"I Had Sort of a Sense that I Was Always Being Watched...Since I Was": Examining Interpersonal Discomfort From Continuous Location-Sharing Applications

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Abstract

Continuous location sharing (CLS) applications are widely used for safety and social convenience. However, these applications have privacy concerns that can be used for control and harm. To understand the nature of concerns that users face, we performed the largest user study to date with 3000 users, 1500 of whom use CLS applications, and 896 who completed surveys. From survey responses, we conducted 23 interviews with participants who had uncomfortable experiences. With these interviews, we perform thematic analysis grounded by sociological frameworks of power dynamics and social exchange theory. We observe that CLS application users face discomfort related to three primary categories that build on each other: (1) overstepped boundaries, (2) continued discomfort, and (3) lifestyle-impacting behaviors. With this foundational understanding, we suggest features that aim to reduce relationship imbalances that CLS applications enable.

CCS Concepts

• **Human-centered computing** → *User studies*; • **Security and privacy** → *Human and societal aspects of security and privacy*; **Social aspects of security and privacy**; **Privacy protections**;

Keywords

Location Sharing Applications, Power Dynamics,Social Exchange Theory, Contextual Integrity, User Study

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1 Introduction

Mobile device users have adopted location sharing at increasingly high rates. A Harris Poll in 2022 found that 79% of people had location sharing activated on their devices, while 16% of people polled had location sharing active all of the time [39]. A popular set of applications used on smartphones offer continuous location sharing (CLS), or the ability to ubiquitously track and monitor the location of others. Commonly used in friend groups, families, and within intimate relationships, these apps are sometimes installed from app stores [1] and in some cases leverage services available from the smartphone operating system [3] or the network provider [6]. These applications can strengthen social bonds and increase perceptions of safety among users [53], while location data is valuable for navigation and targeted advertising.

However, CLS applications can also present security and privacy concerns to users, who may feel vulnerable to pervasive tracking [43]. Levy and Schneier consider these intrusions on privacy within close interpersonal relationships to be *intimate threats* [41]. While these threats are exemplified by a subset of CLS applications called *stalkerware* that can allow arbitrary monitoring of personal information including location without the knowledge or consent of the targeted user [17], we find that all CLS applications can potentially cause discomfort, even *location-focused apps* (LFAs) that report location but not other personal information. However, while past work has primarily examined applications and technologies

that can facilitate intimate threats, there has not been a large-scale study focused on how general CLS applications are used and the discomfort they may bring from a user's perspective.

In this paper, we focus on how CLS applications are used within interpersonal relationships to categorize uncomfortable experiences they can enable. We make the following contributions:

- **Large-Scale Survey and Semi-Structured Interviews About CLS Applications:** To characterize the popularity of CLS applications, we screen 3000 participants and find that 1500 of them, or 50%, use these applications. We surveyed 896 participants who used CLS applications about how their experiences using them, and found that 55 participants identified as having an uncomfortable experience with CLS applications. We then conducted semi-structured interviews with 23 of the participants who had negative experiences and performed a thematic analysis based on interview responses to categorize the discomfort felt because of the applications. This survey and set of semi-structured interviews represent, to our knowledge, the largest user study relating to interpersonal relationships and CLS applications.
- **Categorization and Analysis of Negative Experiences with CLS Applications:** We uncovered three categories of experiences that participants had across all types of CLS applications, including LFAs, stalkerware, and *dual-use*[1] apps: (1) overstepped boundraies with how location was used; (2) continued discomfort with repeated location monitoring; (3) lifestyle impacts as the result of location sharing-related discomfort. We ground our analysis using sociological frameworks of power dynamics and social exchange theory, and observe that location sharing can lead to an increase in power contributing to discomfort. In response to this discomfort, actions may or may not be taken depending on the risks and benefits of each unique relationship.
- **Recommendations to Developers:** We discover requested features of Location-Focused applications (LFAs) that interviewed participants would like to see implemented. LFAs are applications whose feature case closely revolves around location sharing. These features relate to increased autonomy, support resources, tools to easily manage access to location, and protective action by application developers. Based on participant responses, we develop recommendations for improving transparency, notification of location access, and precision of reported location data, and suggest redesigning these apps such that they preserve the contextual integrity of users.

Our work contributes a mixed-methods analysis grounded in sociological theory, based on user experiences, on how location-based privacy issues can lead to lifestyle impacts for individuals. We additionally contextualize concerns and experiences related to location-focused applications (LFAs) in the larger space of continuous location-sharing (CLS) applications that include dual-use and stalkerware applications. Recognizing that LFAs represent a privacy threat to users and can be harmful to their well-being, we examine the current space of LFAs to determine where desired features to support privacy have been added and where they are lacking. Our recommendations aim to preserve the utility that can be garnered from LFAs while mitigating the harms and threats to autonomy and power imbalance that can be a side effect of their use.

[1]Dual-use apps monitor a user's activities on their smartphone, often beyond location tracking, but do not attempt to hide their presence or activity as stalkerware does.

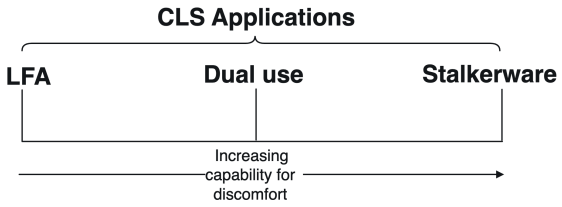

Figure 1: Within this paper we refer to continuous location-sharing (CLS) applications, location-focused applications (LFAs), dual-use applications, and stalkerware. CLS applications refer to all location-sharing tools with the different subcategories (LFAs, dual-use, and stalkerware applications) being defined by the range of capabilities the application provides. While some applications have limited features, there is still functionality that permits malicious behaviors such as stalking.

The rest of this paper is structured as follows: Section 2 provides a background on CLS applications and the sociological frameworks we employ for analysis. Section 3 describes our survey and interview methodologies. Section 4 provides a quantitative analysis of CLS application use based on our survey results, while Section 5 employs thematic analysis to categorize concerns that surfaced during interviews. Section 6 grounds participant experiences through sociological frameworks. Section 7 discusses feature changes in LFAs requested by participants, while Section 8 provides recommendations to developers. Section 9 discusses the limitations of the study, Section 10 additional related work, and Section 11 concludes.

2 Background

Our research looks at interpersonal behaviors with continuous location-sharing applications and how they may present privacy and lifestyle concerns to users. In this section, we define key terms, outline ethical concerns, and describe sociological concepts and how they apply to continuous location-sharing applications.

2.1 Definitions

Continuous Location-Sharing (CLS) Applications: Continuous location-sharing applications encompass all location sharing between two or more individuals. As outlined in Figure 1 this can include location-focused, dual-use, and stalkerware applications.

Location-Focused Applications (LFA): LFAs allow two trusted parties to share a location for an indefinite amount of time while sharing no other personal information. They typically use GPS [45] and/or cellular networks [6, 14] to provide an accurate and up-to-date location for those within the approved network of individuals. LFAs are often used for coordinating meet-ups and safety purposes [53], but also provide a feature set that could be used for monitoring or surveillance. Location functionalities that are included as part of

a larger application such as Snap maps being part of Snapchat will still be referred to as LFAs in this paper.

Dual-use Applications: Dual-use applications allow for location sharing with added functionality such as accessing movement history and viewing battery life. These applications are often marketed for parental monitoring and can be paid services [10]. These applications can be repurposed for remote spying but differ from stalkerware by being visible and marketed for permitted behaviors.

Stalkerware Applications: Stalkerware applications are malicious applications that provide a wide set of pervasive information including location [17]. These applications are often marketed as a way to catch infidelity [33], are installed and run on a victim's device without their knowledge, and will hide their presence on the application. This level of surveillance reduces the autonomy of a victim survivor in a way that can require new devices and accounts for a victim survivor to separate from their abuser [35].

