# LYLO – Exploring Disclosed Configurations for Inter-Personal Location Sharing

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## ABSTRACT

Continuous location sharing (CLS) can foster intimacy, for example, for couples in long-distance relationships. However, turning off CLS can then raise suspicions. To address this, we developed nuanced sharing settings in a focus group ($N = 6$) and implemented them to moderate CLS in an Android app. Crucially, the app also discloses each person's current sharing settings to the partner. In a 16-day field study, four couples interacted with our app and the disclosed configurations, confirming the disclosure's positive effect on transparency. However, features obfuscating the location were considered superfluous, as participants preferred sharing their location exactly or not at all. While participants overall appreciated having the configuration options, changes in their partners' configurations raised questions about their motivations. Instead, participants would adjust the configuration for different intimacy levels (colleague vs. partner) rather than different activities when using CLS with the same person.

## CCS CONCEPTS

• **Human-centered computing** → Field studies; Smartphones; *Empirical studies in interaction design*; • **Security and privacy** → *Usability in security and privacy*.

## KEYWORDS

continuous location sharing, disclosed configurations, data protection, privacy, transparency

**ACM Reference Format:**
Christina Schneegass, Diana Irmscher, Florian Bemmann, and Daniel Buschek. 2021. LYLO – Exploring Disclosed Configurations for Inter-Personal Location Sharing. In *CHI Conference on Human Factors in Computing Systems Extended Abstracts (CHI '21 Extended Abstracts), May 8–13, 2021, Yokohama, Japan.* ACM, New York, NY, USA, 6 pages. https://doi.org/10.1145/3411763.3451652


*CHI '21 Extended Abstracts, May 8–13, 2021, Yokohama, Japan*

ACM ISBN 978-1-4503-8095-9/21/05…$15.00
https://doi.org/10.1145/3411763.3451652

## 1 INTRODUCTION

Sharing implicit data is becoming increasingly popular. By inviting a friend or partner to see our fitness data [1], sharing our heart rate with text messages [9], or our location [8, 16] can create a sense of intimacy that would not be possible without technology. However, the voices calling for more elaborate data protection mechanisms increase. In location sharing, turning off the sharing completely is reported as common means to ensuring privacy. Prior work has evaluated various features to find the balance between the willingness to share data while simultaneously protecting it, such as comparing text descriptions vs map visualizations [14], applying time restrictions [17], or audience selection [6]. However, the user's interaction with more fine-grained configuration options in continuous location sharing (CLS) is still insufficiently evaluated. In this work, we report the results of a scenario-based focus group ($N = 6$) investigating technical solutions to address configuration features for CLS. Based on the results, we developed an Android app titled *LYLO - Locate Your Loved Ones* for CLS among close friends, family members, or partners. In LYLO, the CSL configurations are disclosed to the sharing partner. In a 16-day user study ($N = 8$), we collected the data of four user pairs focusing on their experience in interacting with the (disclosed) configurations in LYLO. Individually distributed surveys and pairwise semi-structured interviews showed that LYLO, particularly its disclosed configurations, positively impacts the perceived control and transparency while sharing continuous location data. However, the study showed that users still encountered situations in which they had to justify changes in their configurations (e.g., reducing location accuracy) to their partner. While the participants appreciated the notification feature informing them about their partner's location retrievals, they rarely saw the need for restricting the partner's access to their location or reducing its granularity. We discuss our findings in light of the increasing demand for privacy and system transparency in today's data-driven world.

## 2 RELATED WORK

With the technological development of GPS and the increasing ubiquity of phones in the general population, location tracking and sharing became possible. In 2005, Consolvo et al. [6] evaluated the voluntary disclosure of location-based information. They found that it is central to users who is requesting the location and how accurate it needs to be. Besides the opportunity to adapt the shared location granularity, the timing of location disclosure and the users' mood can impact their willingness to share their location [6, 12, 13].

