Title
Building Values into the Design of Pervasive Mobile Technologies

Author
Shilton, Katie Carol

Publication Date
2011

DOI
10.2139/ssrn.1866783

UNIVERSITY OF CALIFORNIA

Los Angeles

Building Values into the Design of Pervasive Mobile Technologies

A dissertation submitted in partial satisfaction of the requirements for the degree Doctor of Philosophy in Information Studies

by

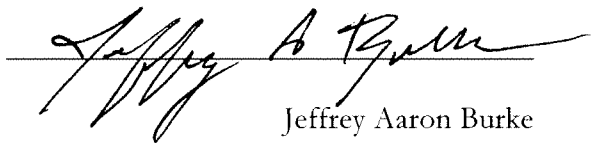
Katherine Carol Shilton

2011

Katherine Carol Shilton

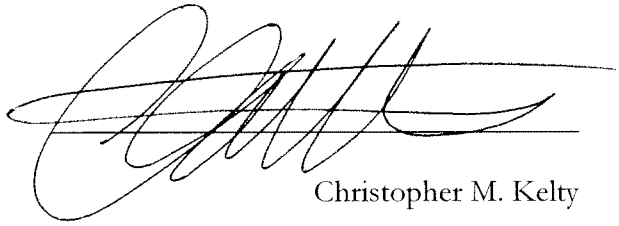
2011

The dissertation of Katherine Carol Shilton is approved.

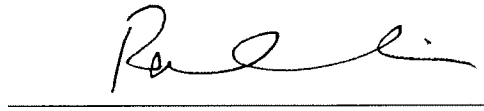


Jeffrey Aaron Burke

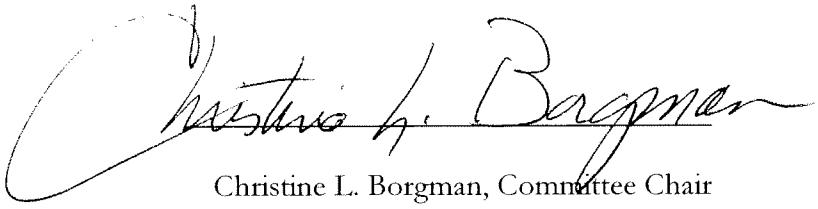
Deborah Lynn Estrin



Christopher M. Kelty



Ramesh Srinivasan



Christine L. Borgman, Committee Chair

University of California, Los Angeles

2011

TABLE OF CONTENTS

DETAILED TABLE OF CONTENTS

LIST OF FIGURES

ACKNOWLEDGMENTS

This dissertation would not have been possible without a large number of wonderful mentors and colleagues. First, many thanks to my committee, whose ideas, feedback and guidance took me from the overbroad ideas of a new graduate student to a finished dissertation. Jeffrey Burke, Deborah Estrin, Christopher Kelty, and Ramesh Srinivasan could not have been more influential in the development and execution of this research. Particular thanks go to my adviser and committee chair, Christine Borgman. Her focus and insight have been invaluable to shaping the direction of my work, and her ongoing guidance means so much to me.

A number of other faculty members at UCLA have also been influential and supportive as I moved from a library school student to an information policy researcher. Jean-François Blanchette, Leah Lievrouw, Michael Curry, Mark Hansen, and Jerry Kang have been fantastic mentors to me, and their ideas and guidance permeate this work. Jim Waldo has been an off-campus collaborator, mentor, and source of inspiration as well.

I would also like to thank the participatory sensing group at CENS, especially Betta Dawson, Hossein Falaki, John Hicks, Donnie Kim, Younhun Kim, Min Mun, Nithya Ramanthan, Sasank Reddy, Vids Samanta, and Josh Selsky, for discussion about terminology, framing, and invaluable feedback on what they agree with – and disagree with – in my analysis. Thanks also to the CENS data practices group, David Fearon, Matt Mayernik, Alberto Pepe, Jillian Wallis, and Laura Wynholds, for several years of feedback, ideas, and support during our weekly meetings. My colleagues Amelia Acker, Patrick Keilty, Andrew Lau, and Michael Wartenbe have been friends as well as go-to references for all things theory, and have been influential in shaping the concepts in this work.

In addition, discussions at three workshops contributed to this dissertation. Ethical Guidance for Research and Application of Pervasive & Autonomous Information Technology (NSF grant number SES-0848097), the Workshop on Surveillance & Empowerment (NSF grant numbers 0623122 and 0853749), and the Workshop on Values in Design were helpful in formulating the ideas in this dissertation. The colleagues who I met at this workshop will certainly find their influences here, as well. This dissertation is based upon work supported by the National Science Foundation under grant number 0832873.

Finally, this dissertation would not have come together without the ongoing help, advice and support of my husband, Nikil Mehta. He has seen the process from start to finish, and was the first person who thought I should head in this direction at all. Thank you, Nick.

Some of the material in this thesis has been modified from previous publications. Chapters 1, 5 and 6 contain edited and expanded material previously explored in:

Shilton, K. (2010). Participatory sensing: building empowering surveillance. *Surveillance & Society*, *8*(2), 131-150

Shilton, K. (2010). Technology development with an agenda: interventions to emphasize values in design. *Proceedings of the 73rd Annual Meeting of the American Society for Information Science & Technology (ASIST)* (Vol. 47). Presented at the 73rd Annual Meeting of the American Society for Information Science & Technology (ASIST), Pittsburgh, PA

Shilton, K., Burke, J., Estrin, D., Hansen, M., Govindan, R., & Kang, J. (2009). Designing the Personal Data Stream: Enabling Participatory Privacy in Mobile Personal Sensing. *The 37th Research Conference on Communication, Information and Internet Policy*

(TPRC). Presented at the The 37th Research Conference on Communication, Information and Internet Policy (TPRC), Arlington, VA.

VITA

1981	Born, Alexandria, Virginia
2003	B.A., History and German Studies Oberlin College Oberlin, Ohio
2003-2005	Legislative Liaison/ Executive Assistant Center for Women & Enterprise Boston, Massachusetts
2006	Archivist Intern The Wende Museum Culver City, California
2006-2007	Graduate Student Researcher UCLA Department of Information Studies Los Angeles, California
2007	MLIS, Specialization in Archival Studies University of California Los Angeles Los Angeles, California
2007-2009	Graduate Student Researcher Council on Library and Information Resources Washington, DC
2007-Present	Graduate Student Researcher UCLA Center for Embedded Networked Sensing Los Angeles, CA

PUBLICATIONS AND PRESENTATIONS

Estrin, D., Burke, J., Hansen, M., Shilton, K., & Mun, M. (2009). Mobile Personal Sensing: A new driver for high performance transaction systems? 13th International Workshop on High Performance Transaction Systems (HPTS). Pacific Grove, CA.

Kang, J., Shilton, K., Estrin, D., Burke, J., & Hansen, M. (in press). Self-Surveillance Privacy. *Iowa Law Journal.*

Mun, M., Hao, S., Mishra, N., Shilton, K., Burke, J., Estrin, D., Hansen, M., et al. (2010). Personal Data Vaults: a locus of control for personal data streams. In *ACM CoNext 2010*, Philadelphia, PA: ACM.

Mun, M., Reddy, S., Shilton, K., et al. (2009). PEIR, the personal environmental impact report, as a platform for participatory sensing systems research. In *Proceedings of the International Conference on Mobile Systems, Applications, and Services*, Krakow, Poland.

Reddy, S., Shilton, K., Burke, J., Estrin, D., Hansen, M., & Srivastava, M. (2008). Evaluating Participation and Performance in Participatory Sensing. UrbanSense Workshop, Sensys 2008. Raleigh, NC.

Reddy, S., Shilton, K., Denisov, G., Cenizal, C., Estrin, D., & Srivastava, M. (2010). Biketastic: Sensing and Mapping for Better Biking. In *ACM Conference on Human Factors in Computing Systems (CHI)*, Atlanta, GA: ACM.

Reddy, S., Shilton, K. Estrin, J., Burke, J., Hansen, M., & Srivastava, M. (2009). Using Context Annotated Mobility Profiles to Recruit Data Collectors in Participatory Sensing. 4th International Symposium on Location and Context Awareness. Tokyo.

Shilton, K. (2008). Review: Cross-Cultural Perspectives on Knowledge Management edited by David J. Pauleen. *InterActions: UCLA Journal of Education & Information Studies* 4 (1).

Shilton, K. (2009, August). Four billion little brothers? Privacy, mobile phones, and ubiquitous data collection. *ACM Queue*, *7*(7).

Shilton, K. (2009). Four billion little brothers?: privacy, mobile phones, and ubiquitous data collection. *Commun. ACM*, *52*(11), 48-53.

Shilton, K. (2010). Participatory Sensing: Building Empowering Surveillance. *Surveillance & Society* (special issue on surveillance and empowerment), *8*, 2, 131-150.

Shilton, K. (2010). Technology Development with an Agenda: Interventions to Emphasize Values in Design. In *Proceedings of the Annual Meeting of the American Society for Information Science & Technology (ASIS&T),* Pittsburgh, PA.

Shilton, K., Burke, J., Estrin, D., Hansen, M., Govindan, R., & Kang, J. (2009). Designing the Personal Data Stream: Enabling Participatory Privacy in Mobile Personal Sensing. In *The 37th Research Conference on Communication, Information and Internet Policy (TPRC)*, Arlington, VA.

Shilton, K., Burke, J., Estrin, D., Hansen, M., and Srivastava, M. (2008). "Participatory Privacy in Urban Sensing." MODUS 2008. St. Louis, MO.

Shilton, K., Ramanathan, N., et al. (2008). Participatory design of sensing networks. In *Proceedings of the 10th Conference on Participatory Design (PDC)*, Bloomington, IN: ACM.

Shilton, K., & Srinivasan, R. (2007). Participatory Appraisal and Arrangement for Multicultural Archival Collections. *Archivaria*, *63*, 87-101.

Srinivasan, R., & Shilton, K. (2006). The South Asian web: an emerging community information system in the South Asian diaspora. In *Ninth Conference on Participatory Design: Expanding boundaries in design* (Vol. 1, pp. 125 - 133). Trento, Italy: ACM.

ABSTRACT OF THE DISSERTATION

Build Values into the Design of Pervasive Mobile Technologies

by

Katherine Carol Shilton

Doctor of Philosophy in Information Studies

University of California, Los Angeles, 2011

Professor Christine L. Borgman, Chair

Corporations, governments, and individuals can increasingly collect new forms of personal data using pervasive technologies such as mobile tablets and phones. These always-on, always-present devices carried by billions can capture and transmit users' location, images, motion, and user input. Mobile technologies could become a platform to document community needs and advocate for civic change, to understand personal habits and routines, or to document health problems and manage chronic illness. Simultaneously, new forms of data collection software utilize techniques traditionally employed by tools of surveillance: granular data gathering, sophisticated modeling, and inferences about a personal behavior and attributes.

There is a shifting and permeable boundary between data collection for individual or social goals, and corporate or government surveillance. This boundary invokes *social values in design*: the features, principles, or ethics we collectively value in the design of data collection

technologies. Because technology regulation is often years behind the rate of innovation, this question is often answered, consciously or un-, by engineering teams.

This dissertation studies an influential engineering laboratory working in *participatory sensing,* a form of personal data collection utilizing pervasive mobile devices. The dissertation employs ethnographic methods to examine design practices and agents that promote social values, and particularly *anti-surveillance values* – privacy, equity, consent, and forgetting – in design. The multi-year study of sensing development reveals how such abstract social values were built into concrete technological features.

Anti-surveillance values became material as the design team built consensus around values such as privacy, consent, equity, and forgetting; and then translated those values into technological features. This process was enabled by *values levers*: practices that opened new conversations about social values, and encouraged consensus around those values as design criteria. While literature on values in design has previously suggested that values help construct the day-to-day work of design, my dissertation illustrates that the opposite is also true: the routinized practices of design work shape the values incorporated into new technologies. If anti-surveillance values such as privacy, consent, equity and forgetting are to be materialized in the design of pervasive sensing technologies, laboratories must be structured to encourage values levers, which facilitate and bolster the process of building values into technology.

Chapter 1: Participatory Sensing, Values, and the Structure of Design

Introduction

The statement that "technologies have politics" has been a cornerstone of information and science and technology studies for decades (Johnson, 2007; Pinch & Bijker, 1984; Souza, Froehlich, & Dourish, 2005; Suchman, Blomberg, Orr, & Trigg, 1999). Investigations into the politics of information technologies – including the social values embedded in those technologies – have increasingly been the province of cross-disciplinary research efforts labeled *values in design* or *values-sensitive design*. As new technologies are conceived and developed, the values of their designers become one part of a complicated socio-technical equation. The values of designers affect how information technologies are imagined; how they handle data, create categories, and draw conclusions; what affordances users have available for interaction; and what the ultimate social consequences of information technology use may be.

The question of the values considered and enacted during design is important because as new technologies emerge, their consequences are often *ethical* rather than *legal*. Technology regulation on a national or international level is often years behind the rate of innovation. Regulating controversial technologies "downstream" is currently one of the most common approaches to dealing with the social consequences of new technologies. Studying and affecting technology values "upstream" – during design – is an alternate and growing approach (Friedman, Kahn, & Borning, 2006). This dissertation explores factors that promote discussion of, consensus around, four specific social values during design. As I will describe, the technologies I investigated invoked a number of social concerns predicated

around fears of surveillance. Because of these concerns, I chose to focus on a subset of social values that I termed *anti-surveillance values*: privacy, consent, equity, and forgetting, which help counter the social harms of surveillance. Some of these concerns were raised by leaders at the technology development site; others were values I culled from the surveillance, information studies and technology studies literatures. The dissertation seeks to understand how these specific and interrelated social values operate within technology design. It examines how design processes and people can promote these anti-surveillance values towards the goal of building just, equitable technologies. It takes as its domain the design of an emerging set of technologies, and technological practices, for ubiquitous personal data collection.

Anti-surveillance values face a number of hurdles during design. They are rarely agreed upon as universal goals; data collection and new knowledge creation are powerful countering arguments (Agre, 1994). These values are also more difficult to incorporate into design than creation-oriented values such as efficiency or productiveness. Privacy, consent, equity and forgetting are more difficult to quantify than efficiency, which can be estimated and measured. They are more difficult to define, stemming as they do from moral and social philosophies rather than from market demands.

I set out to find these values at work within the design practices of a pervasive computing laboratory. I worked as a researcher at the Center for Embedded Networked Sensing (CENS), an NSF-funded multidisciplinary research laboratory using mobile devices to collect data about people and their environments. My focus became *design practices and agents* that advocated for, enforced, or challenged anti-surveillance values. I wanted to know who, or what, influenced social values and ideology at CENS, and how those values and

ideologies in turn influenced design. While previous literature on values in design has suggested that values help construct the day-to-day work of design, my dissertation illustrates that the opposite is also true: the routinized practices of design work shape the values incorporated into new technologies.

Values and pervasive mobile technologies

The collection of information about people – their actions, interests, and habits – is increasingly performed across technological platforms. Browsers record searches, reading and spending habits; social networking sites collect affiliations and user contributions about jobs, moods, or events; email platforms record business and personal communications. This dissertation investigates one increasingly available example of data collection about people: that performed on pervasive mobile devices, particularly the ubiquitous mobile telephone.

Widespread data collection using personal devices as sensors is referred to as *participatory sensing*, and is a subject of research at a number of technology labs primarily in the U.S. and Europe. Mobile phone-based software for data collection is being deployed in a range of contexts, including medical research, urban planning, and personal or hobbyist interest. Phones are ubiquitous and networked, and they can sense and upload data about users, such as images, sound, location, and motion using on-board cameras, microphones, GPS, and accelerometers. I refer to these forms of data collectively as "personal data" throughout this dissertation. They can be triggered and controlled by billions of individuals around the world. Academic and industry researchers are currently coordinating mobile phone networks for purposes ranging from entertainment to improving public health (Burke et al., 2006a; Eisenman et al., 2006b; 2007c; Khan & Markopoulos, 2009; Miluzzo, N. D.

Lane, Eisenman, & Campbell, 2007d). Technologists and engineers involved in participatory sensing endeavor to make these everyday devices a platform for coordinated investigation of the environment and human activity. Researchers are introducing these technologies into the public realm, a move that anticipates sensing by people across the world.

For example, *Your Flowing Data*[1] is a project that asks users to send short messages recording data points (e.g., weight, exercise accomplished, mood, or food eaten) throughout the day. The project provides users with visualizations to explore patterns and learn from their data. A different example is the *Personal Environmental Impact Report* (*PEIR*),[2] an application that uses participants' mobile phones to record their location every thirty seconds. *PEIR* uses this time-location series to infer how much a participant drives each day, giving participants a daily calculation of their carbon footprint and exposure to air pollution.

Pervasive mobile technologies harness the power of an existing platform—a distributed, numerous, and ubiquitous network of mobile phones—for social projects and goods. Users might benefit from phone location awareness to understand their exposure to air pollution as they move through a city. Communities could band together to undertake research projects using tools they already own. Teams might use their phones to snap, tag, and upload photos of community events, perform volunteer assessments of the pedestrian or bike friendliness of neighborhoods, or to improve the ease of reporting environmental threats. Participatory sensing developers draw scenarios from community organizing and environmental justice, and imagine these tools deployed in public interest initiatives. Such

[1] http://your.flowingdata.com/
[2] http://peir.cens.ucla.edu/

powerful, familiar, and plentiful sensors could enable interest groups to make their case through distributed documentation of problems, needs, or community assets.

But these systems for mass personal data collection could also contribute to pervasive, ever-expanding surveillance systems. Corporations and governments seek to inventory the world's information, compiling massive databases on people and their actions (Steel, 2010; Thurm & Kane, 2010). Participatory sensing, with its simultaneous pro-social potential and similarities to surveillance, serves as a complex case study into the shifting line between personal data collection and surveillance.

And because participatory sensing is newly emergent, it serves as a case study into how such data collection technologies are designed and deployed. This dissertation focuses on the values built into ubiquitous personal data collection devices. I have chosen this focus for several reasons. Mobile phones are the most common digital information technology in the world (Kinkade & Verclas, 2008), and are increasingly equipped for data collection with cameras, audio sensors, and location and motion awareness. Additionally, these data are, as of this writing, not widely collected, organized, and transferred by corporations.[3] This is in contrast to browser or social network site data, for example, which are tracked by corporations, sold and resold, and are not readily viewable by users. The newness of personal data collection using mobile devices, paired with the closeness to individuals and both technical and physical accessibility of these devices, makes participatory data collection

[3] Although equivalents of some of this data, especially location data and phone identifiers, is starting to be transmitted to third party companies, particularly advertising companies. See (Thurm & Kane, 2010) for examples.

an ideal site of study, and even intervention, for stakeholders interested in the values embedded in data collection processes and technology.

While mobile data collection is both new and close to individuals, it invokes many of the same concerns posed by other forms of personal data collection: analysis of web use statistics by online marketers, warehousing of credit and retail information by data brokers, and tracking of location data by mobile phone providers and governments. Collections of personal data have wide potential for innovation and new knowledge creation, but they can also be invasive. A recent report by the World Economic Forum predicted:

> Personal data will be the new oil– a valuable resource of the 21st century. It will emerge as a new asset class touching all aspects of society (*Personal data: the emergence of a new asset class*, 2011, p. 5).

If personal data is to be the new oil, participatory sensing is one site to study the values behind its conception and collection, and one of the major social concerns – surveillance – that emerges around this resource.

Surveillance and participatory sensing

Even where design intentions are good – and as I will illustrate, at CENS they largely are – there are a plethora of social challenges introduced by the idea of tracking individuals using their mobile phones. I witnessed a collective imagining of the dark possibilities of participatory sensing during a 2008 presentation on participatory sensing to Communities for a Better Environment (CBE), an environmental justice advocacy group in East Los Angeles. The advocates around the table included high school-age youth leaders from a predominantly Latino neighborhood. The youth reaction to CENS sensing technologies was a resounding "No way." When they realized the phones would track their location, they

became convinced that police would demand the data. These teens, targeted by police in a way UCLA researchers rarely are, immediately sensed the concerns of equity, power, and surveillance that participatory sensing can raise. With no specific legal protections for participatory sensing data, comprehensive databases documenting individuals' movements are prime targets for subpoena (Agre, 1998), and might even be demanded by U.S. authorities without warrant under the Patriot Act.

Risks of unauthorized sharing or data theft can occur at a variety of places in the design process. Small-scale application developers may not be able to follow best practice security, leaving data vulnerable to hackers or thieves (Zittrain, 2008). Developers of location-based technologies may have financial motives to mine personal data, producing targeted advertising, selling valuable behavioral data to third parties, or using location to hone price or product discrimination (Curry, Phillips, & Regan, 2004).

Even designers with excellent security practices and without a financial motive to mine the data may face challenges with large social repercussions. A design culture that encourages maximum data collection and retention, without consideration for targeting, focus or deletion, risks creating databases ripe for "function creep": using amassed personal data for secondary, unforeseen purposes to which data subjects have not consented (Agre, 1994). Designers trained in software cultures where openness is a virtue (Kelty, 2008), or institutions that emphasize data sharing to aid scientific and engineering innovation (Borgman, 2007), may find these values in conflict with users who wish to share data very selectively.

These issues suggest a range of values that might be weighed in the development of mobile data collection technologies. In this chapter, I describe four specific social values that

are often invoked by scholars and advocates to counter the pernicious effects of surveillance, labeling these *anti-surveillance values*. These are a subset of social values that are the focus of my dissertation. Some of these values were articulated before I arrived at CENS. In particular, CENS leaders understood *privacy* to be a particular social challenge inherent to their new technologies. My first role at CENS was to unpack the notion of "privacy" and highlight nuanced values expressed by CENS participants under the rubric of privacy. I will illustrate how these included consent and participation, power and equity, and memory and forgetting. My study investigates how these values unfold during CENS design, and what affects their consideration and adoption.

Research questions

This dissertation asks four questions. The first three focus on understanding values in design:

1. What social values are discussed and agreed upon by the design team during participatory sensing design at CENS?
2. How do design practices and participants influence consideration of anti-surveillance values?
3. How do anti-surveillance values affect technology development?

The fourth question is action-oriented, and focuses on promoting anti-surveillance values in design:

4. How can designers as well as outside advocates make anti-surveillance values an integral part of design?

Observing Design at CENS

My thesis considers empirical data from several years spent as a participant observer in a laboratory at the forefront of participatory sensing design (http://urban.cens.ucla.edu/). Participating in the design lab at the Center for Embedded Networked Sensing provided an opportunity to study the values built into an emerging technological infrastructure as designers embedded values in software, architecture and practices associated with the new technologies.

The Center for Embedded Networked Sensing (CENS) is one of a number of academic and industrial research labs focused on designing and implementing systems for participatory sensing and pervasive personal data collection. CENS has over 300 affiliated members over five campuses; a team of roughly thirty students, staff and faculty at UCLA worked on system design and implementation of participatory sensing technologies. A majority of the team members are computer scientists and electrical engineers. But because participatory sensing questions intersect with human and social science concerns, the team has recruited researchers from outside of engineering, as well. CENS partners with statisticians, health scientists, urban planners, and ecologists to design sensing projects. CENS is a friendly environment for social scientists, having included researchers from information studies since the Center's founding (Borgman, J. C. Wallis, & Enyedy, 2007a).

My research was made possible by this openness to interdisciplinary work. I worked as a researcher within the participatory sensing team. I joined the team in the summer of 2007, and I was explicitly hired to deal with privacy challenges raised by team members and external advisors. Because privacy was a research interest for me as well as an acknowledged challenge at CENS, it became the initial focus of my investigations and research.

As a team member, I enjoyed excellent access to all phases of design. I took part in brainstorming meetings where new design innovations were proposed, discussed, and refined. I met at least monthly with lab leaders to discuss values implications of the systems we built. I also attended ad-hoc meetings with experts in fields that affected our concerns, ranging from data security to privacy law. I had a desk in the CENS laboratory where designers drafted system diagrams, wrote code to support both mobile phone and web applications, and iterated on their designs in small groups. I participated in email discussions about new projects, new architectures, and features and interfaces for new systems. I attended conferences and trade shows alongside (and sometimes as) representatives of CENS participatory sensing. I coauthored both proposals and papers where participation, privacy decision-making, or other human-facing aspects were important to the design process (Goldman et al., 2009; Reddy et al., 2008; Shilton, Ramanathan, Reddy, et al., 2008). I also regularly socialized with student designers, joining them for movies, drinks, and meals. CENS participatory sensing designers were my friends and colleagues. My research at CENS was participant observation with a focus on *participant*.

Why CENS?

CENS provided a complex case study in the challenges of deploying social values, particularly anti-surveillance values, within design. CENS leaders regularly engaged in deep and deliberate discussion of ethical issues. Data privacy and expanding participation in sensing were personal concerns held by lab leaders long before I joined the team. And while I watched and participated, the team debated thorny social issues such as consent, data retention limits, use of sensing systems by children, and the relationship between

participatory sensing and surveillance. But values-sensitive design remained a challenge, because of the simultaneous and sometimes competing needs of other values in design – efficiency, productivity, and creativity. Embedding myself within CENS allowed me to explore these challenges and their resolutions.

CENS was simultaneously an important site for participatory sensing design. Indeed, the term "participatory sensing" was a CENS invention, and is slowly permeating a field previously called "urban" or "mobile" sensing. CENS is led by an influential computer scientist, the Director, whose sway in the field, and with funding agencies, continues to be important to how the field develops. The Director's leadership also presented an ambitious vision. As an engineer on the forefront of internet development in the 1980s, she was convincing when she argued that mobile technologies were the "next big thing" in networking research. CENS was engaged in influential, prolectic research, actively projecting a narrative of the future. For example, an exchange from a 2009 meeting found the Director and her graduate students discussing their active role in agenda-setting. The Director had recently returned from an NSF principal investigator meeting for the Future Internet Design (FIND) program. CENS is partially funded under the FIND program. Her report caused a senior graduate student to chuckle: "My memory of last year's FIND PI meeting was that what we're doing is just so different from what everyone else is doing." To which the Director countered:

> But they gave me the first slot on the agenda. They had an outside panel of dignitaries to review the projects, and they wanted to demonstrate that FIND isn't doing the same old things.

CENS' agenda was to be both influential and imaginative in the emerging field of participatory sensing, making it an excellent site for studying the creation and valuing of these new technologies.

Intervening as a values advocate

Because I worked almost daily alongside CENS engineers and computer scientists, my research focused on the development of pervasive sensing. My long-term presence at CENS not only enabled me to become familiar with CENS design; it also allowed me to be an agent in the design process. My job was to be responsible for organizing theoretical and technical investigations of privacy, and later other anti-surveillance values, at CENS. A major part my role was unpacking and articulating some of the nascent anti-surveillance values at CENS. For reasons I will discuss in Chapter 4, privacy and consent were frequent topics during CENS, but values such as equity and forgetting needed my intervention to be articulated as part of design. An ethics education grant paid my salary and supported my dissertation research. The focus of the grant was improving ethics education, and as such, our primary grant activities were the development of both laboratory interventions and seminar curricula for sensing engineers. This dissertation complemented the grant by investigating practices and agents that enabled and inhibited ethical decision-making during the design process, and evaluating laboratory practices and agents for their potential to push ethics to the forefront of design concerns.

I used this opportunity for action research to explore the role of an advocate in articulating a set of values important to CENS design, and the work required to transform those values into concrete design decisions. As described in Chapter 2, an ethics advocate

may undertake a variety of interventions. In my role at CENS, I conducted technical investigations such as analyzing existing applications for privacy sensitivity (Mun et al., 2009; Reddy et al., 2008). I also cooperated with CENS designers to create both technologies and policies to protect values such as privacy and consent (Shilton et al., 2009). I served this role weekly in CENS design meetings, as well as when I co-authored papers or presentations with CENS designers. My intervention as an ethics advocate benefitted from the interest of CENS leadership, as well as personal fit and friendship with designers in the lab.

Applications and campaigns

CENS participatory sensing used off-the-shelf mobile phones running specialized software built by students or industry partners. The software collected data using phones' available onboard sensors: cameras, a microphone, GPS or cell tower location, accelerometers, and Bluetooth connections to other devices. The software then directed the phone's existing data connection to upload this data to a CENS server. Centralized servers performed data processing, aggregation, and modeling and displayed the results to users via web interfaces. CENS projects largely followed a distributed grid (Foster, Kesselman, & Tuecke, 2001) or cloud computing model (B. Hayes, 2008): data was uploaded from the phones to servers that did the intensive processing work, combining the raw data with existing models, and serving maps and visualizations back to users. Very little data was stored on the phone or on a user's personal computer.

Participatory sensing – both the larger social practice as well as the design processes needed to support that practice – can be difficult to grasp without a few examples. I provide several examples of CENS projects to illustrate the range of social questions that CENS

design tackled, and to orient the reader to the daily concerns of the lab. I have chosen these projects because they were the primary foci of development during my observation of CENS. Interestingly, of the three projects I describe here, two are no longer under development. The phenomena of abandoned projects points to the research, rather than product, orientation at CENS (although as I describe in Chapter 4, this is in continual flux). It is also indicative of challenges with continuity of funding for research projects.

CENS design proceeded around applications and campaigns. Applications were pieces of software to support campaigns. Campaigns were targeted data collection efforts aimed at a sensing goal. "Campaign" is a term borrowed from traditional sensor deployments, in which short- or long-term projects targeted specific data collection goals using sensors designed to fit those needs (Mayernik, J. C. Wallis, Borgman, & Pepe, 2007). But as sensors were embedded with people rather than in static environments, participatory sensing campaign coordination required many fewer interactions with the technology, and many more interactions with volunteers or participants (Reddy et al., 2008). Examples of three campaigns under development during my time at CENS, which I reference throughout my research, are described below.