2.2 Ethical Concerns with CLS Applications

Location sharing presents ethical-related concerns. Academic literature has examined how location-sharing can raise red flags for vulnerable communities like the LGBTQIA+ population when using contact-tracing software during the COVID-19 pandemic [8, 57]. These concerns also apply where location data has been used even by law enforcement to make arrests. "Geofence warrants" sweep for potential leads and suspects by identifying who was in the vicinity of a crime through location data, which experts warn could endanger people of color [25].

2.3 Sociology of Relationships

To grasp the impact of location-privacy concerns from CLS applications on interpersonal relationships, we ground our research through sociological frameworks of power dynamics and social exchange theory (SET).

2.3.1 Power Dynamics. Power dynamics provide a structure to understand how individuals are positioned in a social system. Technology has the potential to accentuate these power differentials between individuals [44] which in turn reduces the feeling of autonomy [31], and may lead to further exploitation from technology (See Figure 2). While the roles of each power type may vary between partners in a relationship, in situations of interpersonal abuse, power imbalances are often observed where coercive power [32, 52] is exerted by one member of the partnership (the abuser) onto the other member of the partnership (the victim survivor) [27]. Threats are an example of coercive power [24]. Informational power can help balance coercive power with proper resources.

2.3.2 Social Exchange Theory. The primary principle of social exchange theory (SET) is that relationships are the combination of rewards and punishments [36]. Within this framework, actions related to relationships are utilitarian by maximizing rewards while minimizing punishments [21]. Social systems have structures of reciprocity and negotiated rules that guide exchange in relationships [47, 48]. The units of exchange include love, status, information, money, goods, and services with each of these units having both concreteness and particularism [30]. Particularism is related to whether the value of the good is intertwined with the individual who provides it. A good, such as money, is not particular compared to love, which is directly tied to who provides it. Concreteness is related to how measurable goods are [42, 51].

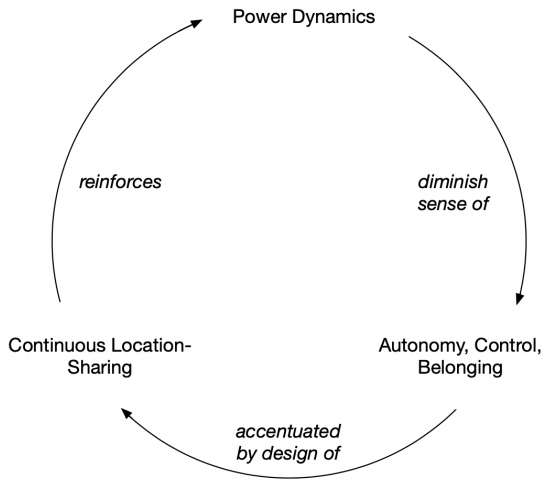

Figure 2: The interaction between technology and power can become a feedback loop that amplifies any adverse effects. This cycle enables CLS applications to devolve from tools for social interaction to platforms for abuse.

SET provides a means of evaluating relationships that are abstracted from traditional titles such as friend, acquaintance, partner, parent, etc. In SET, while there are trends based on relationship title [20], each relationship is unique and can be defined on the spectrum of what goods are reciprocated [30]. This allows for the examination of decisions about the potential rewards and punishments that are particular to a relationship and the action being taken. In this paper, we will use SET to understand location-related decision-making and provide additional context to relationships beyond colloquial titles.

3 Methodology

To investigate uncomfortable situations experienced by users of location-sharing applications, we conducted a series of surveys followed by semi-structured interviews. In this section, we describe the structure of our surveys, our interview protocol, our ethical considerations, and our qualitative analysis process.

3.1 Research Questions

To further the understanding of how continuous location-sharing applications may contribute to interpersonal discomfort, our research has been guided by four research questions:

- **RQ1** Do CLS applications contribute to discomfort in interpersonal situations?
- **RQ2** How often do CLS applications lead to discomfort?
- **RQ3** What is the nature of location-based uncomfortable interpersonal situations?

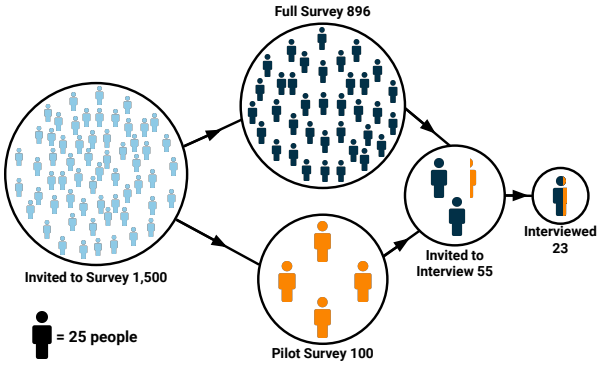

Figure 3: To accrue participants for interviews we screened participants (n = 3000), and of those half indicated location-sharing application usage (n = 1500). We surveyed these users (n = 896), and interviewed individuals who had uncomfortable interpersonal experiences (n = 23). This process allowed us to identify a large number of participants from a diverse background.

	Benign	Uncomfortable	Uncomfortable Percentage
Age			
18-24	115	13	10%
25-34	283	13	4%
35-44	214	13	6%
45-54	146	5	3%
55+	89	5	5%
Gender			
Women	464	30	6%
Men	382	19	5%

Table 1: Demographics of survey participants who had an uncomfortable experience (Uncomfortable) and those who did not (Benign) as well as the percentage of uncomfortable experiences for each demographic. The rate of people who had uncomfortable experiences was highest for the youngest age range but was fairly consistent across the other age and gender demographics.

RQ4 What do people who have uncomfortable experiences want to be changed about CLS applications?

3.2 Survey

To identify a population of CLS application users, we conducted an initial screening survey. We followed this with a pilot survey for quality control before finally distributing the full survey. The full survey, provided in an extended version of our paper[2], worked to both establish a baseline knowledge about CLS application usage and identify users who have experienced uncomfortable experiences through CLS applications. All participants were recruited through the online survey tool Prolific [5]. Within Prolific we selected from a pool of English-speaking, participants residing in the United States who are older than 18 years old. Our study was approved by an Independent Review Board (IRB). For further explanation refer to Section 3.4.

Screening: The screening survey acted as a filter to identify users of CLS applications. Participants were presented with multiple types of mobile device applications and asked which types they use. Of the 3000 who completed the screening questionnaire, 1500 used CLS applications and were later asked to complete the full survey.

Pilot: Following the screening survey, we tested the quality of our survey questions by running a 100-person pilot study with our eligible participants. 27% of the pilot participants indicated that they have had an uncomfortable situation while using location-sharing applications. This rate was much higher than we anticipated and led us to re-evaluate the bias present within our survey design. Because we were asking yes or no questions about negative experiences, the focus of the survey was evidently on seeking negative experiences with CLS applications. As a result, our survey may have prompted acquiescence or response bias [60]. With these considerations, we replaced the series of negative yes or no questions with a single multiple-choice question with a neutral tone and options to determine if they have had negative experiences with CLS applications. Only 7% of the participants from the full survey selected that they have had an uncomfortable situation while using CLS applications.

Survey: Of the 1500 eligible participants from the screening, 1004 responded to our request to complete the full survey. 100 completed the pilot study and 904 completed the final survey. 8 of the final survey responses were removed due to incompletion, completion in less than 30 seconds, or answers indicating that they do not use CLS applications. The resulting sample size for the full survey was n = 896. A breakdown of participant sample sizes for each stage of our research is shown in Figure 3. Our survey participants ranged in age from 18 to 55+, with the mean age being 38 years old. Approximately 55% identified as women and 45% identified as men. The full survey demographics are provided in Table 1.

