



Predators and Prey: Ubiquitous Tracking, Privacy and the Social Contract

Clara Mancini and Lukasz Jedrzejczyk and Keerthi Thomas and Blaine
A Price and Arosha K Bandara and Yvonne Rogers and Adam N
Joinson and Bashar Nuseibeh

15 June, 2010

Department of Computing
Faculty of Mathematics, Computing and Technology
The Open University

Walton Hall, Milton Keynes, MK7 6AA
United Kingdom

<http://computing.open.ac.uk>

Predators and Prey: Ubiquitous Tracking, Privacy and the Social Contract

Clara Mancini*, Lukasz Jedrzejczyk*, Keerthi Thomas*, Blaine A. Price*, Arosha K. Bandara*,
Yvonne Rogers*, Adam N. Joinson*, Bashar Nuseibeh*†

* Department of Computing, The Open University, UK

• School of Management, University of Bath, UK

† Lero, University of Limerick, Ireland

C.Mancini@open.ac.uk

ABSTRACT

Previous work examining privacy interfaces and user attitudes towards location tracking have relied on irregular manual updates from users, imprecise location information or information obtained via specialized equipment. We present a field study where 12 participants used their own mobile phones with automatic accurate location tracking over a 3-week period. We recorded over 1000 user tracking events, over 300 extended experience sampling entries and more than 15 hours of debriefing interviews. Taking an evolutionary perspective on location tracking, we observe how predator-prey dynamics interact with the social contracts that define our relationships and present a three-tire framework accounting for the complexity of users' responses to location tracking technology. We also discuss how the limitations of the technology currently available contribute to misperceptions and misinterpretations impacting on an individual's social interactions and how ubiquitous location tracking encroaches on the individual's fundamental need to safely withdraw from social interaction.

Author Keywords

Ubiquitous tracking, privacy, social contract, virtual tracking, predator and prey

ACM Classification Keywords

D.2.1: Requirements: elicitation methods; J.4 Social and Behavioral Sciences: sociology; K.4.1: Public Policy
Issues: privacy; I.4.8: Tracking

General Terms

Experimentation, human factors

INTRODUCTION

Until recently, the technology to remotely track individuals

Permission to make digital or hard copies of all or part of this work for personal or classroom use is granted without fee provided that copies are not made or distributed for profit or commercial advantage and that copies bear this notice and the full citation on the first page. To copy otherwise, or republish, to post on servers or to redistribute to lists, requires prior specific permission and/or a fee.

UbiComp 2010, Sep 26 – Sep 29, 2010, Copenhagen, Denmark.

Copyright 2010 ACM 978-1-60558-431-7/09...\$10.00.

automatically and accurately has been restricted to intelligence and security agencies. While cell triangulation allows mobile phone users to be tracked on demand, accuracy varies with cell density and can range from hundreds to thousands of meters. Active GPS devices are now used by companies to accurately track assets that are outdoors, visible to GPS satellites, but these usually require an external power source because GPS receivers are power-hungry. Many mobile phones are now GPS enabled and there are many hundreds of applications that allow location-based social networking and tracking but most of these require the person being tracked to manually initiate the application which identifies their location to the tracker. This means that accurate and timely location tracking data is not available on demand. Most studies of location tracking and privacy have used such inaccurate or manually controlled technology.

However, we designed a field study with a software-only technology mash-up that provides highly accurate location data at 10 minute intervals using participants own mobile phones. Our system, called *Buddy Tracker*, has a fully instrumented interface for both trackers and tracked. We studied 12 users over a three week period which included 903 unique user tracking and response events. Of these, 140 were prompted in order to trigger and study predator-prey dynamics. During the study we introduced a real-time feedback feature for the prey to examine how re-establishing reciprocity affected users' behavior. We also introduced a range of location-sharing preferences to observe usage patterns. In this paper we report both the quantitative and qualitative results from this field study, including unexpected observations regarding social translucency, privacy preferences and the attitudes of both predators and prey towards "always on" accurate location tracking.

In the rest of the paper, we first frame location tracking from an evolutionary perspective. We discuss how our study differs in scale, accuracy, and participants from previous related studies. We illustrate the technology and study design and report on the findings, proposing a three-tiered framework to describe the complex set of user responses. Finally we discuss possible threats to the validity of the study and consider future work.

BACKGROUND: THE TRACKING INSTINCT

Tracking is an inherited animal instinct and an essential part of what makes us human [1]. Its exercise was once essential to our survival, when failing to find potential prey could mean starvation, and some even argue that it informed the evolution of our intellectual constructs [2]. However, we never stopped exercising our tracking instinct in the physical world and continue to do so for different purposes, such as conservation, eco-tourism, scientific research, hunting, military operations, espionage or private investigations [3,4].

The practice of physical tracking

Tracking is a complex biosemiotic activity [5], which requires the skillful recognition of visual, auditory, olfactory and tactile signs left behind by a living, moving target (quarry or chase). It also requires the ability to blend in the surroundings to remain under cover, since an essential condition for tracking is the possibility to pursue without being noticed, the ability to see without being seen [3]. In this respect, tracking is a voyeuristic act, in that the successful tracker is eventually able to set eyes on and observe the object of his quest, if only for the brief empowering moments that precede a strike [6]. Those close moments can be so gratifying that they may be all a tracker seeks, when from the safety of his vantage point he can witness the motions of another's life and come closer to the reality of their identity.

