced players (i.e., they started raiding several years ago). This ensured that they could share rich lived experiences because of their familiarity with the gamic environment and communities. At the same time, this focus also leaves room for future analyses that explore novice players' perceptions and behaviors to understand experiences of social interactions in hybrid spaces of a general population. We believe the participants' recruitment process causes this limitation. We recruited participants from Reddit's r/pokemongo board which dedicated the sample to hardcore players rather than the general population. Even though we asked participants in the interview about their social interactions with novice players and non-players, their opinions might be biased. To this end, caution is required in applying our results to the general population's social interactions in LBGs as hybrid spaces.

Thus, future research is needed to consider people's pluralism when understanding their social interactions in LBGs as hybrid spaces. Specifically, we must explore how experienced players, novice players, and even people who had never engaged LBGs before the study would interact in this location-based hybrid space. For example, participants could be recruited from broader channels, not only game-related communities.

In addition, we utilized qualitative methods in our research, which can lead the study to an in-depth exploration of participants' lived experiences. In future works, quantitative approaches such as online surveys and questionnaires (e.g., trait classification tests and demographic info collection) could be conducted to support our analysis. Specifically, with participants' trait classification, we might better understand the cause behind their behaviors and perceptions (e.g., preference between in-person and remote raiding). In addition, as the prior study [66] suggests, players' identities (e.g., gender and race) could influence their play behaviors.

7 CONCLUSION

This study analyses the lived experience of 41 LBG *Pokémon GO* players regarding their social interactions, including coordination and collaboration in a hybrid space. We emphasize person-to-person interactions to fill the gap in the literature identified in the background section. Through inductive thematic analysis of the interview data, we demonstrate the successful case of adding a remote gaming option to the in-person raiding format in *Pokémon GO*, and illustrate the new social dynamics among players in the new in-person/remote raiding format, including large-scale international social media groups formed via third-party applications and newly formed and spontaneous social activities such as leadership and mentorship. Meanwhile, our findings reveal the interoperability issue that participants encountered, which expands the relevant literature by instantiating and affirming the severity of this issue in hybrid spaces. Finally, we make design implications for *Pokémon GO* and other LBGs for a more inclusive, interoperable, and reciprocal hybrid space experience.

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A PARTICIPANTS' DEMOGRAPHIC INFORMATION

No.	Pseudonym	Gender	Age	Citizenship	Game level
01	Timmy	male	30	USA	49
02	Jacob	male	20	USA	37
03	Nicole	female	33	USA	50
04	Nick	male	28	USA	50
05	Lim	male	23	Malaysia	50
06	Sara	female	29	USA	50
07	Dave	male	32	USA	45
08	Melody	female	45	USA	42
09	Kristen	female	38	USA	32
10	Kelly	female	65	USA	39
11	Alice	female	44	UK	50
12	Martin	male	49	USA	50
13	Neil	male	32	USA	48
14	Corey	male	32	USA	42
15	Joanne	female	47	Australia	50
16	Stacy	female	48	USA	50
17	Chris	male	30	USA	50
18	Kevin	male	47	USA	50
19	Dhan	male	22	USA	50
20	Alicia	female	34	USA	45
21	Jim	male	24	USA	40
22	Fabian	female	23	USA	40
23	Adam	male	21	USA	50
24	Joel	male	30	Australia	44
25	Jared	male	32	USA	50
26	Liz	female	27	USA	50
27	Jackson	male	30	USA	50
28	Randy	male	32	USA	50
29	Arthur	male	39	USA	44
30	Kimberly	female	50	USA	50
31	David	male	26	USA	45
32	Pierre	male	46	new Zealand	48
33	Melissa	female	29	USA	50
34	Hermes	female	65	USA	50
35	Alberto	male	45	France	50
36	Caenin	male	27	USA	41
37	Lachlan	male	25	Australia	50
38	Dara	female	25	USA	43
39	George	male	26	Greece	50
40	Alasdair	male	41	UK	47
41	Oleguer	male	42	Spain	43

Table 1. Participants' demographic information and *Pokémon GO* game level at the time of this study

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B   INTERVIEW QUESTIONS

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1. SOCIO-DEMOGRAPHIC QUESTIONS

- What gender do you identify with? (ask for preferred pronoun)
- What is your age?
- In which country do you live?