At the start of the survey, we presented participants with a consent form ensuring they agreed to participate. Next, we established that the participants understood what CLS applications are and provided additional information if necessary. Participants then provided their Prolific ID which allowed us to collect their demographic information.

In the subsequent section of the survey, we deliberately maintained a neutral tone to prevent responses from being biased towards either positive or negative experiences. Participants were asked about their CLS application usage patterns, including the purposes for which they use these applications and their frequency of use. Then the participants were asked to select all that apply from the following list:

- CLS applications have helped me coordinate with friends.
- I have data or privacy concerns with CLS applications.
- CLS applications have helped me feel more safe.
- Other individuals have used CLS applications to make me feel uncomfortable.
- None of the above.

[2]https://github.com/CLS-Application-Discomfort/ExtendedPaper

Participants who selected "I have data or privacy concerns with CLS applications" or "Other individuals have used CLS applications to make me feel uncomfortable" were then asked open-ended questions about their concerns or the specific uncomfortable situation. Due to the sensitive nature of these questions, participants were informed that answering them is optional for the completion of the survey.

3.3 Interview

To select participants for our interview phase, we focused on individuals who expressed concerns regarding data privacy or who had encountered discomfort with CLS applications. We analyzed their open-ended responses from both the pilot study and the full survey. Two researchers independently assessed each response, determining its relevance to the interview criteria. Any discrepancies were resolved by a third reviewer. From the pilot study, we identified six eligible participants, and from the full survey, we identified 49. Of these, one out of six from the pilot study and 22 out of 49 from the full survey agreed to participate in interviews. Despite changes in the survey format after the pilot study, our interview process and protocol remained consistent. The full sample size for the interview process was $n = 23$ and is outlined in Figure 3.

We designed a semi-structured interview protocol with three sections. The first section covers how participants began to use CLS applications, how they currently use these applications, and if appropriate, their favorite uses. In the second section, we ask about the uncomfortable situation the participant described in their survey response and the consequences of the event. Finally, we ask participants what features should be added or removed from CLS applications, as well as their opinion of features suggested by the literature. Participants were given the option to take a break between each section of the interview. The interview protocol is available in an extended version of our paper[3].

All interviews were conducted over Zoom [7] and recorded. Before recording participants were presented with a consent form and asked for their verbal consent to participate. They were additionally given the option to turn off their camera. One researcher led the interviews while a second researcher observed and took notes.

3.4 Ethical Considerations

Since this study is working with human subjects, we gained Institutional Review Board approval before conducting the screening, surveys, and interviews to ensure the ethical consideration of participants. Our study received expedited full approval for all three phases (screening, survey, and interviews). The single screening question paid US$0.14, the survey paid US$1.50, and the interview paid US$15 for completion of the 30-minute interview.

We ensured participant privacy for the screener and survey by maintaining that no personally identifiable information was provided and using only participants' Prolific IDs as a reference to their information. For the interview, we did not record the names of the participants. The audio was recorded over Zoom and transcribed using Zoom's automated transcription tool. Each transcription was manually verified against the recorded audio and edited to remove any personally identifiable information (PII). After verification of the transcript, the original recording was deleted so that only the transcript was maintained within local servers and only accessible to the study staff.

In addition to privacy considerations, we took multiple steps to ensure participants were aware of the risks of participating in our study. Participants were provided an informed consent document stating that participation in our study may be re-traumatizing if participants recall events related to intimate partner violence, stalking, or other negative experiences. Participants were also reminded twice during the interview that questions were optional. Additionally, we bookended our sensitive questions in the interview with breaks and non-sensitive topics to create a comfortable interview environment. Finally, we ensured that we maintained that at least one member of the study staff had the same gender identification as the participant. In the case of acute emotional distress, we had a set of IRB-approved protocols in place, however, none were needed during our interviews. For each phase of the study, participants received compensation for their time through Prolific. Refer to the extended version of our paper for examples of our survey, interview protocols, and protocol for acute emotional distress.

3.5 Data Analysis

We performed thematic analysis [16, 40] on the interview transcripts to derive codes, concepts, and larger themes (i.e., axial codes) from the participant's responses about CLS applications. We implemented the coding in four steps: initial codebook creation, coder evaluation, mass coding, and coder verification. A collective of five researchers conducted the emergent coding to minimize bias and develop agreement across a large number of coders.

To develop the initial codebook, the lead researcher analyzed three randomly selected transcripts creating an initial codebook through open coding. After the codebook was generated, the collective then analyzed three additional transcripts for the coder evaluation. The researchers had the option to either mark existing codes or add new codes for later discussion. After all members of the collective finished coding the three additional transcripts, they reconvened and discussed the differences in their codes, consolidating where relevant and keeping disagreements where appropriate. Calculating the agreement amongst the five coders following the discussion resulted in an initial Fleiss Kappa [23] coefficient of $\kappa = 0.76$.

16 of the remaining 17 transcripts were split amongst the five coders for the mass coding step. The coders separately analyzed their given transcripts and none of the coders received the same transcripts. After the mass coding, the final transcript helped identify if there were any changes in the agreement in the collective for the coder verification step. Each coder analyzed the remaining transcript and a new Fleiss Kappa coefficient was calculated without additional discussion. The collective achieved a new coefficient $\kappa = 0.75$ on the final transcript showing minimal drift in agreement throughout the coding process.

Because the majority of the transcripts only had one coder during the mass coding process, the collective met weekly for one hour over three months to discuss the content of each interview and solidify the results drawn from our thematic analysis.

[3] https://github.com/CLS-Application-Discomfort/ExtendedPaper

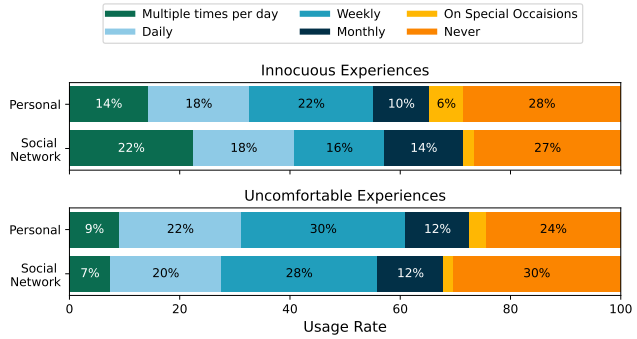

Figure 4: Usage rate of CLS applications. Personal indicates the participant's usage rate. Social Network indicates the perceived usage rate of the participant's social network. In both cases, the majority use CLS applications on at least a weekly basis highlighting the commonality of CLS applications.

3.6 Methodological Limitiations

We excluded individuals having only positive experiences as they did not directly relate to our research questions. Additionally, during the process of obtaining consent for each stage of our protocol, participants may have self-selected out of our study as a result of not feeling comfortable.

During the survey, we were limited to a population of Prolific users. This population is a subset of the general population that is not representative in the context of technology. Additionally, we asked speculative questions related to how participants expect other participants to use technology. Future research with access to ground truth location-sharing application behavior can provide the necessary raw data to supplement what participants speculate is occurring.

3.7 Positionality

Two out of the five research members contributing to the thematic analysis have experienced discomfort because of CLS applications. While the individual contributions of those research members may reflect a potentially cynical outlook on CLS applications, continual communication, and understanding bias have been taken into account to minimize the impact of personal experience toward the objective outlook on how CLS applications lead to interpersonal discomfort.

4 CLS Application Usage

Continuous location-sharing applications are popular tools with a variety of beneficial uses. In 2023, Snapchat reported that over 350M+ users open Snap Maps at least once per month [1], and the popularity of these applications is only increasing as they become a prevalent form of social media for Gen Z users who check the location of their friends for entertainment [37]. Based on our initial screening survey of 3000 Prolific participants, the proportion of Prolific participants who use CLS applications is 50% with a 95% confidence interval of ±1.8% further reinforcing the prevalence of these applications.