However, physical tracking is seldom driven by voyeurism alone, because it is a resource-intensive and potentially hazardous enterprise. Following another may be costly, time consuming and risky. One of the main risks is certainly exposure, which may have undesirable and even dangerous consequences. The hunter who inadvertently reveals his own presence may lose his chance to acquire new provisions and the soldier who is caught in the act may lose his own life. But when tracking takes place among humans, exposure does not just mean losing the possibility to protect or acquire resources, it also affects one's social standing. Being caught may cost the soldier his life, but won't affect his social standing. However, the social standing of a suspicious husband caught while stalking his wife may be seriously affected, to the point of jeopardizing his marriage. Both the soldier and the husband lose something, but for very different reasons.

Tracking and the social contract

As a voyeuristic act, tracking objectifies the person who is being tracked, therefore placing itself outside any social interaction. However, the practice of tracking still takes place within a network of social relationships and its significance is determined with respect to the *social contracts* regulating those relationships. There is a long, philosophical and political, literary tradition behind the concept of social contract [7-10]. Here the term refers to the - explicit or implicit - *expectations* that define the relationships between *individuals*, within a wider social

context. These expectations are informed by each individual's set of values and beliefs and regard an individual's own obligations, responsibilities, rights and inclinations towards others, as well as the others' obligations, responsibilities, rights and inclinations towards them. Moreover, these expectations determine the way in which individuals manage their own social boundaries and observe the social boundaries of others, including privacy boundaries, as others have described them [11]. Privacy boundaries stand between the space in which an individual is accountable within a particular social contract and the space in which they are no longer accountable and have the *right to be let alone* [12].

From physical to virtual tracking

The risks of physical tracking make this practice only viable in response to significant demands or in prediction of significant benefits. Delegating the task to others may reduce the risks, but is costly and represents a commitment that can have practical and social implications. It might be more difficult for the wife to discover that her husband is stalking her, if he uses a private investigator, but if she does find out the consequences may be worse. With the availability of affordable technology [13] tracking has progressively become less risky and less costly, hence more viable in less extreme circumstances.

However, tracking modern mobile phone handsets automatically at the coarse level of cell triangulation is not yet widely accessible to ordinary individuals without prior arrangement with a mobile operator. Nevertheless, applications that manually or automatically log a user's location are becoming available and, although by installing a tracking application on their handset the bearer may implicitly give others permission to track them, they still may not know exactly when or by whom they might be tracked at any given time.

But what happens when tracking another becomes so viable and non-committal that it can be safely done at the click of a button? How does that impact on the way in which people deal with social boundaries? How does it affect the social contracts that regulate the relationships between people? We report on a quantitative and qualitative study of location tracking with two cohesive social groups, whose members did not habitually use tracking technology prior the study and had no apparent need to do so. Much like the ripples generated by a stone hitting calm water, our findings show the perturbing effects that the sudden introduction of tracking technology can produce.

RELATED WORK: MOBILE TRACKING AND PRIVACY

The impact of location tracking technology on social boundaries has been the focus of much investigation and reflection within the ubiquitous computing community. Rather than technologies that monitor people's presence in a place [14,15] or provide information on the proximity of places of interest [16], it is the studies on the use of technologies that remotely locate the bearer of a mobile

computing device that are particularly relevant to our work. Many of these studies have looked at the way in which users manage privacy boundaries with applications that share their location information only with their permission or consistently with specific privacy user policies [17-21]. This work has identified sharing patterns generally defined by the identity of the person requesting the information, the reasons why they ask for it and other contextual factors such as time and place. There seems to be consensus on the fact that generally people feel relatively comfortable with sharing their location with family and friends, but when it comes to others contextual factors play a more important role. But what if users could not choose whether to share their location and do not even know when others are looking at where they are?

Other relevant studies have precisely explored how the use of mobile tracking technology can affect individuals and their relationships, when users have no control over the fact that others can look at their location at any time anywhere. In particular, this work has studied the way in which location tracking devices are used by parole officers to control parolees during their rehabilitation process, highlighting the impact that this technology has on the parolees' lives when they become *accountable* [22] for their every move and on the parole officers' work when location is *commodified* [23]. Evidently, between parole officers and parolees there is a specific, asymmetric relationship of power, defined by a social contract in which voyeurism and control are the exclusive prerogative and responsibility of one party and in which therefore no social boundary management or observation are allowed or required. But what happens when the same conditions are reproduced within a cohesive social group, whose members hold more or less symmetrical relationships defined by social contracts that entail varying degrees of responsibility, care and trust, in which the different parties are both allowed and required to manage and observe social boundaries?

Our research explored the space of everyday social relations among family and friends when their social contracts suddenly come under the pressure of location tracking technology, all day every day for a period of weeks. We wanted to investigate how these technologies interact with social dynamics and affect social relationships, within ordinary cohesive groups. Specifically, our research highlights the tensions between the instinctual behaviors triggered by these technologies and the social contracts that users have with one another, and how this tension puts pressure on people as social and individual beings.

FIELD STUDY: PREDATOR VS PREY

Our field study involved one group of seven and one group of five participants who were asked to use a location tracking application installed on their own mobile phone over a period of three weeks. During most of this period, participants had no way of making themselves invisible to others: they were asked not to switch the application or

their phones off, and had no possibility to limit the access that their co-participants had to their location information. Also, during more than half of the period, they had no way of knowing who was locating them and when. We were interested in exploring the behavioral and social dynamics triggered within the groups under the pressure of constant exposure, when everyone could be at the same time predator and prey of their group members. To find out, we monitored their tracking activities through a fully instrumented interface, modified experience sampling with deferred contextual interviews [24], and individual debriefing interviews at the end.