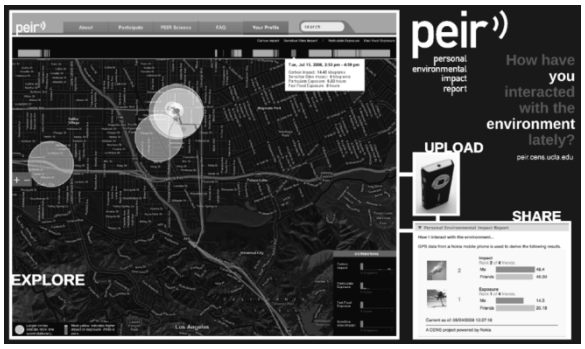


Figure 1.1: PEIR interface

The Personal Environmental Impact Report (PEIR). In this CENS campaign, participants carried mobile phones throughout their daily routines to participate in a self-reflective sensing project. Self-reflective sensing helps individuals gather and consume information in a process of self-discovery. Using GPS and cell towers, the phones uploaded participants' location every few seconds. Based on these time-location traces, the *PEIR* system inferred participant activities (walking, biking, driving, riding the bus) throughout the day. The system mapped the combination of location, time, and activity to Southern California regional air quality data and weather data to estimate personal carbon footprint and exposure to particulate matter. In *PEIR*, sensing a participant's location throughout the day produced previously unavailable information about the environmental harms a person faced, and the harms they created.

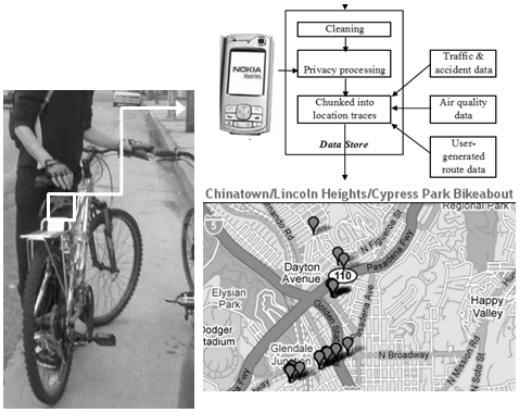


Figure 1.2: Biketastic process & interface

Biketastic. This project was a system to help bikers plan safe routes and collect data to improve those routes. *Biketastic* cyclists carried a GPS-enabled mobile phone during their commute. The phone automatically uploaded bikers' routes to a public website. The phone also used its accelerometer to document the roughness of the road, and took audio samples to analyze volume of noise along the route. Participants could log in to see their route

combined with existing data, including air quality, time-sensitive traffic conditions, and traffic accidents. Participants could also use the system to share information about their routes with other riders. Bikers could document impediments by taking photos with the mobile phone or sending a text message to *Biketastic*. Participants could also record audio messages to remind them of hazards along the route. By combining existing Los Angeles conditions with biker-contributed data, *Biketastic* enabled area bikers to plan routes with the least probability of traffic accidents; with the best air quality; or according to personal preferences, such as best road surface quality or connections with public transportation. *Biketastic* also encouraged bikers to contribute information to improve the safety and well-being of the Los Angeles bike community.

AndWellness. This project was an experience sampling tool to aid in health and wellness studies. *AndWellness* helps participants work with a clinician or therapist to document behaviors and activities, such as sleep quality, stress, eating habits, or risk behaviors, as well as places and times when those behaviors are triggered. Depending on the needs of the study or the participant, *AndWellness* prompts users to input "Ecological Momentary Assessments" (EMAs) throughout the day. These EMAs ask users to sample and record elements of their experience, such as feelings of stress or trouble sleeping, in real time. EMAs might be triggered by a location (e.g., a bar or fast food restaurant) or time of day (e.g., upon waking).

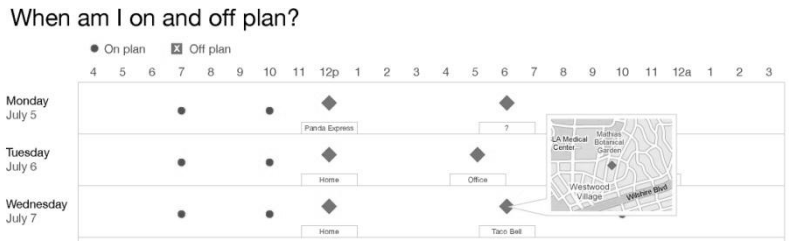


Figure 1.3: An early AndWellness interface

After a week of tracking and data analysis, users can see their experienced mapped to places and time, and work with their doctor to plan interventions.

Anti-Surveillance Values at CENS

The range of applications under development at CENS, as well as the simultaneous possibilities for social change and surveillance, led me to focus on *values* of all types as they manifested at CENS. What was valued during design? How did *anti-surveillance values* manifest at CENS, and how were they incorporated (or not) into technology development? CENS development projects ranged from implementing architectures to support data collection to designing applications that illustrated the usefulness of participatory sensing. Students and faculty worked on software or interfaces to support campaigns such as *PEIR*, *Biketastic*, and *AndWellness*, and also on architecture that could be used across campaigns. Within all of this development resided a series of ethical and social challenges. In this section, I describe a particular set of social values challenges – anti-surveillance values – that manifested at CENS.

The values challenges raised at CENS came from a variety of people and viewpoints. Analysis of the risks of participatory sensing to individual privacy, and the similarity to surveillance, suggested a number of anti-surveillance values would be critical to CENS systems. Privacy was an obvious concern from the beginning of the project, predating my arrival at CENS. Leaders and advisory board members raised privacy concerns in very early CENS personal data projects, and it was these concerns that lead to my arrival at CENS in the fall of 2007.

It turned out that "privacy," however, was being used to describe a number of other social concerns. It became my job to help unpack a number of other values that were being conflated with privacy. I drew on the multi-disciplinary surveillance studies literature (discussed in more depth in Chapter 2) to help articulate values that were nascent, but less discussed, at CENS. While privacy remained important in this literature, authors such as Curry, Phillips and Regan (2004), Marx (1998), and Foucault (1979) suggested that consent and participation, power and equity, and memory and forgetting were all factors that contributed to surveillance.

Privacy

Privacy was one of the first ethical challenges raised by participants in CENS systems that tracked location or automatically captured images. Serious privacy concerns surfaced in early pilot tests. During tests of a project reliant on automatic image capture, for example, a participant walked into a locker room with a sensing-enabled phone dangling around his neck. The phone was programmed to automatically and continuously capture photos. Designers had to manually find and erase the locker room photos from the CENS database. Developers sometimes teased each other about their shared whereabouts (returning to the same restaurant daily, not going out on the weekend) when running location tracking technologies like *PEIR*. In my own experiences with CENS tracking software, I inadvertently revealed a workday shopping trip to a supervisor when showing her my *PEIR* location trace. Privacy concerns, from the serious to the trivial, dominated many CENS conversations about ethics in participatory sensing. I observed privacy concerns at CENS

when developers talked about control of data, data access, data security, or altering or hiding information, which I talk about in more detail in Chapter 4.

Consent and participation

Though privacy was the ethical problem that first garnered attention at CENS, the Center's leaders and designers initiated campaigns that raised questions of consent and participation, as well as power and equity. These ethics were not as openly recognized and discussed as privacy, but remained critical to participatory sensing development.

CENS lab leaders envisioned mobile phones as research tools for investigation of the habits and situations of individuals and communities. This investigation might be personal and informal (S. Roberts, 2004), or organized and carried out by university or industry researchers (Cuff, Hansen, & Kang, 2008). Because of the focus on sensing as research, CENS team members began to consider research ethics that might be extended to participatory sensing. Consent has been a critical concern in research ethics since the Belmont Report (Office of the Secretary of The National Commission for the Protection of Human Subjects of Biomedical and Behavioral Research, 1979), and therefore became relevant to CENS participatory sensing.

Some of the forms that consent took at CENS were traditional. For example, lab leaders implemented a consent form, modeled after those produced by UCLA's Office for the Protection of Research Subjects, for all internal pilot testing. But CENS also put a unique interpretation on consent by expanding towards a focus on *participation.* Influenced by community-based participatory research (CBPR) traditions and ethics, CENS attempted to achieve consent by making campaigns increasingly participatory. Most CENS projects

focused on enabling "human in the loop" sensing, giving individuals some measure of control over data collection and analysis processes. Lab projects such as *Biketastic* were explicitly participatory, involving users throughout the design, sensing, and data analysis process. Though lab pilot projects targeted variable levels of participation in design and execution, the designers largely positioned individuals as involved participants rather than passive users. Discussions about consent forms, data legibility, and long-term user engagement with data manifested values of consent and participation at CENS. I discuss these manifestations in more depth in Chapter 4.

Power and equity

CENS goals also highlighted human interest and social equity. Lab presentations and publications expressed hope that participatory sensing could democratize data collection and change power relationships in the world at large. As a laboratory leader put it in an interview:

> There's some basic thing about the power that data can have to shape policy and shape the world. …If you acknowledge that data are important, then how people make use of data or maybe create their own competing stories becomes like a natural next step and I think that there are a lot of groups that are recognizing that certain problems only get attention when they're framed in the same way. I think that there's a lot of case making, a lot of advocacy going on.

These goals of social equity were reflected in CENS writings, grant proposals, and selection of projects. The Director described health applications as the "killer apps" for participatory sensing, and projects that specifically addressed health disparities (among low-income mothers and HIV positive young men, for example) were among the first health studies targeted by CENS projects. Other projects envisioned public interest initiatives, expressing the potential of technological platforms for advocacy—"making a case" through

distributed documentation of some need. *Biketastic*, for example, aimed to create better maps of bike routes in the famously car-centric city of Los Angeles. The project was envisioned as a low-cost, real-time way to documents areas where city planners could improve existing conditions or increase access through new routes. The *Mobilize* project aimed to put participatory sensing technologies to work in under-resourced computer science and math classrooms in L.A.'s public schools. Finally, the *Boyle Heights Participatory Sensing* project directly engaged questions of race, class, and accessibility while targeting goals of community participation and improvement.

Participation and equity were both challenging values to achieve, however. Motivating student designers to work within participatory frameworks proved difficult. Constraints like deployment requirements, publishing deadlines, and the constant pressures of technical innovation made a slower, stickier, values-oriented design process unattractive or untenable. Traditions of participatory design (PD) were of interest to lab leadership, but further slowed the design process. PD techniques, developed for workplace settings with discrete end users, were additionally complicated when applied to the design of large systems with diverse users (Kensing & Blomberg, 1998; Shilton, Ramanathan, Reddy, et al., 2008). Lab leaders were also frustrated by attempts to frame participatory methods and some social justice projects to capture industry interest. Indicators of equity values included discussions about fairness, uses of personal data, unequal risks among various user populations, and incorporating users into design. I discuss these indicators in more depth in Chapter 4.

Persistent memory and forgetting

CENS discussions also incorporated specters of persistent memory and the social value of forgetting. My own work and that of the ethics team was quite influenced by the "Designing for Forgetting and Exclusion Project" lead by Blanchette, Lievrouw and Curry, and that interest translated into discussion of how best to collect the minimum amount of information needed for any given sensing project. CENS designers explored techniques such as parsimonious activity classification (Mun, Estrin, Burke, & Hansen, 2008) to enable projects like *PEIR* to run with less granular cell tower, rather than precise GPS, data. We drafted data retention policies for projects like *PEIR* in hopes of enabling data deletion and forgetting.

Data retention and deletion, however, were in continual tension with both student designers and clients who argued that less bounded personal data collection might reveal surprising or unanticipated insights. In addition, attempts by both lab leaders and me to commit designers to data retention dates met with frustration. Data retention, like many of the anti-surveillance measures discussed above, required adherence to careful data practices hardly beloved among sensing developers. I looked for concerns about memory and forgetting in conversations about data retention, deletion, and system parsimony – collecting as little personal data as possible to serve project goals. I talk about each of these concerns in more depth in Chapter 4.

From Values to Technology

This dissertation explores how CENS developers moved from grappling with anti-surveillance values to taking action on these values in their design practice. I sketch a three-

part process. The first step was advocacy and consensus-building, leading to the decision to focus on particular social values. The second was the translation of those abstract values into design principles. The third was the conceptualization of design principles as technological features.

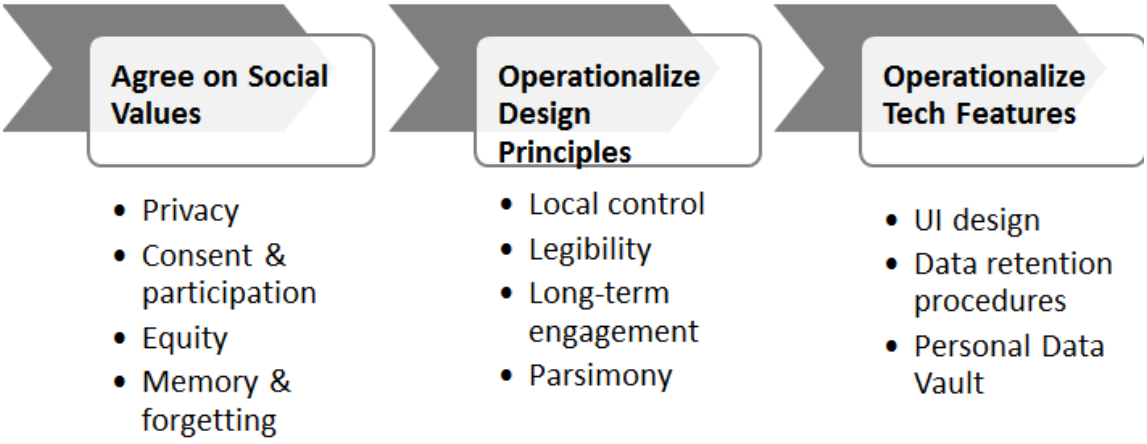


Figure 1.4: Moving from values to technology features

Values levers and the structure of design environments

To understand this process, I began examining design practices and their influence on values. I began by looking for discussion of values such as privacy, consent, equity, and forgetting during design at CENS, and then looked for ways to link these to various design processes: the allotment of funding, the influence of collaborators and mentors, disciplinary backgrounds and knowledge, internal testing of technologies, feedback from system users, and the intervention of an outside advocate. As I began to analyze and write up my ethnographic data, a pattern emerged. Values were surfaced and acted upon by a variety of design practices and activities. These practices were doing a particular kind of work in design: that of raising new conversations about ethics and values. I came to identify these as

values levers: practices that pry openings for discussion of anti-surveillance values during design and help build consensus around those values as design criteria.

For example, I began to notice that conversations about *personal data and resulting inferences* at CENS – what kind of measurements about people (ranging from location to accelerometer readings to photos) were being recorded on the mobile phones, where they were being stored and processed, and what the system or outside observers might conclude from those measurements – tended to become conversations about *values*. Issues of privacy, consent, equity and forgetting were intimately tied to contemplation of what kinds of data were being collected, who could access them, when and how they were shared, and how they could be interpreted. Talking about personal data, and the processes surrounding that data, tended to entail talking about values.

What role was this discussion about personal data playing in design? I was initially tempted to call personal data *boundary objects* or *infrastructure*: popular figures in science and technology studies. Boundary objects are objects or practices that are "adaptable to different viewpoints but robust enough to maintain identity across them" (Star & Griesemer, 1989, p. 387). This seemed to describe personal data, which were not a focal point of study at CENS but instead something interpreted differently by heterogeneous actors in design. Personal data captured by CENS systems have many of the features of boundary objects and infrastructure (Star, 2010): they are embedded, transparent, and have significant reach and scope. What qualifies as "personal data" are learned as part of membership in CENS. Personal data become visible upon breakdown, for example when a data point proved impossible to measure, or too problematic to interpret. And like infrastructure in many other settings, discussion of such user-centric data was not always a focus of design at CENS.

Borgman et al (2007b) report that during early environmental sensing work at the Center, most design attention was focused on system development, rather than attention to data quality and management. Similarly, the engineering challenges of participatory sensing were at the forefront of the team's research. Though gathering personal data was the goal of participatory sensing campaigns, it was not the primary focus of most CENS developers. Instead, designers' focus was often on efficiency and power savings, user interfaces, and whether their algorithms could correctly detect activity or mobility patterns. As a result, data storage and metadata issues that have been a previous focus of CENS research (Borgman et al., 2007a; Mayernik et al., 2007) were not picked up by the participatory sensing team.

But to be a true boundary object, personal data should have linked the work practices of computer scientists, statisticians, and social scientists without requiring these disparate groups to reach consensus. It is here that the personal data collected during participatory sensing served a different role than that of a boundary object. In a recent article, Star emphasized that boundary objects are used in cooperation between groups: "Boundary objects are a sort of arrangement that allow different groups to work together without consensus" (Star, 2010, p. 602). Participatory sensing data, however, were helping disparate actors at CENS *achieve* consensus around social values such as privacy. I needed a new way to view the work of personal data in CENS design. I hypothesized that discussion of personal data was acting as one of many *values levers*: a force applied by a design practice or activity that helped focus attention on social values, and encouraged designers to come to consensus about the importance of those values.

During an initial year at CENS, I became acquainted with diverse practices and activities that were part of design at CENS. These included practices such as working on

interdisciplinary teams and conducting internal pilot tests that focused designers on personal data; designing around values constraints; seeking user feedback; advocacy by leaders and mentors; navigating ethical mandates enforced by UCLA's Institutional Review Board (IRB); advocacy by a values advocate; and gaining new funding for design. As I analyzed my interview and field note data, I began to look for how each of these practices affected consideration of anti-surveillance values. Drawing this connection between practices in design and values levers shaped my primary conclusion: the routinized practices of design work shape the values incorporated into new technologies. By purposefully introducing certain design practices, we can encourage social values as design criteria by fostering and implementing values levers.

This dissertation illustrates how diverse design practices created values levers, which opened space for conversations about, and action on, anti-surveillance values. Three design practices in particular – experiencing internal testing, working on interdisciplinary teams, and advocacy by a team member dedicated to values issues – proved quite effective at generating consensus around, and technological features based on, anti-surveillance values. Two others, including navigating the mandates of UCLA's Institutional Review Board and seeking the feedback of users, hold promise, but need adjustment to be truly powerful values levers.

Building a critical technical practice

As both an observer of design and an advocate for values in design, my purpose was to think critically about the development of participatory sensing technologies in a spirit of constructive, interdisciplinary work. As Phil Agre (1997a) wrote:

> It is true that critical theorists are essentially suspicious; they dig below the surface of things, and they do not expect to like what they find there. But

> critical analysis quickly becomes lost unless it is organized and guided by an affirmative moral purpose (1997a, p. xii).

The affirmative moral purpose in my work was to build participatory sensing technologies that reached their social potential; that genuinely helped their users understand their lives and benefit from data collection, without producing the forms of social control and power invoked by traditional surveillance practices. Agre used a term that I found useful in thinking through this work: building a "critical technical practice." He defined such a practice as attention during design to the values, metaphors, and justifications that underlie technical work. Rabinow and Bennett used different terminology, but with a similar goal:

> This work is accomplished not through the prescription of moral codes, but through mutual reflection on the practices and relationships at work in scientific engagement and how these practices and relationships allow for the realization of specified ends. Straightforwardly: ethics and anthropology can be designed so as to help us pause, inquire into what is going on, and evaluate projects and strategies (Rabinow & Bennett, 2008, p. 81).

The goal of this dissertation was to pause, inquire into what was going on, and evaluate.

When formulating the idea of a critical technical practice, Agre described what such work might entail:

> A critical technical practice will, at least for the foreseeable future, require a split identity -- one foot planted in the craft work of design and the other foot planted in the reflexive work of critique. Successfully spanning these borderlands… will require a praxis of daily work: forms of language, career strategies, and social networks that support the exploration of alternative work practices that will inevitably seem strange to insiders and outsiders alike. This strangeness will not always be comfortable, but it will be productive nonetheless, both in the esoteric terms of the technical field itself and in the exoteric terms by which we ultimately evaluate a technical field's contribution to society (Agre, 1997b).

With one foot planted in design work and one in critique, the participant-observation data I collected during this project illustrates the practices, people, structures and tensions during

design that facilitate or frustrate ethical affordances: technology features that reflect moral values. Further, through changes in design and laboratory practices, my project explicitly asks designers to consider and respond to ethical questions during the process of innovation and development. My research asks not only what values participatory sensing designers espouse, but how values levers deployed by outside social scientists, mentors and colleagues, clients and research subjects, and institutional authorities, might increase designers' ability to consider, foreground and react to desirable ethics within the constraints of design. Understanding when and how sensing engineers weigh social values to make design decisions, and the technological features that result, can reveal the possibilities that participatory sensing holds for secure and equitable use, meaningful community participation, and empowerment.

Organization of the dissertation

To illustrate how values levers help transform social values into technological affordances, I have structured the dissertation as follows. *Chapter 2: Literature Review – Situating Participatory Sensing* explores the design challenges for participatory data collection suggested by literature from technology studies, surveillance studies, participatory research traditions, and values in design. *Chapter 3: Methods* discusses the methods used to gather data during two years embedded at CENS. *Chapter 4: Findings – Observing Values in Design at CENS* describes design at CENS, including the emergence of social values such as privacy, consent, equity, and forgetting, as well as ways that those values compete with other values in design. It also describes the ways in which values levers worked at CENS, altering the design conversation and bridging between discussion of values and the implementation of those

values as technical features. *Chapter 5: Discussion – Values Levers and Critical Technical Practice* analyzes the implications of anti-surveillance values at CENS, and characterizes how values levers became effective in design. It draws the conclusion that the structure of a design laboratory will affect when and how values levers can be deployed. In *Chapter 6: Conclusions*, I draw upon analysis of practices that promote and impede attention to ant-surveillance values in design to suggest how design tools such as interdisciplinary interventions, as well as policy tools such as funding streams, might counter those obstacles. Aimed at scholars in information studies, social studies of technology, and information policy, the conclusions drawn in this thesis will inform design and policy debates for emerging data collection technologies.

Chapter 2: Literature Review – Situating Participatory Sensing

Studying values in the design of participatory sensing systems involves a complicated mix of technical and social infrastructures, laboratory dynamics and contexts, computing culture, and new values challenges. This chapter will trace these social and technical factors, all of which influence the way that social values are expressed and embedded in participatory sensing. Diverse theoretical and empirical literatures from information studies, technology studies, surveillance studies, participatory research traditions, and values in design make contributions to exploring social challenges for participatory data collection.

The chapter begins by defining critical concepts used throughout the dissertation, including the social and infrastructural contexts of participatory sensing. It then explores why surveillance is a possible negative social consequence of participatory sensing. The dangers of social control or chilling effects on social participation produced by pervasive data collection in turn suggest a set of social values challenges raised by the dangers of surveillance: privacy, consent, equity, and forgetting. The chapter explores how each of these values has been explored in participatory sensing to date.

The chapter then explores the ways theoretical perspectives developed in a literature loosely referred to as "values in design" might contribute to understanding surveillance problems in participatory sensing. I discuss how values are understood to be built into technologies, and the tradition of studying how values manifest during the design process. I also discuss the limits of such a design-focused perspective: the ways participatory sensing values are constrained by powerful infrastructures outside of design, including existing telecommunications providers and telecommunications policy. This perspective, as well as its limits, contributes to the theoretical framework I employ in the dissertation. The literature

supports the assumption that design practices and agents affect how social values are incorporated into design. It further supports the proposition that observing design can reveal ways in which the structure of a laboratory contributes to social values expressed in design. To support this framework, I describe lab practices and agents suggested by the literature that may affect values decisions in participatory sensing design.

Defining Critical Concepts

Before moving farther in the dissertation, it is important to define the concepts that lay at the center of my area of inquiry. These concepts are: the technology of participatory sensing; the personal data collected during sensing; and the participatory sensing stakeholders—designers, clients and users—who were my subjects and informants.

Participatory sensing

At its core, the technology under development at CENS and elsewhere drew upon previous work on sensor networks—arrays of devices embedded in an environment for taking measurements of a phenomena—and brought them into social settings. In this context, I use *sensing* to refer to the use of fabricated devices (rather than human senses) to measure, record, upload and aggregate data. This could include arrays of sensors placed in natural environments, such as tools to measure groundwater contaminants or soil moisture levels (Cuff et al., 2008). Sensing could also be performed by devices carried onboard vehicles (Eisenman et al., 2007c) or by mobile phones (Campbell, Eisenman, N. D. Lane, Miluzzo, & Peterson, 2006; Cuff et al., 2008; Eagle, 2008). Participatory sensing, then, referred to sensing knowingly performed by people using technology devices, and collected,

analyzed, displayed and shared through a unified infrastructure. The research trajectory that was "participatory sensing" referred to the building and coordination of this infrastructure.

Participatory sensing was relatively new research trajectory, and as such, did not have fixed terminology or universal consensus about goals and techniques. This branch of research has been variously called "mobile sensing," "personal mobile sensing" or "participatory sensing" (at CENS), "urban sensing" (in workshop and conference titles), and "mobile4development" (among overseas development advocates). CENS was only one innovator in this research. Others included:

- MetroSense at Dartmouth University (http://metrosense.cs.dartmouth.edu/)
- The Senseable City Lab and Reality Mining at MIT (http://senseable.mit.edu/ and http://reality.media.mit.edu/)
- Neighborhood Networks at Carnegie Mellon University (http://www.neighborhood-networks.net/index.html)
- Everyday Behavioral Monitoring at Intel Research (http://www.seattle.intel-research.net/projects.php#ebm)
- MyLifeBits at Microsoft Research (http://research.microsoft.com/en-us/projects/mylifebits/)
- Mobile Urban Sensing and the TIME Project at Cambridge University (http://www.escience.cam.ac.uk/mobiledata/and http://www.cl.cam.ac.uk/research/time/)
- MobileActive (http://mobileactive.org/)
- Ecorio (http://www.ecorio.org/)

An important distinction between participatory sensing and other forms of coordinated sensing is that participatory sensing did not embed new sensors in the environment. Instead, it harnessed existing tools—mobile phones and PDAs—to use as sensors. I describe participatory sensing at greater length in the section "Participatory sensing as scholarly research" below.

Participatory sensing data

The data that could be gathered by mobile technologies were understood to be the focal point of participatory sensing. Collecting, processing and drawing conclusions from data previously too granular or expensive to harvest was the goal of participatory sensing research initiatives. There are many definitions for data, and participatory sensing publications and researchers use the term in a multitude of ways. To simplify the discussion in my dissertation, I define participatory sensing data quite broadly: as any representations recorded by a mobile device and uploaded to a storage facility for processing and interpretation. Examples might be GPS points, user-entered text, or images. The data collected during participatory sensing were also bounded by the technical limitations of sensing devices. Because CENS committed to using off-the-shelf sensing capabilities (for reasons of scalability and cost), the range of media that phones could sense was limited to sound, images, location, co-location, and motion.

Participatory sensing data were frequently *personal data* according to common legal and social definitions. As Kang (1998) described in a legal piece on privacy and emerging technologies, personal information is authored by an individual, describes an individual, or can be mapped to an individual. Participatory sensing data often met all three of these criteria. The participant used a device to collect the data, thereby in some sense authoring the data. The data were often descriptive of a participant's life, routine, or environment. And participatory sensing data could quite literally be mapped to a person. Geotagged photos or a GPS log of a person's movements throughout a day could be used to identify an individual, even if no names or identifiers are directly attached to the data (Anthony, Kotz, & Henderson, 2007; Iachello, I. Smith, Consolvo, Chen, & Abowd, 2005).

Despite the fact that the definition of personal data includes authorship by an individual, U.S. law has not interpreted such data as *owned* by the individual. Instead, legal regimes give control of, and responsibility for, personal data to the institution that collected that data (Waldo, Lin, & Millett, 2007). I describe CENS attempts to challenge this tradition through both technical architecture and legal arguments in Chapter 4: Findings. I also discuss the complexities surrounding participatory sensing data in the section "Values in a Network," below.

Stakeholders: designers, clients and users

My research combined perspectives from, and observation of, a wide variety of stakeholders in participatory sensing. Designers were the major focus of observation and analysis in my research. I define designers as faculty, staff, graduate, or undergraduate students employed by the Center for Embedded Networked Sensing and directly responsible for planning for, supporting, or writing code to enable participatory sensing. This included writing scripts for the mobile phones to collect data, implementing the database that held the data, writing processing algorithms that interpreted and analyzed the data, and designing user interfaces to visualize the data for an end public. Designers were almost entirely students or faculty from the disciplines of computer science, electrical engineering, and statistics.

Designers were not the only important stakeholders in participatory sensing. Clients also had an important impact on design decisions. Clients were scientists and social scientists, community groups, campus organizations, or others with whom CENS designers collaborated to brainstorm, plan, and implement sensing projects. Scientists and social scientists involved in participatory sensing included colleagues at the UCLA Semel Institute

Global Center for Children & Families, who were engaged with the design of health and wellness applications. Partner community groups included the Los Angeles County Bicycle Coalition (LACBC) and BikeSage, two local cycling advocacy groups. Campus collaborators included UCLA Facilities, which was involved in participatory sensing projects to document waste on campus.

Finally, users were the individuals who volunteered to use CENS software to provide data for CENS applications. Users were sometimes independent, interested individuals, part of a client community group or research lab, or part of the CENS design team. Although users could conceivably be anyone with a mobile telephone, for my study, I defined users as anyone who sampled and uploaded data for a targeted CENS data collection initiative. Designers, clients and users were not always distinct groups; some designers fulfilled all three roles at different times, for example.

Participatory sensing coordinated these stakeholders around an emerging technological infrastructure to collect new kinds of data. In order to understand the values that emerge from this network of technology, data, and people, it is important to place participatory sensing in a broader context. In the next section, I briefly discuss historical and technical antecedents to participatory sensing. I then describe the emergence of participatory sensing as an infrastructure that carries within it values commitments and challenges.

Participatory sensing as scholarly research

Participatory sensing's antecedents point to its position as a research topic pursued by academics and students. This shapes the nature of communication, collaboration, and data practices surrounding participatory sensing, and in turn affects the values and norms

under which the technology develops. Publishing venues, academic hierarchies, partnerships and collaborations, and the research environment may all affect the development of particular values – whether moral or practical – in participatory sensing.

Participatory sensing is the focus of a number of formal conferences, providing communications forms during which students and faculty share their ideas and results.[4] Conferences are extraordinarily important in computer science and engineering research, as they are considered to be more timely and competitive than journals or book publications (Borgman, 2007). Both conferences and associated workshops (smaller, less competitive conference venues) generate publications that track and share the progress of participatory sensing work.