Based on the early studies by Consolvo et al. [6], Iachello et al. [10] developed a series of privacy guidelines, such as not to use automatic functions as default, giving the user the control to decide upon sharing requests, or to support purposeful deception.

Similarly, when studying the Reno app, Smith et al. [15] were hesitant about implementing automatic features. They stress that it is important to balance automatism and control for the user. Another finding from this study was that the amount of context users reveal depends on the relationship they have with the person they share their location with (e.g., more context for romantic couples compared to colleagues). With the rise of social networks in 2010, there was a development toward sharing momentary locations with a bigger audience. For example, the platform Foursquare[1] enabled users to share the places they visited and combine those check-ins with feedback and reviews. Building on previous research (cf., [13, 18]), the app Locaccino allowed users to control their privacy while sharing momentary locations [17]. Compared to other applications, Locaccino considered users' wishes, for example, sharing the location only during a pre-defined time interval or when the user is in a certain area.

**Research Gap:** Prior research emphasized the importance of feedback and transparency on the acceptance of CLS apps. To this point, research focused on people's needs for sharing their location but neglected to investigate the requirements for more fine-grained configuration and their disclosure. As making changes in location sharing settings (e.g., reducing granularity or defining time outs) can have severe implications on the partners' relationships, in this work, we investigate users' preferences for the disclosed location sharing configurations and explore how users interact with them.

## 3 CONCEPT

To better understand the needs for configurations in CLS apps, we conducted a focus group ($N = 6$). The focus was on technical features and the design of configurations in CLS apps for close interpersonal relationships such as friends, family members, or romantic partners. We describe the resulting features as a basis for our LYLO implementation.

### 3.1 Focus Group

*Sample.* We recruited six participants ($M = 33 years$, $SD = 7.64$, five male, one female) through a university mailing list and social media channels. These channels were mainly addressing students and employees from the field of computer science and software engineering. Unfortunately, no further female participants responded to our call. Three participants were students and had full-time jobs. Participants reported medium familiarity with the term *location-sharing* ($M = 3.67$, $SD = 0.75$) and medium experience in the usage of CLS apps ($M = 3.17$, $SD = 1.07$, 5-point Likert scales from 1 = "none" to 5 = "a lot").

*Procedure.* In the beginning, we outlined the goal and process of the focus group. The participants read our university's data protection regulations and gave informed consent to the processing of their data and the audio recording of the sessions for post-hoc evaluation. Afterward, we presented six scenarios / statements of problems that can arise when using location sharing in close interpersonal relationships. Those statements were derived from a magazine article [2] and quotes from interviews of a former student research project at our university. For example, we presented the statements "[...] But it easily turns into an obsession to locate your partner. Jealousy rises, mutual trust decreases." and "But I know myself, maybe I would even turn it off, maybe even say that it just wasn't working right now [...]". Participants were asked to make notes about the possibilities of technical adjustments and settings for a CLS app that could protect users in the respective scenario, followed by a discussion. We encouraged participants to rather describe the technical aspects than their personal relationships and emphasized that they are not expected to disclose any personal information. All six participants received a 15 Euro online shop voucher or study credit points as compensation.

*Results.* The participants discussed sixteen features for adjustments and configurations. We will outline the five most frequently mentioned features in detail below (mentioned five times or more, frequency in brackets). We clustered the features based on participants' notes and implemented the first four of these five features in our LYLO app described.

- **Accuracy** (10): Users can adapt the accuracy with which their location is presented (low, medium, high). It can range from a precise location indicator (high accuracy) to a radius of 500 meters (medium) or one kilometer (low) in which the exact location is randomized.
- **Counter** (7): Users can specify a maximum number of location requests by their partner. When this number is exceeded, the partner can no longer retrieve the location until the user resets the counter.
- **Notification** (7): Users can configure if they want to receive notifications when the partner retrieves their location, thus informing them about the request.
- **Time Interval** (5): Defining times during which they share their location with the partner (e.g., 8 am to 4 pm).
- **Emergency Button** (5): This button is not part of the disclosed configurations but is located on the main screen. It enables the partner to emergency request the user's location overwriting the configurations presented above. It is meant for usage in situations where the partner suspects an emergency, as people often use location sharing apps as a safety line during outdoor activities in case of accidents.