Technology

Participants were asked to use our custom-built Buddy Tracker application which allows users to locate their buddies on their mobile device with the benefit of several functions.

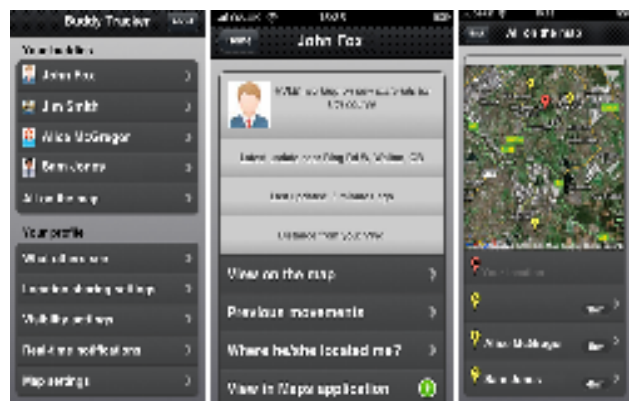


Figure 1. Three anonymized screens from Buddy Tracker: Main menu (Left); Individual Profile (Middle); All on Map (Right).

Functionality

Buddy Tracker's functions are accessible via the two main areas of the interface (Figure 1). These include access to a map displaying simultaneously the location of all the buddies and to their individual profiles providing textual information about their current location and a link to an interactive map application. Other important functionalities which we made available in the second part of the study included allowing the user to set their location-sharing or real-time notifications preferences (shown at the bottom of the main menu in Figure 1).

- **Feedback.** Every time a buddy looks at a user's location, the user receives real-time notification via a text message. Additionally, an aggregated feedback mechanism allows users to see who has accessed their profile, location or location history: every request is stored in a database with time and location information, so users can view all location requests made by their buddies and see on the map when and where these were made.
- **Sharing preferences.** Privacy management options include time-sensitive coarse-grained visibility settings

(e.g., allowing the user to make oneself invisible for a few hours) and peer-to-peer coarse or fine-grained settings (e.g., allowing the user to let a buddy see their location only at city level).

Technical Details

Buddy Tracker's design combines several separate services, which allowed us to quickly prototype, automatically deploy, and update services in the field without access to the participants' handsets. The application uses the Navizon service, which updates our server every 10 minutes exploiting the most accurate positioning system visible to the device at the time: GPS, Wi-fi, or cell triangulation. We found this service to be the most accurate and easiest to set up, while offering the best power economy and highest accuracy among the services we considered. The user interface was developed as a web application, appearing and functioning much like an Apple iPhone native application. This allowed us to activate and deactivate features instantly by changing configuration on the server and to monitor usage of the system, sending real-time feedback to users whose location had just been viewed.

Methodology

Participants

We solicited participants through word of mouth, mailing lists, and social networking sites. For technical reasons and to avoid training and Hawthorne effects, we required all participants to already have Apple iPhones. We then chose our groups based on the number of co-participants they could bring and their regular patterns of mobility and diversity, so that location tracking would be a worthwhile activity for them. Participants were offered a small payment for each week of the study.

The first group was composed of a married couple, their three daughters and the partners of the two older daughters. The married couple was in their fifties, working locally and living together with their youngest daughter, who was in her teens and frequenting high school. The older daughter was in her early twenties and living away from home to frequent university. Her boyfriend of six months was in his late twenties and lived in a different city. The eldest daughter was in her mid twenties and lived and worked in another city with her long term partner, who was in his early thirties. Years prior to the study, the family had used location tracking technology for security purposes, when they were living in their country of origin, where crime levels were high and abductions were frequent. Since starting a new life in a different part of the world, they had felt safe and never needed to use tracking technology again.

The second group was composed of another married couple, their two children and a friend of one of the children. The couple was in their forties, working locally and living together with their younger daughter, who was in her early twenties and worked out of town. The older son was in his early twenties and lived in the same city with his

friend, who was also in his twenties and worked around the country.

Study design

During the three weeks of the study, the participants were asked to carry their phone at all times and leave it switched on, in order to be traceable by the members of their group at all times. We installed Buddy Tracker in such a way that participants could not easily switch it off and monitored all users to ensure they were active. The overall period was divided in four different phases. During the first phase, participants were invited to familiarize themselves with the application by freely tracking their co-participants. During that phase we just monitored their usage patterns and movements via Buddy Tracker's administration panel, in order to acquaint ourselves with the participants' significant places, movement patterns and daily trajectories. During the second phase we started giving participants location tracking tasks, to trigger predator-prey dynamics that would allow us to explore their reactions under pressure. Once or twice a day each participant was asked to locate one co-participant who appeared (from the administration panel) to be in a location of possible interest and far from the participant receiving the task. The tasks were in addition to any tracking activity that the participants were spontaneously undertaking. During the first and second phase, participants were constantly visible and could be located by any of their co-participants at any time without being aware of it. This artificially mimicked the situation of a prey being tracked. However, this arrangement changed with the third phase, in which, without pre-warning, participants started to receive real time feedback, in the form of a text message, every time someone located them. This mimicked the situation of the predator suddenly being exposed, re-establishing a certain balance between the parties and attaining social translucency [25]. During this phase participants continued to receive daily location tracking tasks. Finally, with the third phase, we enabled participants to use location sharing preferences. These allowed them to blur or hid their location completely. This was in addition to the location tasks and the real time feedback.