Participatory sensing is also subject to broad social structures in academic research, including collaboration networks and "invisible collages" (groups of colleagues with similar interests but without shared institutional affiliation) (Lievrouw, 1989). Academic colleagues use these networks to share background knowledge, learn about important developments in the field, and pursue new research. Examining how collaboration networks affect values decisions will be another avenue towards understanding the relationship between engineering practice and values in participatory sensing.

And while participatory sensing is a research pursuit, it is simultaneously a project of engineering and building software. This places participatory sensing in an amorphous

[4] Major participatory sensing conferences include The International Conference on Mobile Systems, Applications and Services (MobiSys) http://www.sigmobile.org/mobisys/, and the ACM Conference on Embedded Networked Sensor Systems (Sensys) http://sensys.acm.org/.

creative space: the methods and practices of software engineering vary widely. As Mahoney put it in a book on the history of software engineering:

> What seems clear from the literature from the field's very inception, reinforced by addresses, panels, articles, and letters to the editor that regularly appear, is that its practitioners disagree on what software engineering is, although most of them freely confess that, whatever it is, it is not (yet) an engineering discipline (2004, p. 8).

The line between research and design affected both goals and practices at CENS, and therefore the expression of values in both those goals and practices.

Participatory sensing as infrastructure and platform

Participatory sensing is not just an academic topic. It is also embodied in an emerging set of intertwined technologies, practices, and stakeholders. As such, participatory sensing represents an emerging computing *infrastructure*. Infrastructure, as Star (1999) defines it in the influential "The Ethnography of Infrastructure," is any backstage support of human organization. Star describes eight qualities of infrastructure, each of them relevant to participatory sensing. Infrastructure, writes Star, is embedded, transparent, has broad reach or scope, is learned as part of membership in a group, both shapes and is shaped by practices within a community, embodies community standards, is built on an existing base, becomes visible when it breaks, and changes slowly and in increments.

These qualities of infrastructure suggest a number of the values challenges posed by participatory sensing. It is precisely the embedded, transparent nature of participatory sensing that creates privacy problems and complicates consent. Participatory sensing is broad in scope, is learned as part of participation in a group, and is both shaped by and shaping of cultural practices and community standards. Each of these features evokes

questions of power and equity. And because participatory sensing is built on top of an existing base of telecommunications networks, questions of openness plague development.

Participatory sensing developers are developing not just infrastructure, but also *platforms:* a term that is not neutral, but instead does important discursive work (Gillespie, 2010). "Platforms" are a springboard for something, an infrastructure that can be marshaled for new goals and purposes. Platforms can mean support for computation, for content, for speech and participation, or for broader social opportunity. CENS development touches on all of these, and participatory sensing invokes this full range of the meaning of "platform".

Antecedents of participatory sensing

The platform or infrastructure of participatory sensing emerged from a history of computer science research, and a long tradition of engineering technologies that sought to understand and improve social systems. As a branch of computer science research, participatory sensing descended directly from earlier investigations into embedding sensors in the natural environment to collect ecological or environmental science data (Cuff et al., 2008). This research legacy brought a variety of technical concerns to participatory sensing, including the importance of sensor placement (Krause, Guestrin, Gupta, & Kleinberg, 2006; Reddy et al., 2008), research into data accuracy and validation, and overcoming power and processing constraints (Burke et al., 2006a). Other technical antecedents of participatory sensing included development of devices now utilized in participatory sensing, such as wireless networks, digital cameras, accelerometers, and GPS devices.

Participatory sensing also echoed research trajectories that harnessed existing distributed technical and social networks for new research goals. Examples as varied as

Cornell University's Great Backyard Bird Count ("Great Backyard Bird Count," n d) and SETI@home ("SETI@home," n d) incorporated volunteers and their technology in search of new findings. These projects traded messy, heterogeneous data for the promise of benefiting from measurements drawn from thousands of volunteers or machines.

Though the goals and approach of participatory sensing mirrored citizen science and distributed computing projects, the tools used tied these efforts to the larger research trajectory of pervasive or ubiquitous computing. Ubiquitous computing imagined computers "embedded everywhere" (Kang & Cuff, 2005). Ubiquitous computing researchers developed systems ranging from handheld devices to an "internet of things" (Dodson, 2003) to social spaces augmented with sensors and computers (Angus et al., 2008; G. R. Hayes et al., 2008; Khan & Markopoulos, 2009).

Like ubiquitous computing before it, participatory sensing was what Kling and Iacono (1988) identify as a "computerization movement": coordinated attempts to increase access to, and simultaneously organize social life around, the introduction of new computing technologies. Advocates bearing ideological commitments about what computers are good for drive computerization movements. The advocates and movements reflected a "preferred social order" (Kling & Iacono, 1988, p. 227) reliant on the forms of processing and organization that computers can provide. Computerization movements have been an influential concept in understanding the rise of ICTs, and a stream of research since Kling and Iacono's initial work has updated and further explicated the concept (Hara & Rosenbaum, 2008). Much like workplace or home computerization movements in the 1980s and 90s, participatory sensing advocates seek to move the perceived benefits of computation into new social settings.

The roots of participatory sensing extend back even farther, linked to cybernetics scholarship and its roots in "scientific" management (Andrejevic, 2007; Hayles, 1999). Frederick Taylor pioneered scientific management in order to improve the efficiency of factories and workplaces. One of the many things that Taylorism influenced was cybernetics, the study of control of social systems through information feedback loops. In his work *The Control Revolution,* Beniger (1986) traced the ways that computing power changed how information about mass production, distribution, and consumption could be collected and communicated. This revolution in control allowed for management of economic and social processes in new ways. Often, these projects had pro-social or even utopian goals (Medina, 2006). Participatory sensing displayed a similar reflexivity to other cybernetic movements (Hayles, 1999): the engineers working on participatory sensing systems produce the data that they assume exists and is discoverable.

Cybernetics related to another antecedent of participatory sensing: surveillance systems (Ernst, 2002). Scholars, policymakers and the public often use the term surveillance to denote any centralized information collection system. There is a broad surveillance studies literature, however, that approaches the topic using more nuanced definitions. Monahan, for example, identifies surveillance technologies as "those that facilitate the identification, monitoring, tracking, and control of people" (2006c, p. x). Lyon (2001) also emphasizes the importance of control, placing information technologies on a continuum between care and control. Technologies can "watch over" people to protect them from danger, but also to prevent undesirable behaviors (Lyon, 2001, p. 3). Surveillance technologies of control range from state-sponsored data collection (Luebke & Milton, 1994) to CCTV cameras (Friedman,

Kahn, Hagman, & Severson, 2006). Though it may be unintended by developers, the "many eyes" of participatory sensing evokes this lineage.

Surveillance Challenges in Participatory Sensing

This history suggests that participatory sensing can be characterized as a platform for not just personal data collection, but for surveillance. Participatory sensing imagines a world where individuals and loosely affiliated groups can use familiar tools such as mobile phones to gather significant amounts of data on themselves and their environment. This is an expansion on the idea of self-surveillance put forward by Vaz and Bruno (2003), employing specialized technology with specific abilities and limits to consider the self as subject. Off-the-shelf technologies currently available can gather images, sound, location, and motion using phone cameras, microphones, GPS, and accelerometers. But such data-intensive self-surveillance can have unintended consequences. Participatory sensing projects gather, store and process large amounts of personal information, creating massive databases of individuals' locations, movements, images, sound clips, text annotations, and even health data. Habits and mood are both socially sensitive (would you want such information shared with a boss or friend?) and may be linked with, or have an impact on, legally protected medical information. Location information is equally revealing of habits and routines. Location data shared with an acquaintance might reveal minor indiscretions, exposing little white lies about plans or social obligations. Surveillance disrupts information privacy, allowing data to flow outside of expected contexts and social norms (Nissenbaum, 2009c). It produces conformity by creating chilling effects on legal, but socially marginalized, activities (Cohen, 2008). And databases of locations and routines allow for segmentation and sorting

of consumers, enabling ever more forms of structural discrimination based on new demographic categories (Curry et al., 2004; Phillips, 2005a).

These possibilities highlight social control enabled through personal data collection. Surveillance has been defined as: "any collection and processing of personal data … for the purposes of influencing or managing those whose data have been garnered" (Lyon, 2001, p. 2). This definition points to the often pernicious effects of surveillance: a focus on social conformity and homogenization at the expense of deviance, disobedience and even creativity (Foucault, 2002). As scholars from Foucault (1979) to Vaz and Bruno (2003) have explained, surveillance is an instrument for normalizing and disciplining individuals. Foucault's influential work on surveillance and the panopticon point to the tendency of the surveilled to supervise and discipline themselves – a goal embraced by self-surveillance applications focused on health interventions or worker productivity.[5] Vaz and Bruno explicitly explore self-surveillance, which often involves identifying something wrong with the self, something that has strayed from the 'correct' path. Similar disciplinary effects are seen when communities organize to collect data, as well. Many community-focused data gathering projects report and discipline perceived social problems such as crime or blight.[6] Data collection, as an accepted avenue to empirical knowledge production, is one tool for gaining power over others and using this power to control. Collecting personal data allows the surveilling party to sort populations, draw conclusions, or track individuals.

---

[5] See for example RescueTime http://www.rescuetime.com/, which, while not a mobile application, is explicitly targeted at self-surveillance for increased productivity.

[6] See for example CitySourced http://www.citysourced.com/, in which predefined categories of community problems include such designations as "homeless nuisance."

Participatory sensing, however, challenges some of the attributes that make traditional surveillance practices particularly damaging. Participatory sensing provides a new wrinkle in what Lyon refers to as "postmodern surveillance" (Lyon, 2001). Such surveillance is large-scale data collection conducted by corporations and organizations in addition to traditional government actors. Both Agre (1994) and Marx (2002) indicate that surveillance is increasingly embedded and invisible. Marx also finds that surveillance is progressively involuntary, as giving up one's data is now required to gain many services. A final pernicious effect of surveillance is its increasingly uneven application, directed at marginalized and disenfranchised groups. Monahan writes that the social relations produced by surveillance systems are "part of larger trends toward sociospatial segregation in modern society" (2006a, p. 14). Broad-scale data collection about purchase habits, location and movements enables data sorting and subsequent social profiling, by governments and corporations (Curry et al., 2004). As Monahan describes it:

> …what is being secured are social relations, institutional structures, and cultural dispositions that—more often than not—aggravate existing social inequalities and establish rationales for increased, invasive surveillance of marginalized groups (2006c, p. ix)

The relationship between participatory sensing technologies and surveillance may be more complicated, however, because the power relations in participatory sensing are not as clear cut as they are in corporate or government surveillance. For example, the capture and control of participatory sensing data is distributed, and peoples from marginalized social positions may use the power to collect and analyze data to confront the powerful. In this scenario, participatory sensing technologies may fit into a tradition of counter-surveillance or sousveillance, the subversion of observation technologies by the less powerful in order to

hold authorities accountable. Examples of this tradition include using video cameras and mobile phones for cop watching and counter-surveillance (Huey, Walby, & Doyle, 2006; Monahan, 2006b), defensive surveillance (Institute for Applied Autonomy, 2006), peacekeeping and economic development (Donner, Verclas, & Toyama, 2008), and self-exploration and play (Albrechtslund, 2008). In these examples, surveillance may not preclude empowerment: there are perhaps possibilities for surveillance technologies to contribute to fairness, equity, or social good. Monahan, who has taken the lead in theorizing possibilities for surveillance and empowerment, writes that there is hope for surveillance systems to correct power imbalances, rather than aggravate them, if systems "are designed for 'structural flexibility', meaning that they are democratic, participatory, localized, and open to alteration" (Monahan, p. 20-21).

Anti-surveillance values

Surveillance concerns illustrate just some of the social concerns, and social values, embedded within participatory sensing. The process of defining such concerns, and values that invoke such concerns, falls into the practice of *macroethics*: philosophy concerned with social responsibility and the broad social effects of work or human actions.[7] As Vallero (2008) writes, "Macroethics involves doing what is needed for the long-term improvement of society" (Vallero, 2008, p. 287). Considering macroethics is particularly important in the design of emerging technologies, when "downstream" effects and repercussions are not entirely predictable.

[7] This is distinct from *microethics*, which is concerned with ethical research and engineering practices such as avoiding plagiarism, not falsifying data, etc.

The macroethical social considerations that I pursue in this dissertation – privacy, consent, equity, and forgetting – spring from study of the literature on surveillance as well as study of values concerns in practice at CENS. These values are not an exhaustive list; the challenges I have raised here are not the only ones suggested by participatory sensing. Values as diverse as sustainability, accessibility, openness, or creativity are all relevant to CENS design. But because the social concern of surveillance is so specifically invoked by the data collection tools of participatory sensing, I have chosen to focus on *anti-surveillance values*. Privacy, consent, equity and forgetting are all tied to questions of surveillance, and each has emerged during two years spent discussing and debating these issues in the CENS lab, with UCLA mentors and fellow students, and with colleagues at workshops. Challenges such as privacy and consent, as I will illustrate, arose among designers. Others of these challenges, such as power and equity, and memory and forgetting, are specifically grounded in science and technology studies, information ethics, and participatory research ethics.

In the field of information ethics, scholars such as Marx (1998) have provided guidelines for values and ethics in the design of surveillance technologies. These include weighing the *means* of collection, the data collection *context*, and *uses* of the data. Picking apart the means, context, and uses of participatory sensing systems at CENS has been one of the ways in which values such as privacy and consent have arisen.

The values under consideration in this thesis have been influenced by traditions of participatory research (PR) ethics, which focus on values such as participation, autonomy, empowerment, and engagement in research processes. PR is a set of research methodologies that position research subjects as co-investigators (Cargo & Mercer, 2008). PR partnerships between academic researchers and co-investigators from partner communities are gaining

prevalence in a diversity of fields, including health sciences (Cargo & Mercer, 2008; Horowitz, Robinson, & Seifer, 2009), urban and environmental planning (Catalani & Minkler, 2009; Corburn, 2003), and information system design (Byrne & Alexander, 2006; Rambaldi, Chambers, McCall, & J. Fox, 2006). PR has previously incorporated primarily qualitative and survey-based social science data collection methods, but its values are newly relevant to questions of pervasive data collection, as well. Because its tenets focus on the ethics of collecting and analyzing data from individuals and communities, PR can be used as a model for large-scale or ubiquitous data collection. PR adopts the standpoint that data collection, sorting and use can be empowering, if it is conducted by the people most affected by the data collection – the research subjects themselves. PR traditions develop their research questions with the cooperation of partner communities and engage community members in research design, implementation, analysis, and dissemination. Involvement with every stage of the research process allows participants to target local knowledge and benefit from the results of systematic investigations. PR successes in health and environmental research have improved the ability of marginalized or underserved groups to act on the results of the data they have helped collect and analyze (Horowitz et al., 2009).

Focusing on anti-surveillance values – privacy, consent, equity and forgetting – also balances a blend of ethical frameworks. Privacy and forgetting are traditionally considered to be *utilitarian* ethics: focused on balancing costs and benefits of particular actions (Ess, 2009). A utilitarian framework tries to pursue acts that bring about the greatest number of positive consequences for the most number of people (Johnson, 2000). Privacy and forgetting both focus on consequences: they are assumed (by theoreticians such as Marx, above) to ensure consequences that lead to greater happiness. Conversely, values such as consent and equity

emerge from *deontological* ethics, as articulated by philosophers such as Kant (Ess, 2009). Deontological ethics hold that some universal principles are inherent and inviolate. Deontological ethics are at the heart of human rights such as equity and human dignity; consent and equity are often seen as instrumental in the pursuit of human dignity.

Privacy in participatory sensing

CENS participatory sensing projects are marked by tensions between the benefits of ubiquitous data capture and individual desires to hide, alter, or delete data. Basic participatory sensing functions such as "activity classification"—the ability to infer a person's activities from their location trace or other data— rely on accurate, frequent, and granular data capture. Such functions, however, provide a number of opportunities for privacy invasions.

Privacy regulation and protection are critical topics in the design of ubiquitous and pervasive systems (Anthony et al., 2007; G. R. Hayes et al., 2007; Hong & Satyanarayanan, 2007; Joseph, 2007; Surie, Perrig, Satyanarayanan, & Farber, 2007). There are also rich literatures on approaches to privacy in computer science and engineering, policy, law, and ethics. Computer science and engineering research innovates methods to obscure, hide, or anonymize data in order to give users privacy options (Ackerman & Cranor, 1999; Agrawal & Srikant, 2000; Fienberg, 2006; Frikken & Atallah, 2004; Ganti, Pham, Tsai, & Abdelzaher, 2008; Iachello & Hong, 2007). Human-computer interaction research considers ways that systems might notify or interact with users to help them understand privacy risks (Anthony et al., 2007; Bellotti, 1998; D. H. Nguyen & Mynatt, 2002). Policy and legal research frame new regulations that could encourage individual and social privacy (Cohen, 2008;

Nissenbaum, 1998b; 2004; Rule, 2004; Swarthout, 1967; Waldo et al., 2007). Ethics and information science researcher analyzes the function of privacy as a social norm (Altman, 1977; Capurro, 2005; Palen & Dourish, 2003) and critiques new technologies and technological practices on privacy grounds (Agre, 1994; 1998; Burkert, 1998; Camp & Connelly, 2008; Marx, 2006a; Phillips, 2003).

In the United States and Europe, *fair information practices* are one macroethical standard for organizations that collect personal data. Originally codified in the 1970s by the U.S. Department of Health, Education & Welfare, the Code of Fair Information Practices respond to citizens' rights to privacy (*Personal Privacy in an Information Society: The Report of The Privacy Protection Study Commission*, 1977; U.S. Department of Health, Education, and Welfare, 1973). The U.S. Codes were later adapted and expanded by the Organisation for Economic Cooperation and Development. These codes are still considered "the gold standard for privacy protection" (Waldo et al., 2007, p. 48), and fair information practices have been voluntarily adopted by other nations as well as private entities.[8] Because of their importance and prevalence, the Codes of Fair Information Practice form a natural place to begin consideration of privacy in participatory sensing.

Participants in sensing certainly deserve notice and awareness, choice and consent, access and participation, integrity and security, and enforcement and redress as recommended by fair information practices. These practices, however, assume a transactional model of privacy. Theoretical and empirical work in information ethics, however, demonstrates that privacy regulation goes beyond the transactional approach that

8 An excellent local example of the influence of the Codes of Fair Information Practice is the UCLA Statement on Privacy, which can currently be found in draft form here: http://privacyboard.ucla.edu/

fair information practices depend upon (Camp & Connelly, 2008; Palen & Dourish, 2003). Instead, privacy is interpreted as a process of enforcing personal boundaries (Shapiro, 1998) or a method of portraying particular, sometimes changing identities (Phillips, 2002; 2005a). Scholars such as Nissenbaum (1998b; 2004) suggest that individuals' sense of appropriate disclosure, as well as understanding of information flow developed by experience within a space, contribute to individual discretion. For example, whispered conversations in crowded cafés may feel private, because there are no known modes of distribution for that information (Cohen, 2008). Individuals may also be willing to disclose highly personal information on social networking sites because they believe they understand the information flow of those sites (Lange, 2007).

Nissenbaum (2004) labels this concern for fluid and variable disclosure "contextual privacy" and argues that its absence not only leads to exposure, but also decreasing individual autonomy and freedom, damage to human relationships, and eventually, degradation of democracy. Other researchers similarly suggest that concerns about data capture extend beyond the protection of individuals. Curry, Phillips and Regan (2004) write that data capture makes places and populations increasingly visible or *legible*. Though explicitly forbidden by fair information practices, increasing knowledge about the actions of people and their movements has led to function creep in a number of instances. For example, function creep enables social discrimination through practices such as price gouging or delivering unequal services predicated upon demographic data.

All of this cross-disciplinary attention points to the fact that *building systems* that protect privacy remains a challenge. Systems designed to protect privacy, often called Privacy Enhancing Technologies (PETs), have a mixed legacy (Burkert, 1998; Goldberg, 2008;

Phillips, 2004). While PETs increase attention to privacy in both technical and social realms, their limitations are very real. PETs often can protect a single user from a more powerful organization but do not deal well with peer-to-peer data sharing, where sharing decisions may be fluid and changing. PETs also follow strict definitions of "identifying information" (for example, name, social security number) and do not grapple with difficult concepts such as location privacy, in which identity may be implied from data (Burkert, 1998). Finally, PETs reify constrictive definitions of privacy, restricting privacy to controlling release of personally identifying data without recognizing fluid identities or contexts (Phillips, 2004).

Though technical responses to privacy challenges are still evolving, the literature on the importance of privacy to the public is clear. The foundational research of Alan Westin helped to establish pre-internet understandings of American public opinion on privacy (Westin, 1970). Over several decades, Westin used large surveys to confirm variation in privacy concerns from "privacy fundamentalists" (very concerned) to pragmatic (sometimes concerned) to unconcerned. Westin's work has inspired a number of follow-up studies. Sheehan (2002) confirmed similar variability among internet users. A number of information science pieces have attempted to redraw scales for online privacy preferences. For example, both Yao et al (2007) and Buchanan et al (2007) suggest factors by which to measure online privacy concern. Yao et al (2007) focus on psychological variables, while Buchanan et al (2007) incorporate different aspects of privacy (for example, accessibility, physical privacy, and benefits of surrendering privacy). The Pew Internet & American Life Project has produced several reports of privacy preferences based upon large U.S. surveys of adults (Madden, S. Fox, A. Smith, & Vitak, 2007) and teens (Lenhart & Madden, 2007). The Pew survey of teens finds strong concerns about some kinds of privacy among teenagers,

countering a popular view that today's children have abandoned privacy as a value. The survey of adults also found growing awareness of our "digital footprints." Similarly, a study by Strickland and Hunt (2005) found widespread confusion and distaste among information professionals—generally considered a technically adept population—about new data collection technologies such as RFID chips and smartcards.

A persistent problem, however, in surveys of privacy preferences is that individuals frequently report privacy preferences that they don't act upon in practice. There is evidence that many privacy studies prime respondents to think about privacy violations, making them more likely to report privacy concerns (John, Acquisti, & Loewenstein, 2009). These studies also make problematic assumptions that people act on a rational privacy interest, an assumption that has been increasingly challenged by privacy researchers (Acquisti & Grossklags, 2008).

Studies that observe people's real-world use of systems attempt to correct for these problems. Raento et al (2008), for example, present results from three years of field trials of social awareness software that uses smart phones to show contacts' locations and length of stay in those locations as well as free-text descriptions of activities. Congruent with Palen and Dourish's definition of privacy, the authors found that:

> …users are not worried not so much about losing their privacy rather about presenting themselves appropriately according to situationally arising demands. (Raento, p. 529)

Privacy, of course, is only a relative value, and can frustrate other social goods. As Kang (1998) points out, commerce can suffer from strong privacy rights, as there is less information for both producers and consumers in the marketplace. Perhaps worse, truthfulness, openness, and accountability can suffer at the hands of strict privacy

protections (Allen, 2003). Participatory sensing research directly confronts this tradeoff between privacy, truthfulness, and accuracy. For example, researchers are developing algorithms for participatory sensing that allow users to replace sensitive location data with believable but fake data, effectively lying within the system (Ganti et al., 2008; Mun et al., 2009). What is good for privacy may not always be good for accuracy or accountability.

Consent and participation in participatory sensing

Privacy is not the only surveillance challenge raised by participatory sensing. The continuum between consent and participation, for example, is such thorny issue in participatory sensing that I have separated it from privacy as its own area of values inquiry. Meaningful consent is complicated when using devices such as mobile phones: opting out of the mobile phone network is not a realistic option. Consent was at issue in the recent dust-up over Apple and Android location tracking, when it was revealed that both companies were storing location data over and beyond what users were notified of and consented to (Cheng, 2011; Markey, 2011). And consent, despite recent corporate practice, may even be considered a minimum ethical bar. For research systems that reside so close to individuals and collect such personal data, participation in data collection and analysis might be a stronger form of consent.

Consent is central to research ethics in the United States, which have traditionally relied on federal guidelines such as the Belmont Report (Office of the Secretary of The National Commission for the Protection of Human Subjects of Biomedical and Behavioral Research, 1979) and Title 45 Code of Federal Regulations, Part 46 (Office for Protection of Research Subjects, 2007). These codes emphasize respect for human subjects, beneficence,

and justice. A critical component of respect, beneficence and justice is "informed consent." While the Belmont Report and 45 CFR 46 provide excellent ethical starting points for participatory sensing research, the granularity, personal proximity, and participatory nature of sensing complicate notions of "informed" consent. Much as in the case of fair information practices, participatory sensing demands enhanced ethical frameworks.

Researchers such as Gary Marx give examples of the ways that situational or structural factors weaken ideals of consent (Marx, 2006b). Marx points out that law enforcement, government agencies, airport security, and other agents of power increasingly use "soft" surveillance techniques to collect seemingly voluntary but actually compelled data from individuals. Examples include searches to enter planes or subways (voluntary, but individuals may not ride the transport if they do not volunteer), and withheld benefits by the Social Security Administration for parties who do not 'voluntarily' submit personal information.

Participatory sensing systems are one example of what could easily become (or may already be) a soft surveillance system. Because ubiquitous, networked sensors enable data collection in all spaces and places of users' lives, they imply continuous participation of people either *in* or *with* the system. People can be involved *in* the system simply by agreeing to collect data.[9] Such consent is fairly passive and may even be construed as soft surveillance if compelled by incentives or punishments. In order to build systems that collect both meaningful and ethical data, systems must go beyond passive consent and encourage people

[9] This assumes researchers have secured informed consent. It is certainly possible to imagine scenarios where researchers use mobile phone sensing data without knowledge or consent of the mobile phone user. This would be the most privacy-invasive use of this system.

to engage *with* them. This means that participants make decisions about system use or, in some scenarios, even design (Byrne & Alexander, 2006). Empowering users to participate in decisions about data collection, analysis, and research results preserves individual autonomy while interacting with otherwise invasive capture technologies.

Traditions of Community-Based Participatory Research (CBPR) and Participatory Action Research (PAR) provide established methodologies that empower research subjects as co-investigators and emphasize consent as participation (Byrne & Alexander, 2006; Cargo & Mercer, 2008). CBPR and PAR traditions develop their research questions with partner communities and engage those communities' members in research design, implementation, analysis, and dissemination. Involvement with every stage of the research process empowers users and helps justify tradeoffs between new knowledge production and research risks for participants. CBPR successes in health and environmental research have not only increased the validity of research data, but also improved the ability of marginalized or underserved groups to act on the results of the data they have helped collect and analyze (Cargo & Mercer, 2008). Empowering individual participants also means giving participants input into the design of systems that collect, analyze, and share data. Techniques developed by practitioners of participatory design (PD) can involve sensing participants in iteration on and improvement of participatory sensing systems (Muller, 2003; Shilton, Ramanathan, Reddy, et al., 2008).

Adopting ethics of participation may also help systems designers recognize and meet the needs of populations underrepresented among researchers. Engaging communities in research can incorporate *local knowledge* into the research process: knowledge held by community members and developed through experience living within that time, place, and

social group (Corburn, 2003). Participatory research's success in bridging research with practice (Cargo & Mercer, 2008) and empowering participant decision-making (Byrne & Alexander, 2006) are well-suited to designing and managing systems embedded in people's everyday lives. In addition, participatory design methods can address the fluid nature of people's willingness to collect and share data about their activities and routines. Incorporating the *participatory ethics* of CBPR and PAR into participatory sensing system design and research may be critical to democratizing the use of these systems.

But while participatory ethics foster a stronger notion of consent, they may also complicate design as well as data collection, aggregation and analysis practices. Established methods for participatory design can be time-intensive and require training, patience and cooperation on the part of engineers (Dearden, Lauener, Slack, Roast, & Cassidy, 2006; Kensing & Blomberg, 1998). Participatory research traditions have also been criticized for gathering inaccurate data or incorporating bias. Participants who purposefully withhold sensitive data from participatory sensing campaigns may create problems of data representativeness or accuracy.

CBPR approaches help to address concerns of consent within participatory sensing. But participatory sensing is built on top of an existing infrastructure that further complicates consent. Mobile phone companies build the instruments on which sensing depends, and telecommunications providers maintain the infrastructure along which sensing data is transmitted. These companies have already created technologies to track customers using cell tower triangulation. This tracking system facilitates the Enhanced-911 (e-911) emergency system, a service mandated by the FCC by which phone calls to 911 can be traced to geographic location during emergencies (Federal Communications Commission, n d). Under

U.S. law, users consent to this tracking by purchasing a mobile phone plan. Though the e-911 infrastructure is currently protected and limited only to emergency use, mobile phone providers are pursuing secondary infrastructures that would allow them to use location information for targeted advertising, or to sell the data for commercial or research purposes (Phillips, 2003; 2005b). I further discuss the implications of these infrastructures in *Values in a Network*, below.

Power and equity in participatory sensing

Drawing lessons from CBPR traditions also suggests that questions of equity, power, and control lie at the root of participatory sensing.[10] Who controls data collection, analysis, and presentation? Who instigates projects and sets research goals? Who owns the data or benefits from sensing? Accumulating and manipulating information is a form of power in a global information economy (Castells, 1999; Lievrouw & Farb, 2003). Participatory sensing specifically targets this power, making previously impossible data gathering and interpretation its reason for existence. How do participatory sensing stakeholders—designers, clients, and users—decide in whose hands this power will reside?

In the anecdote included in Chapter 1, Latino youth leaders immediately interpreted participatory sensing as a surveillance technology. They quickly made a conceptual bridge between information gathering and control. It is control that separates surveillance from other information systems (Lyon, 2001), and it is the pivot on which the question of participatory sensing technologies as surveillance turns. Do forms of power at work in

[10] For a discussion of why I use the term "equity" instead of "equality," see (Lievrouw & Farb, 2003, pp. 502-503).

participatory sensing (for example, the relative power of institutions that gather data versus the individuals who provide it) tilt participatory sensing towards control and increased surveillance? Or can distributed sensing and analysis shape technologies of care or even empowerment? In what ways are the outcomes of sensing initiatives caring or controlling?