2. RAIDING IN Pokémon GO

- Do you consider yourself a casual or hardcore player of Pokémon Go?
- What Pokémon Go level are you?
- When was the first time you joined a raid? What got you into it?
- How long have you been raiding in Pokémon GO? How many raid battles have you done in Pokémon GO?
- How has covid influenced your raiding experience?
- Do you raid more frequently post covid rather than before or not, and why?
- What type of area do you usually raid in?
- What time do you usually raid?
- Who do you usually raid with? (e.g.; family members, group of friends, people in the neighborhood, random strangers)
- How many new friends have you made over the course of raiding, if any?
- How do you gather information about raiding and raid bosses? (e.g.; what pokemon to use)
- How important is it to know which raid bosses you are facing, and why?
- How often do you raid?
- What factors help you decide whether to go for a raid?
- Do you raid more frequently post covid rather than before or not, and why?
- Do you do remote raids, in person, or both?
  - Why do you do remote raids?

3. RAIDING EXPERIENCES

- Have you had any memorable raiding experiences?
- What is your favorite or most interesting memory while raiding? Please describe it.
- What's your worst experience/memory while raiding?
- Have you made any changes to your schedule or lifestyle for raiding? If so, what?

- Have you had any negative or embarrassing experiences while you were raiding? If so, what were they?
- How has raiding impacted your relationships with non-Pokémon GO playing friends and family (if any)?
- What kinds of reactions do you get from people who do not play or raid? (could be a family member/onlooker) What do you think of them?

4. COORDINATING RAIDS

- How do you learn about raids that are happening around you? Either in-person or remote?
- In your opinion, what is the difference between the two kinds of raiding format (i.e., pure in-person raiding format vs. in-person/remote raiding format) regarding the raiding coordination?
- Do you use any technology or app for raiding and coordinating raids other than Pokémon GO? If yes can you give more information about the technology or app? Do you use any other way to coordinate raids, e.g.:
    - Discord,
    - Facebook Group,
    - Text Messaging,
    - PokeRaid,
    - Other
- When did you first start using X technology/app and how did you learn about it?
- What is lacking in Pokémon GO that drives you to these apps?
- Do you use these for in-person or remote raids? Do you use technologies/apps for only one type of raiding - remote/in-person?
- Why do you use X technology/app and not others?
- Describe your typical experience using the X technology/apps to coordinate for raids (both in-person and remote). Do you use any specific channels, groups, or notification settings?
- What are some inconveniences that you wished these apps can improve on?
    - How would you stack rank these problems?
- Do you have any privacy or safety concerns while using the above apps? If so, what are they?
- How often do you organize or initiate a raid group? In-person or remote? Do you prefer to initiate one or another? Why?
- If you don't organize a raid, do you wait for others to organize or initiate a raid?
- In general the raids you participate in, how are they organized?
    - REMOTE: Do you invite someone not in the same location to join? Are they your friends/families or strangers?

- ■ How do you communicate with them?
- How do you strategize your gameplay for raiding? Can you give examples?
  - ■ I try to group by teams
  - ■ I try to group with people I know even if they are from other teams
  - ■ I try to split teams based on the number of players to cause more damage
  - ■ I have no particular strategy and raid with a group that is available
- Where do you learn these strategies from? Youtube, Reddit, Twitter, Word of Mount, etc?
- REMOTE: Does your strategy change when remote raiding? Or when you have some folks remote and some folks in person? Can you give examples?
- What challenges do you face in planning and coordinating raids?
  - ■ Time of raiding
  - ■ Waiting for others
  - ■ Distance to the raiding location
  - ■ Not enough people to raid with
  - ■ Communication (both in general and during raids with the remote players)
- Why does it, or does it not matter, who you raid with? Is it different for in-person vs remote?
- What motivates you to coordinate with others?
- If you use multiple apps, which one do you check first and why?
- How many other raiders are you looking for each time, and why?