Data collection

We gathered the participant's feedback on their experience both during the study and at the end of it. During the study, we used an enhanced form of experience sampling [24]. Because Buddy Tracker was developed as a web application and we were able to monitor usage of the system, we could send instant sampling requests to the users' mobile phone, upon each tracking event. Therefore, Every time a participant tracked a co-participant, the system would send them a text message asking them to follow a link and fill an online questionnaire accessible via their phone. This included three pre-defined multiple-choice questions and a request for a memory phrase to help the participant remember the specific episode during the debriefing interview. The questions asked users: 1) why

they had just carried out an action, 2) if what they found was what they expected, 3) how they felt about what they found.

At the end of the study, each participant was interviewed. Individual interviews lasted between one and two hours, during which participants were shown the print-outs of the maps outlining their daily trajectories for the duration of the study, with the request to identify places significant to them. They were also shown all the experience sampling forms they had submitted. Finally, they were shown the records of the activities they had undertaken as predators and those they had undergone as preys. They were asked detailed questions about all the data sets they had generated. The questions were aiming to explore their reasons for, feelings about and context around their tracking behavior.

Findings

Our system recorded a total of 903 unique user tracking events. 140 of these were instigated by us, but the rest were the result of spontaneous usage. Of all these events, 31 were viewings of the current location of all buddies; 147 viewings of the current location of a single buddy; 121 viewings of the current location of a single buddy on a map; 7 viewings of the past location of a buddy; 1 viewing of one's own location as seen by others; 2 activations of location-sharing preferences. The viewing solicited a wide range of emotional responses, as evidenced by the participants' answers to the experience sampling questions. However, the debriefing interviews offer us a much better insight into the participants' experience with location tracking.

A morality of tracking

On the surface, the findings appear diverse and sometimes even inconsistent, but a closer analysis reveals a richly articulated picture of feelings, attitudes and behaviors around the participants' location tracking activity. The apparent heterogeneity of the findings can be explained by taking into account the interaction of three variables: a participant's set of values and beliefs; their perception of the social contracts defining their relationships; and their assessment of their and others' reasons for tracking. More specifically, the participants' set of values and beliefs appeared to determine their perception of what the social contracts defining their relationships with others entailed. In turn this appeared to determine the way in which participants assessed their motivations for tracking their co-participants and their co-participants' motivations for tracking them. Here we illustrate the interconnection between these variables from the point of view of the participants as 'predators'. This is only because, in their active role, participants were compelled to reflect on what they were doing and therefore their input as 'predators' provides a more fine-grained picture of the dynamics at play than their input as 'prey' does. However, the underlying responses we received from both sides were consistent and symmetrical, as we discuss later.

• **Values and beliefs.** While participants' sets of values and beliefs varied, emerging against their cultural, emotional and experiential background, we found that they invariably informed their general attitudes towards location tracking technology and the compatibility of its use with respect to the social contracts defining their relationships with the other co-participants. For example, the mother from the first group commented that, compared to their country of origin, she found the country where she currently resided with her family very safe and therefore she felt that there was no necessity to track her children: *"Like if they were in [country of origin] and I was living here I would worry more...but here they are safe...nothing happens here so I'm crossing the line. I do it because I can and that's not good enough."*

She also commented how, unlike partners, children have a life of their own and as a parent she ought to respect that: *"I think I would feel bad checking on the kids because I do feel that is overstepping a privacy line...I think mummy can't know everything about children...I would feel bad checking on the kids...I would only check on the kids in an emergency..."*

However, the mother from the second group commented that, doing social work in the rehabilitation of young offenders, she was aware of how many dangerous people there are out there, especially driving on the road, and therefore found herself driven to frequently check on her adult children to make sure they had made it to their destination safely: *"I'm a big worrier and especially since my son moved out and if my daughter goes out because I know what people are like on the roads and I just know what it could be like...I think it's alright checking on them"*

She also commented that their children were aware of and accepted the fact that she was a protective mother: *"It's not to go in their space (about tracking) – I mean both of them have said any time I can phone them or text them..."*

In this respect, the participants' views were some times opposed. For example, one of the participants from the first group felt very uncomfortable about the whole idea of tracking, whether she was tracking or being tracked: *"...I must say I don't feel very comfortable with this technology so I don't like using it very much at all."*

Whereas her partner had no problem with it and, on the contrary, was very enthusiastic about the technology and what it can achieve: *"...makes me feel closer to [my partner] and 99% of the time I know exactly where she is anyway, because we are speaking or standing next to each other, so that is nice..."*

• **Social contracts.** The participants' perception of what the social contracts defining their relationship with the other co-participants entailed played an important role in determining their use of the technology and their feelings about it. Participants seemed to make clear distinctions between the meaning of tracking a parent, a child, a partner,

a sibling or a friend. For instance, their attitude varied with the level of responsibility they felt towards each co-participant. The mother in the second group used the tracker almost exclusively towards their children, rather than her husband, as a way of fulfilling their maternal role: *"I felt god about it because even though they've got mobiles and I can get hold of them at any time, with this I was looking where they were without disturbing them...because [my son] doesn't live at home anymore, it's reassurance that I know he's in a certain area ..."*

The older sisters in the first group felt more inclined to use the technology to track the younger one, as they felt more protective towards her: *"I feel more protective of [my youngest sister] than I do for [my other sister], I feel as though I am entitled to know what she is up to, more than with [my other sister], because I know [my other sister] is grown up, she'll be fine, she's running her own life..."*