The relationship between information, power and equity has long been a topic of interest in the information studies literature (Lievrouw & Farb, 2003). So-called vertical perspectives have analyzed access to information, and ways that social demographics limit or enhance information access. Horizontal perspectives take a different approach, emphasizing the subjective and context-dependent nature of information needs and access, even among members of one social group. All of these discussions, however, focus on equity of information access. Participatory sensing turns this equation on its head. When individuals are *generating* the information in question, equity comes to hinge on who benefits from this information collection.

The power of information generation and use is reminiscent of what Foucault called "biopower," which defines what people are, and therefore how they are treated and governed, by classifying them into biological categories using statistics or data (Foucault, 2007). Biopower is one part of the consolidation of state powers, whereby states govern and control their peoples as biological entities. Public health campaigns, the development of insurance, and birthrate and life expectancy statistics are all manifestations of biopower. The data generated by participatory sensing, if wielded by governments, may join these as a new form of biopower.

Participatory sensing and biopower invoke questions of the balance of power and participation between institutions, such as governments and corporations, and more

informal publics. Traditional social theory posited that loosely organized publics provide a balance of power with tightly organized organizations (Fish, Murillo, L. Nguyen, Panofsky, & Kelty, n d). But the rise of participatory culture has challenged this traditional model, organizing publics and tying them to organizations. For example, participatory sensing shows elements of both organizations and publics. CENS is an organization that actively recruits informal groups of participants into sensing projects. Will organizations like CENS hold the power that data, categories and social sorting can bring, or can it be distributed back to the publics who collect that data?

Surveillance powers are not the only influence in question in participatory sensing. Acquisti and Grossklags (2008) recognize that the power imbalance between data subjects and data collectors (what they call "asymmetric information") results in a privacy decision-making challenge:

> Data subjects often know less than data holders about the magnitude of data collection and use of (un)willingly or (un)knowingly shared or collected personal data; they also know little about associated consequences (Acquisti & Grossklags, 2008, p. 364).

The intersection of information systems, values, and culture is also important to consider. Cultural expectations and norms are deeply embedded into the design of information systems, shaping everything from representation of relationships within databases (Srinivasan, 2004c; 2007) to the explanations drawn from data (Byrne & Alexander, 2006; Corburn, 2003). The design process is never value-neutral, and questions of what, and whose, values are embodied by software and system architecture have been controversial for decades (Friedman, 1997). Affordances built into a technology may privilege some uses (and users) while marginalizing others, highlighting values as a critical (if

sometimes invisible) influence on the design process. Design areas where values (and therefore bias) can become particularly embedded include user interfaces (Friedman & Nissenbaum, 1997a), access and input/output devices (Perry, Macken, Scott, & McKinley, 1997), and sorting and categorization mechanisms (Bowker & Star, 2000b; Suchman, 1997). Participatory design traditions, which seek to actively incorporate end users as decision-makers in the design process, have gained scholarly and practical traction in the design of workplace information systems (Gregory, 2003; Kensing & Blomberg, 1998; Muller, 2003; Schuler & Namioka, 1993). The intersections between culture, meaning, and information systems have spurred researchers to experiment with culturally-specific databases, media archives, and information systems for indigenous, diasporic, and marginalized communities (Boast, Bravo, & Srinivasan, 2007a; Monash University School of Information Management and Systems, 2006; Srinivasan, 2007; Srinivasan & Shilton, 2006). Such "alternative design" projects seek to investigate, expose, redirect, or even eliminate biases that arise in mainstream design projects (Nieusma, 2004).

Participatory sensing, however, often adopts a universal rather than relativist vision, taking "everyone" as its intended users. What does it mean to design for everyone? As Suchman (1997) points out, designing technology is the process of designing not just artifacts, but also the practices that will be associated with those artifacts. What do participatory sensing designers, implicitly or explicitly, intend the practices associated with participatory sensing to be? And how will such practices fit into, clash against, or potentially even reshape diverse cultural contexts?

Forgetting in participatory sensing

Always-on, sensitive data collection brings up a number of theoretical and normative questions about whether and how this data should persist over time. What are the implications of creating an archive of people's movements, habits, and routines? What could be benefits of this new conception of an archive? And what problems might the totalizing nature of this memory raise? As Green writes,

> On the one hand, while technically mediated memory work can produce both proliferating digital artifacts as well as enabling the 'instant' forgetting of the digital form. On the other hand, the archival impulse seems to be spreading, particularly at institutional scales, producing increasingly commodified "memories" about individuals and populations over which they have no control (2009, p. 267).

The dangers of total memory are a new area of inquiry within surveillance and information scholarship, as only recently has storage space become cheap enough to create the specter of total memory. Historically, archives focused on throwing records away, keeping only a tiny portion of records deemed historically valuable (Boles, 1991; Cook, 1991). But the explosion of data generation paired with cheap storage and cloud computing raises the possibility of saving much more evidence of daily life. This possibility has become a subject of both celebration (Gordon Bell & Gemmell, 2007) and debate (Blanchette & Johnson, 2002).

The ability to record everything and save it indefinitely to supplement fallible human memories is intriguing and perhaps even empowering. Limitless personal and community archives promise everything from improved health care (G. R. Hayes et al., 2008; 2007) to memory banks that "allow one to vividly relive an event with sounds and images, enhancing personal reflection" (Gordon Bell & Gemmell, 2007, p. 58). And new kinds of archives

could help to counteract the power structures that control current archival and memory practices, in which the narratives of powerful groups and people are reified while others are marginalized (Ketelaar, 2002; McKemmish, Gilliland-Swetland, & Ketelaar, 2005; Shilton & Srinivasan, 2007).

But as more data is collected and retained indefinitely, we must consider pernicious social consequences as well. Blanchette and Johnson (2002) point out that U.S. law has instituted a number of social structures to aid in "social forgetting" or enabling a clean slate. These include bankruptcy law, credit reports and the clearing of records of juvenile offenders. As information systems increasingly banish forgetting, we may face the unintended loss of the fresh start. Drawing on this argument, Bannon (2006) suggests that building systems that forget might encourage new forms of creativity. He argues that an emphasis on augmenting one human capacity, memory, has obscured an equally important capacity: that of forgetting. He proposes that designers think about ways that sensing and other information systems might serve as "forgetting support technologies" (2006, p. 5). Mayer-Schoenberger (2007) presents a similar argument, advocating for a combination of policies and forgetful technologies that would allow for the decay of digital data.

Dodge and Kitchin (2007) provide an explicit critique of pervasive memory in ubiquitous computing systems such as participatory sensing. Their article explores the phenomenon of "life-logging" and the new form of memory that such electronic sensing and logging practices provide. They write:

> Rather than seeing forgetting as a weakness or a fallibility, we argue that it is an emancipatory process that will free pervasive computing from burdensome and pernicious disciplinary effect (2007, p. 431).

The negative effects they foresee include total accountability for one's actions, increased surveillance in the home and workplace, and the automatic sorting of people into commercial and social categories.

Theoretical Framework: Values in Design

There are many ways a researcher could research values challenges engendered by new technologies. User studies, close readings of engineering literature, or analysis of popular media reports are just a few (Franklin & C. Roberts, 2006; Friedman, Kahn, et al., 2006; Landecker, 2007). To explore the ways in which privacy, consent, equity and forgetting manifest in emerging sensing systems, this thesis employs a theoretical framework based in *values in design* or *values-sensitive design*. These similar traditions, developed in the media studies and human-computer interaction literatures, explore the ways in which moral or social values become part of technological artifacts.

For simplicity, I will refer to both rubrics as the values in design perspective, or VID. VID emerges from simultaneous work in computer ethics (Johnson, 2000), social informatics (Hara & Rosenbaum, 2008; Kling & Iacono, 1988), and participatory design (Schuler & Namioka, 1993). Values in design posits that the process of designing something is about both interpretation and meaning (Latour, 2008). As an individual or group "designs" an artifact, they construct its uses and meanings. They also immediately broach a question of ethics: as Latour (2008, p. 5) puts it, "*good versus bad design"* (emphasis his).

Values in design is also characterized by a proactive perspective, which seeks to influence technology during the design process (Friedman, Kahn, et al., 2006). However, values in design also recognizes that the values embedded in a technology are shaped by

endogenously, by their designers and their eventual technical affordances, as well as exogenously, by their users (Friedman, 1997). Values in design is primarily concerned with moral values, or what Friedman describes as "values that deal with human welfare and justice" (Friedman, 1997, p. 3). Friedman, Kahn and Borning define these as "pertain[ing] to fairness, justice, human welfare and virtue" (2006, p. 13), encompassing a variety of ethical perspectives including deontology, utilitarianism, and virtue ethics.

Friedman, Kahn and Borning (2006) describe three primary thrusts within the values in design perspective. A conceptual focus seeks to explain normative questions, such as what human factors should be valued in design. An empirical focus investigates what values are present in design settings, and what values are present in the contexts in which a technology is deployed. A technical focus examines what values are materialized and enacted in the technology product.

This dissertation could be categorized as encompassing all three of these thrusts: a conceptual investigation of what values respond to social concerns such as surveillance, an analysis of the ways these values are discussed and weighed during design, and a technical description of how these values affect technology design. Like many researchers in this growing area, I am interested in how values manifest, and are then hardened or made durable in technological artifacts (Latour, 1991). I am simultaneously interested in the ways in which values are engaged with *practices*. As Collier and Lakoff (2005) describe it, ethics and values can be seen as anthropological problems:

> Here the term "ethics" refers not to the adjudication of values but, as Bernard Williams puts it, to the question 'How should one live?' Ethical problems, in this sense, involve a certain idea of practice ('how), a ntion of the sunject of ethical reflection ('one'), and questions of norms or values ('should') related to a certain form of life in a given domain of living. This

> engagement with philosophical discussions helps to frame ethical questions in terms of techniques, practices, and rationality (Collier & Lakoff, 2005, p. 22).

My work seeks to examine values and ethics in this way – as anthropological phenomena embedded in actions and practices of design. This is an approach shared by investigations into ethics and technology ranging from regulating reproductive technologies to trade in human organs (Collier & Lakoff, 2005).

Studying values

Sociologists, anthropologists and economists have long tried to study what individuals, communities or societies *value*. Studies of what is valuable, whether economic or social, center around notions of worth. Worth is often difficult to measure or determine; as Girard and Stark write:

> The life of business organizations is no less an arena of puzzlement and contention over issues of worth. … These questions are particularly acute in times of rapid economic, technological, and social change when contention about how to measure 'performance' is less a by-product of change than an engine of dynamisms (Girard & Stark, 2005, p. 294).

Values, then, are among the many things in a business or organizational setting that are considered to have worth. This can be economic, for example products to sell in the marketplace; but in an academic setting, worth is often much less tangible. Friedman et al (2006) describes values in the context of design as: "what a person or group of people consider important in life." This echoes Collier and Lakoff's (2005) notions of "regimes of living."

Values in the lab

The assumption that values are made durable within the design laboratory depends upon science and technology studies (STS) interpretations of the laboratory as a space for learning, reifying, or reinventing what it means to be a scientist or engineer. STS researchers have long understood laboratories to be spaces where disciplinary and professional expectations are shaped and performed (Latour & Woolgar, 1979b). Observing and describing the laboratory as the setting in which science or technology is made can help social scientists understand the technical, social, and values products of those environments (Forsythe, 2002). A site to begin learning about the value dynamics of technology development is the design laboratory. As McGregor and Wetmore (2009) argue, learning about values from the people most invested in, and familiar with, a new technology may be just as important as introducing the engineers to outside values debates.

One of the best ways to understand the process of, and decisions behind, design is to observe designers in-situ. Ethnographies of design settings have a rich history in information studies and science and technology studies. Ranging from initial investigations of scientific laboratory settings by Latour and Woolgar (1979b) to more recent observations of artificial intelligence laboratories (Forsythe, 2002) and open source software development (Kelty, 2008), social studies of technology have demonstrated that we can better understand the implications of technologies by understanding the design process. The laboratory observation techniques of science studies can be extended to studying engineering. In fact, it is perhaps easier to accept that the process of engineering is one of politics, ethics, and values. As Latour put it: "A politics of matters of facts and of objects has always seemed far

fetched; a politics of designed things and issues is somewhat more obvious" (Latour, 2008, p. 6).

Promoting values in design

Recent literature builds on constructivist views of technology development to go beyond describing values in design, and argue for values-oriented interventions by social scientists and ethicists. Constructivists argue that both social and technological pressures shape technology design decisions (Pinch & Bijker, 1989f). Embedding values debate and dilemmas among those pressures can potentially encourage the design of socially desirable or beneficial technologies. This is distinct from downstream approaches, such as regulation, which attempt to reform existing technologies to social norms or desires. Work by Fisher (2007), for example, describes interventions that encourage scientists and engineers to see the lab as a space for values reflection. Ottinger (In press) explores how classroom interventions focused on environmental justice altered engineering students' identities and professional imaginations. Exposure to activist clients and socially-focused engineering projects helped engineers see themselves as participants in a broader social good. In both examples, interventions focused on values encouraged science and engineering students to weigh the social implications of their own work.

The work of both Fisher and Ottinger employ a theoretical perspective that I use in my project as well. Both authors use the socio-technical perspective of STS as a tool to encourage scientists and technologists to explore the macroethical implications of their work. Johnson (2007) makes this relationship explicit: theoretical perspectives encouraged by STS scholarship can illuminate new values perspectives. Johnson concentrates on

nanoethics, but I extend her principles to the technology design process. STS perspectives can help engineers recognize their agency and responsibility, as well as the structural and technological limits on that agency, within a socio-technical system. The relationship between design and ethics can be a theme pushed by an outside ethics advocate, colleagues, or mentors within the lab. Realizing user agency can be a goal of design meetings with users, and presentations might help designers understand public reaction to new design developments. Interacting with institutional rules and ethics might also affect the way designers discuss and consider ethics. Each of these interactions can be a space within design to foreground ethical perspectives that take into account the codependence of social and technical actors.

The emphasis in macroethics on the relationship of the engineer to a broader social whole returns to the argument for teaching core concepts of science and technology studies as part of ethical curricula. Science and technology studies traditionally emphasizes the situatedness of scientists and engineers within larger networks of institutions, technologies, and social infrastructures (Johnson & Wetmore, 2008; Latour, 2007; Sismondo, 2004). Building an understanding of macroethics that embraces situatedness, social and technical constraints, and designer agency within those constraints is a growing movement within design and laboratory interventions (Johnson, 2007).

Laboratory Structure: Design Practices and Activities

What practices within design might lead to discussion and consideration of social, and particularly anti-surveillance values? I have drawn on information studies, computer ethics and values in design literatures to frame five practices within the CENS design setting

that may influence engineers' consideration of privacy, consent, equity and forgetting among the things they value in design.

Data practices

One set of design practices that clearly affect the values expressed in sensing technologies are the laborious practices necessary to enable and enforce privacy, access, and retention policies. As discussed above, provenance and contextual metadata enable systems to enact and follow privacy, access, and retention policies. But tracing provenance and context for sensor data gathered across distributed contexts can be extraordinarily complicated (Borgman et al., 2007a; Mayernik et al., 2007). Participatory sensing faces many of the same challenges for data analysis and preservation as data-intensive projects in the sciences (Gordon Bell, Hey, & Szalay, 2009; Hey & Trefethen, 2005). GPS coordinates sampled every thirty seconds for days may add up to terabytes of data over time. Deciding how best to retain personal data over time as storage formats change and programmers graduate or move on provides an ongoing challenge (Berman, 2008; Galloway, 2004). Participatory sensing designers will need to undertake significant efforts to ensure best-practice data collection. The time and energy they are willing to devote to what may be rather mundane tasks as documenting data may influence the efficacy of system privacy and data retention measures.

Of course, the opposite of data retention and documentation may also impact values in participatory sensing. It is incredibly difficult to delete personal data once it has reached "the cloud" (Bannon, 2006). Emerging, experimental techniques to make data "disappear" (Perlman, 2005) are both complicated to implement and do not delete data shared with

servers beyond a user or single application's control. Good faith efforts to prevent persistent memory may be stymied by the nature of data sharing in a world of cloud computing.

Disciplines, mentors and collaboration networks

The social environment in a lab can also influence the values problems and decisions confronted during design. Most participatory sensing engineers come from electrical engineering or computer science disciplinary backgrounds, where they have learned specific values during years of training. In addition, engineers have mandated relationships with faculty, and may engage in informal mentoring relationships with other lab leaders. Finally, designers work with, and are influenced by, colleagues both inside and outside the lab. Each type of social network may affect the ways that designers interpret social values and incorporate them into design practices.

Disciplinary training can affect both the range of knowledge from which a designer draws, as well as the methods they use during design in response to that knowledge (Borgman, 2007). As Borgman writes:

> Although disciplines in their present form are only about a century old, they are powerful forces in the academy. Individual scholars self-identify with their fields more than with their universities, seeing their departments as local chapters of national and international enterprises (2007, p. 151).

Disciplinary affiliation is influential in the development of an individual's base of knowledge, research practices, professional identity, and subsequent values and ethical decisions (Herkert, 2001).

The values held by an adviser or mentor may also affect the projects a student designer pursues, and their willingness to consider and tackle ethical problems within the design process (Hollander, 2001). Advisers are an important part of graduate-level education,

and participatory sensing design within academia is subject to relationships between students and advisers. Advisers model behavior, attitudes, and values with their students (Bandura, 1977). Influences on ethical decision-making may extend beyond formal advisers, as well. As Weil (2001) points out, there is also a distinction between an adviser and a mentor. Adviser can be a mandated, formal, and even hands-off role, while mentoring designates a specific, voluntary and time-intensive relationship. Students who have forged relationships for advice and professional development outside of the advisor/advisee role may also be influenced by the values and ethics of their informal mentors.

Though collaboration with authority figures inside or outside the lab may be influential, collaboration with colleagues is also important to investigate. Collaboration networks and "invisible colleges" (loosely defined as social relationships between researchers based on anything from informal communications to co-authorship) have always been influential in scientific work (Knorr Cetina, 1999; Lievrouw, 1989). Collaboration consists of formal and informal interactions around a common research area, and often relies upon shared resources such as data or tools. Collaborations also produce artifacts such as papers or software (Borgman, 2007). Participatory sensing collaborations may occur between academic labs, industry partners, or labs, clients and users. What participatory sensing designers learn from collaborators may be an important influence on values and ethical decision-making.

Internal pilot testing

Designers learn not only from networks of colleagues, but also from various practices integrated into the process of design. For example, software engineers frequently

test their designs themselves and their design colleagues before releasing them to a general public. Self- and colleague testing serves as a rudimentary form of user testing, a critical part of user-centered design (Gould & Lewis, 1985; Shneiderman & Plaisant, 2005). Internal testers may test their software for technical issues (for example, system speed and debugging), interface issues, and usability.

Because testing the participatory sensing innovations of coworkers often involves uploading and sharing personal data with colleagues, designers may feel some of the same values sensitivities as outside users during the course of internal testing. Designers, however, have a much different perspective than "naïve" users. During the course of design, an engineer normalizes the practices required to use a sensing technology, and may not find these practices alien or troubling (Suchman, 2007). As Shneiderman and Plaisant write about user-centered design:

> Every step in understanding the users and in recognizing them as individuals with outlooks *different from the designer's own* is likely to be a step closer to a successful design (2005, p. 67).

Designers may well make connections between ethical problems and their design process by testing their own systems. But this form of learning should be contrasted against another type of testing: user testing as described within user-centered and participatory design traditions.

Seeking user feedback

Gathering, accepting, and iterating on feedback from system users has long been an ethos of user-centered and participatory design traditions (Carroll, 2003; Schuler & Namioka, 1993; Shneiderman & Plaisant, 2005). Considering user needs from the beginning of a design

process, involving users in testing system prototypes, and learning from and iterating systems according to user feedback are foundational principles of usability design (Gould & Lewis, 1985). User-centered design textbooks suggest "ethnographic" observation of users (Shneiderman & Plaisant, 2005) inspired by the success of anthropological study of users at places like Xerox (Suchman, 2007) and Intel (Genevieve Bell, 2006a). Design methods incorporating user feedback extend into a variety of technology domains, including mobile phone hardware and software (Love, 2005; Vaananen-Vainio-Mattila & Ruuska, 2000).

Though techniques for user interaction have been taught in HCI and user-centered design courses for decades, it is a continual challenge for engineers to incorporate interaction with users into design (Gould & Lewis, 1985; Vredenburg, Mao, P. W. Smith, & Carey, 2002). Gould and Lewis (1985) suggest that user-centered design is often undervalued or dismissed due to time considerations. Gould and Lewis (1985) also suggest a difficult ontological problem: designers may believe (rightly or wrongly) that users do not know or are unable to express what they need. In a follow-up study to Gould and Lewis' work, Vredenburg et al (2002) find that user-centered design techniques often lose out in cost-benefit analyses.

It is certainly true that interactions with, and learning from, users can be time consuming and complicated As Shneiderman and Plaisant write: "The process of getting to know the users is never-ending because there is so much to know and because the users keep changing" (2005, p. 67). Dourish explains the divide between getting to know users in the field and practical design implementations:

> What we have learned is that, despite our best intentions, field studies and design activities often sit uncomfortable together. … The different perspectives, concerns, orientation, and training of the participants result in

> each partner's feeing that the others fail to understand the complexity of their position. … To the design community, these "implications" [for design drawn from the field] often seem obvious, insubstantial, or vague; to the sociologists, they deny the richness of the settings to which they refer (2001c, p. 156).

Despite the difficulties, iteration with users persists as an important design principle. Gathering user feedback can help adapt technologies to diverse user skill levels, modify the tasks a device performs to fit the goals and needs of users, and tailor interfaces and interaction styles to user preferences (Shneiderman & Plaisant, 2005). And ultimately, feedback loops are critical because, as Dourish writes, "Users, not designers, create and communicate meaning" (2001c, p. 170). Though designers attempt to communicate the uses of a technology through design, the user ultimately decides how to use the artifact. Designers aware of how users interpret, or even subvert, their design may be better able to express their intentions in the next iteration.

Almost all the literature on user-designer feedback loops emphasizes the importance of interactions between designers and users for the benefit of system usability (Shneiderman & Plaisant, 2005; Vredenburg et al., 2002). Some participatory design literature, however, emphasizes the fact that engagement with users can also affect designer perspectives and attitudes (Kensing & Blomberg, 1998). My work will investigate whether engagement with, and learning from, users can affect not just product usability, but the values perspectives and decision-making of designers.

Navigating institutional ethical mandates

Institutions also implement rules of their own that their members must follow. These internal policies can affect, and reflect, the values of the institution (Johnson, 2000).

As discussed in *Consent and participation in participatory sensing* above, basic ethical requirements for human subjects research are nationally mandated for educational institutions. These requirements are enforced at the university level by an Institutional Review Board (IRB) (Office for Protection of Research Subjects, 2007). As a result, CENS participatory sensing designers collecting human subjects data must regularly interact with a regulatory body focused on ethics.

The UCLA IRB and the administrative arm that supports it, the Office for Protection of Research Subjects (OPRS), takes education about research ethics as one of its explicit goals (*UCLA policy 991: protection of human subjects in research*, 2009). OPRS requires a short online training of all research staff, and if requested, offers educational presentations for investigators and research staff. OPRS staff also communicate requirements and changes to researchers who have submitted applications for IRB approval. Lessons and influences (quite possibly positive or negative) that designers take away from this interaction may affect their values and decision-making during the design process.

Advocacy by a values worker

Finally, the CENS lab has a design agent focused explicitly on values in participatory sensing: my role on the team as an advocate devoted to values issues. Joining a design team or science lab to serve as a point person for ethical concerns is not unusual in the social sciences. A long tradition of embedded social science researchers includes some of the most notable work in STS, including the work of Suchman (1995; 2007), Bell (2006a), and Star (1999). Recent studies follow the traditions established by this earlier work, incorporating description and analysis of design practices with a clearly interventionist agenda. For

example, Guston and Sarewitz propose a method for social scientists to intervene in lab settings, using "Real-time Technology Assessment" to "significantly enhance the societal value of research-based innovation" (2002, p. 93). Manders-Huits and Zimmer (2009) recently finished fieldwork as ethics advocates in separate commercial design settings. Van der Berg (2009) relates mixed success intervening in a biotechnology design lab. An ongoing project lead by Fisher (2007) embeds graduate students in twenty science laboratories to report on and influence ethical decision points. Rabinow and Bennett (2008) relate the ultimate failure of an intervention into bioethics.

The embedded ethicist approach is formally codified in some research areas, thanks to National Science Foundation grant guidelines that include "Ethical, Legal and Other Societal Issues" (ELSI) requirements. Areas such as nanotechnology frequently invite a social science principal investigator onto the project to examine ELSI issues. Researchers report, however, that principal investigators and design team leaders often see this function as marginal to the major thrust of the research (Guston & Sarewitz, 2002; Manders-Huits & Zimmer, 2009; Rabinow & Bennett, 2008).

Serving as an ethics advocate consists of having a designated interest in, and lobbying for, social and ethical concerns within the design process (Friedman, Kahn, et al., 2006; Manders-Huits & Zimmer, 2009). As Friedman et al (2006) describe the role, the ethics advocate can launch conceptual investigations, questioning who stakeholders are in a design process and how system features might affect them. An ethics advocate may also facilitate technical investigations into "how existing technological properties and underlying mechanisms support or hinder human values" (Friedman, Kahn, et al., 2006, p. 4). Finally,

Friedman et al recommend that the advocate undertake empirical evaluations of user experience.

Beyond analysis of technologies or users, serving as an ethics "gadfly" within a lab may also influence the ethical thinking and values decision-making of team members. Initial studies in ethics education for engineers have showed promising results of gadfly or advocate intervention models (Fisher, 2007; McGregor & Wetmore, 2009). A variety of individual and social factors, however, may limit the effectiveness of an ethics advocate. Manders-Huits and Zimmer (2009) define critical factors such as an advocate's ability to justify a values framework; the ability of the advocate to adopt a "leader" (rather than authoritarian or supporter) role; and the ability of the advocate to negotiate between competing values. Perhaps most importantly, ethics advocates need to be able to work alongside designers to operationalize values into features that can be built into a technical system.

The Limits of Design: Social, Structural and Technical Constraints

Adopting a perspective focused on the values issues that manifest during design also has its limitations. As the values in design perspective points out, VID does not see values as fixed only during design. Instead, it simultaneously focuses on the context of adoption, user agency, and the co-construction of the social and the technical (Friedman, 1997). Technology creation and use is an assemblage of designers, infrastructures, manufacturing, users and use practices. This assemblage affects the agency that designers have to resolve ethical issues and embed their own values. (Philip, Irani, & Dourish, 2011). While values decisions remains critically important to the project of participatory sensing, the agency of

designers is necessarily constrained by a number of social, infrastructural, and technical factors.

Distributed control

One simultaneously social and technical factor that limits the values agency of participatory sensing designers is a lack of control over the infrastructure on which participatory sensing relies. Most people in the U.S. have a choice of at least four mobile telephone carriers, and switching between them is easy and frequent (Nuechterlein & Weiser, 2005). These competitive carriers provide the networks on which participatory sensing data travels. In the U.S., the laws governing these carriers and the networks they manage are not nearly as complex as those regulating traditional wireline telecommunications (Nuechterlein & Weiser, 2005). The FCC controls spectrum allocation, and liberalization of spectrum policy opened the market to carriers in the 1990s. Since then, regulators have favored a hands-off policy, letting competition govern the market for wireless services. Wireless services are subject to only very basic common carrier requirements, as well. The FCC has exempted wireless services from most parts of common carrier codes leaving only mandate against "unjust" discrimination (Nuechterlein & Weiser, 2005, p. 270).

However, as wireless communications begins to be a replacement for, rather than simply a supplement to, wired services, a number of regulatory issues may start to have social impacts. For example, as multiplying data streams begin to clog provider's networks, providers may eschew mobile network neutrality (Lessig & McChesney, 2006). In 2005, the FCC designated broadband providers as "information services" rather than telecommunications services. This released these companies from the previous mandate to

provide common carriage over broadband networks. Since this decision, phone companies have threatened to establish priority tiers of broadband service for content providers who pay a steeper fee (Windhausen, 2006). Deep packet inspection or other means by which to prioritize data transfers could potentially slow participatory sensing data upload and sharing, and potentially compromise the privacy of participant data (Singh, 2009). For these reasons, national and international debates over network neutrality, and any resulting policy, will affect values in participatory sensing, as well (Windhausen, 2006). Carriers' control over bandwidth access and upload capabilities may stymie broad visions of data sharing and participatory data analysis. Bandwidth access may affect both the practicality and accessibility of participatory sensing.

Mobile phone manufacturers control hardware and phone operating systems, creating potential barriers for designers. Operating systems may pose technical limits on how users may collect data (for example, the iPhone's prohibition on programs running in the background). Hardware controls what sorts of data can be collected (geotagged images, accelerometer, GPS vs. cell-tower, etc). Mobile phone manufacturers also provide software for phones, including data collection software such as Nokoscope ("Nokoscope," n d). Participatory sensing designers who adopt such software to facilitate data collection will inherit values (for example, resolution of data collected, how data is stored and with whom it is shared) embedded in the software.

The effects of these diverse infrastructural constraints could be complicated. The loss of network neutrality might affect efforts to build open, equitable systems. If carriers demand high fees for high-quality data plans, the expense might exclude participant populations from participatory sensing. On the other hand, in traditional sensor network

research, infrastructural limitations drove development of local processing (performing processing directly on the device, rather than in the cloud). If network limitations choke data upload, a need for local processing could help to alleviate privacy and surveillance concerns. For example, mobile devices could upload only inferred activities to application servers, rather than more granular and sensitive location data. Conversely, limits on processing capacity imposed by manufacturers could prevent privacy-enhancing local processing. These examples illustrate that designers share control over values with phone manufacturers, carriers, and national and international policy.