Less frequently mentioned features included: providing a "fake-location" (2), disabling location sharing temporarily (opposite of the time-interval feature) (2), providing a location history (2), increasing the accuracy radius with each location request (2), showing status

[1] Foursquare: https://foursquare.com/, last accessed February 24th, 2021

or mood in the app (2), including a chatbot to nudge the user not to request the other person's location (2), sharing location only when location changes (1), combining the timer and notification feature (1), omit to share of battery status (1), allowing users to share their company (i.e., the person they are with) rather than location 81), or asking for a justification for the location request (1).

## 3.2 Implementation

The LYLO implementation consisted of three parts: the database (set up with MariaDB [2] version 10.4.13), a web server application (built in Node.js [3]), and an Android application. We chose to implement the LYLO app for devices running Android 6.0 or higher with a foreground service and active notification to allow for CLS requests. For communication between app and webserver, we used https requests, and Firebase Cloud Messaging [4] to send downstream messages from the webserver to the app. The app retrieved the device location from Android's Fused Location Provider API [5]. It combines the information of multiple device sensors (usually GPS, Wi-Fi, and cellular network) to provide an optimal location in varying conditions, considering power consumption and the desired accuracy. The app requested a new location every 5 minutes in ideal conditions but not later than every 10 minutes (depending on location availability and power impact). A balance between power consumption and accuracy, avoiding updates for small location changes below 100 meters, was configured[6]. For data privacy reasons, only the last known location was stored on the webserver.

## 3.3 Structure & User Interface

The main screen of the LYLO app is a map view that visualizes the location of the user's partner. A card view on the bottom shows the partner's username and the date of the currently displayed location. The refresh button on the top right updates the latest partner location. Via its menu (top right of the activity or in the card), users can access the LYLO settings screen. The location accuracy is visualized either with a red marker on the map (high accuracy, see Figure 1, left), while the medium and low accuracy is visualized using a circle for the radius similar to the Google Maps location accuracy feature (Figure 1, middle). On the settings screen, the user could configure the following features:

- **Accuracy:** Determines the radius of location randomization (size of the circle, visible for the partner). LYLO offers the options *High* (show marker, no randomization), *Medium* (circle with a radius of 500 meters), and *Low* (circle with a radius of 1000 meters).
- **Counter:** The number of location retrievals by the partner is shown next to the refresh button.
- **Notification:** If enabled, the user is notified every time the partner requested the location.
- **Time interval:** Allows for temporary location sharing: The location is only shared with the partner during a configured time-frame within a day. Time Intervals are intended to be used temporarily, thus a configured Time Interval is applied only on the day of configuration.

We did not implement the emergency button, as its use case was neglectable for our study during Covid-19 conditions.

## 3.4 Disclosed Configurations

Additionally to the settings of the app itself, LYLO contains a view for the disclosed configurations, i.e., the configurations of both the users and their partners. Here, the users can manipulate their own settings while the partner's settings are view-only. This view enables users to check if their partner's configurations changed and if their configurations deviate from the user's own configurations. The partner's configurations were accessible through a "show" button on the personal configuration page (see Figure 1).

# 4 USER STUDY

## 4.1 Procedure

During the recruitment phase, we already informed people about the purpose of the study and the data collection[7]. Participants were made aware of our university's data protection regulation and provided informed consent. Participants were asked to fill in a first survey asking for demographic information such as age, gender, and occupation. Further, they stated their Android version running on their smartphones, their familiarity with location-sharing apps, and their affinity toward technology in general using the Affinity to Technology (ATI) scale [7].