The young males in the first group also used the tracker more protectively towards their partners than the other way round: *"...I looked and I saw that she was at home, I knew that she was safe, it was nice..."*

However, the son in the second group felt less comfortable about tracking his sister than he did with his mother, because he considered that to encroach on his sister's independence: *"I feel I shouldn't check on her so much, as she is her own person and I ought to respect her independence..."*

The mother in the second group made a clear distinction between tracking her children and tracking someone else's child, her son's housemate: *"...I thought, what am I doing checking on him, he is not even my son..."*

We also observed how, as the relationship between two co-participants evolved, their social contract underwent an unspoken revision and, as a consequence, their attitude towards tracking the other were no longer the same. As the mother in the first group became acquainted with the recent partner of her daughter, her feelings about tracking him became more ambivalent. While prior to their acquaintance she did not feel motivated to look up his location but at the same time felt perfectly comfortable in doing so when we gave her the task to do so, following their acquaintance she felt more motivated to protectively check on him but at the same time she started feeling uncomfortable about crossing a boundary and entering his space uninvited: *"...quite honestly I wouldn't have known he was sick, I wouldn't have cared, but because he spent the weekend here and he tried so hard not to be sick and he was polite and charming and helpful so he really went out of his way...I looked where he was, because if he was at home I probably wouldn't have texted but because I saw he was at work I texted to say I hope your are better...I felt uncomfortable [about checking, now that I knew him better]..."*

Another participant confessed that they had no problem tracking one co-participant who had previously breached

the social contract between them by breaking their trust. The participant deemed the co-participant no longer deserving of boundary observation and was checking on them expecting to catch them at fault: *"...I feel because they have shown in the past that they are not trustworthy, that kind of they started it and it means I can check up on them and not feel too bad...they are unlikely to do what they say they do so anything you see [on the tracker] is probably just going to confirm that..."*

Our findings also show that two participants' could have different perceptions of what their social contract entailed and this difference resulted in different expectations with regard to tracking behavior: *"I think even for my children I think is a strange application...I would not mind [them tracking me] but I would ask them why they are checking..."*

"I feel with my parents, I feel entitled to know where they are all the time and what they are doing whatever...my mother, she would be thrilled to know that we are checking on her..."

Overall, the findings indicate that within social contracts participants tended to feel varying levels of interest and responsibility towards others, which proportionately translated into either a sense of entitlement to entering others' personal space or into a sense of concern about crossing that boundary. Outside of social contracts there tended to be no interest or responsibility towards others and therefore neither there was sense of entitlement or concern. However, if others breached a social contract, there remained interest but not responsibility, and therefore there was sense of entitlement but not concern, which permitted predatory behavior.

• **Tracking motives.** We found a strong correlation between the way in which participants felt about tracking and the way in which, within their set of values and beliefs and with respect to their social contracts, they assessed their motives for looking at others' location. The motives emerging from our data included: protection, care, connection, reassurance, co-ordination, curiosity, inspection and of course execution (when participants were carrying out a task).

There were instances in which participants looked at a co-participant's location in the intent to protect them from potential harm and, because that intent was consistent with their social contract with the co-participant, they deemed that acceptable. For example, the mother in the first group once tracked her youngest daughter hoping to be able to spare her the reproaches of the sisters for being late: *"...they were asking where is she and the sisters sometimes do have words between each other so I thought I would try and find [name] and tell her to move it. I was trying to save a fight between the sisters."*

In other instances participants used the tracker to offer some form of care and support to their loved ones, which was also deemed consistent with their social contract and

therefore acceptable. For example, the eldest daughter in the first group once looked at her younger's sister location knowing that she was unwell and unable to take a phone call because she was studying: *"So it was kind of like I wish I was there with her because I could bring her tea...when you're sick you want people to look after you, you want them to be there but you know that was the next best thing I could do and I knew she was trying to study so I wasn't going to call her and disturb her."*

At times participants tracked a co-participant in order to bridge physical distance between them and feel closer, as the partner of the eldest daughter in the first group did several times with no concerns: *"So I was already checking on her, I'd only just arrived at the airport and I was already missing her..."*

Tracking a co-participant with the intent of reassuring oneself evoked mixed feelings. Reassurance could concern different things and was assessed accordingly: reassuring oneself that a loved one is safe was seen as caring act even though a self-serving one; reassuring oneself that everyone is where they are expected to be and that everything is in order was seen as self-gratifying but relatively innocuous; reassuring oneself that that one still occupied a certain rank in the social scale of another was seen as less acceptable. For example, the father in the first group once checked on his youngest daughter to reassure himself she was safe one night when she went to a party: *"I saw that she was still at the party and not somewhere else and I felt reassure that she was in no riskier place than I expected..."*

On the other hand, the mother in the first group once looked at her eldest daughter's location from whom she had been waiting a phone call to reassure herself that the daughter had not just forgot about her: *"I would have been very disappointed if I had seen her back in her office and that she hadn't phoned me. That she had not found two minutes to phone me in between but she was still exactly there [at the interview] and she did phone me before she left the building."*

The intent to co-ordinate one's movement with another to save time and work had no social implications in the view of the participants and was clearly seen by everybody as a perfectly legitimate motive for tracking. For example, by the father in the second group: *"If I am going to be picking her up from university and I want to check where she is so that I am not too early or too late I don't have a problem with it, because it is part of an interaction between the two of us and it is leading to that interaction."*