Distributed data collection

Lack of control over the participatory sensing infrastructure suggests another values constraint on participatory sensing designers: the sheer number of other organizations collecting mobile phone data. Major corporations such as Yahoo ("Fire Eagle," n d) and Google ("Google Latitude," n d) have launched location-based services that collect and process GPS data from mobile phones. Wireless carriers provide the networks on which sensing data travel, and in many cases, collect data similar or identical to those collected in participatory sensing. For example, location data is collected by U.S. mobile phone providers under the e-911 mandate (Federal Communications Commission, n d). Providers were compelled by 1996 Federal Communications Commission (FCC) regulation to develop ways to locate mobile phones that call 911. Complying with the regulation was a slow and expensive process for providers (Novobilski, 2002), and mobile carriers now have a strong financial incentive to recoup that cost. As Curry et al. point out, the e-911 mandate provided an "economic bootstrap" (2004, p. 366) for an infrastructure with which mobile phone

companies can pursue location-based advertising and services. Further complicating the data collection landscape is competition among providers due to telecommunications deregulation (Phillips, 2005b). As a result, each major carrier is developing their own system for tracking customers.

While common carrier law, as well as security measures like encryption, prevent access to the content of messages flowing through these channels, telemetry (like location) falls outside of this protection, even though location is in itself useful and sensitive data (Waldo et al., 2007). Similarly, function creep, such as when data gathered for emergency services are sold to advertisers, is an ongoing worry for such sensitive data (Curry et al., 2004). Protections for data collected about and over the mobile network are still in flux, but the legal landscape does not look promising for data protections and individual control (Green & S. Smith, 2004; Waldo et al., 2007). The U.S. Department of Justice is currently appealing a court ruling that prohibits law enforcement from compelling providers to release user location data without a warrant (Freiwald & Swire, 2009). Participatory sensing researchers provide an alternative and possibly more participatory infrastructure for collecting location data, but values are undeniably affected by the mix of interests already collecting location data.

Mobile phone providers are not the only organizations collecting data from mobile phones. Individuals are already engaging in collection and sharing practices enabled by commonly available tools such as exercise tracking software and Flickr. The data collection context into which participatory sensing emerges reflects an argument made by Zittrain (2008) that he calls "Privacy 2.0." He writes:

> …the Net enables individuals in many cases to compromise privacy more thoroughly than the government and commercial institutions traditionally targeted for scrutiny and regulation (2008, p. 200).

Individuals are already involved in gathering personal data and sharing it with each other. With this comes privacy risk, but also new interpretations of what privacy might mean or what actions might be desirable to protect privacy. What Zittrain writes about privacy is true for consent, equity, and forgetting as well. Values norms are continually in flux, and participatory sensing designers must exist within, and attempt to respond to, this fluctuation.

Even where intentions are good, the granular personal data collected during participatory sensing projects are easily shared, subpoenaed, or stolen. It is also incredibly difficult to delete data once they have reached "the cloud" (Bannon, 2006). Emerging, experimental techniques to make data "disappear" (Perlman, 2005) are both complicated to implement and do not delete data shared with servers beyond a user or single application's control. Good faith efforts to pursue democratized data collection and empowering surveillance may be stymied by the nature of data sharing in a complex network of government regulations, carriers, application providers, and individual users.

Taking a perspective focused on design also ignores the agency of users to adapt a new technology's uses to their needs. There is an emerging literature that documents the ways users protect their own privacy through obfuscation practices (Brunton & Nissenbaum, 2011) or otherwise user technologies in unexpected and locally-specific ways (Srinivasan, under review). Because participatory sensing technologies are in their infancy, we don't know how the values embedded in their design will affect adoption and use. Further studies into use practices will be necessary as participatory sensing becomes a more common technological practice.

Individual morality and values

Finally, even within the design setting, each member of the design team brings their own set of moral values to their work. While the moral development of individual developers is critically important to design, analyzing and even changing such ethical perspectives would be a difficult psychological, educational, and perhaps even a religious task. Because I am not a psychologist or educator, I have taken individual ethical development to be out of scope for this project. But because my background in STS and information studies emphasizes design practices and structures, I have taken a different tact. Instead, my work focuses on the opportunities for ethical discussion and learning that the variety of design practices discussed above present.

Summary: The Design Setting and Values in Design

Participatory sensing, as a technological and social object of inquiry, presents a range of interesting questions for study. It demonstrates a variety of social values of concern, particularly those invoked by the problems and threats of surveillance. Adopting a values in design perspective enables an investigation into the ways that participatory sensing is shaped by, and shapes, values such as privacy, consent, equity and forgetting. Focusing on specific design practices and agents allows this dissertation to examine the ways that the design setting in turn shapes consideration and materialization of these values.

Chapter 3: Methods

This chapter discusses the methods used to gather data during two years embedded as a researcher at CENS. To analyze and promote social values in participatory sensing design, I pursued a qualitative research project that drew on ethnography as well as action research. Using interviews, document analysis, and participant observation, I investigated practices and agents in the design process that enabled or impeded discussion of, and decision-making about, anti-surveillance values.

Research Questions

Through interviews with and observation of CENS participatory sensing stakeholders, I explored the ways in which practices and people within design encouraged discovery, discussion, and incorporation of values like privacy, consent, equity, and forgetting. This investigation addressed the following research questions:

1. What social values are discussed and agreed upon by the design team during participatory sensing design at CENS?
2. How do the design practices and participants influence consideration of anti-surveillance values?
3. How do anti-surveillance values affect technology development?
4. How can designers as well as outside advocates make anti-surveillance values an integral part of design?

Research Design

I used a participant observer approach (Spradley, 1980) to study the discussion and embedding of values during the design of participatory sensing technologies. As a member

of the CENS participatory sensing research team, I had excellent access to the design setting, and participated in all phases of design. I investigated my research questions using field notes from observations in the CENS laboratory, interviews with laboratory members, and analysis of presentations, papers, and technologies produced by the design team. Observation and interviews revealed how designers recognized and discussed social values in participatory sensing, what values issues designers were aware of or discovering, and how designers addressed these issues through design. It also revealed how laboratory practices, structures and agents affected values perceptions and decisions.

I collected two years of field notes from weekly design meetings, as well as day-to-day jottings as I worked in the CENS lab. These provided notes on over 500 contact hours with CENS designers. I also compiled transcripts from 30 interviews, each approximately an hour in length. I recorded each interview and had the recording transcribed. I conducted interviews with each of the UCLA-based faculty, staff and students involved with participatory sensing from 2008-2010. Each member of the participatory sensing team agreed to participate in the interviews, and consented to my note-taking. Respondents included eight staff, four faculty, two post-doctoral scholars, eleven graduate students, and five undergraduate students. I have also collected notes from informal follow-up interviews with two faculty, one staff member, and three students who served as key informants. I took memos on my thoughts and reactions after interviews, and have included these in the data set.

I recorded the majority of my observations between September 2008 and September 2010, and performed my interviews between June 2009 and August 2010. This research timeline fit the academic cycle at CENS. Students arrived in September and worked on

discrete projects through the following August. Sensing campaigns were not strictly tied to the academic schedule, but the academic year certainly affected the pacing and life of the lab.

Finally, I analyzed the text of publications by CENS authors published during the two years (2008-2010) of my fieldwork. I compiled a list of all publications authored by participatory sensing laboratory members from CENS annual reports published during 2008, 2009 and 2010; this totaled 25 publications. I included all publications on which members of the participatory sensing team worked.

I excluded publications on which I was the first author, although I was a co-author on four of the 25 selected articles. This decision was based on an understanding of the conventions of authorship at CENS. The first author on a CENS participatory sensing paper had the most control over the direction and content of a paper, and therefore the values it embraced. Co-authors often discussed the paper themes with the first author in advance, contributed sub-sections to the paper, and helped to edit writing and content. But the themes, structure and content were largely decided by the first author. I excluded my first-authored publications because they were all explicitly focused on values in design at CENS; I was worried that including them in the dataset would skew the results. This was not true of papers on which I was a co-author; only two of the four that I co-authored contained a privacy section, for example. Therefore I left the four co-authored papers in the dataset.

Sample selection

Because I undertook a single-sited ethnography, my population of interest was too small to sample. CENS participatory sensing team members were a small, self-selected group. Although researchers perform similar sensing development across the world, I had

extraordinary access to CENS researchers. I therefore chose to focus on the benefits of thick description and internal validity that such detailed access provided.

Within the group of CENS researchers, I observed and interviewed everyone who consented to my research, which turned out to be the entire group. This allowed me access to 30 undergraduate and graduate students, staff, and faculty. Although I had less exposure to other participants, my field notes occasionally included interactions with visitors to the lab and external collaborators.

The CENS participatory sensing group was not demonstrably representative of sensing researchers or engineers as a whole, introducing sampling bias into my study. Though I could not systematically sample the entire (presumably international) population of participatory sensing researchers, I did pay careful attention to the distribution of my informants. Students, staff and faculty had different goals, motivations, and perspectives. Ensuring that I interviewed and observed informants holding different power and perspectival positions within the laboratory setting helped to reduce error and bias (Lofland et al., 2006).

Consent, confidentiality and collaborative ethnography

I secured UCLA IRB approval for the interviews and observations conducted as part of this project (materials included in Appendix 1). Before my formal data collection began, I asked all CENS research subjects to consent to the recording of field notes in meetings and workshops. CENS designers also consented separately to interviews. I gave all designers the option of being excluded from interviews and/or note taking, but all consented to participation in the research. There was some flow in and out of the research population as I

worked. During the two years of observations, five new students and staff joined the lab. I consented each of them within a few weeks of their arrival. Over the same two years, eight of the subjects graduated or left CENS for other opportunities.

I have identified all research participants with a pseudonymous initial or title in my write-up. Because the role of the laboratory leaders is so important, I identified them with a representative job title. Their roles made their identities difficult to mask; simultaneously, many were participants in the collaborative nature of this ethnography. I have therefore asked and been granted permission from all laboratory leaders to use the quotations I have included in this account. I used fictitious initials to identify students and staff members.

Because of my closeness to my ethnographic setting and subjects, my work was influenced by the tradition of "collaborative ethnography," drawn from critical and feminist approaches to anthropological fieldwork (Lassiter, 2005). Collaborative ethnography, wrote Lassiter, is:

> …an approach to ethnography that *deliberately* and *explicitly* emphasizes collaboration at every point in the ethnographic process, without veiling it—from project conceptualization, to fieldwork, and, especially, through the writing process (2005, p. 16).

Two influential members of my research population sat on my dissertation committee, played a pivotal role in the conceptualization of this research, and regularly reviewed my progress. I shared my questions and findings with CENS lab members in meetings during 2009 and 2010, and individually as as they were willing and interested. I regularly discussed my work informally over meals and drinks with CENS friends and colleagues. Their opinions, feedback and input, whether offered during interviews, over dinner, or through formal critique of my writing, were an important part of this research. This feedback also

helped to provide what Lofland et al. (2006) refer to as "member checking": validating the findings and analysis with members of the subject group. This practice can help to check on observational and interpretive errors.

Observation and interview protocols

To answer my research questions and observe values important to design at CENS, how anti-surveillance values affected technology development, how the design setting and participants influenced anti-surveillance values, and how designers as well as outside advocates can make anti-surveillance values an integral part of design, I observed and took field notes, and performed semi-structured interviews with all members of the CENS participatory sensing team.

My observation of design meetings and workshops focused on values debates and decision-making during the design process. I coded the field notes to foreground conflicts over values questions and the reasoning behind design decisions. I looked for how values issues arose for designers, and how they addressed those issues through design. I examined the values issues they seemed to avoid, dismiss, or reframe. I looked for stated justifications for the decisions they made, as well as actions or practices that supported or contradicted those justifications. I examined how designers weighed social values against other interests, such as completing a project quickly, elegantly, or efficiently.

The interviews data served to fill gaps in my observation data, allowing me to probe deeper into questions left unanswered during observation of the design process. Interviews sometimes revealed personal experiences and opinions that designers were reluctant to disclose in group meetings, public presentations, and proposal and paper writing. The semi-

structured nature of the interview protocol allowed for new areas of interest to emerge during the interview process.

Because "social values" sometimes seemed like a difficult or daunting subject for designers focused on their own projects and concerns, all interviews started by asking the informant to describe the projects in which they were involved. Talking about projects grounded our discussion, engaged the informant, and presented openings to talk about ethical decisions they faced or made in their work (Fisher, 2007). As the interview subjects raised specific values issues (privacy, consent, equity, etc), I probed for more information.

I prepared the following probes for the interview process:

A. Personal characteristics:

1. What is your academic status?
2. How often do you come to participatory sensing meetings? (Corroborate against field notes).
3. How often do you have smaller design meetings with colleagues?
4. Which colleagues do you meet with in those meetings?
5. Do you have colleagues who you work with remotely (at other labs, in other situations)?
6. Who is your adviser?
    a. Do you have other mentors at CENS?
    b. Other faculty who you work with frequently?

B. Current projects:

1. What campaigns are you involved with at CENS?

2. Tell me about the primary focus of your work or research at CENS.

C. Reactions to design practices and interventions:

1. Do you work closely with your adviser on [X project]?
    a. Who else at CENS would you call a "mentor"? Why?
    b. Do you have other faculty you work with closely?
2. What other designers did you work closely with on [X project]? (Inside/outside CENS?)
    a. What was their role in the development of the project?
    b. Who was responsible for the personal data gathered during the project?
    c. What do you think you learned from [each outside designer]?
    d. What did outside designers learn from you?
    e. How was working together challenging?
    f. How was working together easier?
    g. Where did you store the personal data you collected?
    h. How did working together make dealing with personal data easier?
    i. How did working together make dealing with the personal data more difficult?
3. What CENS technologies have you tried yourself?
    a. How frequently have you done this?
    b. What was this experience like for you?
    c. What did you find out from your testing?
    d. What happened to the data you collected about yourself?
4. What projects have you tested with outside users?
    a. How frequently do you interact with those users?
    b. Describe how you interacted with them (email, meetings, etc)
    c. What happened to the personal data from the outside users?
    d. What did you learn from the users?

e. What did you learn from the users' data?

f. What do you think the users learned from you?

g. Probe for negatives – was it a pain? Did it slow them down?

5. On what projects have you collaborated with clients?

    a. What were your experiences interacting with clients like on [X project]?

    b. What did you learn from clients?

    c. What do you think clients learned from you?

    d. Probe for negatives – was it a pain? Did it slow them down?

6. Did you have to get IRB approval for [X project]?

    a. What was that like?

    b. Did you try to avoid getting IRB approval?

    c. What did you have to change about your project to get IRB approval?

7. What was it like to have a social scientist like me on the design team when you were working on [X project]?

C. Anti-surveillance values:

(As informants raise privacy, consent, equity, persistent memory or other issue, ask more about it with these probes)

1. Do you think a lot about [values issue]?

    a. How concerned about [values issue] are you in your everyday life?

    b. How concerned about [values issue] are you when it comes to CENS technologies?

2. How did you get interested in [values issue]? Probe for the following:

    a. Mentors?

b. Someone bringing it up in discussion? Who?

c. Testing the technology yourself?

d. Talking or interacting with clients or users?

e. Working with the IRB?

3. Did you address [values issue] in your design process?

    a. How did you go about trying to resolve the problem?

    b. What did you do differently because of [values concern]?

4. What other social or ethical issues do you think participatory sensing designers need to worry about?

5. What are incentives for designers to address these issues in the design process?

6. What are your most important concerns about the future of participatory sensing?

7. What do you think we (at CENS) worry too much about?

Auto-ethnography

Though interviews and participation observation formed the crux of my data collection and analysis, another lens also helped to answer my research questions. This was the technique of auto-ethnography (Lofland et al., 2006). Because I was serving a dual role as a researcher and ethics advocate, I was hardly an impartial observer. I was an actor in the design process. Critically considering my own role and reactions to impediments or new values developments was therefore an important part of considering values levers at CENS. Such critical reflection also helped to illuminate what social scientists might do to encourage ethical decision-making within the design setting. Further, explicit critique of my own role as an observer was good ethnographic practice. Feminist and critical traditions in social science

encourage reflexive or auto-ethnography as a way to consider the ways that power dynamics may affect the reliability and validity of research results (Wolf, 1996). Explicitly reflexive ethnography can also help to counter the "voice from nowhere" that traditional descriptive ethnography can privilege (Lofland et al., 2006, p. 191).

Data analysis and coding

At the end of each interview or day of observation, I transcribed my field notes, memos and interview text. I organized my transcripts and coded them using the Atlas.TI qualitative data analysis software package. Coding is a process of identifying topics, patterns, and themes in qualitative data. I used this practice to organize my field notes, interview transcripts, and CENS publications, and foreground the values issues that designers brought up, and processes and agents that affected their consideration of those values.

Coding interview data and ethnographic field notes helped to refine the initial set of questions about values in design into a description of the ways in which values levers enable ethical decision-making in the design setting. New codes emerged through a process called axial coding (Lofland et al., 2006) as I saw unforeseen issues materialize in my observations and interviews.

I began with a very wide set of codes, and narrowed and grouped codes as my data analysis proceeded. Because I was the sole researcher on this project, I had to be careful to avoid coding bias. I solicited a graduate student colleague to review my coding schema alongside samples transcripts that I had coded. We both coded a set of three interviews, and then discussed discrepancies and differences of opinion in our coding. This helped to refine my coding schema according to his suggestions. Application and refinement of the coding

schema was also a tool for pattern discovery in both the observation and interview data. I analyzed the coded field notes for evidence of relationships between particular design processes and agents, and changes in thinking about the values issues at play in participatory sensing.

The overbroad coding scheme that I began data analysis with is listed below:

Demographic information

A1. Academic Status

- Faculty
- Staff
- Grad
- Post-doctoral scholar
- Undergrad

A.2 Disciplines

- Computer science
- Electrical engineering
- DMA
- Statistics
- Film, Theater, Television
- Information studies

Design processes and agents

A.3 Interactions with ethics advocate

- Exposure to advocate
- Expresses appreciation/Expresses frustration

A.4 Institutional norms

- Exposure to IRB
- Avoidance
- Compliance
- Expresses appreciation/Expresses frustration
- Institutional mandates
- Liability
- Paperwork pipeline

A.5 Mentorship

- Identifies mentor (who?)
- Exposure to mentorship (how much?)
- Quality of mentorship
- Conflicts between student & mentor

A.6 Internal testing

- Exposure to internal testing
- Learned from testing
- Normalized tech use

A.7 User and client interaction

- Exposure to clients
- Exposure to users
- Learned from users
- Learned from clients

A.8 Funding

- Funding concern
- Funding source
- Resource limitations

Values in design

B.1 Identification of Agency

- Design constraints
- Designer agency
- Lack of agency
- Limits on agency
- Relinquishes responsibility
- Technological agency
- Technological limits
- Technological optimism
- User agency

B.2 Identifying Ethical Issues

- Consent
- Data representation
- Environmental concerns
- Ethical analogies
- Intercultural ethics

- Parsimony
- Participation
- Persistent memory
- Power differences
- Privacy
- Surveillance
- Trust
- Usability

B.3 Expressing Values: Attitudes

- Accessibility
- Behavior change
- Choice
- Deadlines
- Efficiency
- Equity
- Ethical justification
- Flexibility
- Idealism
- Individualism
- More data
- Quantitative data
- Public good
- Sharing
- Utility

B.4 Enacting Values: Actions

- Creativity
- Data hiding
- Data responsibility
- Data storage
- Data verification
- Design process
- Obscuring identifiers

B.5 Motivations

- Data purpose
- Identifies motivation
- Reliability
- Security

I defined each of the codes; the code definitions are included in Appendix 1.

Code refinement and grouping

As I coded my data, I came to refine the codes and group them thematically. This helped the idea of "values levers" emerge as a bridge between my objects of study (design processes and agents) and values of interest (privacy, consent, equity and forgetting). I grouped the codes into two categories: ***Processes and agents*** and ***Values***.

Processes and agents

- Disciplines
- Ethics advocate
- Institutional norms
- Mentorship
- Internal testing
- User and client interaction
- Funding

Values

- Identifying Ethical Issues
- Expressing Values: Attitudes
- Enacting Values: Actions

Where the two kinds of codes intersected in my data, I looked for values levers: the process or agent that was raising the values discussion.

Methodological Limitations of the Study

I investigated values in design in a very specific setting: a university research lab inventing tools for participatory sensing. Though the values that arose in this space overlapped with other areas of interest, my research was not a treatise on, for example,

online privacy, Facebook, or Google's location services. It was also not a theoretical or empirical evaluation of the social or personal value of privacy, consent, equity, or forgetting. Instead, I took these areas as *challenges* that were part of participatory sensing, and investigated the way my informants wrestled with these issues.

This dissertation also could not be a comprehensive history of the emergence of participatory sensing. I endeavored to place participatory sensing in its historical context in order to understand the way ethical debates in the design setting were be shaped by the larger history of computing. This context gathering, however, was based largely on a review of secondary literature, rather than archival investigation into the history of ubiquitous computing. I chose to devote my time and energy to a field site rather than an archive, and though those categories overlapped (documents produced by the CENS team might be an archive in their own right), my contribution is sociological rather than historical.

My project was a single-sited, rather than multi-sited, ethnography. There are many arguments as to why participatory sensing development might be studied in a multi-sited way. It is a phenomena investigated in multiple industry and academic labs. It is also a node in a much larger web of social actions, including law enforcement and medical surveillance, personal health and lifestyle improvement, and urban planning and environmental research. However, in order to narrow the scope for my dissertation, I centered my analysis on one site. That said, the site does not exist in a vacuum. I paid attention to networks of collaboration with people outside the lab, including clients and designers in other labs. I also contextualized my analysis with literature from other participatory sensing development labs, and I drew on my experiences visiting outside labs and discussing participatory sensing with doctors, urban planners, environmentalists, and users to suggest new areas for future inquiry.

The limitations of this study are comparable to those of most qualitative research, in which researchers sacrifice reliability across sites for internal validity within a site. By using observation and interview methods, I elicited a high degree of truth from my informants, and my research had high internal validity: that is, its conclusions hold true for CENS participatory sensing designers. But because of the highly context-dependent nature of the research methods used, it is unlikely that a researcher who repeated my work would generate the same findings.

My small sample also limited the possible viewpoints expressed. This must be recognized as a fault in the study of values decisions, a phenomenon that depends greatly on cultural and individual influences (Capurro, 2007). My sample could not possibly encompass all of the sub-cultural viewpoints that might affect ethical decision-making. In addition, my sample of graduate students and academic faculty was not representative of the population of sensing designers as a whole. While my results suggest motivations valid across design communities, it remains that my data was collected from a very particular case study with limitations imposed by the distinctive nature of the community.

Chapter 4: Findings – Observing Values in Design at CENS

This chapter draws upon interviews, document analysis, and participant observation to describe values at CENS, and how these values work in design. I have looked for narratives about values, and patterns in designers' ways of looking at values in personal data, infrastructure, and software. I have searched for designers' repeated or preferred representations about why they do what they do. I have used the various ethnographic data types – interviews, observations, and publications – to find crosscutting themes and inconsistencies. I describe how values were discussed in interviews and meetings, and ways in which these intentions contrast to the actions and decisions of engineers. My description explores the way that anti-surveillance values such as privacy, consent, equity and forgetting are raised as subjects in design, agreed upon as design criteria, and are transformed into concrete technological features.

I have organized this chapter according to my research questions. The first three questions sought to understand values in design: What social values are discussed and agreed upon by the design team during participatory sensing design at CENS? How do design practices and participants influence consideration of anti-surveillance values? How do anti-surveillance values affect technology development? I begin the chapter with a discussion of my own role as both an ethnographer and values advocate at CENS, and describe the day-to-day life of design at CENS. The following subsections present evidence to answer my research questions. *Values in CENS design* trace the values, anti-surveillance and otherwise, that were important at CENS. *Values levers in design* explains how design practices and activities affected consideration of these values during design. *From values to technical*

specifications and *From values levers to critical technical practice* explore how anti-surveillance values are translated into technological features during the process of design.

My fourth research question was action-oriented, and focused on promoting anti-surveillance values in design: How can designers, design leaders, and outside advocates, make anti-surveillance values an integral part of design? My description of values levers in this chapter, and the actors and practices at CENS that deploy those levers, leads to a more thorough discussion of this question in Chapter 5.

Between Ethnographer and Values Worker

In answering my research questions, I have also provided a rough timeline of my own interactions at CENS: trying to orient myself to the nature of CENS design, exploring what values matter at CENS, the discovery of values levers that opened new conversations about ideology and ethics, and finally an understanding of how values are transformed into concrete design decisions. In this work, I have walked a line between traditional ethnographer and an advocate for social values in design.

I arrived at CENS with an interest in privacy and forgetting based on previous work, paired with a (probably unfair) dislike for the idea of self-tracking based on previous research into "total capture" work at places like Microsoft Research (Gordon Bell & Gemmell, 2007). I was what the CENS Director sometimes describes as "typical North Campus": secure in my knowledge of ethics, right, and wrong; and insecure in my knowledge of technology and design. I was convinced that my job was to figure out how to change technologists' minds, while unsure of how "technical" I'd need to get to do this.

This "North Campus" attitude, however, was countered by a deep-seated personal desire to be liked by the CENS team. Working on the CENS team was a job as well as a research project, and I wanted to be good at my job. And so I tried not to lord my (presumed) moral superiority over my teammates, and instead spent the first few months trying to get invited to happy hours and design meetings both.

My fit into the CENS team was greatly facilitated by early acceptance from two key CENS leaders: the Director, and the Area Lead. We grew to like each other very much, and to enjoy working together. The Director came to trust me not to be too "North Campus" in my attitudes and opinions. I came to see her as both an incredible thought leader and a personal role model. The Area Lead, meanwhile, appreciated having another "North Campus" voice in the design conversation, and he and I formed a natural team for working out responses to values challenges. Due to trust from these leaders, I was given quite a bit of latitude to outline my own project. I was also given power within design. I was given a voice in design meetings, and students knew that leadership respected my opinions. This turned out to be an invaluable factor for influencing values in design, which I examine in more detail in Chapter 5.

My daily work at CENS was a combination of listening, talking, and writing. I attended a lot of meetings, both formal and ad-hoc. I tried to keep up with the technical conversation while asking pointed questions about features that might distribute personal data, lead to security problems or features, or complicate consent or user interactions. I helped write a number of technical papers, while trying to point my co-authors towards topics like data control and access, data legibility, or data retention policies. I worked with system designers to author data management and retention policies (a role I describe in *From*

design principle to technical specification, below) and I helped lab leadership implement data management procedures (a role I describe in *Leadership: advocacy and procedures*, below).

As it turned out, eagerness to be liked combined with secret conviction of moral superiority was a good combination for a values worker, but not necessarily an ethnographer. I spent the first year at CENS concentrating on finding the least annoying ways to bring up anti-surveillance values with the team, and translate those values into technical implementations. I worked on conceptual investigations to name define the values I explore in *Ideologies at CENS*, and grappled with issues of advocacy, definition, and translation that I describe in detail in *From values to technical specifications*. But because my focus was on values and advocacy, it took a very long time to figure out what I should be looking for *outside* of my own role. Even while I was writing my dissertation proposal, a year into my tenure at CENS, the questions of how to *see* values in design, and what objects of study would reveal those values, were fuzzy.

It took another year of interviews and observations, and shifting the focus away from advocacy and onto design, to find the right objects of study. I had to turn back to a long tradition in sociology and technology studies: looking for practices and expressions of ideology or justifications. Practices and justifications were things I could see in my ethnographic data. The process of writing up the data from my interviews and field notes was a process of extracting values from practices and ideologies.

Of course, this process of extracting values points to how deeply intertwined the ethnography and advocacy roles were for me. There was a sort of Mobius strip of values: I had identified concerns such as privacy, consent, equity and forgetting as early objects of concern, yet I was simultaneously finding them in my data. It became very difficult to

disentangle which values were inherent to CENS design, and which I had raised and focused as a values advocate. Naming and defining values for CENS design had been one of my tasks as a values advocate; a process I talk more about in *From values to technical specifications*. Determining which values concerns were 'native' to CENS design, and which introduced by my actions, is one of the challenges I faced in writing up this work. I have attempted through interviews, in particular, to find and demarcate values concerns that preexisted my time at CENS.

Another thread in my account has been my own process of learning about and understanding the technologies and practices involved in participatory sensing. I came to CENS with little technical background, and no skills in coding or system design. Home with a cold one day early in 2008, I took a conference call in my living room, placing myself on mute. Hearing the technical talk on the other end of the line, my computer scientist husband asked, "Why are you even IN this meeting?" He was verbalizing something I asked myself all the time during my first few years at CENS.

But of course the answer was: to be an ethnographer. Foreignness and feeling out of place is important to the ethnographer's role, if difficult in the advocate's role. In the end, I made a conscious decision not to become too technical. I began and abandoned a project to learn the Python scripting language. I didn't have the right application for that knowledge – it wasn't a skill set I found useful to studying values in design. Instead I concentrated on learning to envision and understand systems at the data level. How is personal data generated, where does it flow, and who can touch it along the way? And when something struck me as odd or alien, I tried to pay attention to why. I give an example of this struggle

to understand as a values advocate, and the insights it can give the ethnographer, in *From infrastructure to values levers*.

Design at CENS

As both an ethnographer and a values worker, I began observing design at CENS by orienting myself to the practices and people that move CENS research forward. The laboratory is guided by four faculty leaders. I have given each a pseudonym that reflects their role and their relationship to each other: the Director, the Co-PI, the Statistics Lead, and the Area Lead. These leaders cover a broad range of both experience and background. The Area Lead is an adjunct professor in the School of Film, Theater and Television. The Statistics Lead is a full professor in Statistics, and both the Co-PI and the Director are full professors in Computer Science. CENS also had eight staff members involved with participatory sensing during my observation, five as programmers and three as project coordinators. There are two postdoctoral scholars who regularly work on participatory sensing projects. Both started as students in embedded environmental sensing, and moved into participatory sensing after graduation. There have also been eleven graduate students and five undergraduate students involved with participatory sensing over the two years I spent in the field. Of the thirty members of the participatory sensing team, six were women (a relatively high percentage for computer science). Nine moved to the United States for college or graduate school from homes in Europe, the Middle East, and South and East Asia. The graduate and undergraduate students were largely in their early to late 20s; many of the staff were around the same age. I identify staff members, postdoctoral scholars, and students with a consistent, individual, and fictitious first initial throughout this account. CENS designers

worked on a variety of environmental, community, and personal sensing projects, with much overlap and moving between projects. Figure 4.1 illustrates the variety of software development projects undertaken by CENS during two years of observation, as well as the overlapping students, staff, and leaders who worked on these projects.

