Understanding Recording Technologies in Everyday Life

Feedback about the reality of using today's recording devices can provide insight into how design, technology, and policy can work together and inform the appropriate usage of such devices.

Electronic records of our daily activities are now common, with both corporations and government agencies regularly amassing financial transactions, healthcare records, Internet browsing habits, and more as "digital dossiers."[1] Similarly, most of us now regularly accumulate our own myriad recordings of ourselves, our friends and family members, and even strangers to share on sites such as Flickr, Facebook, and YouTube. Closed-circuit television (CCTV) systems operate 24/7 almost everywhere, from homes to shops to public squares, and are used for vastly varied purposes. For example, some cameras might protect certain spaces against theft and vandalism, but restaurant managers might use them to watch for tables in need of service.

Existing recording technologies help us study the issues inherent to emergent pervasive computing applications, including how people reason about such technologies, assess their presence or absence, and consider the data they record. In turn, these processes provide insight into how people can and should be informed about the context of recording (who does it, when, where, and how). As more pervasive recording technologies enter the research and market spaces, understanding how and when to inform people about recording will become even more important.

Despite this need, grounded reactions to recording technologies can be difficult for researchers to obtain. For example, the Pew Internet Project asked experts to speculate on the future of recording technologies and found that approximately half of those involved in Internet technologies believed that, by 2020, the benefits of recording technologies wouldn't be worth the cost paid in the loss of privacy.[2] Various other projects have focused on directly querying concepts about pervasive recording in town squares and other public arenas.[3] These studies all follow a similar approach: ask people about hypothetical or abstract situations regarding emergent pervasive recording technologies. Another approach has been to focus on new technologies under development in controlled or semicontrolled trials. During these studies, participants are typically aware of the recording technologies because the researchers asked them to participate in a trial or provided a description of the technology prior to the study.

In contrast, we approached studying the understanding of recording technologies as a series of contemporary and situated phenomena, highly contextualized and intertwined with not only the abstract beliefs of the in-

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Related Work in Pervasive Recording Technologies

Video surveillance technology has existed for approximately 50 years and is today most widespread in Great Britain, where it's estimated that in 2003 there were approximately 4.3 million cameras in use. Previous studies surrounding these technologies in the UK report that most people think it's acceptable to use hidden CCTV but that they have the right to know when they're on camera.[1] Furthermore, they note that most people believe that CCTV can be abused. They also demonstrate the ways in which society is quickly evolving and adapting to these technologies. For example, in 1992, most of a survey's respondents wanted a large notice where cameras were used.[2] However, by 2003, the majority of this group no longer wanted these signs.[1]

In pervasive computing research, very few in situ studies have been conducted that focus on attitudes toward and perceptions of recording services. Giovanni Iachello and colleagues reported that when probed after specific conversations, people wanted to know about audio recording but wouldn't ask for recordings to be discarded.[3] Batya Friedman and colleagues recorded passersby and then notified them of an observer watching a video feed from a different location. The experimenters conducted interviews, observing that what people perceive as privacy violations change depending on technical, social, spatial, gender, and psychological considerations.[4] In these studies, participants were explicitly informed of specific hypothetical, or real recording technologies and probed.

Researchers have developed theories surrounding issues that are important and related to recording technologies, such as privacy. Giovanni Iachello and Jason Hong provide an excellent overview of these works in the areas of privacy and security,[5] a scope too large for this article. Interestingly, many findings in this area have resulted incidentally from studies exploring other issues. For example, Chris Beckmann and colleagues offered as a design principle the importance of avoiding the use of cameras, microphones, and highly directional sensors based on data from two participants (of 15) who disliked the use of cameras or microphones to monitor energy usage in the home.[6]

Awareness of user perceptions toward how specific technologies work and their potential benefits and costs (such as with Web-based information disclosure[7] and shoulder-surfing risks[8])

can reveal usability concerns and inform future designs. Our specific approach focuses on user perceptions of and attitudes toward specific recording technologies in specific situations. Through the analysis presented here, we provide grounded implications for pervasive recording technologies' design and technical and sociopolitical implementation and deployment. Furthermore, we present an in-depth description of how people construct models for understanding recording.