A. IN PERSON Raiding specific questions

- How do you travel to raids?
- How do you identify people who have gathered for a raid?
- When you raid in person, how do you communicate with the players that are in your raid remotely? Why do you need to?
- When you are in-person raiding, do you mind having remote players in your raid?
- What kinds of interactions and/or conversations have you had with people during raiding?
- Have you made any new friends while raiding? Do you hang out with people you met during raiding outside raiding?
- Have you had any conflicts during raids in person? How do you manage them?

- Do you have any concerns about privacy and/or safety during raiding? Please describe why or why not?
- What are some other challenges you face while raiding? (after getting to the location) Have you tried/done certain things to prevent/avoid those challenges?

B. REMOTE Raiding specific questions

- Where do you usually remote raid from? (Home? Work?)
- Have you had any conflicts during remote raiding? How do you manage them?
- When you do remote raids how do you communicate with the players that raid in person? And if you raid in person and how do you communicate with co-located/remote players?
- Have you had people that you raid with remotely becoming friends and discussing things beyond the game?
- Do you have any concerns (such as privacy and/or safety) during remote raiding? Please describe why or why not?

5. **OTHER**
- What do you like/dislike about in-person raids?
- What do you like/dislike about remote raids?
- How does in-person raiding compare with remote raiding? Which one do you prefer?
- In your opinion, what is the difference between the two kinds of raids?
    - Gameplay, social, coordination/organization of raids, experience
- Do you play other location-based games? What are they? How do you compare Pokémon GO with them?
    - IF YES - Compared to other location-based games you play, how is raiding in Pokémon GO?
    - IF YES - Compared to other social interactions you have in location-based games you play, how is raiding in Pokémon GO?
- Finally, what changes would you ask Niantic to make for creating your ideal raiding experience? Or what would your ideal raiding experience look like?
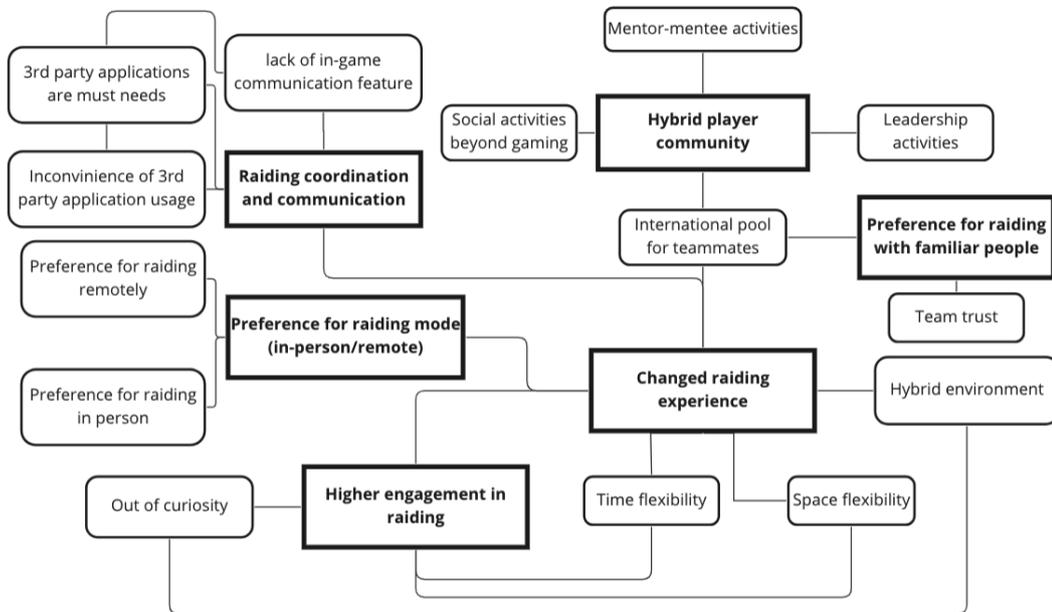
C   THE INITIAL THEME MAP

Fig. 4. The initial theme map for interview data analysis