	Environmental	Community	Personal
	PEIR	Boyle Heights	DietSense
	What's Invasive	Biketastic	AndWellness
	BudBurst	Mobilize	
Students	A., C., D., F., G., I., J., L., M., N., T., W.	A., D., G., I., T., Z.	A., B., C., D., G., I., J., L., W.
Staff	A., B., D., E.	A., E., I.	A., B., L., I., M.
Leaders	Director, Co-PI, Area Lead, Statistics Lead	Director, Area Lead, Statistics Lead	Director, Co-PI, Statistics Lead

Figure 4.1: CENS projects and staffing

CENS staff members generally worked standard 40 hour workweeks in semi-private cubicles in the lab. CENS students were assigned desks in less private, open rows, sitting four or six to a row. CENS students spent quite a bit of time in the lab; I estimated that many averaged between 15 and 20 hours per week. Participatory sensing student and staff desks were centralized in one area of the lab located near the main conference room.

Figure 4.2: A design meeting at CENS

Design at CENS was also a cerebral and virtual, rather than physical, activity. Design could be very hard to see, but design decisions were often documented in transcriptions of meetings as well as emails. During meetings, participants largely stayed seated, talking to each other with a minimum of gesture. Someone would occasionally rise to capture ideas on the whiteboards that lined the conference room, or stand to give a slide presentation. But for the most part, interaction was as depicted in Figure 4.2: discussion around a conference table. Ad-hoc meetings sometimes entailed one person standing over another as they both gazed at a computer screen; but just as often involved two people facing each other in office chairs, talking about the problems they'd encountered. Those problems were almost entirely contained on a computer or mobile phone screen.

It also became evident very quickly that design at CENS was largely structured around meetings. As the Statistics Lead put it: "CENS is like a host of meetings." Most of the laboratory leaders met with their students at least once a week, and there were full group meetings that ranged from once a week to once every two weeks, depending on the needs of the project. There were also many ad-hoc design meetings where students gathered to hash out a particular research problem. Meetings provided opportunities for designers to compare

notes and exchange ideas, deadlines for development, and times for laboratory leaders to check in on and advise projects. In an interview, the Director described meeting content this way:

> It just depends on what's going on. We might be talking about defining their research problem, defining their experiments, talking about a research paper, thinking about what to do next, talking about why they're stuck, all sorts of things, or a combination of those.

A large part of the dynamic of these meetings was joking or teasing. Other users of the CENS lab reported that they know when a participatory sensing meeting was taking place, because of the laughter. The Director teased the other faculty members as well as her students. Other team members, particularly faculty, teased the Director in return. For example, from my notes from a 2009 meeting:

> The meeting started late because the Area Lead and the Director were going over slides for her upcoming talk at the National Institutes of Health. The Director joked, however, that the late start should be blamed on the fact that graduate student M was late.
>
> When the meeting started, the Area Lead and M introduced an update on Remapping LA projects. They added that they would focus on the relationship between these projects and the Personal Data Vault, one of the Director's recent projects. The Director joked that this focus was only so that the Area Lead could get her to listen. He agreed.

On another occasion, the team discussed how images uploaded to a park service site could be marked valid or invalid. T., the graduate student in charge of the project, remarked that he was manually marking photos as valid or invalid, joking "Because I am the oracle." The Director shot back "You're Google, Jr.": a (values-laden) joke about T.'s sometimes dictatorial outlook on personal data collection and participation.

Meetings, though a backbone of development at CENS, were not uncontroversial. Many of the graduate students disliked them, and found ways to convey their boredom or

frustration through body language or overt verbal hostility. For example, laptops were not allowed to be used during meetings. However, there were a few students (and occasional faculty) who pushed back on this rule, routinely keeping their laptops open until someone (usually the Area Lead) explicitly ordered them to close the machines. (Notice the open laptop in Figure 4.2). Even then, students would sneak internet access on their smart phones. I also witnessed students reading printed papers during meetings, working on revisions to print copies of papers of their own, and using their phones to test software applications.

Students, in particular, complained openly about meetings and found ways to use the time in ways they felt were more fruitful. But the reason there were so many meetings was that CENS design was largely a group activity. Even when PhD students were entirely focused on their own dissertation work, they regularly called on other graduate students for advice and collaboration. T. in particular had a reputation for recruiting undergraduates to work on his projects. Several other doctoral students regularly collaborated with a lab at the University of Southern California, or labs where they had spent summer internships.

Another reason for the many meetings at CENS was that the participatory sensing team developed software with real-world users in mind. In many university computer science labs, individuals work on pet projects alone or in small teams on "proofs of concept" that may never become working products. But because CENS participatory sensing students built software and architecture tools meant to be deployed with real users, they found themselves in need of larger teams. These teams had to oversee such non-research elements as user interfaces, database structures, and network security, and so they often included professional staff willing to work on non-research development. These teams worked in an iterative and

fairly loose process. Many members of the lab reported being inspired by Agile programming, a form of software development characterized by work in small teams, rapid iteration, and face-to-face communication ("Agile software development," 2011). CENS design, however, suffers around two important areas of Agile coding: requirements analysis and code documentation. Requirements analysis traditionally consists of formal or informal methods to assess what parts of a system are needed, and how they should function. This process was quite ad-hoc at CENS, as students mixed a blend of suggestions from lab leaders, their own opinions and intuition, and advice from others in the lab. Speaking of how he perceived design requirements, graduate student T. put it this way:

> I mean a lot of it is independent, I just kind of do the work and then I... I mean [the lab leaders] advise me as well obviously, but it's more like, I think they give general direction and details are left up to me.

A staff member, B., put it this way:

> You know I'm pretty comfortable, I think that you need to be comfortable to be self-directed. We run ideas by during the meetings but we don't think "we should run this by [the Director]" unless it's more of an administrative or legal issue or whatever, like really high-level kind of problem. You know we're pretty comfortable making our own decisions. …

The tension between professional and proof-of-concept quality design is frequently discussed and ongoing at CENS. In one design meeting for *AndWellness*, the debate played out explicitly:

> Graduate student G. says that our external collaborators will never accept our code, because, as he puts it, "graduate students write bad code."
>
> The Director disagrees; she replies that they will accept our code, and emphasizes that we have to be part of this external community so that we're not isolated.
>
> G.: "Producing quality code isn't a top priority for graduate students."

> Director: "Which is why there are an increasing number of non-grad students in the room."

The continuing redefinition of the line between research and production meant ongoing discussions about what was valued: innovation, usability, and practicality were all valued, but the balance between them was constantly in flux.

Values in CENS Design

As these examples suggest, design meetings, as well as interviews, fostered frequent discussions about what was valued in CENS design. Design conversations also produced discussions focused on a particular set of values: those relating to privacy, consent, participation, equity, and forgetting. Focusing on these conversations provided evidence to answer my first research question: What social values are discussed and agreed upon by the design team during participatory sensing design at CENS?

Over two years of observing design at CENS – and indeed, even before I arrived – one overarching concern was the relationship between the data recording devices under construction at CENS and the specter of *surveillance*. This focus on avoiding surveillance became, alongside values like innovation and practicality, an important ideology for CENS design.

"Surveillance" is a loaded term, associated in the popular media with government power and repression, historical police states, and pernicious actors. Much of the initial negative response to "surveillance" at CENS may have been in reaction to the negative connotation of the word. CENS designers didn't want to be labeled as building surveillance tools. This fear of the term surveillance was demonstrated during a CENS planning retreat. At the end of the two-day long meeting in 2010, during which we'd talked about a spectrum

of sensing activities deploying a wide range of definitions of participation and consent, a lab leader made a surprising accusation. "Some people," he said, looking at me, "think that if a system is not participatory, then it's surveillance." This was not an accusation that I intended to make, and I thought I had been careful to express the large and diverse spectrum between fully participatory (in the sense of Community-Based Participatory Research) projects and surveillance projects. But the concern of surveillance – which I had mentioned as part of that spectrum – weighed so powerfully that it, apparently, was all this leader had heard.

But designers also demonstrated that it wasn't just the pejorative *term* surveillance, but the values underpinning surveillance to which they objected. For example, even if aspects of surveillance were portrayed as useful, innovative, or novel, values of control and personally-identifiable data collection were sometimes resisted by CENS engineers. For example, in late 2010 I received an email from G., a CENS doctoral student. The email contained a link offered without comment. Clicking through, I was dismayed to find a poorly written and argued news article about the "usefulness" of surveillance. The journalist used the occasional bad behavior of workers and the public to justify surveillance cameras and tracking technologies. At the end of the article, the journalist cited G.'s research on battery life (which involved collecting data about what functions a phone performs throughout the day) as a "useful" application of surveillance.

I didn't know what to do. G. had forwarded the article without comment. Was he proud to have his work cited in the press? After all, such citations are positive for students' careers and work. Did he buy the author's arguments that surveillance could be justified and useful? I sat on the email for a day, stewing over my response. I finally typed back a careful reply:

> It's cool this cites your work!
> I do wish the author had mentioned the things your program does that help preserve individual privacy and avoid surveillance. I think her overall argument that surveillance is warranted is way too simplistic. But obviously reporters don't always write what we'd like them to, darn it :-)

To which G. responded:

> I contacted the author. She responded and I explained why what we do is not surveillance. I hope they will correct the online article or do something.

Like most at CENS, the graduate student didn't want to be identified with "surveillance," even if it meant attention to his work. The next time I saw him at CENS, we followed up on the conversation. I asked him which parts of his work weren't surveillance, and he identified his efforts to collect battery information anonymously, so as not to identifiably track individuals' phone usage. He had a long exchange with the author of the article pointing out these measures, but G. was regretful that no correction was ever issued.

In early 2010, I was working on a paper about the relationship between participatory sensing and surveillance. As part of the writing process, I brought this question to the group: "Is participatory sensing surveillance?" I explained that surveillance was, at its most basic, personal data collection. I gave the example of medical surveillance as an example of how the term was not always construed as negative. We discussed parents or schools watching the behavior of teenagers. This led to a discussion of whether surveillance had to be secret. I., a staff programmer, asked: "So if there's a camera and I know someone is watching me, that is not surveillance?" This began a discussion of whether surveillance had to be, as the group termed it, "opaque" or secret. The Director responded: "It's that you're not seeing the data."

> I.: But in that case, if this is the room, I see what the camera sees at the same time, so it's not opaque.

Katie: You can see what the camera sees when you are in the room presumably.

I.: But you don't know how much…

Katie: You may or may not know whether it's on.

I.: Can you delete it, can you…Okay, manipulating the data, that's what, opaqueness? … I think letting people manipulate it doesn't mean opaque.

Katie: No I think you're right. I think that's the opposite, that when people can manipulate it, it's not…

I.: No, I mean, here's the point. If you interview me, is that surveillance?

Director: It's a gray area…. But I think what I. said is getting at it, which is that if you're being interviewed for data that's collected and put in a file for other things you don't see or know to read, that really feels more like it passes that litmus test of surveillance.

I.: It's almost like there's a scale.

This was encouraging – this was exactly the point that I was hoping to get at, emphasizing the spectrum of surveillance activities. I responded excitedly: "Yes, there's definitely a scale."

Director: But there's something different about whether the data is being collected only for the purpose of the person you're talking to versus it being…

I.: I think all these could be cleared [up] by an attribute, like putting an adjective with the word surveillance and distinguishing them together, not necessarily that these are hierarchical but…

Director: Right. They create different types of surveillance.

Katie: Right, so there's like police surveillance or…

Director: Invisible, hidden versus visible dimensions.

Later in the conversation, we discussed kinds of participatory sensing that could be seen as surveillance. T., who sometimes shied away from values issues (especially when dealing with institutional rules or authority figures), volunteered:

> T.: I don't know if I would say participatory sensing is not surveillance. … It depends on your point of view, I guess. I'll give you an example, this garbage thing I'm doing. For probably the [UCLA] maintenance [workers], it is surveillance.
>
> Director: Oh, they were checking up on whether the maintenance folks are actually doing their job. … That's a really interesting point.

T. then went on to distinguish surveillance from "evil" surveillance:

> I find my system matching somewhat those criteria of surveillance. Like people do interact with it, I collect the data centrally, I analyze it myself, people really don't - honestly most people who sign the consent form don't really understand exactly what each of those pieces of data I collect means. … So in that sense I find that it's surveillance but I don't find it *evil* surveillance.

In these conversation, factors such as anonymity, "opaqueness" (or visibility) of personal data collection, the idea of the secret "file," and the intention of data collection and use revealed the need to pick apart the term "surveillance" into constituent values: pieces of surveillance that could be defined, and then encountered, avoided or incorporated by CENS technologies.

Privacy

As these examples illustrate, privacy was an ongoing concern at CENS. Developers sometimes teased each other about their shared whereabouts (such as returning to the same restaurant daily, or not going out on the weekend) when running location tracking technologies like *PEIR*. In my own experiences with CENS tracking software, I inadvertently revealed a workday shopping trip to the Director when showing her my *PEIR*

location trace. Privacy concerns, from the serious to the trivial, dominate many conversations about social values in participatory sensing.

Privacy was also a concern long before I arrived at CENS. In an interview, the Director discussed the advent of privacy concern at CENS:

> From the very beginning, DietSense was conceived of as an application that would need some way of dealing with privacy. Either the user is in control of when it's on, or the user can pre-screen their images before they're handed off to somebody else... It's just no question if one of your meals is breakfast, you're at home, people are running around half dressed … So in our very first writing about all that stuff, privacy was a big piece of it, and how could you bring privacy mechanisms in? … You're focusing on people and privacy and all that, because people had always brought up this question about monitoring and surveillance and such.

Privacy was a theme in participatory sensing publications written at CENS, as well. Of the 25 publications written by members of the participatory sensing team between 2008 and 2010, nine included sections devoted to privacy concerns. Two undertook privacy as a major motivating theme. I was a coauthor on only two of the nine articles with explicit privacy sections.[11] Even without my explicit contribution, privacy was regularly engaged in CENS' contributions to the computer science literature.

Privacy also came up repeatedly in my interviews with students and staff. One reason for this was that everyone at CENS associated me with privacy. I was hired to deal with privacy concerns at CENS, and did the groundwork for defining CENS' approach to privacy (Shilton, Burke, Estrin, Hansen, & M. Srivastava, 2008). But though my presence no doubt prompted students to talk about privacy, it didn't seem to shape *how* they discussed this

[11] I excluded publications on which I was a first author.

value. In interviews, students talked about privacy in many different ways. For example, graduate student G. described it this way:

> I think about it more in a case-by-case manner. So for example, when I'm running *PEIR*, if I'm going somewhere and I don't want anyone to know I went there, then I will think okay, I need to turn off this application or do something about it, or leave my cell phone... So I'm kind of aware of it in a case-by-case manner.

The same student added:

> So I can envision that putting some of this stuff together can lead to systems that can be very invasive, privacy invasive. I think it's totally possible but again I think it should be discussed case by case.

L., another doctoral student, summarized an experience with privacy concerns this way:

> I did data collection for T. on a mobility data thing. For that kind of thing I actually need to collect data throughout the day, like for a week for two weeks or something. Then I feel like, not privacy ... But I feel that I want to go out more actively. [Laughter] I feel oh, they are watching me, I need to be more active. …Because T. would keep telling me oh, you don't go to any place, you just stay at home for a week [laughter], so later, I do more active things.

Other students struggled to define privacy, or struggled with when data protection measures might be necessary in a CENS system. For example, N., an undergraduate, worked through the issues this way:

> I find it interesting for a couple of things, like one, is there's a question of what data should not be private anymore. Because there's a point where, sure it's important to keep it personal: but the cost benefit of it? Sure you can give something away, but you gain a lot out by giving us that information. … So what is the ultimate way to keep track of what a person wants or does not want, and how do you create policies that are adaptable? Because if they are too rigid then the service hurts. And if they're too open then the consumer hurts. So how do you find the Zen of privacy?

Another graduate student, C., questioned whether "privacy" of this data was a manageable concept at all. As he put it:

> When we talk about revoking and deleting data, I feel like it's more similar to saying something to someone. Once it's out of your mouth... You don't have any control... So you want to make sure... You know, before it's out of your mouth and once it's out... I don't know.

CENS designers often struggled with the reasoning that this personal data would get out there somehow. Were our efforts to control such release worth it?

In conversations like these, students at CENS displayed a host of reasons, from the personal to the professional, why they were interested in privacy. They also discussed a diverse set of definitions of what privacy means, and when it might be applicable to CENS systems. Privacy was clearly important to many of the people involved in design at CENS, but CENS subjects struggled with when and how to apply these values to design.

Consent and participation

A confrontation with the question of consent was many visitors' first experience when entering the CENS lab. Posted in three places in the entry hallway is this sign:

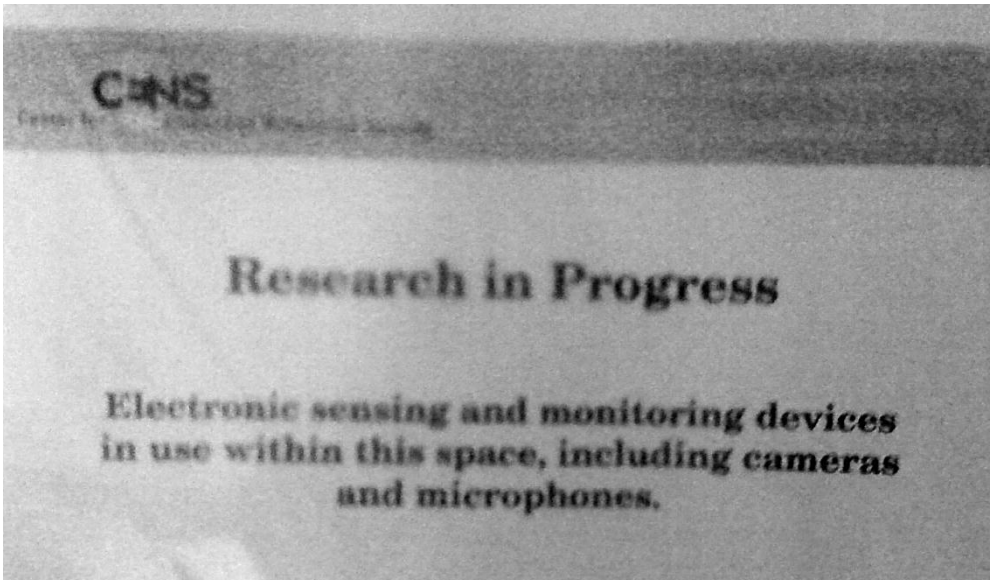


Figure 4.3: Notification sign at CENS

Indeed, the exposed beams overhanging the laboratory cubicles are dotted with little cameras and various other sensors. I've always been under the impression that no one is recording or viewing data collected by those cameras, but then, I've never been quite sure who to ask. This sign, and the instrumentation of the CENS lab, points to immediate conflicts between data collection and consent.

Consent arises as a values challenge in participatory sensing because CENS undertakes its data collection in the service of research (rather than, for example, art, as in the example given by the Statistics Lead above). CENS participatory sensing designers envision mobile phones as research tools for investigation of the habits and situations of individuals and communities. This investigation might be individual and informal or organized and carried out by university or industry researchers. One long-standing ethic in human subjects research has been consent, and the question of consent manifested in CENS design as well.

One approach to securing consent at CENS has been issuing traditional consent forms to all participants in internal pilot testing as well as external trials. A., the staff member in charge of distributing phones for testing, also oversaw the authoring and collection of consent forms. This mimicked consent in traditional research ethics, where consent is secured through a one-time written document.

In a meeting about values issues in ongoing sensing projects like AndWellness, we talked about some of the drawbacks of this model. I raised the question:

> But something that we've been talking about with [the Director] and with [the Area Lead] is: is a higher bar necessary when somebody is consenting to being tracked all the time, or having their cell phone on their body or body sensors on their body, or anything else that's easy to forget about, right? … And so is a check box at the beginning, is this online EULA model where

> you say, "Yeah, okay, sure, I just want the software," is that like a meaningful form of consent? And so what I wondered about, the different projects you guys are working on, AndWellness and other participatory sensing projects, is what have you guys thought about in terms of the consent process, and in terms of keeping people informed about what data is being collected about them.

M., a postdoctoral researcher in charge of the AndWellness project, responded:

> Right now mostly what would be done for at least AndWellness would be following the current [consent form] process. And if we're doing that then everything's fine, so you end up not thinking beyond that process sometimes. So it would be hard to envision something beyond that.

This led her to think about the drawbacks of the current consent form process.

> But as a participant, certainly as things change or as you go along to study your perceptions of things that you initially had would change, and therefore your sense of what you think might require privacy would change. And I don't know quite how you would address that in some of these studies, given that you're supposed to follow these protocols and only talk to participants about these things, and we're kind of hampered. I mean, in the sense that, it's funny to adjust or change as you're going along in the process.

Paperwork is not the only way of dealing with the challenge of consent at CENS. A more complicated manifestation of values of consent has occurred in ongoing discussions about a broader but related social value: participation. The meaning of "participatory" in "participatory sensing" was a topic of ongoing debate at CENS. Use of the term "participatory" was contentious, primarily due to agitation by the Area Lead. While the Director advocated for the term to describe all kinds of human-in-the-loop sensing, the Area Lead thought that CENS should aspire to a stricter definition. As he explained it:

> I feel like I need to push on the participatory definition. … I was very interested in the political articulation of what participatory has meant in education and in health fields. I feel a level of responsibility that the term be respected in what it's meant in those fields, even if that's difficult to articulate to funders. So I've been hesitant about CENS' use of the word "participatory" to describe an area that doesn't actually have participatory design with stakeholders in all of its projects. I think there's been a really

> good back and forth discussion with [the Director] about which projects are really participatory and which are not. I put my foot down and said, "It can't be participatory unless it's about these things." …

The result of this rigidness around the definition of "participatory" was not totally positive, however. The Area Lead went on:

> Then it became this very confusing morass of terminology. When [the Director] was looking at, "What should CENS do next?" because I had been so adamant, she didn't feel like all the projects were really participatory in that political sense of the word. At some point in one of these discussions we decided somewhat collectively: maybe it's more important to emphasize participation and a spectrum of participation than it is to drop the name because of not having every project meet that political, that definition of true participatory design or participatory projects.

"Participation" at CENS has since come to imply a range of behaviors, and a range of involvement in each project. In almost all CENS projects, a basic level of user participation requires user input (whether turning sensing on and off, taking a picture, or entering text) to target and restrain personal data collection. Most CENS participatory sensing projects explicitly focus on "human in the loop" sensing, giving individuals some knowledge of, and control, over data collection and analysis processes. The project titled *What'sInvasive* (http://whatsinvasive.com/), for instance, used human recognition of plant species to locate and photograph invasive species in national parks. *AndWellness*, as described in Chapter 1, gave a different picture of the ways individuals could be kept in the sensing loop. One *AndWellness* implementation used a combination of activity patterns (walking, running, sitting, driving) and user-input "experience samples" to monitor cardiovascular risk factors among young mothers. Experience samples asked users to answer survey questions that recorded behaviors, such as their diet, stress, or exercise. Another pilot asked a population of users at high risk for contracting HIV to document risk behaviors such as sexual activity and

drug use. After short periods of tracking and data analysis, users could see correlations between places, activities, and behaviors. To encourage behavior change, *AndWellness* not only engaged participants in data entry, but also in reviewing those data and learning from them over time.

Other CENS projects took a more expansive definition of "participation," involving users throughout the design, sensing, and data analysis process. The *Biketastic* project engaged in a series of focus groups with area bike advocates to brainstorm system features. These advocates also volunteered as early pilot testers and gave feedback on the usefulness of system features (Reddy et al., 2010). Two newer projects, the *Boyle Heights Participatory Sensing* project and the *Mobilize* project, were perhaps the most participatory CENS undertakings I observed. The *Boyle Heights Participatory Sensing* project goals were defined by community organizers from a mixed-income Los Angeles community. Residents used CENS technologies to document routes to school and work, the availability of health eating options, and gathering places for youth, as well as less desirable aspects of the community like safety hazards and poor housing conditions. At the end of the data collection period, the community group *Boyle Heights Planning for Place* used the data to create a healthy community plan. Residents and organizers, rather than CENS designers, defined what to sense, when to collect data, and what would be done with that data.

Exploring techniques for participation in data analysis was another way that consent and participation cropped up at CENS. Techniques for engaging participants in their own data analysis remain among the difficult challenges in CENS development, focusing as they do on fostering data literacy among diverse user populations. The *Mobilize* deployment targeted this question directly. *Mobilize* worked with Los Angeles public high school teachers

to integrate participatory sensing projects into computer science and math curricula. Students undertaking new sensing projects were engaged in defining data collection goals, building the tools necessary to reach those goals, and analyzing project outcomes. *Mobilize* targeted data learning as part of a broader math and science curriculum among high school students. By introducing kids to mobile phone technologies, the *Mobilize* project helped foster understanding of a new kind of research, and new kinds of data, among high school students from predominantly underprivileged communities. As the project organizers wrote in their proposal:

> At its heart, participatory sensing is about data collection and interpretation—with the type of information collected, how it is organized, and how it is ultimately used determined by the participants themselves.

Though the definition of "participation" was continually in flux at CENS, the ongoing discussion around these definitions allowed the team to continue to talk about the values issues implied in their definitions and project approaches. As the Area Lead put it:

> I feel good about the negotiation that happened and good about that decision because I think it still allows us to continually ask the question: what does participatory mean? But to back off on being super dogmatic about it.

Power and equity

As the ongoing debate over consent and participation at CENS points out, anti-surveillance conversations generate concerns about fairness and equality, and the concept of power lurking behind those values. Questions of who should participate in sensing, and who benefits from sensing, also pervade design decisions. Attention to social equity has been an intentional move on the part of the Center, largely because of many of the laboratory leaders' social ideals. As the Director described in an interview:

> If it's about selling something, I figure the market is going to figure it out better. So I have this overall filter looking for things that are not well-served by traditional markets. I think it's the role of the university to try to take on some of those. Those problems won't get solved, because they don't have a clear revenue stream and business model, so it seems to be a useful role for us to play.

At CENS, discussions about equity began with an emphasis on designing personal data collection systems that utilized the widely available and accessible mobile phone. CENS team members frequently cited the availability of such devices across race and income lines both in the U.S. and abroad. Unlike traditional tools of surveillance (cameras, card readers or specialized data collection software) phones are cheap, easy to find, and easy to use, providing a foundation from which anyone can theoretically participate in a sensing project. CENS undertook a commitment to realistic and accessible participatory sensing by endeavoring to create sensing projects for all types of mobile phones. An example arose in a spring 2009 meeting discussing possibilities for measuring ambulation. The amount of physical movement a person engages in is often a good metric for measuring the progression of chronic diseases such as Multiple Sclerosis. This prompted graduate student C. to express what he felt to be the easiest way to measure ambulation: adding a mote or secondary sensor to a phone. The Director was adamant in her response:

> Do the homework to see the money it would take to do a device. Factor in the charger, nice packaging, accuracy… The market is not big enough to support inventing a brand new device. The economy of scale is in using existing devices - phones - to do this.

And although smartphones (with GPS capabilities and increasingly user-friendly touch screens) offered both attractive programming interfaces and data collection abilities, CENS projects also incorporated simple data collection (such as SMS messaging) that could be accomplished on less expensive devices.

Beyond issues of accessibility, laboratory leaders expressed hope that sensing itself could help level social playing fields and achieve goals of social equality. As the Statistics Lead put it in his interview:

> There's some basic thing about the power that data can have to shape policy and shape the world. …If you acknowledge that data are important, then how people make use of data or maybe create their own competing stories becomes a natural next step. I think that there are a lot of groups that are recognizing that certain problems only get attention when they're framed in the same way. I think that there's a lot of case-making, a lot of advocacy going on.

CENS writings, grant proposals, and selection of projects have similarly undertaken an agenda broadly focused on equity, predicated on serving those who don't traditionally have access to personal data collection, and the presumed power that quantitative, organized data can bring. Projects that specifically addressed health disparities (among low-income mothers and HIV positive young men, for example) were among the first health studies targeted by CENS projects. Other projects envisioned public interest initiatives, building technological platforms for advocacy—"making a case" through distributed documentation of some need. *Biketastic*, for example, aimed to create better maps of bike routes in the famously car-centric city of Los Angeles. The project was a low-cost, real time way to documents areas where city planners could improve existing conditions or increase access through new routes. The *Mobilize* project aimed to put participatory sensing technologies to work in under-resourced computer science and math classrooms in L.A.'s public schools. Finally, the *Boyle Heights Participatory Sensing* project directly engaged questions of race, class, and accessibility while targeting goals of community participation and improvement. CENS developers write that sensing technologies can "start and facilitate conversations" among individuals and groups (Mun et al., 2009) and can create a:

> data commons … generated through decentralized collection, shared freely, and amenable to distributed sense-making not only for the pursuit of science but also advocacy, art, play, and politics" (Cuff et al., 2008, p. 29).

In a vision document prepared by the CENS team (including myself) for the Woodrow Wilson Foundation, we argue that participatory sensing could follow three equity models:

> *Collective Design and Investigation* … the community of participants owns the entire process and is vested in its outcome, whether it is research and discovery or effecting change in the community. By combining local knowledge and individual empowerment with widespread technology, this approach develops a community's potential for self determination. … *Public Contribution* … Participants are actively involved in the collection of data, but not necessarily in the definition of research questions or use of the results. By recruiting interested individuals in this way, organizers can acquire data at a scale unachievable by professionals acting alone, and participants can contribute to an effort they find meaningful. … *Personal Use and Reflection*. Individuals log information about themselves and use the results for personal discovery (Goldman et al., 2009).