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dividuals involved but also their conceptions of the specific places, spaces, and interactions of the moment. Furthermore, we approached the study of recording technologies with a particular focus on those situations in which people might or might not know whether such recording exists.

This work contributes to the field by not only assessing grounded reactions to current technologies but also using these responses to uncover research and design considerations for new technologies (see the "Related Work in Pervasive Recording Technologies" sidebar for more information).

Method

People's understanding of encountered recording technologies—in particular, when considering privacy, security, and control of data—is a highly contextualized, personalized, situated concern. Thus, this study focused on maximizing data collection
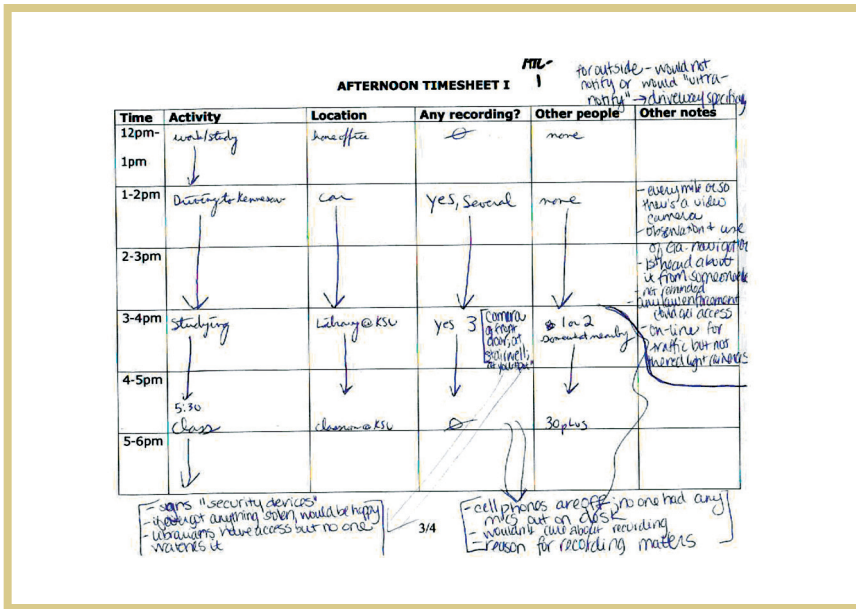
Figure 1. A completed Day Reconstruction Method (DRM) timesheet survey. Most of the interviewer's notes are in the rightmost column, written in the margins, or delineated using brackets; the participant's notes fall within the boxes.

in grounded experience, while ensuring that we considered a breadth of experiences. The Day Reconstruction Method (DRM)[4] provides an avenue of inquiry in which participants respond to questions grounded in the context of real, recent situations. Essentially, it asks participants to reconstruct or recollect a full day (24-hour period) from the recent past—typically, the day before. Ground truth about the existence of recordings that participants report to have encountered doesn't exist, but this study is about uncovering participants' perceptions about the recording they encounter, which is often as important—if not more so—than the reality of the situation. The DRM includes a combination of a semistructured written recollection of daily experiences and a complementary probing interview to discuss those experiences. It constrains the inquiry domain to situations directly experienced by each participant, often as part of a daily routine, rather than the hypothetical situations that can lead to false predictions or speculations about behavior.

Participants

We initially used both word of mouth and responses to flyers posted in ac-

ademic buildings to recruit participants. Then, during the interviews, we encouraged them to solicit further participation from their own acquaintances, which sometimes resulted in recruiting more participants.

In total, we recruited 19 people from three cities in North America. Urban participants included those from two large cities—one in Canada ($n = 12$), the other in the South ($n = 3$)—and suburban participants from a small town in the mid-Atlantic region ($n = 4$). Participants were aged 19 to 53 and represented a variety of professions, including actors, students, homemakers, and office workers.