However, curiosity was seen as a much less legitimate motive, as it seemed to have no other aim but the voyeuristic intent to take a pick in someone else's personal life, as the mother in the second group was well aware: *"I think it is not good when someone is just being nosey, that's not right, just looking to be nosey..."*

A typical example of inspective tracking was the one mentioned above of one participant checking on a co-participant to expecting to catch them were not supposed to be: *"...I was checking on them...if the tracker had shown them anywhere else [other than where I expected them to be] I would have gone ah! my worst suspicions are confirmed..."*

Finally, participants consistently felt completely detached when they were carrying out a tracking action to execute our tasks. In those instances, they delegated responsibility for that action altogether and didn't even need to assess its legitimacy:

"...it was easier to do when I was asked to do so...I didn't feel it was my responsibility...it wasn't me doing it, I was just carrying out a task..."

The above list of motives does not intend to be exhaustive but only to illustrate how participants' attitudes, feelings and behaviors about tracking their co-participants were a function of the way in which they assessed their motives. Generally speaking, participants found their motives for tracking a co-participant acceptable or even commendable when these were honoring their social contract with them, by facilitating the social functions entailed by that contract. However, when their motives could not be justified with respect to those functions, the tension between the two generated in the participant feelings of discomfort proportionately to the perceived incompatibility between motives and functions.

The liabilities of tracking

Participants' feelings of comfort or discomfort reflected their general level of acceptance of, or concerns about, the use of tracking technology. The technology was generally seen as having a beneficial impact on the participants' lives as long as it supported the fulfillment of their social contracts by facilitating the social functions that those entailed. However, participants also expressed significant concerns regarding fundamental and less socially acceptable aspects of the tracking practice, which are emphasized by mobile tracking technology. These emerge symmetrically from the participants' activity as predators as well as their activity as preys. They can be divided in two main categories pertaining respectively to the technology's mediation of social interaction and to the technology's mediation of a-social action.

• **Tracking technology and social interaction.** In their role as prey, one of participants' main concerns was the possibility that their behavior might be misinterpreted on the basis of location information alone. If a participant did not appear to be where they were expected to be, or if they did not appear at all, others might have jumped to conclusions: *"She was really sick one night and I was at home, she was ill and she was ringing me to say she can't sleep, and I didn't answer my phone coz my battery was flat and I remember the next day she said what happened why*

did you turn your phone off and I said my phone wasn't off, my battery was flat."

Moreover, of all the participants, only one ever made use of the location-sharing preferences and only once; otherwise a number of participants said that they did not or would not have used the location-sharing preferences because others would have questioned why they felt the need to hide:

"...no I didn't use the privacy settings because if I had they the others could have asked me why did you hide your location, have you got something to hide?"

Symmetrically, in their roles as predators, participants were equally concerned about the possibility that they might make unexpected discoveries about the location of others and not being able to refrain from making assumptions: *"It is just with Ryan there was one night...I know he had gone out and I wanted to know where he was, so that I could know if he was at home and I could phone or if he was still out and wouldn't answer his phone, so I looked him up but it said it was last tracked four hours ago which was when he left work. So I thought oh did he turn his phone off? ...or did he turn the tracker off and why did he do that because I now he is going out, and so then and also I was ill so I start thinking so why didn't he tell me? Who is with? And why is he there? And that was the thing. Actually he was at home and asleep. I phoned him and his phone was on silent so he didn't answer..."*

Some participants also said they would prefer not to receive real-time notification when someone checked their location, because that would make them question others' motives: *"...I would prefer not to know, because otherwise I would have to start asking myself why they are checking on me...have I done something wrong...are they after something..."*

In sum, as preys participants were concerned that the information provided by the tracker might distort others' perception of who they are, while as predators they were concerned that the information provided by the tracker might unnecessarily destabilize their perceptions of their co-participants, perceptions on which they relied to maintain their social contract with them.

• **Tracking technology and asocial action.** By definition voyeurism objectifies the viewed person and therefore cannot be integrated in social interaction, nor can it facilitate the functions of entailed by a social contract. Both predators and prey seemed to be well aware of that and seemed uncomfortable with the voyeuristic aspect of the tracking practice unless their activity could be somehow absorbed within their social interactions. As predators, participants tended to feel most uncomfortable when tracking was just motivated by curiosity without any other justifiable purpose, but they were aware of it in general. Yet, they found it difficult to resist the temptation of using the tracker to pursue others: *"...I don't think it makes me a better person checking up on people...I think what drives*

these questions is never really a positive thing, it's either I am afraid for you or I don't trust you, it implies some sort of insecurity on my part..."; "...it is not my place to [check on people] and I know that so I try and stay far out of it as I possibly can because it's none of my business at all, but this [technology] makes it a little bit too easy, doesn't it, you are only human..."

Some found it even addictive: *"...yes, it's quite addictive...I got used to using it a lot and now that the study is over I really miss it..."*

Only as they started to receive real-time notifications about the fact that they were being located, they suddenly realized that their co-participants must be getting notifications too and most of them started refraining from voyeuristic uses of the tracker. Across both groups we noticed a significant drop in the frequency of location checks once notifications were activated.