We instructed the participants to use the app for sixteen days and explore the configurations as they see fit[8]. During the study, we logged our participants' interaction with the app, particularly with the disclosed configurations. After the two weeks, participants were presented with a second survey including the System Usability Scale (SUS) [4] and an open usability feedback question to make sure the app did not contain usability issues that would negatively affect participants' opinion of the app. Additionally, we used a questionnaire on privacy concerns by Buchanan et al. [5] to assess participants' attitudes toward privacy and data protection. Lastly, we conducted pair-wise semi-structured interviews with the participants for an in-depth discussion of their shared experience with the LYLO app (one in person, three online). We used guiding questions but reserved the right to inquire more about certain details stated by the participants during the interviews.

## 4.2 Sample

Eight people participated in pairs (five female, three male), having a mean age of 38.63 ($SD$ = 10.34). Two couples were married (P3+P4 and P7+P8), one couple was in an unmarried relationship (P5+P6), and one was a mother and (adult) daughter duo (P1+P2). None of them participated in the focus group. We informed all participants that they would have to share their location openly with their partner and could withdraw from the study at any time.

[2] https://mariadb.com/
[3] https://nodejs.org/en/
[4] https://firebase.google.com/docs/cloud-messaging
[5] https://developers.google.com/location-context/fused-location-provider/
[6] https://developers.google.com/android/reference/com/google/android/gms/location/LocationRequest#public-static-final-int-priority_balanced_power_accuracy, all websites last accessed February 24th, 2021

[7] Ethical approval granted: https://www.mathematik-informatik-statistik.uni-muenchen.de/ethikkommission/index.html; case number EK-MIS-2020-014
[8] As this study was conducted during the COVID-19 pandemic, most of the communication with the participants was moved online. Our assessment on the potential influences of the pandemic on our results can be found in the limitation section.