We initially conducted the study in the Canadian city and later expanded it to include additional participants in the other areas for two specific reasons. First, the additional sites added more participants with diverse occupational backgrounds to the study. Second, these participants provided reactions to recording experiences from locations that are of a different size and regions of North America than the original site. The findings were complementary, and the use of three geographic locations lent further credibility to the results.

The small sample size might raise

concerns over generalizability, but this study doesn't have as its focus a broad but potentially shallow and likely predictable conception of reactions to recording technologies. Rather, the focus here is on a deep understanding of specific individuals' reasoning and conceptualization processes across a wide range of experiences. This participant set encountered a large variety of situations and technologies and demonstrated a diverse set of strategies for resolving concerns and confusion.

Procedures

Participants first completed a timesheet survey detailing their activities for the previous day (defined as midnight to midnight for the day immediately preceding the day of the interview). Figure 1 shows an example. We varied the days to include a sampling of weekdays ($N = 15$), weekends ($N = 4$), and major holidays ($N = 3$). Each survey included a space for each hour of the previous day and the following details: a summary of activities taking place, locations visited, people nearby, whether any recording occurred, and any additional comments. To avoid the disclosure of sensitive information, we instructed participants to cross out any time periods they wanted excluded from the discussion. No participant exercised this option.

Our use of the term "recording" in instructions to participants could lead them to think immediately of audio or video capture. Because we didn't want to limit our study to those tools only, in our introductory discussions with participants, we encouraged them to consider the creation of any type of record. However, this latter instruc-

For situations where the participant perceived recording to exist...
 1. How did you learn about the recording going on here?
 2. How often did you want to be reminded that you were being recorded here?
 3. How did you feel about being recorded in this place?
 4. Who do you think has access to recordings taken in this place? What do you think the purpose of the recordings was?
 5. How did you want to be notified or reminded about the recording?

For situations where the participant didn't perceive recording to exist...
 1. How did you know that you weren't being recorded in this place?
 2. What strategies did you use to determine whether you were being recorded? What evidence led you to think there was recording? What evidence led you to think there wasn't recording?
 3. How would you feel if someone in this place was recording with a camera?

tion was left intentionally vague to support exploration of the meaning of records and the act of their creation. Consequently, the range of activities and artifacts our participants included was vast—audio, electronic tracks of computing activities, CCTV, family photographs, and other forms of records.

Once they completed the timesheet, we asked the participants some general questions—if there were any time ranges they couldn't remember, whether any locations visited were new to them, and so on. Using the completed timesheet survey as a guide, we probed each individual activity and time segment for details about the potential of recording technologies (see Figure 2). The interview closed with a general description by participants of their strategies for evaluating if recording occurred and a debriefing by the researchers about the study's purpose and results. This debriefing often resulted in further participant commentary.

We taped and transcribed the interviews with participant consent. When recording wasn't feasible, we used detailed notes to document participant responses. Interviews lasted between 40 and 80 minutes, and we compensated participants with a $10 gift certificate.

The purpose of this research was to explore specific issues surrounding recording technologies already in the literature and to allow for the emergence of new themes. Thus, we used a combination of deductive (bringing in themes of interest from the literature) and inductive (letting the themes come from the data) coding schemes. Initially, we identified six major themes from the literature as important:

• attitudes toward capture,
• notification frequency,
• notification methods,
• perceptions about availability of access to recordings,
• potential needs for recording, and
• strategies for managing awareness of capture.

Next, a researcher closely read the transcripts to draw out subthemes of interest. Two researchers independently rated the transcripts using the original themes and the emergent subthemes in a three-pass analysis that included one round of independent coding by both researchers, one round of discussion regarding interpretation of the coding scheme, and a final round of independent coding.

Results

As mentioned in the previous section, we intentionally used the terms *recording*, *records*, and *record keeping* without narrow definitions to support exploration of the meaning of recording. Participants considered monitoring of desktop computer activity, message texting, emails, swiping a keycard for door entry, and seeing people writing notes as recording without being prompted. In such instances, participants often queried us as to what exactly we meant by recording to confirm that they could list these activities.