Symmetrically, as prey, several participants were clearly uncomfortable when they were shown the printouts with the maps outlining their daily trajectories: not only was that evidence of the fact that we had been tracking them, it was also putting them in a self-voyeuristic position that made them aware of their potential vulnerability: *"...even seeing my life all laid out on a map, if I cannot remember a place I went to and I can't explain, it's really uncomfortable..."*

Some participants were also uncomfortable about being 'voyeured', as they feared that they would have to be able to explain their every move. Even though they had nothing to hide and even though where they went or what they had done was not significant, they felt that they would have to be able to offer an explanation that they did not have: *"...it might be I've done nothing wrong but I might have not done enough right. I thought you were at the office but it took you long enough to get there. Well I got lost, didn't do anything wrong. Well why did you get lost. Well it doesn't matter..."*

There are trails in our daily life that we cannot explain and that may be insignificant, but their representation via a tracking device, does give them significance. However, because it *commodifies* those trails [22], trails outside any social interaction, it reduces them to objects of possible predation, which seemed to make both predators and prey uncomfortable.

Threats to validity and future work

There were certainly limitations to our study. Our sample was not very large or representative. Many observations would only apply in a close family group, therefore our findings cannot be generalized at this stage. However, generalization was not our aim here: our intent was to start exploring the dynamics that are triggered by the use of automatic, accurate location tracking technology and how these impact on the interaction between the individual and their immediate social environment. More extended studies will need to be carried out to generalize our findings. The

duration of the study was also relatively limited. However, we were interested in examining the effects of the sudden introduction of such an intrusive technology in an environment in which there seemed to be no obvious demand for it. Finally, certainly our manipulation of the application's features and the assignment of location tracking tasks to participants introduced a certain level of artificiality into our study. However, it allowed us to approach such a complex phenomenon in a more analytical way by dissecting it into significant components.

DISCUSSION AND CONCLUSION

There has been much emphasis in research on the aspects of privacy that concern the protection of information, whether from being unduly collected, processed or disseminated [26]. However, some [27] distinguish another important aspect of privacy concerning one's protection against invasion. In particular, one form of invasion seems directly relevant to the issues raised in our study of mobile location tracking technology: *intrusion*. This includes boundary breaches such as incursions into one's life, disturbance of one's daily activities, alteration on one's routines, or encroachment on one's solitude. Solitude is the state of being alone or able to retreat from the presence of others [12] and rest from the pressures of living in public or performing public roles [28]. In other words, the state of solitude is the possibility of not having to be accountable within a social contract. This includes not having to engage with the world through a social contract, and not being perceived by others or by ourselves with respect to our ability to honor a social contract. As one of our participants said: *"I like to be with my wife and when I am with her I obviously take her into consideration and I adjust my behavior to accommodate that. So being free of those limitations whatever benefits they bring to my life at certain stages, it's pleasant. The nature of this cuts into those freedoms, that even if it is that I might never use them again, in other words that I might spend the rest of my time living inside the house, the concept of when I drive somewhere or I do something the next set of decisions and choices don't have an explanation required, they are what they are, they stand on their own."*

The state of solitude is so important that it is protected by the individual's *right to be let alone* [12]. But the very concept of location tracking seems to be at odds with the idea of being let alone, perhaps because places are so connected to the activities that give them meaning, which in turn are connected with what we may be doing in those places and, ultimately, who we are. Yet, in our study, for the most part people opted not to use those features of the tracker that would have allowed them to regain their solitude following a relatively long period in which they had none. But as we saw, this was mostly because they were concerned that hiding themselves might be negatively assessed by others. However, for as long as we perceive our instinctive desire to hide to be looked at with diffidence or suspicion by those we are socially engaged with, location

tracking technology will make it difficult for us to find our state of solitude and exercise our right to be let alone.

We have seen how people tend to be socially concerned and worried that the information provided by their tracker might either distort others' perception of who they are or their perception of who those related to them are. These concerns result from the tension between the real-time representation of one's movements and the impoverished representation of their context provided by location tracking technology currently available [23]. While on one hand the iconic signs of a map are inadequate to describe the context that the map poorly refers to, on the other hand the indexical sign of a dot moving in real-time elicit an impression of reality that triggers an inferring response. The exercise of tracking in these rudimentary virtual environments is far removed from the skilful biosemiotic activity of physical tracking, but the instincts that are triggered are the same and so we respond in a similar way. Only tracking technology capable of mediating context in a much more sophisticated way could begin to address this issue and reconcile its contradictions. However, if such technology was ever developed, that would exasperate what appeared from our findings to be an even bigger concern: voyeurism.

But what's so wrong about voyeurism and why is feeling watched so uncomfortable, after all? From an evolutionary point of view, voyeurism is not end to itself, it serves a purpose. The aptitude of voyeurism is instrumental to the pursuit and capture of a chase, and therefore voyeurism is instinctively associated with the imminence of a strike. Just as tracking is a primordial instinct, so is our reaction to being watched imprinted in us. Unless it can be somehow absorbed in the fulfillment of acceptable social functions, voyeurism is bad news and, in this respect, mobile location tracking technology is the messenger. In those brief moments in which we are momentarily exonerated from honoring the network of contracts that define who we are with respect to others and are free to roam and graze alone in the woods, we do not need to be reminded that we are always potential prey for a hungry predator.