Fisher's Exact Test
Benign vs. Uncomfortable Experiences

Tests:	p-value:
Age	0.082
Gender	0.461
Personal Usage	0.428
Social Network Usage	0.018

Table 2: We ran a Fisher's Exact Test to determine if the demographics (age or gender) or usage rate of participants who had an uncomfortable experience differed from those who did not. We find that an association exists between experiences and the social network's usage rate, but personal usage rate and demographics do not differ between the two groups.

The full survey sheds light on the frequency with which participants and their social circles use CLS applications. Figure 4 illustrates both the usage rates among survey participants (Personal) and the perceived rate at which their location is checked by their social group (Social Network). A majority of participants engage with CLS applications at least weekly, underscoring the integral role these applications play in people's daily routines.

The responses to our survey's final multiple-choice question (provided in Section 3.2), highlights some of the ways participants use CLS applications. The ability to share one's location generates a sense of security and the majority of participants (64%) affirm that CLS applications enhance feelings of safety. Additionally, these applications streamline social coordination, as evidenced by 49% of respondents indicating that CLS applications facilitate planning with friends. However, 7% of participants reported that they had uncomfortable experiences using CLS applications.

4.1 Uncomfortable Situations

Although CLS applications offer numerous benefits, users still encounter uncomfortable experiences. We conducted a Fisher's Exact Test [29, 58] to determine if the demographics of participants who had an uncomfortable experience differ from the demographics of those who did not. The results of the Fisher's tests are presented in Table 2. Because the p-value is well above 0.05 for both age ($p = 0.082$) and gender ($p = 0.461$), we cannot conclude that a difference between the two groups exists.

In many cases, the uncomfortable situations did not deter users from continuing to use CLS applications. In some cases, participants who had a negative experience still use CLS applications multiple times per day. Figure 4 shows the differences between the usage rate of participants who had an uncomfortable experience and those who did not. To further analyze the difference in usage rate between the two groups, we conduct additional Fisher's Exact Tests and also provide those results in Table 2. We run two tests on usage rates, the first to determine if an association exists between participant experiences and their usage of CLS applications. We also determine if there is an association between experiences and the usage rate of a participant's social network. We find that no association exists between personal usage and experiences ($p = 0.428$) while an association may exist between experiences and the perceived usage rate of a participant's social network ($p = 0.018$).

5 Observations of Abusive Situations

We perform a thematic analysis relating to the discomfort participants face when using location-sharing applications. This section details the categories of participant discomfort: overstepped boundaries, discomfort with repeated location monitoring, and location-related lifestyle impacts.

5.1 Overstepped Boundaries

Our thematic analysis of 23 interviews yields seven participants who feel uncomfortable because of other individuals overstepping privacy boundaries. For these participants, the duration of the discomfort was short and resolved through either conversations or revoking access to their location. The discomfort for these participants primarily stems from the realization that an acquaintance could obtain location which is a general concern. This is different from our other categories where the discomfort is specific and directly from another individual.

Relationship Type: Of these seven participants, the discomfort was caused either by an acquaintance (5/7), a stranger through a dating app (1/7), or the management of a company (1/7). This hints that when people have only privacy concerns, the origin of the discomfort is an individual in a weak relationship with the participant. This will contrast with observations in future sections.

Cause of discomfort: In these scenarios we find that participants forget that their location is being shared or do not understand how it is being shared in the application. As such it leads to feelings of discomfort. For example, participant 5 said, *"There are times that I've realized like I forgot to turn [location sharing] off. And that was upsetting"*. This indicates that the discomfort is related to the idea of the location being shared rather than targeted discomfort toward another individual. For five out of seven participants, this discomfort was the only mechanism by which they were made to feel uncomfortable. The other two participants were made uncomfortable because of behaviors the acquaintance exhibited in response to the location and faced more severe privacy violations. P15 experienced privacy violations from an acquaintance making unexpected appearances that *"made [them] feel crazy. It! It was like every time [they] looked over there was dude again"*.

Resolution: To resolve these situations we find that in all but one scenario the action was simply to remove access to location sharing. The alternative for one participant was to have a conversation about boundaries with their acquaintance. By the time of our interview, all of these discomforts had been resolved. In response to these events, five out of seven participants had an increase in privacy concerns related to location sharing. P7 took action to ensure their accidental share was limited to one application: *"I checked all the settings in my phone and stuff, but to make sure I didn't... wasn't sharing location unwittingly with anything"*. While the issues in this category may have been resolved quickly and with decisive action, these experiences had a lasting negative impression on the individuals and their perspective of CLS applications.

The quick and decisive resolution in these situations is related to the nature of these relationships where even though there is a risk of conflict, the significance of the conflict is low because of the relationship being less strong.

5.2 Continued Discomfort

In this section, we outline the experience of 8 of our 23 interviewed participants who described being uncomfortable with another individual repeatedly monitoring their location. These experiences involved strong relationships and discomfort from location-related conversations and were difficult to resolve, because of the close personal connection between individuals.

Relationship Type: When CLS applications cause continued discomfort to the participant we interview, we find that the source of the discomfort is parents (3/8), intimate partners (3/8), close friends (1/8), or siblings (1/8). We find that a diverse set of relationships can lead to frustration surrounding location sharing with the commonality being a strong bond between individuals.

Cause of discomfort: Because these participants have a close relationship with the party questioning their location, the cost of ignoring or making the party unhappy is high. P9 *"had sort of a sense that [he] was always being watched"* that was exacerbated by his mother asking questions such as: *"Why aren't you at church? Where are you? You haven't left the house in a day and a half"*. Instead of asking their mother to stop, potentially upsetting the balance in the relationship, P9, *"figured out how to spoof [their] location which took a lot of tinkering and effort."*

Conversations in these scenarios are often frequent and over a long period. For example, when P21 was in their late teens, they had to answer phone calls from their parents multiple times a week related to their location and felt their parents *"were trying to catch [them] in a lie"*. This was not an isolated experience with P22 having to justify being in unsafe areas late at night to their elderly parents and P19 needing to have a conversation with their sister about obsessive location-checking behavior.

Resolution: Resolution in these scenarios was achieved by 6/8 of the participants we interviewed. For the two that did not find a resolution, both participants were in intimate relationships where the level of discomfort and conflict was significant enough to bring about the end of the relationship. In the other scenarios, these repeated conversations were able to resolve the location-based issues in the relationship. P9 who is in their mid-thirties was an outlier by spoofing their location to avoid conflict with their parents. Resolution in that scenario was achieved when P9 pretended that the dual-use application Life360 [4] was unable to be installed on their new phone and used technological deception to avoid further discussion.

While resolution was frequently achieved, it was a strain on the relationships of these participants. The resolution was the result of sometimes years of discomfort as was the case with P9 who struggled with their mother *"from probably like 2019 until about [July 2023]"*. While there is a high cost to resolve these situations, we observe that the benefit provided by the strong bond and trust provided in these relationships is to the point where participants were willing to put energy into repeated conversations.

5.3 Lifestyle Impacts

In 8 of the 23 interviews, we see that the participants were facing discomfort to the extent that their location or their location-sharing was being used to control them. These include threats and unwanted appearances representing location being used to escalate issues.

These participants were usually in romantic relationships, felt anxiety, and changed their behavior in response to the abuse they encountered. In response to this level of discomfort and invasive lifestyle impacts, these participants usually ended their relationships with the person making them uncomfortable.

Relationship Type: In this category we observe that intimate partners (6/8), friends (1/8), and parents (1/8) are the individuals who made participants uncomfortable. The bond for all of these relationships was strong at the time of the discomfort. Along with this level of strength, there were also factors in the relationship that made confrontation more difficult such as threatening behavior.