Participants tended to interpret recording to be an active process that aims to capture information, rather than something implicitly collected while performing another activity. For example, many participants described buying items at stores or restaurants (a dominating activity), but no one mentioned that credit-card purchases might be recorded by the computers processing them or that a printed receipt inherently creates a record. This selective definition of recording has implications for pervasive computing systems in which creating a record isn't the individual's primary goal.

Presumption of Recording

Nearly every participant presumed the existence or absence of recording technologies at some point with little or no evidence either way. Participants reported making these assumptions in a breadth of places, including stores, restaurants, race tracks, and academic buildings. We could group the locations reported in this study into three sectors: private (for example, home), public (the street or a shop), and shared (an office). Across these different sites, participants used common cues to match former experiences with current activities. Past experience factored across all the situations and locations encountered, but were most common with a particular

location in private and shared spaces or the same or a similar location in public spaces. Relationships and trust of people and spaces were extremely important to presumptions about recording in private and shared spaces. Externally observable features, such as the type of building and its surrounding areas, were more fundamental to presumptions of surveillance in public spaces.

Naturally, participants reported little to no recording at home (the exceptions being visible photography and videoconferencing with webcams). The notion that other occupants were trusted and would openly reveal any recording was nearly universal in the responses. Some participants went so far as to say that anyone recording them at home would be an "interloper." These sentiments prevailed across different living situations, from friends to roommates to single-family homes. Shared spaces produced similar expectations of minimal or no recording, in particular in places where strong power dynamics are at play, such as in an office space. These findings echo those of a study focused on recording in a shared academic building.[5]

Participant reports of encounters

most often considered to be something likely to be recorded:

> Don't know for sure, but it's a knowledge of location. … convenience stores are high risk, and don't know anyone that does not have a camera in the store these days, given the area. If I was in [an upscale neighborhood] I might say no, but because I was on [a street in a run-down part of town], yeah... It's the "nice" convenience store in the area, probably do more to protect their profits and store.

In other settings, people presumed no recording based on the site's role:

> [I]t's supposed to be a warm welcoming building for international students, and if they had surveillance it would make it a whole lot less welcoming.

Participants often noted abstractly perceiving surveillance to be in place based on past experience with public infrastructure and utilities. For example, participants in both suburban and urban areas mentioned roads monitored by traffic cameras because they noticed

designers, know how to notify those who might be affected by recording, to make them truly aware of it.

Recording indicators often include visible cues. Our results verify that such cues do in fact help users determine the presence of recording at the moment of it potentially happening. These cues include many of those indicators that might be designed and implemented explicitly for notification, such as signs, as well as more implicit visible cues, such as the style of a particular camera or observers manually taking notes. Some individuals described looking for cameras when entering an unknown or new location. For example,

> [In] the lobby, I take a look around. There is a camera on the ceiling or walls … not a natural camera … a camera like the circle ones.

The type of camera or recording device used also indicated what kind of recording was taking place and who might observe it. For example, dome cameras with tinted glass were associated with crime prevention and security. Meanwhile, uncovered but similarly mounted cameras out in the open were associated with other uses, such as traffic monitoring. The frequent coupling of a recording device with notification through this physicality can create problems as ubiquitous recording technologies evolve. Although the ubicomp vision is to provide computing services available throughout the physical environment but invisible to the user, if recording devices become physically unnoticeable or so commonplace that they're no longer perceivable, users might lose an important mechanism for notification and understanding about recording technologies.

Explicit notification about recording beyond the device itself also often relies on the visual channel. Participants noticed explicit signs most frequently,

The type of camera or recording device used also indicated what kind of recording was taking place and who might observe it.

with recording technologies, or the potential for such encounters, often included logic based on heuristics and stereotypes. For example, a building's condition and usage fed the perception that the owners might use video surveillance to protect their property—likewise, the area surrounding such buildings greatly impacted assumptions. Particularly for urban participants, property perceived to be more valuable than its surroundings was

traffic camera feeds on websites or TV. However, they consistently noted being uncertain about which roads or intersections were specifically recorded.