Discussions of equity are not just held at the level of selecting and describing projects, but are also part of CENS design meetings. For example, a spring 2009 meeting with a visiting European PhD student delved into the definition of social goods or benefits. It illustrated the ways that participatory sensing designers regularly engage with questions involved in building technologies targeted at social change. I recorded the following conversation in notes on the meeting:

> [The visiting student]'s presentation focused on persuasive technology - technology that can persuade people to make changes. He based this work on, as he put it, the social principles of self-monitoring, social comparison, social facilitation, and something he calls reduction. He was meeting with the CENS group because he hoped to port *PEIR* to Stockholm and then alter the UI around these principles to do experiments on user behavior change.
>
> The Statistics Lead began a conversation about tradeoffs and social problems with more complex factors and variables than, say, weight or carbon footprint. He pointed out that there are some social questions where "good" is not as easily quantified or as obvious. We discussed problems like immigration or gentrification as examples of these.

Problems of social equity – and socio-technical approaches to those problems – were certainly a part of CENS discussions. CENS leaders also felt an imperative to make discussions of equity influential in the broader field of participatory sensing beyond CENS. As the Area Lead put it:

> I still feel like I could promote it more, and that there's probably work to be done out in the community… I mean I get a Google alert on participatory sensing, and I see all the places that it's used I'm like: "Damn it, we need to be out there describing what we think participatory, what the aspiration is."

Discussing social goods was one challenge, but discussing possible negative consequences of personal data collection was more difficult. In a 2009 design meeting, I raised this issue:

> I think power asymmetries is sort of an important thing in mobile sensing and it's something that doesn't come up a lot for whatever reason in our discussions. And is that because we don't feel that we have power over the people that we're sensing?

The group, including the Area Lead and graduate student T., responded in various ways:

> Area Lead: I think it's because the questions are hard and they slow down development. I just think they're hard questions.
>
> T: Actually I think the studies that we do, I don't know, I don't think a lot of these things are that serious. That's my opinion. Because when I talk to people about the stuff that we're monitoring, they just don't care. They're completely fine with it.
>
> Katie: Do you think that's different from the stuff that you're working on, as opposed to AndWellness?
>
> T: I don't know. I don't know anything about the health stuff, so it's more just, I can only talk about the stuff that I worked on.

We went on to discuss whether projects being opt-in or even participatory affected the power differential between participants and the data collector (in this case, CENS):

> Director: [Biketastic] was a little more self-selecting though, because people who participated actually wanted to, whereas I think [Katie] meant some of the other applications where we were doing random recruitment.
>
> T: But that's also opt-in for them too. No one's forcing them to do it.
>
> Director: So I don't think you can generalize from Biketastic.
>
> T: Sure, I'm not saying that. But I'm just saying at least in the [campaigns] that are a little bit more participatory that are not health-related, it seems that people are much more willing to give up [data], just because they care or whatever. It's always opt-in or something like that.

Then we came back around to the power of data collection, and who data collection benefits:

> Katie: The other thing to sort of flip thinking about power is who benefits from this kind of data collection? And I think something that I've seen at CENS which is really interesting, that you don't see anywhere, is a lot of what we do we justify by saying it's for the people who are collecting the data. It's good for them. It's going to benefit them. And so I wonder if we feel better about the kinds of location tracking because we have this idea that it benefits the individuals who participate.
>
> Area Lead: A really interesting survey would be to survey researchers to basically ask for a ratio of benefit to us to benefit to the individuals, and then ask the participants the same question, because - I don't know. Because I would be willing to bet in some of the cases where we have very early applications that aren't exciting, they feel the benefit is all for us. And we feel the benefit is probably actually higher. … I don't know whether it benefits people in the short-term or not.
>
> T: I think a lot of the campaigns I did, they knew that it wasn't really a benefit for them at all. Like collecting images of garbage is not really going to be of benefit to them to a certain extent. But I guess they were happy because they were helping somebody else, or helping a larger cause.
>
> Area Lead: I think it all depends on how you define benefits.

Discussing everything from the accessibility of mobile devices to who benefits from participatory sensing was all part of considering questions of power during design of CENS applications.

Forgetting

CENS discussions have also incorporated specters of persistent memory and its opposite, forgetting. My own work at CENS, as well as that of the Director and Statistics Lead, was quite influenced by participating in the "Designing for Forgetting and Exclusion Project" lead by Blanchette, Lievrouw and Curry. That interest translated into consideration of how best to collect the minimum amount of information needed for any given sensing project, and how to build in workable data retention policies. CENS designers explored techniques such as parsimonious activity classification (Mun et al., 2008) to enable projects like *PEIR* to run with less granular cell tower, rather than precise GPS data. Sometimes data retention was relatively easy to accomplish. For example, when a national news article revealed that Apple had been storing unencrypted location data on iPhones (Cheng, 2011), graduate student G. proudly wrote to the team listserv:

> From these blog posts it seems the [Apple] file is equivalent to our WiFiGPS cache. Although ours does will remove "transient" and "stale" records, so even if someone reads it, it will not reveal [location] tracks.

CENS was doing a better job than Apple at deleting unneeded location information.

Sometimes data retention was more complicated to implement, however. We labored to set data retention policies for *PEIR*, the most developed participatory sensing campaign, in hopes of enabling data deletion and forgetting. There were logistical challenges to deleting data, however, that complicated CENS data retention plans. In a 2009 design meeting, I discussed the technical limitations on forgetting with postdoc M. and the Statistics Lead:

> Katie: What about with something like AndWellness, what are the provisions for data retention? Do we know how long that's going to be kept?
>
> M: We've talked a little about it, so there's going to be a retention mechanism built into the system. So far what we're thinking is that we'll just, like the

> researchers will decide, and then it'll be part of the consent process. And so for our initial pilots we're saying I think like a month or something. …
>
> Statistics Lead: I know it's impossible to answer this, but will that really do it? I mean, in the sense that will there really be no record in backups and everything. … Like how seriously will it be --
>
> M: Right. No of course, we're not going to wipe the backups but backups naturally wipe themselves.
>
> Statistics Lead: What?
>
> M: Well, meaning like we only have backups for like the last couple months.
>
> Statistics Lead: If I'm going to court tomorrow and I wipe my data, and it's still backed up, it's not very useful to me.
>
> M: No, no it's a good question. It's a good question. So the backup system, I think we only keep, it's like a circular buffer so I think we only keep the last month or something.
>
> Statistics Lead: Yes, and I think in some of our IRB protocols we've sort of said that, that it would get wiped from the production system and then eventually that would trickle through the backup.

In addition to logistical hurdles, data retention and deletion were controversial with designers and clients who hoped to discover new and unanticipated correlations in personal data. How could limited personal data collection be balanced against new knowledge discovery? In addition to philosophical controversy, attempts to commit designers to the logistics of data retention dates met with frustration. Data retention, like many of the privacy measures explored at CENS, required adherence to careful data practices: tracking, deleting, and ensuring that back-ups have been deleted. Such practices were disliked, or simply disregarded as unimportant, by sensing developers focused on new systems development. In fact, it was forgetting and parsimony that met with the most technical resistance at CENS, due to competing values in design. The next section will explore some of the sources of that competition.

Competing values in design

CENS designers truly valued privacy, consent, equity, and sometimes even forgetting. But they also faced significant competing values that sometimes outweighed ethical principles. There were technical limitations on the projects and system features that designers could pursue. The team worked with a limited number of phones to distribute to pilot testers, and those off-the-shelf phones had restricted features. Team members faced pressures to move their design process along quickly, and sometimes values-based design was seen as an impediment to quick progress. Students eager for success as academics faced stringent deadlines and pressure to publish their ideas before anyone else did. The constant pressures of technical innovation often combined to make a slower, stickier, values-oriented design process unattractive.

The tensions around anti-surveillance values like forgetting and innovation values like new knowledge discovery, or systems values like efficiency and practicality, pointed to a problem of competing values in the CENS design space. Any value that fostered a slower design process faced an uphill battle at CENS. An example of the tensions between deadlines and values-based design occurred during construction of the *PEIR* system. *PEIR* tracked an enormous amount of personal data, recording latitude and longitude readings every thirty seconds and translating these data points into activities (walking, driving, staying still, etc.). The team agreed early in system development that the system should enforce data retention policies, keeping raw data for only six months at a time. But the *PEIR* team suffered from staff turnover, strict paper deadlines, and a frenzied push to get the system running before a national technology exhibition. Emails from the Area Lead to students stipulated: "We should discuss a data retention plan at a later date." The later date never

arrived. The data retention plan was continually moved to the back burner, and in the end, never implemented. This was not an uncommon occurrence at CENS. Asked if he had implemented privacy mechanisms for a completely different project, staff member B. offered:

> Not yet. We have created, uh, formulated strategies that we are going to implement later. … When we don't need to see this data anymore, let's implement a system of deleting. Or: take the first mile of each route or whatever, so you can't precisely pinpoint the house.

The frequency of tensions between anti-surveillance values and values like expedience and efficiency was high; nearly every project dealt with these tensions.

As an illustration, the development of the Personal Data Vault (PDV), a critical plank of the technical implementations of anti-surveillance values at CENS, faced similar challenges. The team simply didn't have the staffing or funding to support the PDV, and the brunt of technical work on the PDV fell to L., a single interested graduate student. As the Director said in an interview:

> I think that we actually need to have three people working on the PDV. The analogy, if you ride a bicycle too slowly, you actually can't ride the bicycle. This isn't about L. at all. It's just an underpowered project. So I'm looking forward to *AndWellness* getting situated enough that [a staff member] can play a serious role in PDV development.

Lack of time and resources are not the only impediments to implementing anti-surveillance values in design. Pushing back on social values was something designers value perhaps most of all: innovation. Many designers held the perception that values such as creativity or innovation are particularly opposed to values such as forgetting (and in some cases, consent, participation, and privacy).

The importance of innovation values – values such as creativity, invention, and new knowledge creation – was demonstrated by the number of meetings devoted to trying to inspire new project ideas. Frequently the weekly participatory sensing meeting was given over to visiting guests ranging from urban planners to health researchers to environmental advocates to interface designers. A common question was: how can participatory sensing help address your problems? Perhaps three quarters of the time, the answer wasn't entirely clear. More often than not, my field notes from these meetings end with "We need more time to think about if/how we could help these efforts with our technology." But occasionally, such a meeting would lead to new collaborations, new projects, and resulting software and architecture innovations to support the project. In an interview, the Director described the importance of these meetings with diverse real-world clients to foster innovation:

> We try to define *real* problems to solve, and [I try to encourage students to] hold themselves to the standard that the problem is worth their time. … We try to think about the bigger context in which their research lies. If they have a larger context, there's always this sanity checking going on in their head of whether that next assumption they make to get the next 10% improvement in the performance of whatever they're doing actually makes any sense or not. So to have a real situated sense of their work they're doing and not to get too narrow a field of vision. At the same time, to try to find some places where they can exercise some puzzle-solving and have some creativity. So it's sort of a balance between those two.

A focus on both real-world design and creativity had direct consequences for day-to-day design at CENS. Because so much of participatory sensing development was not research, but basic coding and database work, a professional staff to support development was critical to implementation. Graduate students didn't want to spend a lot of time on basic coding, and when they did, the work was often quick, buggy and unsustainable. It was staff

members who would devote workdays to setting up databases in a scalable fashion, writing code, and piecing systems together. As the Director said in an interview, "What I'm usually looking for is money to support staff."

Hiring staff could be challenging, however, because CENS design culture was quite different from industrial design culture. As the Director explained in an interview:

> We were looking for somebody on the mobile health side that had professional experience in building, architecting and running online web-based systems, and yet who seemed to have the flexibility of becoming adaptive to our semi-chaotic, very exploratory process. Whereas normally in industry you have a better idea of what you're building before you build it, we are constantly in an iterative loop of building and deciding what we're trying to build.

The focus on balancing real-world products with research produced the "iterative loop of building" that the Director described. This led to a very particular design environment focused on building rather than documenting, and new ideas rather than design requirements.

In this sort of environment, features needed to collect personal data (such as capture and upload mechanisms) were implemented much more quickly than those needed to limit collection, restrict sharing, or delete data. When I ask graduate students about this fact, their response would hinge on the definition of "functional." Their efforts were primarily focused on building a functional prototype. But it was clear that their definition of "functional" included personal data capture, but not necessarily data protection or deletion.

Designers rationalized their decisions to delay social values decisions in favor of expediency in several ways. Some declared that issues such as privacy or abuses of power weren't truly pressing or dangerous, like staff member B.:

> Like I don't really think about hackers abusing the system and crazy things that we hadn't envisioned. Or you know data being gathered and then used for nefarious purposes. …Because whether it can happen or not I don't think there is point to losing your sleep over it. If someone's gonna do something, like that to thing you've never thought of, then what's the point in spending your time thinking about it? … And we are not going to, like, cancel the project just because someone might do something.

Or as graduate student L. put it:

> I think it's because it's tedious stuff to do. Just like for IRB, I feel that sometimes it's kind of too much... Maybe because we are not a company, right, we are like a research lab in a school. So, we know that we're not going to use this data for, like, my personal use or anything. So I feel personally that we worry too much about, like, releasing this data or using this data for other purposes.

Some students saw values such as privacy protections as important, but outside of their scope of expertise. As undergraduate F. put it: "[Privacy] really should be in the philosophy department." He went on to say, however:

> But I mean definitely I think a lot of [concern about privacy] just comes from the work at CENS' core. You should feel that it is nice to be respected and give respect to people.... It all goes back to very - at some point it goes back to a certain level of common sense, morality, whatever that might mean...

F. also tempered this view with a suggestion that not everyone would agree with his sense of morality:

> And then there's also, you know, certain cynical minds, who don't consider and care. Which always are contagious. Hee hee.

Graduate student J. also identified general 'moral principles' as a reason to care about values in design. As he said:

> I don't know, just the fact that we know we have the power to fix it, because not all users are going to know that their data is susceptible to that kind of thing. There are not always going to be IRBs when things go public and that kind of thing. I guess a moral... I don't know.

But then J. got pragmatic:

> But also just to avoid law suits later on down the road, given when you've made something you've gotta be able to assure the users, and the users could get back at you if somehow their data is compromised. Even if you did have some sort of statement. I'm rambling. I haven't really figured this out.

Others students indicated that such values simply weren't a design priority; a functional system was more important. Graduate student I. offered the following description of the privacy implementations built into *AndWellness*:

> We initially were going to have the PDV, the Privacy Data Vault system, but it vanished basically. Like that's kind of gone on the wayside unfortunately, so we're just like interfacing the phone directly to the database. We're going to have, not in our first prototype but our second prototype we're going to have full authentication and security for everything. There's a lot of background setup for that, so we did not have time to get that for the first rollout...

More rigorous design requirements analysis might challenge this definition of "functional," bringing social and ethical considerations into a definition of a functioning system. But because of CENS' ad-hoc design process, requirements analyses were often unspoken or were reliant on individual efforts and opinions. As staff member I. put it:

> I think the design process is too fast. [Taking your time] is really important for shared understanding and because if you have a good design it actually makes the implementation of that design faster, because you don't have to ask questions. … There are always going to be hidden requirements that you didn't find until you get so far into a project, but I think spending that time on design is really, really important. [At CENS] there seems to be a much more of an emphasis on just getting something out in front of somebody.

Combined with the already-existing conflicts between innovation and anti-surveillance values, the informal nature of the design process presented a strong challenge for incorporating values such as privacy, consent, equity and forgetting into CENS systems.

As I began to notice conflicts between values at CENS (largely identified by rationalizations for *not* addressing values such as privacy, consent, equity, and forgetting),

and the problem of setting design requirements, I began to look for how such conflicts were resolved in design. In particular, I began to notice *practices that already existed* during design at CENS that acted to strengthen requirements analyses and help move considerations of the protection of personal data into the realm of functional requirements. I began to label these existing practices "values levers": tools that helped pry open a conversation about anti-surveillance values in the midst of the rush towards software products and new publications.

Values Levers in Design

As the examples above illustrate, the anti-surveillance values discussed during CENS design surfaced in interesting and sometimes confusing ways. They were an amalgamation of personal values held by members of the team, combined with lessons learned from a variety of sources within design. It was this latter factor that was the focus of my second research question: How do design practices and design participants influence consideration of anti-surveillance values? What factors within design encouraged engineers to confront anti-surveillance values? As I started to see privacy, consent, equity and forgetting surfacing at CENS, I tried to untangle what practices and activities encouraged these values to manifest.

Early during my observations at CENS, I began tinkering with the idea of boundary objects in design. As explored in Chapter 2, boundary objects have been a theoretical lens through which many information and science studies scholars have observed scientific and technical collaboration. However, I was unsure that what I was seeing were boundary objects. There were topics, practices, and people who raised values concerns for discussion, but what I was observing was a consensus-building process. Practices that raised values issues were focused on building a consensus around those values, helping to transform

values into agreed-upon design criteria. However, Star has been quite clear that a boundary object is something that allows disparate researchers to work together *without* consensus (Star, 2010). What I was seeing could not be labeled boundary objects.

Instead, I began searching for a new theoretical lens. The practices I examined were not translational, but functioned more like levers: tools that opened up new conversations. I was identifying design activities that encouraged designers to pry open new conversations about values. I started calling these tools "values levers." These activities allowed for the building of consensus around what values were important to the design group as a whole. I began looking for examples of these levers in design at CENS.

From infrastructure to values levers

When I began my interviews at CENS, I planned to ask questions about the personal data collected during campaigns. To me it was quite obvious that many of the surveillance issues in CENS technologies resided in the personal nature of the data and its associated processes and inferences: what data was collected, at what granularity, who could access it, and how it would be processed, interpreted, used and disposed of. And so, in my first set of interviews, I asked students questions like: what are the personal data in your project? And: who is in charge of the personal data in your project?

These questions produced a serious of unclear and confused answers from the students. Respondent like graduate student U. replied with answers like:

> "I guess it's kind of hard to say who…I guess I was responsible as the one who was dealing with it. Most of the other stuff was D., and actually T. also…"

And from postdoc M.: "No, I'm not sure about the *AndWellness* data." And from graduate student C.: "Who's responsible for the data? Might I ask why this is important?"

These responses confused me. I was asking a question that was, for some reason, difficult to answer. This moment turned into what Star (2010) has described as a "pre-sneeze" – the tickle in your nose when ethnographic data is pointing to a puzzle.

A discussion with a key informant, postdoctoral scholar M., helped clarify the problem. I realized that "Who is in charge of the personal data?" was framed badly for computer science students. One of the major challenges for early-stage design is that much of designers' intellectual energy needs to be spent on systems, rather than the domain-specific data flowing through the systems. CENS graduate students are responsible for building new systems, and as a result focus largely on the algorithms and storage undergirding the data. Their research posits how to build these algorithms and database structures more elegantly, effectively, and efficiently. As the Director explained to me: "Understand that there would *be* no data without first having a system." The students at CENS were focused on the pipes (and occasionally data such as system health and evaluation metrics that they collected about the pipes), not the personal data. This was consistent with findings of previous studies of CENS development, in which early attention to systems for scientific data gathering gave way to attention to scientific data as the development process matured (Borgman et al., 2007b).

This realization led me to revise and ask more concrete questions. I began asking: where is the personal data from your project stored? And who has access? Framing the questions as about logistics, rather than responsibility, led in many cases to very specific, knowledgeable answers. T., a senior graduate student, explained:

> So that data is going to Sensor Base. Actually the way our system works is that, the phone goes to a mux. A mux is basically one input, several outputs. Essentially the data goes into one place and then it can be diverted to different places. So right now it is being diverted to SensorBase and that's it.
>
> In some future… it will go to a server that we have, the What's Invasive server. And then the What's Invasive server diverts it to Sensor Base. Then we also have these like geocoded images that come. And you can think of them as another stream of data. … They go to Flickr for storage.

While a handful of students gave concrete, detailed answers like T.'s, this specificity wasn't the case in all of my interviews. Many participants in CENS design were still confused or ambivalent about where project data was stored, and who had access: two questions basic to the security of the data. I received answers like this one, from graduate student I.: "I have no idea what happened to the data. I assume it went into SensorBase and then, it's like washing around there, but I have no idea." And from staff member B.:

> I don't really set the [database tables] up. Who set up the tables? At one point it was me, at one point it's [grad student] U. At first it was me, and then U. did it. Or I don't know who did it. But whatever me, U. I knew U. had access to it and probably [postdoc] M., probably [grad student] C. and maybe at some point [staff member] Q. was cc'ed on email containing login information. So directly any one of those people.

Project data responsibility, security and access were clearly confusing issues for designers at CENS.

Once I began seeing the design disconnect between personal-data-as-background and personal-data-as-values-issue, I started to look for practices and people that would help focus design on personal data, and the values issues wrapped around the data. This became my first exploration of a values lever. Personal data was part of the existing infrastructure at CENS: one rarely-considered piece of the background that made sensing possible. This data met all of Star's qualities of infrastructure (Star, 2010): it was embedded, transparent, and

had significant reach and scope. It was learned as part of membership in CENS - what qualifies as project data was almost taken as a given, and it linked with existing conventions of practice. It became visible only upon breakdown.

Values levers, however, could call attention to this data infrastructure in the service of opening up discussions about social values. Instead of serving as a boundary object, sensing data was largely forgotten until someone or something created a reminder. Then the personal data became a fulcrum for the translation from project work to values thinking. Unearthing this data infrastructure was critical to values considerations.

Experiencing internal testing

I observed many instances where design activities encouraged discussion of, and interaction with, personal data at CENS. Some examples were straightforward: After participating in a data collection pilot for *AndWellness*, graduate student G., previously blasé about issues of privacy and surveillance, wrote: "Just browsing the survey questions, I now understand how critical privacy is for such an application." The kinds of data under request (including location as well as questions about eating, sleeping and exercise habits) allowed the student to imagine what inferences might be made about his behavior, and made the surveillance and privacy concerns concrete for the designer in a way that his previous design work had not.

Another memorable example of the link between attention to personal data and values concerns was an instance when L., a graduate student working on activity inferences based on GPS traces, shared her recent location traces in a slide presentation to the team. As soon as the mapped GPS traces went up on the screen, we noticed something odd. It was

obvious from the erratic path of her GPS trace that L. had been cutting through parking lots and gas stations on her way to and from UCLA in rush hour traffic. L. was hugely embarrassed, and pulled her data off of the screen immediately. She was subject to teasing about her driving for weeks after this incident.

Both of these examples illustrate the role that experiencing internal testing had as a values lever that refocused designers on the complexities of personal data. At CENS, as in many development labs, it is common practice to try new systems internally, before they are tested with users. There is nothing novel about the finding that internal testing is important to good design. Designers throughout academia and industry are, in design-speak, encouraged to "eat their own dog food." Indeed, in the HCI literature, internal testing is seen as necessary but insufficient: the practice can lead to too many assumptions about audience and the normalization of interfaces and routines (Shneiderman & Plaisant, 2005).

However, the effects of such testing on designers' consideration of social values have gone unexplored. CENS designers frequently used themselves and their colleagues as initial pilot testers. The lab served as a ready group of volunteers with an interest in the system and willingness to endure and report bugs and problems. For example, as part of the lab, I volunteered to pilot *PEIR*, a trash-monitoring campaign called *GarbageWatch*, a citizen science project called *What'sBloomin*, and an unnamed project that involved taking pictures of street signs. Internal testing as a practice was particularly emphasized and enforced by the Director. A spring 2009 meeting provided one of many examples of the Director reminding students that they needed to participate in testing. She began by emphasizing that everyone in the participatory sensing group needed to be: "…running our friends' and colleagues' applications. There's so much to learn from just a few users." The Director went on to

remind people several times during the meeting to run each other's applications. To which staff member A. responded: "I'm watching you all!" Prompting the Director to joke: "But not in an IRB sense."

Evidence of the link between participating in internal testing and values concerns pervaded my interviews. L., already subject to teasing about her driving, also related an anecdote about running a location-monitoring program over a weekend at the request of a colleague. When she returned to work on Monday, her colleague, privy to her location data, teased her about the fact that she had not left the house all weekend. Mortified by the teasing, L. later attributed some of her subsequent interest in privacy design to this experience.

This pattern emerged over and over again in my interviews and observations. In an interview, staff member A. put her reaction to seeing her own data this way:

> It was a big shock showing my data on GPS. I was totally surprised at the effect of that. … the first time I had to show this map to someone and realized it identified where I lived and where I went to work, I had a moment of, Gasp! That's the best way I can describe it. I had something that actually tightened up inside of me. … Suddenly here I have something that anybody can look at and I don't control or don't feel like I'm controlling…

Over time and repeated testing, she came to normalize data sharing, but the effect of that initial encounter with testing stuck with her:

> Since, I've relaxed. Now it's no big deal, but I remember it that first moment and totally being surprised by it, completely caught off guard that this would actually be a concern, when I had gone in thinking I knew what I was doing.

In both of these cases, experiencing internal testing helped designers focus not only on the personal data being collected, but the possible inferences that could be drawn from that data. It was these inferences that would lead to occasional censure by peers and resulting

awareness of privacy issues, in particular. Exploring possible inferences that could be drawn from personal data also occasionally led to sensitivity towards values such as equity and power. L., already sensitive to privacy, related in an interview:

> I think I feel safe with the data we collected, because we already knew [that my colleagues] were not really interested in my location traces. They just use my location traces for their research and they're not looking at it. But if this campaign was something owned by a company, I would feel kind of scared. Because I would not know where [the data] is, actually, and how it's used.

Experiencing data collection for herself helped the graduate student identify not only that such personal data could lead to sensitive inferences, but that the sensitivity would depend upon context: who collected the data, and what they chose to do with that data.

It's important to note that internal testing didn't always lead to hesitancy to share personal data. In some cases, it allowed participants to share willingly, feeling that they understood the inferences and consequences. The Director was recognized in the lab for her willingness to share location data. As she put it, "I give it to anybody who wants it." She believed it was vitally important for her students to have real test data:

> …it's real in the sense of it's full of noise because of GPS connectivity, or it's full of noise because of user phone dies, or someplace where I decided not to turn it on, so it's real in that sense and I think richer because of that.

At the same time, the Director was quite sensitive about other sorts of disclosures – those about personal life, health information, etc.

> But there's so much more information in a stream of self-reports ... That's not just location data. I actually suggested to the *AndWellness* group that we have an application that asks three simple questions three times a day. I don't think I did it intentionally, but those are questions that I would have no problem - but it's not fair for me to impose on everybody else, but they do happen to be questions that I wouldn't have a problem reporting on in the morning about sleep, in the middle of the day about something you've eaten and something about exercise and what interfered with it. But they are not

> mood questions because if I knew that this was going into being seen by all those people, I would end up not actually answering authentically.

The Area Lead had a completely different take on testing applications himself. He shared his concerns about sharing his location data with colleagues:

> I used [*PEIR*] for a fairly limited period of time to get experience with the system and see how it worked. I mean [the Director]'s run it every day for extended periods of time and I haven't done that. The reason is I'm not interested in having my location data available.

For the Area Lead, testing applications also pointed out a fundamental issue in their appeal and usefulness:

> I'm personally uninterested in using any of these [applications like *AndWellness*]… I am interested in their potential and I'm very, very interested in these sorts of ideas and the relationship that everybody is pursuing and what these devices can do. But I'm not that interested in where they are. … I guess the explanation for that is, I've spent a substantial amount of my adult life trying to be less regimented or quantitative in my relationship to myself and other people and time and stuff like that. I don't want that, but that's a very specific, personal decision.

This opinion points to another values discovery predicated on experiencing the data: that self-tracking and pervasive data collection may not become a universally popular tool.[12]

Working on interdisciplinary teams

Internal testing was not the only design practice that led to greater focus on personal data and a resulting awareness of anti-surveillance issues. The unusually interdisciplinary nature of CENS design had a similar effect, positioning the data collected by participatory sensing as a bridge between computer science, statistics, design/media arts, and information studies.

---

[12] For another example, see the Quantified Self blog entry "Why I Stopped Tracking" (Carmichael, 2010).

The majority of CENS participatory sensing designers had (or were pursuing) undergraduate degrees in computer science (CS) or electrical engineering (EE). They attended CS and EE conferences and took summer internships with supervisors who had advanced degrees in these fields. They spent years immersed in these disciplinary identities. As staff person A. described: "They've been students all their lives."

But not all CENS designers were computer scientists and electrical engineers. A small but critical number of the design team hailed from statistics, design/media arts, and information studies. A design practice that refocused the participatory sensing discussion on personal data was the collaboration between these groups. Statisticians, for example, attended weekly meetings and were a regular part of design. They were seen as "us" rather than "them." Their needs were almost as primary to the design process as those of the computer scientists. This was an unusual feature; as the Statistics Lead explained:

> Statisticians [usually] hang around at the beginning of the study and at the end of the study and sometimes we get to watch what happens in between. … But in a genuine collaboration it's hard to maintain very strict boundaries. "Oh, that's not my job. I don't do that." …So here, while you could take a very strict view and say, "Well, there's some experimental design stuff and then maybe there's some smoothing at the end or python process crap," or whatever, in point of fact, there was a lot of talking about what the device is capable of, a lot of riffing the privacy stuff we're talking about.

The work of statisticians on the design team was an example of a values lever. In meetings with statisticians (sometimes faculty, sometimes staff, and sometimes students), the comments and interests of the statisticians continually referred designers back to issues inherent in the data collected by users. This refocusing on project data was the (largely unintentional) deployment of a values lever. It allowed for not only statistical discussions, but also ethical debate about data representation, sharing, and security.

An example from a spring 2009 design meeting demonstrated how this worked. In the meeting, the Statistics Lead was discussing a statistical software tool, r, which he suggested would be useful to T., an advanced graduate student.

> Statistics Lead: What else do you want to do after you put points on a map?
>
> T: I want to explore different levels of granularity, when you zoom in vs. zooming out to see clusters or some overview of the info. There should be some inferences [about the data] produced when you zoom out.

This led to a discussion of virtues of, and representational contrasts between, bubble plots, heat maps, and examples like swine flu maps of the world. The discussion included how to represent time and longitudinal variables. The Statistics Lead pointed out that however the graduate student chose to represent data should represent at least 50% of the variation. So for example, the system should show one "favorite flower" only if that turned out to be statistically interesting. Otherwise, it might be more important to represent the diversity of the data collected, for instance. Staff member B. chimed in: "We should present useful, but neutral, information: like time, location, who you're with: only facts." To which the Statistics Lead responded, "I have a concern that we're encouraging people to chase noise - there might be so much uncertainty in a week of data." Here the Statistics Lead raised concerns about the nature of the project data – whether variables like time and location, taken for granted by the computer scientist, were in fact meaningful.