Cause of discomfort: The primary cause of discomfort is the intensity of obsessiveness of location-based checking and subsequent questioning. A trend we see with this population is that as the discomfort gets worse, participants are questioned about what they were doing while actively completing a task. For example, P2's boyfriend would monitor their location: *"if I didn't tell him that I was gonna go to the store...he would literally call me and be like, where are you?"*. In response to this, P2 felt *"it ruined [their] like whole first year of college"* because of missed social interactions. In response to these questions, our participants strategically stopped sharing their location (6/8) and/or make lifestyle changes (5/8) such as not visiting friends as an effort to avoid questioning.

When participants strategically stopped sharing their location they faced threats (2/8) from the person with whom they were sharing their location. An example is P1, whose boyfriend threatened to *"potentially call the police, or like, say that [they were] missing"*. These behaviors led the participant to continue sharing location and change their behavior in an antisocial way as a mechanism to avoid further confrontation.

Another behavior we observe is unwanted appearances (3/8) where location sharing is used to locate the participant for a confrontation. P4 mentioned that their friend had *"The audacity to show up to [their] place of work, and [be] very angry and nasty with"* him. This trend directly relies on CLS applications to complete the action. Without having the participant's location, their friend would not have been able to show up and confront them, leading to the discomfort.

Resolution: Because of the severity of discomfort in these relationships, the resolution was usually achieved through separation (6/8). P16 described how the end of their relationship was directly tied to location sharing: *"Not giving them my location anymore was very symbolic of like an end of the relationship"*. Only P4 and P23 were able to repair their relationships. For P4 it took multiple years and their friend received help related to mental illness. For P23, their concerns were resolved over the years when they repaired the trust in their relationship following location sharing being used as a monitoring tool following an affair.

For the participants who sought resolution through separation, we can observe that the level of discomfort was extreme enough where the benefit of a full separation was greater than the benefits the relationship provided. When looking at families and intimate relationships, we see that a high threshold of discomfort is necessary for people to feel the need to separate from another individual.

6 Sociological Framing For Participant Experiences

6.1 Power Dynamics

When used for convenience or safety, CLS applications do not inherently create power differentials. However, as observed by our participants, the continuous nature of the location reporting can cause applications to be used as monitoring or surveillance tools. When used this way, the individual who is being surveilled experiences a power reduction, as pervasive location monitoring serves as a proxy for monitoring the behaviors of that individual. Revisiting the cyclical representation of power dynamics (see Figure 2) we see this power differential can be self-referential and lead to increasingly severe discomfort among participants.

This phenomenon manifests itself in the range of participant experiences related to discomfort caused by CLS applications. These categories in order of discomfort in order of severity are: overstepped boundaries, continued discomfort, and lifestyle-impacting location-sharing behaviors.

Overstepped boundaries: When participants feel that their boundaries have been overstepped by someone who has access to their location, there is an observed power differential. The individual viewing the location has access to information that the participant did not intend to share, such as daily behaviors or patterns. In relationships where this occurs continually, we see increasing power differentials.

Continued discomfort: Participants feel increasing levels of discomfort when their location is being continually questioned or discussed in a relationship and there is a clear behavior of obsessive location viewing. In relationships where this questioning only occurs in one direction without reciprocation, there is a power differential created by the surveillance capabilities.

Lifestyle impacts: In some cases of continued one-way surveillance, participants report threats and unwanted appearances leading to anxiety and behavior changes such as reduced social contact. In these situations, continuous location can further increase power differentials by facilitating credible threats and unwanted appearances.

While power dynamics begin to explain how situations begin and evolve, we turn to social exchange theory (SET) to better understand the factors that make escaping this cycle difficult.

6.2 Social Exchange Theory

Generalizing the experiences of participants through the lens of social exchange theory helps to explain why there are vastly different experiences among the participants we interviewed. Depending on the nature of the relationships, there is a specific threshold of discomfort with a location-sharing application that needs to be reached for action to occur. Viewing this through the utilitarian viewpoint of social exchange theory, relationships will be maintained only if the benefits outweigh the costs. For action to be taken, the same principles apply where the benefits need to outweigh the risks. These risks and benefits include probability if the outcomes are uncertain. For example, when a child is asking for a toy, there is a concrete benefit of getting a toy but the potential cost of being made uncomfortable is uncertain. Whether or not this child asks

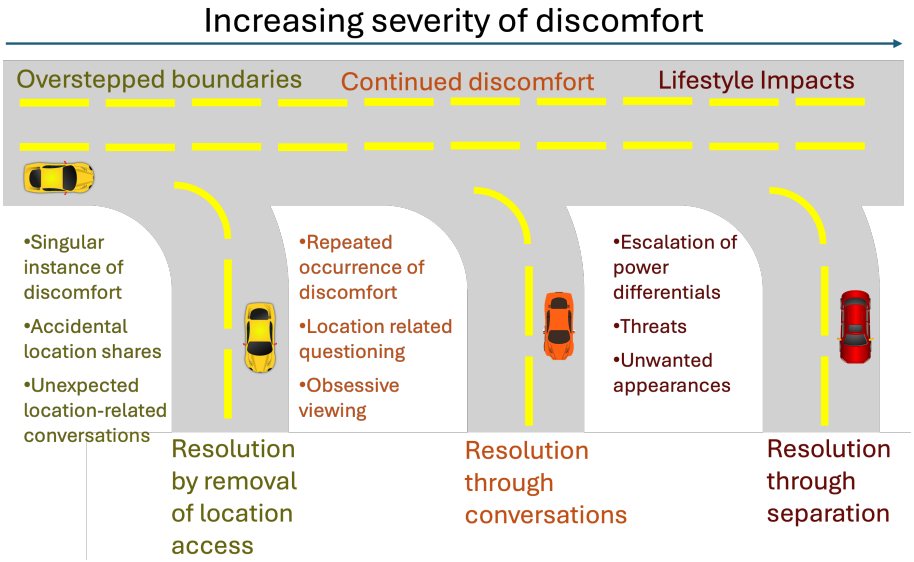

Figure 5: The experience of participants is categorized into three sections with the first representing overstepped boundaries ($N = 7$), the middle section representing continued discomfort ($N = 8$), and the rightmost section representing lifestyle impacts ($N = 8$). Continuing on the road of discomfort leads to increased discomfort and additional uncomfortable behaviors. The exits from the road represent the most frequent way participants achieved a resolution to their concerns. With greater discomfort, we observe more severe actions are necessary to find resolution.

for a toy is a calculation of whether the risk is worth the reward. A high chance the parent will say yes to the request means the child will ask, but if historically there is no toy given and the child is made to feel guilt, shame, or discomfort, then the child will not ask.

Applying SET to CLS application users, the action to be taken is having a conversation or removing access to the location from the source of discomfort. Revisiting the experience of P16, there is a risk of conversations leading to the escalation of issues: *"not giving [my parents] my location anymore was very symbolic of like an end of the relationship"*. The perceived chance of negative consequences is unique to each relationship with healthy, trusting relationships having a low risk and volatile relationships having a higher risk. In cases of abuse, these actions can carry the risk of retaliation [28]. This risk is associated with the strength of the bond between the participant and the individual making the individual uncomfortable. For P17, having a conversation with a stranger who they perceived to have stalked them through a dating app ended the chance of having a date, but the cost of that action was low compared to losing a friend, family member, or intimate partner.

The benefit of location mitigating action relates to the severity of the discomfort such that the greater the discomfort, the greater the benefit the action can have. Whether limiting location leads to the removal of discomfort is probabilistic based on the unique interworkings of each relationship.

After considering risks and benefits, there is a threshold where the benefits of action outweigh the risks. This threshold can fall at different levels of experience depending on how severe the risk is to the relationship. This is visualized in Figure 5 by the offramps representing what resolution was necessary based on the experience of participants. For participants who resolved their situations in the first category, there was a low threshold to take action and they decided to immediately remove location access. This low threshold is also correlated with the low relationship strength of the individuals in this category indicating that the ease of removing location is tied to the strength of relationships.