Visibility, Notification, and Awareness

Solutions for usable but private and secure recording technologies often include considerations for notifying people about the recording. Inherent to this goal is the belief that we, as

followed by oral notification (being told), which was mentioned only a little over half as many times. A sign obviously can alert people not yet aware of any recording to its presence. For signs to be effective, however, they must be constantly visible. A common problem associated with signs is overlooking them. For example, one person noted

if they put up a sign, it can stay there constantly because there are many people coming in and you don't know if they have read it or not.

In addition, people might become habituated to the presence of signs and even recording devices, especially in crowded urban areas or shared semi-private spaces they inhabit regularly.[5] Participants commonly commented that constant notification or regular reminding would be desirable or necessary due to this sort of habituation.

In contrast, participants said in many other situations that they simply didn't care to be notified or that disruptions associated with being reminded would be a larger problem than forgetting about recording due to habituation. In the latter cases, participants reported preferring no notification or only a single notification at the start of recording or upon entry into the recorded environment. For example,

I would like some notice at the entrance. It is nice when they have those signs showing that they do record…subtle reminder [that's encountered] just once.

In any environment, what a particular person determines to be acceptable behavior might be governed in part by who else is present and could bear witness. The potential for consequences based on the presence of recording technologies, real or imagined, can greatly impact how people act when these technologies are perceived to be present. Concerns about lasting repre-sentations echo those expressed with regard to audio recording on mobile devices, simple activity logging in offices, and more. Thus, people must be notified about and understand not only that recording is taking place and who might have access to it in the immediate future but also the potential for future users and audiences. This study's results, however, indicate that people don't have that lengthy understanding and rely instead primarily on the simple channels of posted policies and visual elements to assess recording.

Control and Access

All participants reported expecting and tolerating recording in public settings; nine also reported feelings of "helplessness." Participants commented that they didn't have the tools, motivation, power, or knowledge necessary to effect a change in the recorded environment. No participant presented a situation from the specific days reconstructed in which he or she took action to prevent or alter undesirable recording. During the open interview time after the DRM reconstruction portion of the interview, however, participants did note both past and potential situations during which they would take action. For example, one participant resigned from his job a few weeks prior to the interview because he believed the presence of surveillance cameras in employees' computer screens had turned his workplace into a hostile environment.

Further comments by participants and from related research[5] indicate common reasons for this lack of active resistance. First, power and authority might make it impossible or unlikely for people to effect this type of change. For example, one person commented about eating in a semipublic area,

I feel invaded if there are cameras … But what can I do? I can sign up and demand a referendum that

Participants commented that they didn't have the tools, motivation, power, or knowledge necessary to effect a change in the recorded environment.

they get rid of cameras. I can do some civil unrest. But I can't do much beyond that.

Second, the degree of perceived risk might be low enough not to warrant spending time or money to take action or avoid the recording:

I stayed with that restaurant, and I know there are privacy issues but because money is more important for me … I don't have really the choice to go somewhere else.

Many recording technologies affect a group of people and thus could be evaluated in the context of that group. For example, one individual expressed distaste for family photographs but yielded to them in consideration of his family members:

It's my parents who want to do it … It's something they want to keep, so I'm not going to take that away from them.

Most interview participants described recording in at least one incident to be a "trade-off" or "necessary evil" related to the good of the group or society. For example, in reference to a gas station with an outdoor camera,

It doesn't bother me … They're there for security reasons, they're just trying to keep people safe and it's not keeping me from what I'm supposed to be doing.

All those interviewed reported making assumptions about those people who might have access to the recordings, which in turn affected how they reacted to the recording. When considering control not just of recording but also of access, one important trend focused on the expanding hierarchy of people believed to have it. In some cases, such as at a private party in someone's home, people initially commented that the only person who could access the recording was the person taking the picture. Upon further probing, interviewees gradually added other people to the list:

My fiancé's family [has access]… Perhaps the people who develop the photos or anyone else they want to show the photos or video to.

At commercial locations, the perceived list of people with access to recordings typically included security

In some situations, the perceived effort to extract information from recordings impacted perceptions about their use. For example, one participant argued that the people with access to recordings of a school's outdoor race track would never identify him because it wasn't a rational use of their time or money:

They don't need to check the tape to see who was on the tape and I understand that. They would have to go through and ID me, and the resources associated with that, they don't need to go through that.