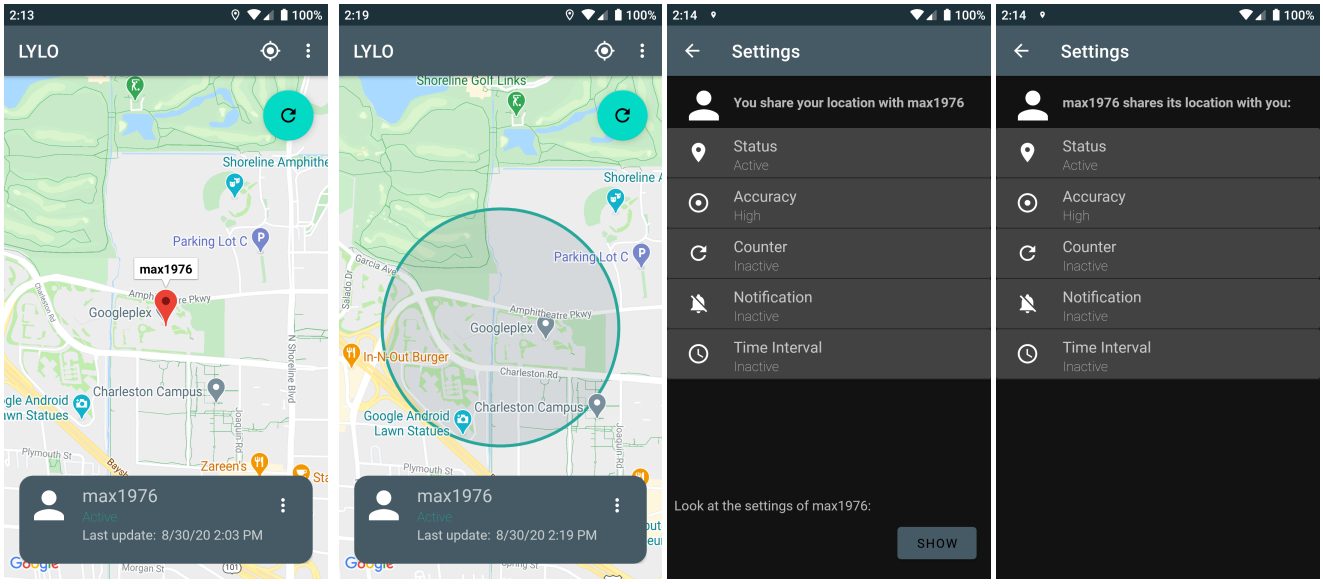


**Figure 1: The LYLO app (from left to right) with its (1) main map view showing the accurate location of user max1976, (2) the medium accuracy location of the user, and (3) the configurations for the CLS as viewed by max1976's partner. By clicking the button "show", the user can view max1976's current disclosed configurations as seen in (4).**

## 4.3 Results

In the following, we will summarize the results of our user study, describing the interactions performed with the app, the configurations the participants adapted, and questionnaire and interview results.

*4.3.1 Questionnaire.* Our participants reported being not very familiar with location-sharing in general ($M$ = 1.75, $SD$ = 0.83, on a 6-point Likert scale from 1 = "not familiar at all" to 6 = "very familiar"). They showed an average affinity toward technology on the ATI questionnaire. The mean score was 3.43, while the average can be expected to be around 3.5, the center of the scale [7]. Furthermore, we applied a privacy and data protection questionnaire by Buchanan et al. [5] that differentiates between general caution (GC), technical protection (TP), and privacy concern (PC) in technology users. Overall, the participants' values for the PC scale are below average with a mean of 44.38 (min 16, max 80), but show variations among participants ($SD$ = 6.69). Similarly, the participants' scores for TP and GC can be perceived as average ($M_{TP}$=21.50, $SD_{TP}$=2.74, $M_{GC}$=18.88, $SD_{GC}$=1.76; avg on these scales is 18). In terms of app usability, the mean SUS score of 80.63, indicating excellent usability, did not reveal any concerns for LYLO.

*4.3.2 User Interaction & Configurations.* Every participant regularly interacted with the app over the sixteen days. The interaction count ranged from 45 to a max of 151 over the course of the study period ($M$ = 67.25, $SD$ = 33.33). Interactions with the app and the configurations were more frequent in the beginning and declined slowly over the 16 days. The location-sharing was not disabled during the study by any of our participants. However, participants adjusted the settings individually, as can be seen in Figure 2. Besides P5 and P6, who did not change the disclosed configurations, all participants adjusted at least one setting. For example, P1 turned on the notifications on day 2 to be informed when the partner retrieves the location. P5, although not changing the settings, viewed the settings in detail. Five participants decided to turn on the *Notification* feature at least once during the study and had it active for one to fourteen days. Four participants further set the *Counter* for location retrievals to amounts between three and ten already early during the study on day one or two. While P7 increased the counter from five to seven, partner P8 decreased the counter from five to three and finally deactivated it all together after day three. In total, five participants defined a *Time Interval* for their partner in which the location was continuously shared. Intervals spanned at least six hours (P8) up to fifteen hours (P2), thus covering most of the waking hours of our participants. Three of the five participants disabled the setting again before the end of the study. Lastly, the *Accuracy* of the location sharing was adjusted by four participants. With "high" being the default setting in the beginning, participants explored the medium accuracy (P3, P4, P7) and also the low accuracy setting (P4, P8). However, all participants returned to the high accuracy setting until the end of the study.