For the second category, we see that resolution is achieved through continual conversations. This is also tied to a stronger bond between participants with parents, intimate partners, close friends, and siblings being the population who made the participant uncomfortable. These conversations were a high-cost action but were taken because the alternative of not taking action and continuing to feel discomfort was even more costly.

Finally, with lifestyle-impacting relationships, the severe action of separating from the individual was needed in all but one relationship. In these relationships, we observe that the discomfort reached a threshold higher than the benefits the intimate partner or parents provided.

We observe that this behavior does not only apply to situations where the unit of exchange is tied directly to a relationship. P8 mentioned that when their company wanted to install cameras and use location sharing, they *"felt like the pay they were offering wasn't worth it for that process"*. The monetary units of exchange were not worth the loss of autonomy created by this level of surveillance.

Part of the concern with location-sharing applications is that there is an asymmetric cost between sharing and removing a location; it is easy to share a location and hard to remove sharing. Part of this cost is tied to the element of trust that location sharing provides; removing location sharing can be symbolic of losing this trust. From the perspective of the individual granting location

		P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13	P14	P15	P16	P17	P18	P19	P20	P21	P22	P23
Increase Autonomy	Less Exact Location	●	○	○	○	○	○	○	●	○	○	○	●	○	○	○	○	○	○	●	○	○	●	○
	Don't Notify When Sharing Stops	●	●	○	○	○	○	○	○	○	○	○	○	○	○	○	●	○	●	○	○	○	○	○
	Ghost Mode	○	●	○	○	○	○	○	●	○	○	○	○	●	○	○	●	○	○	○	●	○	○	○
	Spoofing	○	○	○	○	○	○	○	○	○	●	○	○	○	○	○	○	○	○	●	○	○	○	○
	Reports of Who Checks Location	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	●	○	●
Protective Action	Authentication to view	○	○	○	○	●	○	○	○	○	○	●	○	○	○	○	●	○	○	○	○	○	○	○
	Report obsessive checking	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	●	○	○	○	●	○	○	○
	Report unusual behavior	●	○	●	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
	Report abuser nearby	○	○	○	○	○	●	○	○	○	○	○	●	○	○	○	●	○	○	○	○	○	○	○
Location Management	Authentication to share	○	○	○	○	○	○	○	○	○	○	○	○	○	○	●	○	○	○	○	○	○	○	○
	Notifications	○	○	○	○	○	○	○	○	○	○	○	○	○	●	●	○	●	○	○	○	○	○	○
	Mutual Sharing Requirements	○	○	○	○	○	●	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Support Resources	Support Resources	○	●	●	○	●	○	○	○	○	●	●	○	○	○	○	○	○	○	○	●	○	○	○
	Education	○	○	○	○	○	○	○	○	●	○	○	○	○	○	○	○	○	○	○	○	○	○	○

Table 3: Participant-requested features have been grouped into four categories in the order of increased autonomy, protective action, location management, and support resources. ● Represents that a participant requested that feature where ○ represents this feature was not specifically discussed during unprompted application change discussions. The sparse nature of this graph represents that there was not a consensus on what should be changed about CLS applications, however, all participants gave suggestions indicating that change is necessary.

access, in important relationships, there is a high cost to removing location which in turn requires a high level of discomfort to spur action. In some relationships, these costs can allow location sharing to evolve into a mechanism for abusive behavior before location-mitigating action is taken. For the remainder of the paper, we will use SET and power dynamics as frameworks to evaluate user-suggested changes to CLS applications and help provide our recommendations to developers of CLS applications. Changes to CLS applications should help to reduce power differentials and reduce the threshold for location-mitigating action.

7 Participant Requested Features

This section pertains to the final part of our interview where we focus on features that participants wanted to be added or removed from location-focused applications (LFAs). For participants who faced discomfort through stalkerware applications, we directed the conversation specifically toward LFAs. We initiate this part of the interview by asking the participants to describe their desired changes to LFAs without any prompts from the interviewers. We then ask for opinions on four specific prompted features: removal of indefinite share, reports of locations shared, corser-grained location sharing, and intelligent notifications. These suggestions are chosen from prior literature [54] and are intended to spur creativity. We finished the interview by allowing the participant an additional opportunity to discuss any ideas that were spurred by the prompted questions. The following section discusses the groups of desired LFA changes and how the requested features differ based on which application the participant uses.

7.1 Participant Desired Feature Changes

From the interviews, we see four types of desired changes to LFAs emerge: increased autonomy, protective action, location management, and support resources. A detailed breakdown of each participant's feature suggestions is shown in Table 3.

7.1.1 Increase Autonomy. Most participants (13/23) request features for increasing autonomy with the ability to manage how their location is shared or for providing greater transparency around when their location is viewed. Specifically, some participants want an option for less precise location sharing. P22 mentions that they *"kind of wish [LFAs] had like just a general area where you're at."* When asked in one of our prompted questions if participants would use a feature that allowed for less exact location, 15 out of 23 participants said they would. Less precise location helps increase the control and level of privacy that LFA users have over their shared location which can help prevent severely uncomfortable situations such as unexpected appearances.

As part of their desired autonomy, participants are interested in changing the way that reports/notifications are given. They would like to know how often their location is checked by others, and they do not want notifications sent when location sharing is stopped or restarted. For example, the Apple Find My application sends the other party a text message when location sharing is stopped. This causes some contention for situations where the user desires location privacy. P16 recalls an experience where her friend's boyfriend *"stopped sharing his location at a jewelry store"* which immediately indicated his intention to propose. Conversely, adding reports of how often location is checked could inform the user of obsessive or excessive location watching. P9 elaborates: *"[y]ou could have that as receipts more or less to be like this person was obsessively watching."* This increased transparency allows users to make informed decisions based on behaviors occurring and reduces the power differential that is caused by a black box of location sharing.

The final autonomy-increasing features that participants suggest are related to selectively hiding their location. P19 states that *"a location spoofer or something would've been nice."* In this case, spoofing refers to the act of manipulating the LFA to disguise their true location. While P9 states that they used location spoofing in the past, they note that the loss of integrity would cause issues in the

"business model that would fall apart pretty quickly." Additionally, P9 finds the level of attention that location spoofing requires to be arduous. An alternative suggestion is a ghost mode which 5 out of 23 participants suggested. This feature would allow a user to hide their location for a specified amount of time without providing notifications. Ghost mode is currently available in Snapchat but not in other applications, and it gives users the autonomy to be private while not affecting the integrity of the applications.

7.1.2 Protective Action. 8 of the 23 interview participants propose features that can aid in their protection when they encounter difficult situations. Specifically, they want their LFAs to help identify anomalous behavior, give them notifications when an abuser is nearby, and require a level of authentication to view their location.

We see multiple viewpoints on the need for anomalous behavior detection. In some cases, participants want to be notified of obsessive monitoring behaviors, where P16 specifically states they want to know when *"that person is checking their location religiously."* This differs from reports of location sharing because the application and detection mechanisms are taking action to determine if a behavior is worthy of a conversation instead of the individual. Conversely, P3 is interested in their device sending a notification if their behavior is abnormal. They feel as though this type of reporting would increase personal safety suggesting it will help them feel *"a little bit more comfortable if someone saw that, you know I was stuck in the same place for a long time."*

Once the participants experience uncomfortable situations, they become more vigilant when it comes to interactions with abusive individuals. P12 wants a feature that *"when the stalker is close to [their] location, [give them] a notification,"* since they were previously stalked by an ex-girlfriend. P4 mentions that they manually implemented this feature by *"[using] their location after the fact to avoid seeing them on campus."* While some might find proximity notifications beneficial, these features present a risk when used by an abusive individual.