ACKNOWLEDGMENTS

[removed for blind review]

REFERENCES

- [1] P. Shepard and M. Midgley, *The others: How animals made us human*, Island Press, 1996.
- [2] P. Carruthers, *The roots of scientific reasoning: infancy, modularity, and the art of tracking*, Cambridge University Press, 2002.
- [3] D. Diaz and V.L. McCann, *Tracking-Signs of Man, Signs of Hope: A Systematic Approach to the Art and Science of Tracking Humans*, The Lyons Press, 2005.
- [4] A. Lindgren, C. Mascolo, M. Loneyan, and B. McConnell, "Seal2seal: A delay-tolerant protocol for contact logging in wildlife monitoring sensor

- networks,” *In proc. of IEEE Int'l Conference on Mobile Ad-hoc and Sensor Systems (MASS08)*, 2008.
- [5] J. Conesa-Sevilla, “Thinking in Animal Signs: Tracking as a Biosemiotic Exercise, Ecopsychological Practice, and a Transpersonal Path,” *The Trumpeter*, vol. 24, 2008, pp. 116-125.
- [6] “Why Do Hunters Hunt - Why Hunters Pursue and Kill Animals.” <http://hunting.about.com/library/weekly/aa022899.htm>, last accessed 12.03.10
- [7] J.J. Rousseau and D.A. Cress, *Basic political writings*, Hackett Publishing, 1987.
- [8] J. Rawls, “A Theory of Justice,” *Harvard University Press*, 1971.
- [9] D.P. Gauthier, *Morals by agreement*, Clarendon Press Oxford, 1986.
- [10] W. Charles, “Mills, The Racial Contract,” *Cornell University Press*, vol. 18, 1997, pp. 26–27.
- [11] P. Dourish and L. Palen, “Unpacking” privacy” for a networked world,” *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI'03)*, Ft. Lauderdale, Florida, USA: ACM, 2003, pp. 129–136.
- [12] S.D. Warren and L.D. Brandeis, “Right to Privacy,” *Harvard Law Review*, vol. 4, 1890, p. 193.
- [13] “Spy Shop – The Risk of Voyeurism - Spy Equipment UK.”, www.spyequipmentuk.co.uk/spy-shop-the-risk-of-voyeurism.html, last accessed 12.03.10
- [14] P. Dourish and S. Bly, “Portholes: Supporting awareness in a distributed work group,” *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI'92)*, New York, NY, USA: ACM, 1992, pp. 541-547.
- [15] B. Brown, A.S. Taylor, S. Izadi, A. Sellen, J. Kaye, and R. Eardley, “Locating family values: A field trial of the Whereabouts Clock,” *Proceedings of UbiComp 2007*, Innsbruck, Austria: Springer-Verlag, 2007, pp. 354-371.
- [16] L. Barkhuus and A. Dey, “Location-Based Services for Mobile Telephony: a study of user's privacy concerns,” *Proceedings of INTERACT 2003, 9th IFIP TC13 International Conference on Human-Computer Interaction.*, Zurich, Switzerland: IOS Press, 2003, pp. 709 -712.
- [17] S. Lederer, J. Mankoff, and A.K. Dey, “Who wants to know what when? privacy preference determinants in ubiquitous computing,” *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI'03)*, Ft. Lauderdale, Florida, USA: ACM, 2003, pp. 724-725.
- [18] S. Consolvo, I.E. Smith, T. Matthews, A. LaMarca, J. Tabert, and P. Powledge, “Location disclosure to social relations: why, when, & what people want to share,” *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI'05)*, Portland, Oregon, USA: ACM, 2005, pp. 81-90.
- [19] A. Khalil and K. Connelly, “Context-aware telephony: privacy preferences and sharing patterns,” *Proceedings of the 20th Conference on Computer Supported Cooperative Work (CSCW'06)*, Banff, Alberta, Canada: ACM, 2006, pp. 469-478.
- [20] N. Sadeh, J. Hong, L. Cranor, I. Fette, P. Kelley, M. Prabaker, and J. Rao, “Understanding and capturing people’s privacy policies in a mobile social networking application,” *The Journal of Personal and Ubiquitous Computing*, vol. 13, 2009, pp. 401-412.
- [21] L. Barkhuus, B. Brown, M. Bell, S. Sherwood, M. Hall, and M. Chalmers, “From awareness to repartee: sharing location within social groups,” *Proceeding of the SIGCHI Conference on Human Factors in Computing Systems CHI'08*, Florence, Italy: ACM, 2008, pp. 497–506.
- [22] E. Troshynski, C. Lee, and P. Dourish, “Accountabilities of presence: reframing location-based systems,” *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI'08)*, Florence, Italy: ACM, 2008.
- [23] I. Shklovski, J. Vertesi, E. Troshynski, and P. Dourish, “The commodification of location: dynamics of power in location-based systems,” *Proceedings of the 11th Int'l Conference on Ubiquitous Computing*, Orlando, Florida, USA: ACM, 2009, pp. 11-20.
- [24] C. Mancini, K. Thomas, Y. Rogers, B.A. Price, L. Jędrzejczyk, A.K. Bandara, A.N. Joinson, and B. Nuseibeh, “From spaces to places: emerging contexts in mobile privacy,” *Proceedings of the Int'l Conference on Ubiquitous Computing (UbiComp'09)*, Orlando, Florida, USA: ACM, 2009, pp. 1-10.
- [25] T. Erickson and W.A. Kellogg, “Social translucence: an approach to designing systems that support social processes,” *Trans. on Computer-Human Interaction (TOCHI)*, vol. 7, 2000, pp. 59-83.
- [26] A.F. Westin, *Privacy and freedom*, New York, NY, USA: Atheneum Publishers, 1967.
- [27] D.J. Solove, *Understanding privacy*, London, UK: Harvard University Press, 2008.
- [28] P. Koch, *Solitude: A philosophical encounter*, Open Court Publishing, 1994.