*4.3.3 Interviews.* In the pair-wise interviews, participants indicated that they all at least looked at each other disclosed configurations in LYLO (P1, P2) and talked about the settings they set as well as their partner (P3-P8). When asked for their opinion, most participants liked the settings with which one can specify the CLS. P4 states that "[due to viewing the settings] you know where you stand", while P1 calls the settings "[...] a cool compromise" that makes the location sharing more transparent. Especially when hypothetically discussing the usage of LYLO for multiple users, our participants liked the idea of setting different configurations relative to their relationship with the individual person (P1, P4). For

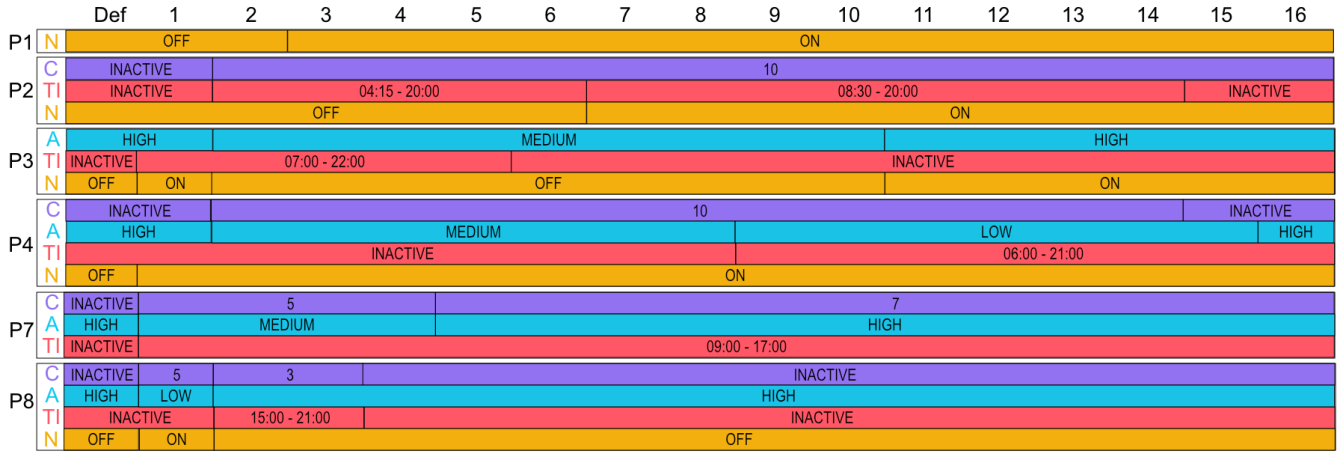


**Figure 2: The changes participants made in their location sharing configurations over the 16 day study period (x-axis). For each participant (pairs P1+P2, P3+P4, P7+P8, y-axis), the configurations Notification (*N*; ON|OFF), Counter (*C*; INACTIVE|n), Time Interval (*TI*; INACTIVE, time), and Accuracy (*A*; HIGH|MEDIUM|LOW) are shown. Note: P5 & P6 kept the default settings at all time.**

example, P4 mentions that "I actually thought it was pretty good because you could decide for yourself what to [share] and how intensively you wanted to be tracked [...]." P1 further highlights the benefits of the timer function and differentiates between times of the day where location tracking is ok and private times, i.e., in the evening starting 8 pm, saying "[...] what I do [from 8 pm on] is no longer anyone's business. Yes, I think that's a good thing." P3 and P4 positively emphasized the notification feature, considering this configuration option their favorite in the LYLO app. In particular, P3 mentions that "[he finds] the notification very good because, despite being checked, you can ask critically: Why do you want to know where I am every quarter of an hour? So it's a good instrument." Replying, P3's wife critically reflects on the implications of observing changes in configurations and that she would ask herself, "What purpose does he want to fulfill with it? I think then you interpret much more into it than is actually intended. If [he] now decides to go from the exact location to the radius, then I would ask myself, why is he doing it now." (P4). Critically reflecting on the performance of LYLO, our study participants noted that they were sometimes confused, on the one hand, because they mixed their configurations with the disclosed configurations of their partner (P1, P2) or because LYLO presented outdated location information (P3, P4). To make the location transmission more transparent, P3 suggests enabling users to set the frequency for location updates themselves. Regarding the accuracy feature, P3 noted that one could still determine a pretty accurate location of the other person by using multiple location requests. Similarly, P5 questions the usefulness of the app itself if one can hide one's own location by setting a radius. In general, participants would rather use the LYLO app if the underlying map information were not accessible to companies such as Google or Facebook, saying "What actually annoyed me [was] that I have my Google position active. That Google then also knows where I am [...]" (P3) or "[...] When I use Google Maps, I always have a bit of a dubious feeling". They would prefer using a system they consider more trustworthy (P3, P7, P8) and removing the foreground service(P7, P8).