The last suggestion for protective action involves the use of authentication to make it more difficult for someone untrustworthy to view their location. P11 elaborates on this by stating *"Two-factor authentication would make it all the more difficult for these parties, especially those with malicious intent to access [location] information."* This situation assumes the threat model of device theft allowing a threat actor to access the location of interest through a shared contact. Authentication requirements to view location adds a level of security and help reduce this risk.

7.1.3 Location Management. A concern we notice amongst the participants is the stress and discomfort due to accidental or automatic location sharing. Often, location-sharing features are turned on automatically with the opt-in set as the default. As a Snap Maps user, P15 states that *" I wish it told me that my location was being shared 24/7 because... I don't remember anything about allowing my location to be shared."* Requiring authorization to initiate location sharing would add more transparency for the user and allow them more conscious control of their sharing habits.

During the interviews, one of our prompted questions asks the participants if they would like to be notified if their location is currently being shared with someone they have not talked to recently, and 20 of the 23 participants indicated this is the case. The

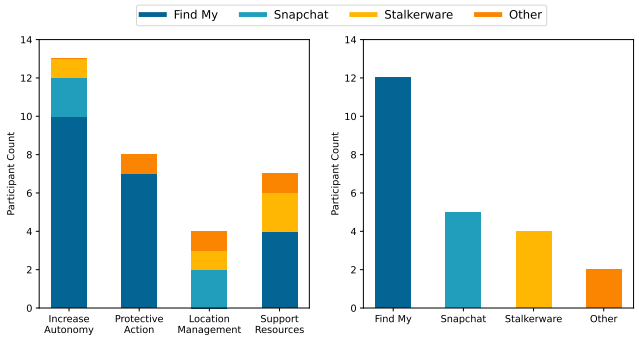

Figure 6: Categories of requested features by the application that caused discomfort. Notably, while Apple Find My users represent the majority of our participants, none requests a change in how their location is managed.

3 opt-outs mention a level of discomfort to this style of notification with P3 expressing *"it's a very invasive way"* to notify that your location is being shared. Users easily lose track of everyone they are sharing locations with and participants express that an easier management system would aid in their ability to regulate who they are sharing locations with.

Another suggestion from the interviews to help avoid accidental sharing is to require mutual sharing. Instead of automatically sharing locations with everyone, mutual sharing would let the user be more intentional with whom they share by requiring an exchange to occur before sharing can begin. This feature also helps in cases of abuse when an individual wants to secretly install location sharing such as the experience of P14 and the T-Mobile Anywhere app.

7.1.4 Support Resources. Another common suggestion (6/23) is for LFAs to provide support resources that are easily accessible to users within the application. One participant recommends that *"It might be helpful to have, like a resources tool on the app itself, of ways that you could reach out for help"* (P2). Due to having obsessively worried elderly parents, P9 believes that *"parents, you know, need to be sort of given a reality check like, hey, what is going on here? How old is your child? You know this is a serious thing."* Support features help to educate people using these applications about the potential harm LFAs can have on both parties. They also provide aid so that people will have a lower strain when seeking help. Both support resources and educational materials can help individuals be more critical and conscious about the severity of discomfort that location sharing can cause.

7.2 Application Specific Observations

From the 23 participants, we notice that the application being used influences what features they desire. While using an LFA, the interview participants often want features from other LFAs, suggesting that there is a collection of positive features amongst LFAs that people want when using location sharing. Figure 6 shows the number of participants who want each feature type along with what application they use.

For example, Snap Map users mention that they would like it to be more difficult to start sharing with P5 saying they want *"just*

Recommended Feature	Apple Find My	Snap Maps	Google Maps	Grindr	Life360	FamilyWhere
Require explicit permissions before sharing location	●	○	○	●	○	●
Report when location is checked	○	○	○	○	●	○
Mutual sharing requirement	○	○	○	●	○	○
Don't notify receiver of location when sharing stops	●	●	●	○	●	●
Don't notify receiver of location when sharing starts	○	●	○	○	●	○
Offer in-app support resources	○	○	○	●	○	○
Optional granular location sharing	○	○	○	○	○	○
Allow sharing location for limited time periods	●	○	●	●	○	○

Table 4: Our suggested implementations are compared to existing functionality within location-sharing applications. ● Represents that the application satisfies our suggestion and ○ represents that the application does not. While WhatsApp was discussed in the interviews as causing discomfort from permanent location shares, since 2020 they have only allowed for shares as long as 8 hours. As such, we did not consider WhatsApp for analysis of current CLS applications.

more transparency" and were upset that they shared their location by accident or *"just turned it on by default"* (P5). These suggestions are unique to Snap Map users with none of the Apple Find My users referencing making it more difficult to share their location. The lack of concern present in the Apple Find My users demonstrates opt-in location sharing is a good starting point for transparency.

Conversely, with Apple Find My we see several participants suggest the removal of location notifications or the addition of ghost mode to temporarily hide their location without notifying the person with whom they are sharing their location. Apple Find My is transparent when someone is stopping or limiting their location which our participants report has spurred conversations and discomfort.

Overall, we see many different suggestions for features that would positively impact the experience of the interviewees. While the uncomfortable experiences that the participants encounter influence these suggestions, the experience of each person with their respective application shapes the lens through which they see issues with LFAs. By finding a positive group of changes to LFAs, we can create the possibility of using LFAs without the uncomfortable consequences that our interview participants face.

8 Recommendations To Developers

Based on our analysis of the 23 interviews, experience in secure system design, and sociological frameworks, we recommend 8 changes to location-focused applications falling into the categories of increased transparency, notification changes, in-app support resources, options for granular location, and functionality-specific location-sharing. Table 4 outlines our recommendations and evaluation of existing CLS applications. The discussion focuses specifically on LFAs as the threat models for dual-use and stalkerware applications are different and outside of the scope of our contributions.

8.1 Transparency

Seven of the 23 interview participants believe that location-sharing was enabled on their devices by accident or default. Another three had their application installed by someone else. Developers of location-focused applications should provide clear communication regarding who has access to a user's location within these applications. This clear communication can prevent individuals from experiencing unexpected privacy violations, and lead to quick recognition of an LFA that was covertly installed.

With none of the 12 Apple Find My [3] users reporting transparency concerns, this application serves as a positive but incomplete design. The application requires a user to approve before their location is shared with a new individual. This process offers two-factor authentication through device ownership and requires the ability to unlock the device. This process also is a conscious action tied to granting an individual location which can help with managing who has location access. To improve upon this, application developers should consider monitoring how many times a location is distributed to different individuals and providing that information to the person sharing the location. Granting full access to location-checking behavior may introduce anxiety; Participant 16 mentioned they *"feel worried about if people checked, how often I checked their location."*. With logs representing how frequently location is checked, developers should first warn individuals with obsessive location-sharing behavior, if patterns persist then the person whose location is being checked would be notified. Additional audits of location-checking behavior should be permitted in special circumstances such as known cases of domestic violence.

Including a requirement for mutual location sharing would also improve transparency by allowing the list of accessible locations to act as a list of what location is shared. This also functions to reduce the power differential that is created immediately upon a one-sided location share. In some relationships such as a business that needs to see the location of an employee, there is a different context in which location is shared. In these special circumstances, alternatives to mutual location sharing should be permitted.

8.2 Notification Settings

Transparency around who has the user's location is beneficial, but full transparency for the receiver of the user's location can cause discomfort to the sender. The Apple Find My application is used to notify the receiver when a user stops sharing their location. Several interview participants found this feature troublesome because, without the notification, the person who had their location may have never known it had been revoked. As of March 2024, Apple Find My no longer sends these notifications. However, a notification is still sent when the user's location is re-shared with the receiver. As a result, a person in an uncomfortable situation still cannot covertly turn location-sharing off and back on. Two participants also mentioned disliking this notification feature because of harmless situations, such as ring shopping or planning a surprise party. To retain the benefits of notifications we suggest developers give the individual the option to not send notifications when sharing their location. This would allow users to take location-restricting action with a lower chance of retaliation without significantly altering current functionality.