However, as the effort level required to identify someone changes over time—for example, due to advanced computer vision or data mining techniques—these assumptions will no longer match reality. Thus, designers must develop new notification and education interventions alongside these new technologies to encourage the usability of these systems in terms of security and privacy.

Our findings also suggest that a lack of control over recordings can actually make a person more tolerant of that re-

been decided, they can do the work of rationalizing it and producing an adequate explanation:

I don't think there's a whole lot I can do about it, so I don't worry about it, if someone is secretly recording me walking down the street and I don't know about it there's nothing I can do about it.

This phenomenon can certainly be used to inflict new recording and surveillance methods that don't match the target population's underlying beliefs and desires. Thus, technology designers and implementers must consider the political and institutional context into which their technologies might be deployed in the future. Although they can't be expected to predict this future, an important goal is to create interventions for explaining, controlling, and notifying people about these technologies.

R&D Considerations

Context-awareness and capture and access technologies are two common application threads in pervasive computing applications. Both types of systems leverage data capture from sensors and recording technologies to enhance user applications. The concerns involved with exposure to constant tracking and recording of potentially sensitive information have made privacy a prominent research problem in the area of pervasive computing.

Our study reveals considerations to be addressed when developing and deploying pervasive computing applications. First, people have different expectations about the existence of recording in different types of spaces. They can often expect recording in public spaces and outright reject it in private, with many options in between. Thus, researchers and designers must explore techniques for bridging user expectations of recording in an environment to the actual existence of sensors in that space (for example, in semipub-

> **Our findings also suggest that a lack of control over recordings can actually make a person more tolerant of that recording, not less.**

personnel, employees, owners, and the police. Most participants didn't reference incidental or malicious distribution of material.

In addition, six participants reported believing that they would be granted access to recordings in public places in which they appeared:

[I]t's a public place … it's probably for security purposes… if there was a crime to occur, I'd be able to go and ask for footage.

cording, not less. This tolerance due to inescapability matches psychological research that notes how people generally prefer inescapable fates over escapable ones. For example, Sandi Wiggins and colleagues showed that people experienced an increase in happiness both when tests revealed that they had a dangerous genetic defect and when they showed that they didn't have this defect. However, there was no increase in happiness when the test was inconclusive.[6] Once an inescapable fate has
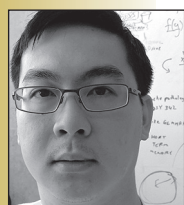
lic spaces such as classrooms or meeting rooms). Second, people might eventually habituate to recording, resulting in recorded experiences that people might have wanted to keep private, anonymous, or otherwise unpreserved. Thus, designers should consider techniques for supporting access control, deidentifying collected data, or preventing data capture or storage.

In addition, findings from this study suggest specific ways to design recording systems and notification about them. People often rely on the visual channel to detect the presence of recording—they might also determine the recording's intent based on the camera's physical design. This suggests that a visual language can be designed to convey to inhabitants of a space the different elements of a recording system through unique camera shapes. Alternatively, these elements can be conveyed through a sign at a space's entry point. However, these signs might be missed or forgotten, so when creating them, designers must add visual attractors that change the notice itself to prevent inhabitants from missing the sign or becoming habituated to it.

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Concerns about security, privacy, and control of data surrounding surveillance technologies are exacerbated by the problematic nature of the varied notification levels desired by participants in different locations. Certain expectations exist in certain locations. Furthermore, although these expectations are somewhat pliable and change over time, they play a large role in determining comfort levels, understanding, and utility of these technologies. Cultural and social norms govern these places, and likewise govern the importance and frequency of notification and positioning of recording equipment and computational elements. People who are habituated to common forms of capture (such as security cameras) often don't want extensive notification about

ongoing recording because they understand how these technologies work. On the other hand, as novel sensing and recording devices become more common, people must develop new understandings and create new explanations for what is being recorded and how it might be used. ⚟

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