As further suggestions for improvement, P5 recommends adding a history view of location requests. P8 says she would benefit from more contextual information included in the map view, such as available in Google Maps to look up more information on a location (e.g., which shops are in a building).

## 5 DISCUSSION

We have presented the implementation of LYLO, a CLS app with disclosed configurations. In a 16-day user study with eight participants, we evaluate the effect of the disclosed configurations on users' interaction with them and their general attitude toward CLS apps implementing such setting transparency.

Even though prior work has emphasized users' need to adapt the location accuracy [6, 10, 11], our study participants did not feel the need for changing the granularity of their shared location. Six participants explored the feature but all of them set it back to the default high accuracy before the end of the study, wondering why one would share their location while at the same time disguising it by reduced accuracy. Participants state that they rather differentiate the audience they share their location with. They preferred receiving notifications about location retrievals performed by their partner. However, our participants also report that this feature can create the feeling of being monitored. The decline in interaction with the configurations could also indicate a novelty effect.

Considering the possibility of CLS with multiple people of different levels of intimacy (e.g., friend vs. partner), our participants positively value the number of configurations in LYLO. Being able to adapt the configurations for individual people can convey a sense of control and flexibility in CLS. Through those different settings, participants can implement different levels of privacy. For example, one participant suggested specifying time intervals to distinguish between public and private times (i.e., working hours vs. leisure

time). Future work has to evaluate further how the use of disclosed configurations is perceived in other relationship formats such as parents with underage children, where location tracking can easily perceived as surveillance [3].

As CLS shows great trust in a partner, turning it off even momentarily can raise suspicions. Configurations reducing accuracy or setting time frames can help circumvent completely turning off sharing. However, these restrictions can, in the same manner, make people question the partner's reasons for not fully disclosing their location. In our study, participants reported, on the one hand, a positive increase of transparency due to the disclosed configurations and, on the other hand, having started interpreting changes in their partner's configurations – thus making them suspicious.

As the study ran during the COVID-19 pandemic, participants experienced limitations in moving freely, thus not following their "normal" activity behavior. Situations such as going out with friends or business trips did not occur. This limits the generalizability of our results. However, particularly during times where physical contact is limited (as for example in our mother-daughter pair), CLS may offer benefits of increasing the feeling of closeness and intimacy. Another limitation results from the imbalanced focus group gender distribution (80% male). This may have impacted selection of features for our system and has to be confirmed with a larger and diverse sample.

## 6 CONCLUSION & FUTURE WORK

In conclusion, our results show that people explored different CLS configurations as offered in our LYLO app. While their preferences for using features such as reducing the granularity of the location or being notified about location retrievals was highly individual, the participants agree that the configuration's disclosure increases the transparency of the app and the partner's actions. Overall, people appreciated the variety of features the LYLO app includes. However, they suggest using them to differentiate between relationships of different intimacy levels (i.e., colleague vs. partner) rather than changing them in different situations – while sharing their location with their partner, as they prefer to be fully transparent. As our sample included couples of high trust level and three couples of shared households, it remains for future work to investigate the acceptance of disclosed configurations in CLS in couples with less trust and control.

## ACKNOWLEDGMENTS

This project is funded by the Bavarian State Ministry of Science and the Arts and coordinated by the Bavarian Research Institute for Digital Transformation (bidt).

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