8.3 In-app Support Resources

While four out of the six applications we examined had help screens, only Grindr included resources for domestic violence. We suggest that developers offer in-app links to domestic violence hotlines and other emergency response services within their support menu. This was our most requested feature primarily mentioned as a way to help people in difficult situations such as domestic abuse. Providing in-app access to these resources would help people easily access sources in an efficient manner. Providing these resources would also help to reduce the impulse needed to take action in extreme cases of discomfort.

8.4 Option for Granular Location

Additionally, we suggest options to share granular provided within LFAs. This allows for individuals to have control over how accurate of location they are willing to provide based on factors in each unique relationship. Included in this should be an option to override granular location sharing in emergency scenarios. If an emergency accurate location is requested, the participant who is sharing the location should be notified this behavior is occurring. Optional granular location sharing serves to provide a low-cost option to subtly reduce the specificity of location sharing in a relationship and could help people maintain some privacy when location-restricting options are not available.

This feature would differ from OS-level options provided by both IOS and Android OS. The functionality provided by OS-level solutions has an application-wide impact and does not offer options to access more specific locations in emergency scenarios.

Recipients of location who receive granular location may have a reduced functionality related to that location; However, in this scenario, this reduced choice is deliberately chosen by the individual who is sharing location.

8.5 Purpose Driven Location-Sharing

The results of our survey and interviews find that LFAs have an intended usage for safety and coordinating meetups. However, through our analysis of uncomfortable situations experienced by users, we find a lack of contextual integrity [49] with applications being used outside of their intended design. Purpose-driven design of location-sharing applications is necessary to mitigate these privacy risks while still providing a tool for safety and convenience. We suggest that LFAs include functionality to share location for a limited amount of time to allow individuals to share their location with intentionality toward these functions.

Another example of purpose-driven location sharing is Apple Check In which was released in January 2024 [2]. With this feature that is included in the Apple iMessage, a user can either choose to have the application notify a trusted individual when they have reached a specific destination or the user can set a timer that will share their location with a trusted individual if the timer is not turned off before it runs out. This allows the location to be shared only if unexpected behavior is exhibited. Apple Check-In provides strong safety functionality for going on dates, long commutes, or endurance exercises without the risk of usage outside of the intended context. For 9 out of 23 participants, safety was the primary reason for using CLS applications, and using more purpose-driven tools such as Apple Check-In could provide security without the risk and privacy infringement that comes with continuous location sharing.

Developing highly specific applications for goals such as coordinating meetups or helping spontaneity could be an approach to further minimize the adverse effects of location sharing. This would allow privacy-conscious individuals to suggest specific tools as an alternative to giving full continuous location access.

9 Discussion

Additional observations from our study are outlined in the following section. We observe the added modality for abuse that location presents, contribute to the ongoing definition of CLS applications, and discuss our limitations.

9.1 Vectors for Location-Related Discomfort

Throughout interviews, we observe two phenomena relating to the source of discomfort; unintentional discomfort, and location-sharing as a new vector for intentional abuse.

In some scenarios, while the participant felt uncomfortable, there was no malicious intent. One interviewee, P19, felt like his sister was obsessively checking his location and admitted that they too *"would kind of do the same thing."* Similarly, in cases where privacy concerns were the primary issue, we observed the actions taken by acquaintances caused discomfort regardless of intent. The map-based interface where all shared locations are visible simultaneously has also led to discomfort when privacy is desired [37]. The existence of unintentional discomfort highlights the need for more transparency in location-sharing applications.

Where there was malicious intent, we recognize that shared location is a new vector for abuse. LFAs allow for functionality through existing features which categorize this vector as intended use [56] similar to how IoT devices are used for spying on intimate partners. For location-sharing this occurs in long-distance relationships (4/23), or when location is used to make unexpected appearances (4/23). Without location sharing, individuals would not know where to make an appearance, and exerting control over a long-distance relationship would require obvious actions, not untraceable location viewing habits. Options for more granular location, and allowing reports when locations are checked would help reduce the extent to which these behaviors are possible.

9.2 LFAs Versus Dual-Use

The definition of dual-use applications includes any application that can be used for remote spying [10]. Location-focused applications (LFAs) are included in this broad definition however, in this paper, we deliberately chose to separate LFAs from dual-use applications. Typically dual-use applications are discussed in the context of feature-heavy applications such as parental control tools that can be repurposed in ways similar to stalkerware. The threat model for these dual-use applications differs from LFAs because of the different target audience, and features provided.

For future literature, we advocate for the consideration of LFAs as a separate category of location-sharing applications. While the threat model may differ, the consequences are still severe. Furthermore, a better understanding of the limited features provided by

LFAs can help to understand the role that location sharing plays in dual-use and stalkerware applications.

9.3 Limitations

Our research is limited to observing a population older than 18 years old. Because of this, we were unable to gather how location is used in the unique social dynamic between cohabitating parents and children. The sensitive nature of our conversations and the need for informed consent from parents would skew results and require a change of context for the work contributed. For these reasons, we chose not to include minors in our study.

10 Related Works

Prior work has studied group dynamics when using location-focused applications in a controlled setting [53, 54] finding that location-sharing leads to spontaneous social planning and fostering intimacy in relationships. Similar location-sharing features have been examined under the context of abuse through work examining covert stalkerware applications, commercial spyware installed without the knowledge of the user, and dual-use applications that may initially be used to improve a victim's quality of life (e.g., location-sharing for safety) but can be used in a coercive manner by an abuser [10, 27]. With a spectrum of positive and negative effects that CLS applications can lead to, location sharing is a significant privacy concern for users [34]. This privacy concern is not limited to applications that specifically share location; users of fitness tracking applications share workouts and by proxy can unknowingly share location with followers on a platform that operates similarly to social media [46]. Outside of the realm of location sharing, similar concerns to CLS applications can be seen with online status indicators (OSIs) being used to deduce information about individuals resulting in altered behavior and manipulating status indicators [18, 19].

Researchers have also examined location used by a host of different software applications ranging from social media to fitness tracking applications, and even employer-to-employer software to track an employee during their workday. Suggestions have been given for protecting user's location through different ways such as privacy-preserving schemes, disclosure-control algorithms, and app permission managers with awareness nudges [9, 11, 22, 34]. Furthermore, privacy-sensitive data is ascertained by social media and data brokerages, this data is not well protected by the companies or by-laws [15, 38]. This becomes increasingly significant when private information such as religious affiliation can be deduced through location information [13]. Research indicates that reducing the accuracy of location when stored long term is a sufficient mechanism to increase comfort with location [12].

From psychological journals relating to intimate partner violence, there is evidence indicating how issues with attachment styles can influence factors in relationships related to the occurrence and continuation of intimate partner violence [26, 55, 59]. Sharing location can improve social attachment when done voluntarily however the impact of involuntary location-sharing applications is unknown [50].

11 Conclusion

Features of Continuous Location-Sharing Applications allow for interpersonal discomfort. We find that CLS application users encounter discomfort in three primary categories that build upon each other: overstepped boundaries, continued discomfort, and lifestyle-impacting behaviors. To reduce the rate and severity of these concerns, we suggest five categories of changes to location-focused applications: (1) increase transparency, (2) improved notifications, (3) in-app support resources, (4) granular location exaction location, and (5) the creation of functionality-specific location-sharing applications. Additionally, we contribute to the evolving definition CLS applications by differentiating location-focused applications as a subset of CLS applications that are separate from dual-use. These efforts will advance the conversation in a way that enables the safety and convenience of shared locations while navigating privacy concerns.

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