In a follow-up interview, the Statistics Lead discussed the conversation, and his concerns about unsophisticated uses of data, this way:

> The first thing with Garbage Watch [graduate student T.] wanted to do is make a heat map of where things are being thrown away or not. But if you look, then you start to realize you just … You don't have a baseline at all, so it's not like you have a survey and then you're averaging. You've got these other things, so it's a weird - and it's not even that weird. It's just harder

> than just doing the straight thing. There are going to be lots of problems like that and they're problems that people bring up. Every problem that someone brings up about people collecting data with bias and all the other things, incentives and whatever, all those intuitively-felt problems translate into some sort of statistical problems if you want to aggregate the data and talk about the aggregate somehow.

Because of his concerns about the data, the Statistics Lead often brought up issues of data collection and representation as part of his everyday work in the lab. This was a pattern that repeated itself when statistics graduate students worked on the *PEIR* user interface, as well as when statisticians from a collaboration with public health researchers met with designers to discuss *AndWellness* design. For example, during a 2010 design meeting, a staff statistician from public health (S.) discussed visualization needs for an outside project with the Director.

> S.: What are the researchers looking for in the data?
>
> Director: The project is very exploratory. It's a discovery process. They're not looking for anything specific right now.
>
> S. indicates that he was asking if other kinds of visualization (besides the existing calendar view and graphs) would be useful.
>
> Director: Oh yes, there's tons of more interesting stuff to do. But there aren't any *requirements* for this tight deadline.

Again and again, statisticians returned the discussion to the project data – even when it wasn't a design requirement. And talking about personal data, particularly about representation and visualization, was popular among design team members, as well. One meeting was focused around a presentation given by a professional interface designer. The students were rapt during the meeting, learning lessons like "data should scream" and "use real data – even in mock-ups" from the designer. At the end of the meeting T., who was normally recalcitrant during meetings, declared: "This was the most useful urban sensing meeting ever." This declaration was followed by a brief discussion of how academic

Computer Science "hates on" (the student's words) interface design. These CS graduate students felt there was no respect in their field for the importance of data visualization. They were clearly hungry for the experience dealing with data, and were happy to have teammates and outsiders who contributed experience in this area.

Designing around constraints

Values levers that focused design on the personal data produced by participatory sensing were the first levers that I identified at CENS, but they were not by any means the only. A different sort of values lever were practices that helped change the perception of a values-based design process, from slow and cumbersome to creative and fruitful. Values were not only a constraint on design, but also a creative set of potential conditions that could be met with innovative new designs. As the Statistics Lead put it in an interview:

> I think that unconstrained design is often boring. If you take a very practical view of it, the privacy constraints pose really good challenges, right? So whether you choose to be all North Campus and want to respect people's rights, at the very least the constraints that you get are beautiful. In a way, that's a kind of sales pitch for the student who doesn't buy the "Just be respectful or you're going to feel queasy afterwards" and all that.

Designing around values-based constraints as a form of creativity was first pointed out to me by the Area Lead. We both attended a meeting on technology ethics education held by the National Science Foundation. The meeting's hosts and attendees seemed to interpret ethics education as training students to follow rules about the responsible conduct of research. But at CENS, we were beginning to see interest in the technical aspects of ethics: how to design for privacy, how to think about consent as a technical challenge. This dynamic struck the Area Lead strongly, and we began to discuss the forms of creativity that could arise from ethical concerns and constraints.

This framing of creativity from ethical constraints had legs with the leadership at CENS. Like the Statistics and Area Leads, the Director saw privacy as not just an important social value, but also a potential space for creativity and innovation. As she said in an interview:

> [Privacy] is a first-class design objective to the point that sometimes I feel a little opportunistic about it. In the sense that it is a source of design innovation and gives us something intellectual to work on the CS side. … It's an interesting computer science problem.

She continued:

> I think people see [privacy] as an interesting technical challenge and a place to be creative. I think some of them who have started working on it for those reasons have come to care about the issue more through direct connection to it.

Students at CENS sometimes made similar discoveries about the creativity that could arise from the constraints on data collection posed by anti-surveillance values. As L., the graduate student who became the lead developer of CENS privacy software, said in an interview:

> At first I wasn't really interested in [privacy]… Before, when I thought about privacy in computer science, I just thought about like security problems or what kind of security protocol to use. I'm not really a security person... But our process is more like, we believe that we already have secure systems and then we try to build, develop services with which people have control over data. And that's, I think, more interesting. But before I never really tried this topic because privacy is really difficult to define. So people tend to avoid working on that topic… I didn't really know that privacy could mean that the user has control over the data. I feel it's exciting actually … it's kind of a new concept for me, defining privacy by having control over the data.

When values-based design was seen as a boon to creativity and new innovation, it formed a values lever, opening up space for values to become design criteria. This could take the form of new technologies that used the values in question as design principles, or

adjustments within a given technology based on anti-surveillance values. In the last year and a half, CENS designers began technical work on questions related to values in design. The most visible manifestation was work on the Personal Data Vault (PDV). The PDV was protected cloud storage for personal sensing data controlled by the individual data collector (Shilton et al., 2009). In early CENS systems, personal data flowed from a participant's phone directly to a sensing application provider (in this case, CENS servers). Due to concerns about privacy and participation, the CENS leadership team, graduate student L., staff member I., and undergrad C. began work on the PDV. The PDV was explicitly intended to give individual users the power to collect, aggregate, and interpret their own data before sharing them with third parties. The vault was designed to sustain values of local control, participation and transparency, translated as design principles. Various students working on the PDV investigated on research challenges such as meaningful, effective filters for the data, or issues of identifying, tracking and auditing the data. Several computer science papers published in conferences and at least one dissertation resulted from work on the PDV. A prototype implementation is currently under development for use in projects such as *AndWellness*. The PDV was one of the most visible expressions of the kind of technical creativity that rose from constraints imposed by anti-surveillance values.

Seeking user feedback

At CENS, sensing technologies were just beginning to be deployed during the two years I observed the lab. Therefore designer interactions with users were relatively few. The interactions I did observe, however, produced some interesting observations. Users provided feedback and criticisms, and their opinions and reactions deployed a different kind of values

lever. Users were outsiders in the design process, but they were also the intended audience, and therefore, a sort of sanity check for the importance of anti-surveillance values. Their opinions proved an influential, although sometimes inconsistent values lever when introduced into the design space.

CENS leaders felt feedback from users and clients to be quite important to helping students shape their research problems. The Statistics Lead at CENS came from a discipline where professionals regularly consult with clients. He observed that CENS was increasingly incorporating a relationship with clients and users as part of design:

> That's actually one thing that's become increasingly important in computer science. As computer science starts, or at least [the Director]'s brand of computer science starts to do more of this work, then there are clients/collaborators that theoretical computer scientists of another day might not have had. So there's something about transforming computer science into a collaboration that I feel like they're going to end up rediscovering a lot of stuff that [statistics] did in terms of how you train students to be able to do that.

In a discussion about how to balance between real-world problems and computer science innovations, the Director put it this way:

> In some sense to put them in a context where they're working with the stakeholder or client probably is the most effective way [to achieve this balance], and not shield them from that. … There's resistance to it, but I try to have enough conviction that it's good for them that I don't let it slide.

The resistance mentioned by the Director is worth noting. Involving users in CENS design took lots of coordination, slowing down design and often involving many rounds of sometimes frustrating iteration. Finding well-suited partner organizations, and the funding to support long-term collaborations, was an ongoing challenge at CENS. More than one project idea has been abandoned due to lack of fit between designers and community organizers, or lack of resources to continue a partnership.

These tensions were illustrated in my observations of *Biketastic*, which was designed in partnership with Los Angeles bicycle advocates. *Biketastic* was fueled by the personal and work interests of a small team of CENS developers. The developers, including graduate student T., staff member B., and undergraduate F., had some experience as cyclists and an interest in applying their work to bike transit challenges. As the project received no outside funding, the designers were only able to give it full-time design attention for a few months. *Biketastic* developers liked the idea of seeking advice from bike advocates, and found several sets of expert Los Angeles bikers with whom to consult. But time constraints and the demands of other projects made them reluctant to undertake the considerable logistical effort required to organize design meetings, focus groups, and pilot trials. Community members, who were volunteering their time, proved equally difficult to corral for meetings and advice.

While meetings with bike advocates produced a number of useful and creative ideas, technical limitations circumscribed the feature set that the design team was able to produce. For example, bikers prioritized a mash-up of routes with real-time traffic information. But because designers could not find a compatible source of traffic data, this feature remained outside the realm of possibility. Designers instead tried to meet biker wishes by approximating traffic along a route using noise readings taken with the phone microphone. This was a creative use of the available tools, but received mixed reviews from pilot testers. This was one of several examples of bikers holding expectations for sensing capabilities difficult to meet with available technologies.

Feedback sessions between bikers and developers could be tense, as well. Developers felt the need to defend each design decision challenged by the bikers. Designer T. explained

his defensive reactions, indicating that he believed it important to educate the pilot testers on the design team's reasoning and the limitations of the technology.

These feedback sessions, as well as user feedback from pilots of a number of on-campus sensing projects, sometimes led to the perception that users didn't care about surveillance. T. was a particular advocate of this view in a conversation with postdoc M.:

> T: I'm pretty explicit about what we're monitoring, what you can find out. There's no care at all, I mean, at least among the groups that we work with, that's like, campus students I guess. Maybe it's different with the outside people, but I don't know.
>
> M: What's your most vulnerable thing about your study, you think?
>
> T: I think for me, I would think that it's the mobility data that we collect, but I don't know, people just don't care. And I guess part of it is because their lives are always public in some way. You have Facebook, you have Twitter. You already update your location status indirectly in some way. So then I don't know, I don't think many people care too much about it. …Even when I was doing the Biketastic one, I mean, it was like all opt-in so no one cared. Like that was basically the thing, since it's like you have to install an app and it monitors you.

A more successful collaboration with users was one that was funded, guaranteeing payments to focus group participants as well as staff to coordinate ongoing focus groups (and eventually, user pilot testing.) *AndWellness* received a small amount of money to test software for tracking risk behaviors among HIV positive users. As part of the process, one designer met with several focus groups of HIV positive individuals at the AIDS Project Los Angeles (APLA) headquarters.

The strong opinions of users were on full display during these meetings. Faced with documenting extremely sensitive information such as drug use and sexual acts, users displayed nuanced understandings of contextual privacy. They were willing to delineate who they would collect such information for (sometimes doctors, sometimes therapists,

sometimes researchers), under what conditions (including compensation), and at what granularity.

> [Focus group leader] asks if participants would respond to questions about sexual behavior as part of a *study*. He emphasizes this specific context.
>
> One person volunteers: "Before sex, yes, but not after."
>
> [Focus group leader]: But what about if you were receiving money as part of a research study?
>
> Another participant expresses that sex behaviors are private, for example, a one night stand. An application that sent reminders about being safe would be ok, but at least two people are vocally resistant to providing information about their sex behaviors.
>
> The focus group leader then asks if the group has previously participated in research surveys. Four out of nine participants have. The focus group leader makes the analogy between CENS applications and a survey.
>
> …
>
> It's taken a lot of emphasis on contextual information (surveys, research, and incentives) to get us here, but when the focus group leader returns to the question at hand (documenting sexual behaviors), the group now seems willing to volunteer sex behaviors.

These rounds of negotiations between context, personal data, and acceptability continued as the focus group progressed. When the focus group leader began asking questions about documenting illegal drug use, a very similar conversation ensued:

> "That's the limit, that's going too far" someone says. Another participant volunteers that someone they knew got busted for texting about meth. This leads to a debate about whether cops can look through your phone messages when you get arrested.
>
> The focus group leader refocuses the conversation away from sending information via text message to sending it via a smart phone application. He compares it to taking a research survey on the internet.
>
> Still a participant says "It's none of their business!"

> "Well," says someone else, "if you volunteered for a research study, that's what you signed up for."
>
> Another participant chimes in, "It depends on if you pay me."
>
> The focus group leader reiterates the context again: "It would help us study safer sex." He also brings up password protection. Some participants have experience with this from other services.
>
> Password protection seems to change things, making participants feel more secure. Some people volunteer that yes, they'd answer drug use questions if they were password protected.
>
> One participant volunteers: "Yeah, ok, because it's going straight to a computer – straight to a doctor or whoever's doing the study."

In these examples, users show quite a bit of nuance in their willingness to share personal data based upon context. For the designer who sat in on the focus group, this helped make definitions of 'contextual privacy' (a concept from the privacy literature that we had discussed in the abstract) concrete. After the focus groups were over, M., the postdoctoral researcher in attendance, emailed:

> One concern that seemed to resonate was that people were concerned that their answers were understood in the appropriate context. For example, answering that "I'm really stressed" or feel suicidal may not actually mean they are feeling suicidal, but just may be a momentary expression of stress. Wanted to make sure context of questions was captured.
>
> Nobody wanted to answer questions about drugs because they were worried about government/police tracking. Level of savvy, bordering on paranoia (IMHO), about government monitoring using technology/cellphone towers. Repeated concerns that police would look at the phones and see surveys on drug use if they were arrested.
>
> People really interested in what the point of the study was. Many of the answers highly depended on what the point/motivation of study was. Thought they would be willing to answer drug-related questions if they were part of a survey (almost seemed synonymous with being paid 'incentives'), but would not do it voluntarily because of privacy concerns.

M. also had an emotional reaction that she wanted to share:

> [Group leader], thank you for making the focus group happen! There was so much valuable information I learned... I'm also humbled by the experiences people shared and have renewed respect for your ongoing and committed work with communities dealing with some really severe shit (painfully trite I realize, but it just really stayed with me so wanted to share it).

She was clearly moved by the experience, the users' concerns, and the values lever deployed by working directly with users.

Leader advocacy

Users were not the only agents who deployed values levers in CENS design. Because CENS is an academic research lab, faculty members hold a large amount of power to decide which projects students pursue and what issues students must face during design, testing, and implementation. Many members of the CENS design team have the Director as both supervisor and faculty adviser, making her a very influential person in their careers. And most CENS students have both formal and informal mentoring relationships with other faculty and staff involved as principal investigators at CENS.

CENS participatory sensing efforts are led by a group of well-known, accomplished, and influential academics from computer science, statistics, and film, theater and television. At the helm of the Center, and of participatory sensing, is the Director. The Director's leadership was quite firmly motivated by her social ideals. She was advanced and successful enough in her career that she no longer worried about the boundaries between basic and applied research, or whether an application would provide a rigorous enough research platform. As she described in an interview:

> I've been trying to … focus on meaningful applications, where we can identify clients or stakeholders, and work with them in a collaborative and iterative manner. … I guess because I am so far past tenure and promotion things and all those things, I feel like I have the ability to take the

> professional risk of doing things that are less "traditional research," and do what I think in this moment in time is very impactful and is an equally important role of academia, which is to support public good applications in an open manner.

In her work on forming and leading a research trajectory for CENS, she drew upon past values-laden experiences, such as her work in the open-source software movement. For example, on a conference call with collaborators, she drew an analogy between a current project and the open source movement: "Open source felt Don Quixote-ish. But it seems a lot less so now." This experience made her much less afraid of appearing to chase windmills.

The Director's personal feelings about privacy also influenced the focus on privacy at CENS. Like many people, she had a complex, contextual relationship with privacy and disclosure:

> So I can think of two concrete examples of [my personal concern for privacy]. How much do I worry about identify theft? I'm just too lazy to bother worrying about it so I do online purchases, I don't consistently shred my documents, it's all just too much work and too much effort. Even though at some intellectual level I know what should be done, I just don't take the time to do it. So I guess that would be an evidence of not caring about privacy. On the other hand, I don't use Facebook … because I just feel that there are, for me, natural, comfortable boundaries in life and [Facebook] is completely at odds with that sense of boundaries. So one-on-one and to colleagues, I'm actually relatively disclosing about things about my personal life or what I'm doing or how I feel, but I feel self-conscious of doing that in a broadcast manner. So I have a kind of innate self-consciousness, which dictates my privacy more than anything more legalistic or financial or something like that. It's a very visceral, personal, psychologically-based sense of privacy.

Her values brought her beyond her own experience and preferences, however, when it came to considering privacy in CENS design. She was explicitly aware that power and equity were at question in CENS design:

> I have an intellectual interest in building systems that support a wider range of people's notions of privacy, because I absolutely believe in uneven power

> and people with stigmatized activities and behaviors and things like that, so I have an intellectual commitment to that, even though that's not so much where my personal version of the concern comes from.

The Director's ideals-driven design interests were countered by another leader at CENS, the participatory sensing Co-PI. The Co-PI was often described by students as more "rigorous" in his technical approaches. The Director credited him with mentoring students along a more traditional academic path, fostering successful publications and academic careers. Because of his strengths in this area, the Co-PI often functioned as a co-advisor for the Director's students.

The Co-PI often served as a critic at CENS. In meetings and email exchanges, he offered the voice of hard reality, economic interest, and technical determinism. He often argued for a less "social" mission for CENS design, preferring instead one more focused on economically sustainable applications. He also tended to be critical of the privacy and values work at CENS. He brought up his concerns in an interview:

> I think privacy is an illusion. … Why is that? I think in the face of the kind of technology that can be brought to bear to break privacy … I think there are way too many ways of breaking it… I mean, I remember long ago an economist had discovered the end of privacy. I think that kind of put it pretty well…
>
> So to answer your question, I mean, I don't particularly care about my privacy. I do take prudent measures in the sense, sure, I don't put my social security number or stuff like that out there, but beyond that, in terms of hiding my social traces, I don't even make an attempt. … Just to give you an example, I mean, my home is currently recording 24 channels of electrical consumption, and whole-house water data. And from that anyone can tell even things like when is my daughter taking a shower, stuff like that. I mean, it's pretty… I don't care. So I guess I don't think it's worth the effort.

But even having made this point, the Co-PI hedged his opinions around questions of power and ownership of data:

> Now, having said that, I probably still would not want [the water data] to be owned by a utility. I still would like the ownership of the data to be with me. So it should be me who's putting it up on the Web and not someone else, but other than that -- So maybe the way I would put it for me is it's more about control as opposed to privacy, per se.

The Co-PI's professed disinterest in social applications and anti-surveillance values was countered by another leader in the space, a professor with a humanities as well as a technical background. The participatory sensing Area Lead, a title established by the Center's grant structure, was responsible for the directions taken under participatory sensing, as well as logistics like organizing project meetings. He worked very closely with the Director to supervise projects and establish new directions for sensing. The Area Lead's self-embraced role, much like the Co-PI's, was to be a bit of an agitator. The Area Lead provided a strong voice for considering social impacts in design, and for broadening the kinds of questions designers ask and do. He could write code (and often had to, for example when *PEIR*'s messy code base had to be entirely rewritten one summer) but he has also read social theorists and worked on arts and cultural heritage projects. As he described his role in an interview:

> [The Director] had this interest in mobile phones as a key platform for sensing that involved people. Over some very early conversations I became really interested in that as well, but increasingly adamant about the participatory aspects, because these things were so close to people. I think that resonated with her. … So when the *PEIR* Project came along I was interested in how we could promote this idea of user participation in sensing on mobile handsets.

The Area Lead was also broadly involved in the visioning and ideology activities of the lab. He worked with the other laboratory leaders to set a research trajectory. The Area Lead's particular focus was finding a use for participatory sensing focused on creativity and expression:

> I'm now trying to see if I can find avenues for cultural and expressive connections. As I've moved into a more permanent position in [an arts department], it fits … overall I need to be focusing on things that are in that area, so I'm promoting these sorts of cultural projects.

The Area Lead talked explicitly about his role in mentoring students, which he saw as quite values-oriented. He described it this way:

> One [of the most important things I try to convey to students] is sort of a humanistic perspective, even for students that have a technical background... I'm interested in having a rigorous or at least attentive, having an attentiveness to the humanistic set of values that exist by calling this participatory sensing. And that represents what I perceive as an interest among certainly the faculty, certainly [the Director] and [the Statistics Lead] and most of the students, in being relevant and being humane.

Finally, the Area Lead served as an important voice for a critical technical practice. He frequently questioned the trajectory of technology development at CENS, and saw it as his role to do so. As he explained:

> … I'd say the concerns that I have are again this assumption that technology is on a trajectory and that we have to ride that trajectory in order to innovate. …It's a subset of a more general concern with the idea in computer science and information technology that there is a trajectory for this tech: an unstoppable and totally reasonable trajectory for what technology should do, and that therefore we just have to figure that out. I think that [my concerns about] location data is a subset of that overall concern, which is that we can sense people's position and so we *should*. … So I'm interested in sort of the practical aspect of, "Okay we're there. What do we do?" and the question of, "Is this a good thing?"

He went on to talk about how he approached these questions in his design leadership:

> I don't deal with the "is this a good thing?" in CENS just because it's not, those are the kinds of things that are frustrating for [the Director] because they stop development. But I think I try to bring it up in private or express it in ways that I think are offering an alternative perspective.

This statement pointed to an interesting possibility for leadership values lever: private or one-on-one advocacy for social values.

The final active leader in the participatory sensing space is a statistician, the Statistics Lead. The Statistics Lead is not only a statistician, but also an artist who constructs large-scale installations based on data. His interest in art and aesthetics is reflected in how he talks about his work, and choosing projects:

> A choice of project, a choice of research questions or whatever, that's an aesthetic judgment. I don't know that I'm really good at it yet, but I know people who I admire, like other statisticians, and there are a few that have this exquisite taste in problems. ... It allows us to apply our tools in a way that there's just something when you go, "Wow! That's gorgeous." The interesting thing, too - interesting is the wrong word, but that's the thing that's hard to teach, to have people go: "that's sexy!" … You can say that I really love this problem or this really breaks my heart… It's more of an art than anything else, knowing to look at this or to look at that or knowing what this might imply or knowing what to expect becomes a softer thing than people typically expect of statistics, which you like to think of as hard-edged, keeper of knowledge, production kind of thing. But then there's this soft side of it that looks at data and compares things and uses judgment and that's much more of an artistic thing.

The Statistics Lead was also quite open with his personal values during design meetings. He wanted projects to be elegant and beautiful, but also has a sense of justice and fairness. For example, in a call with interdisciplinary collaborators, the subject of privacy scare stories came up. A collaborator brought up an MIT research project that was able to make inferences about sexuality based on Facebook networks. She raised this as an example of how individuals can't hope to control personal information. The Statistics Lead's reaction was: "Why does sexuality have to always be the example of a disclosure "problem?' That's so broken."

The Statistics Lead tended to work most closely on projects that reflected his social and aesthetic values. He cared deeply about data literacy and education, and so chose to lead

Mobilize, an initiative to use participatory sensing in Los Angeles public schools as a teaching tool for computer science and statistics curricula. As he described:

> I'm hoping that with *Mobilize*, what we start to do is teach the students that idea about the power of data, but also practical questions like what does it mean to share data? …There's little things I want the students to see about the way data can or can't move and how information gets encoded. I'm hoping that what it means is a much more nuanced sense of data literacy and at some level, a change in what my field thinks the important questions are.

The Statistics Lead was also aware of power and surveillance issues. In his interview, before we'd started talking about issues like privacy and surveillance, he volunteered this story, about a set of projects at a local art school that he had been asked to critique:

> Then what I got to sit down with was their final project, which is how they would learn about someone using a kind of sensor set-up. So the first couple set a trend that put me off. The first couple was the coffee guy, the one who staffs the coffee cart, then a janitor was the next one. So it was kind of weird the people they were selecting. None of these people were really in a position to say no to this data collection and they were doing some pretty invasive stuff. They were putting a GPS, like the janitor was carrying a GPS for a week or something like that, so they saw everywhere the janitor went. The janitor always went from work to home, except for those days that he went to church or McDonald's. At that point, it's breaking my heart that you're doing this. … There was no appreciation for power or what they were taking. That by collecting data, they were *taking* something, so to get them to realize that it's not just take, that there's a social exchange taking place when you collect data like this... We do all that stuff to large carnivores in the Santa Monica mountains or sperm whales... Treat [people like] something other than an animal, right?

The Statistics Lead's concerns incorporated not only power and equity, but also parsimony: the idea that as little personal data as possible should be collected for reasons of privacy and forgetting.

> There was this impulse to just collect all the possible data. So to have [the students] realize that data are necessarily this incomplete record of reality, so no matter how much you try to collect, you're not going to really get at the soul... So I think there are just some issues related to that first step of translating the world into data that I think the students need to appreciate,

> especially when it becomes these participatory things. So to stop [graduate student T] from viewing the world as an automaton that can go and collect data in one way or another. I don't believe that any of that comes from a bad place. I think it's not an appreciation for something that could be more subtle or graceful or something like that. Respectful, how about that?

A different lever is implementing procedures that provide a check on the values deployed in design. Quite soon after I joined CENS, I worked with the Director and Area Lead to put an ethics compliance procedure in place for the lab. The CENS ethics team implemented a mandatory, short online form that designers planning any personal data collection had to fill out. The form asked questions about proposed data collections, including population, types of data under request, and plans for storage and reuse. It asked whether privacy or participation measures would be built into a pilot, and required the drafting of a consent form. This form was a procedural values lever deployed by lab leadership, designed to help investigators think through values issues in their data collections, and to help lab leadership keep an eye on data collection practices. The Director felt that establishing this procedural check was a success:

> I am extremely happy, for example, with the way the participatory sensing data collection form has become part of the way that CENS projects are approached.

However, due to its similarity to other paperwork, as well as its implementation by an administrator also charged with overseeing CENS' relationship with UCLA's Institutional Review Board (IRB) this form quickly became associated with another values actor: the IRB, discussed in the next section.

The values interests and expressions by the participatory sensing leaders at CENS, whether their focus was anti-surveillance values or innovation values, were powerful and well-articulated. They in turn used their principles to deploy values levers, whether it was

advocacy for certain positions, or procedural levers like requiring project documentation or changing project directions and agendas.

Students, however, were much less reflective about whether and how their mentors' values affected their design practice. Graduate students had remarkably complex relationships with their faculty advisers. All students had an assigned adviser (one of the leaders described above), and their funding generally flowed through this adviser. The laboratory leaders consequentially had quite a bit of power over graduate students. They could require students to take on projects, constrain research questions, and block academic progress. Because most of the advisers at CENS were openly concerned about anti-surveillance values such as privacy, consent, equity, and forgetting, I assumed that advisers would be able to deploy powerful values levers. And there is no doubt that the continuing presence of issues like privacy on the design agenda, thanks in part to the interests of lab leaders, affected graduate students' work. A small number (2 interviewees) openly acknowledged this influence. But the majority of graduate students interviewed were hesitant to acknowledge this power. Most did not consider their adviser to be a boss. Instead, students described lab leaders as colleagues and sources of advice on the way to making the best decision themselves. CENS graduate students were adamant about their ability to choose their own research projects, and to decide the best ways to go about their work.

This stated independence did not seem completely honest. I had observed advisers influence and even directly change the direction of research projects using a combination of persuasiveness, authority, and control over funding. T., a graduate student about to graduate, skirted around this issue of ethics influence in a group meeting in early 2010.

T: Like if I had total liberty, I don't know if I would be doing exactly the same collections as I have been doing.

Katie: So what do you mean by total liberty?

T: I guess okay, so I think my audience which I would say right now is the college students, they may have different interests than maybe what the university would want, you know? … I don't know. There may be some purposes that they would use it for which may not be what the university may think is actually useful.

Katie: So what do you think the pressures are that are, like, taking from that idea that you would have total liberty and you could do the data…

T: For instance, would they [the university] like to be associated with sustainability or would they like to be associated with some random thing that's like on campus? Like I want to monitor…

Director: Selling coupons.

T: Yes, something like that, or monitoring weirdoes that exist on the Bruin walk that bother me a lot. What if I asked people to monitor that? … I want to catch all those people.

T seems to imply in this first part of the conversation that there are pressures from the "university" to undertake certain kinds of projects. I decided to try to pry into who, exactly, he thought was imposing these pressures.

Katie: Right. So what I'm actually really interested in is that you have felt social pressure or… pressure or something to not do that.

T: It's not like pressure from anybody around here. It's just that I feel that…

At this point, the Director couldn't hold back her incredulity. She cut in:

Director [incredulous]: Do you really think that?

T: I think that. You don't think that, too? You don't think that NSF would look…

Director: I don't know, but I was talking about another form of pressure.

T: I mean, like my own self-conscious…

Director: No. There's something in between you and NSF.

At this point, the Director is talking about herself, and her role of defining permissible projects for her advisee. She's was trying to get T. to admit to the values pressures she puts on him. But T. won't take the bait:

> T: That [the NSF] is the source of the pressure. You just transmit it. … But I kind of consider you part of the…
>
> Director: Believe me, the NSF can actually be fine about doing things that are focused on selling more coupons. They are.
>
> T: Okay, sure.
>
> Director: But some of it has to do with, we try to do things that are complimentary to what's going on in the commercial arena. The commercial arena has so much more resources to do things. It's crazy to take on, at some level, things that are exactly within their crosshairs because what are we contributing to the world? Are the problems going to get solved? … I think it's a natural way in which in general academia you see people focusing on things having to do with public good. They don't yet have a revenue stream. It's not as much a business model. Sometimes those things turn into things that do, but there's a natural segmentation which is just a sort of rational way of doing things.

At this point, T. backs off of his "total liberty" arguments, claiming that his own interest and moral compass have pointed him towards public interest projects:

> T: And it's because, I don't know, I think more people are motivated by this public good thing as opposed to finding weirdoes on a campus or something like that, you know? It's just that's more appealing. It made me feel good about doing that, and then do it, to actually participate in…

CENS mentors also disagreed with students' perceptions of themselves as autonomous decision-makers. In his interview, the Area Lead expressed it this way:

> AL: I do think that the relationship among the [primary] investigators at CENS is a formative one. The relationship to the graduate students, there's a lot of different opinions and different styles, but I think that's probably the most important thing. … I think it affects how graduate students make decisions. I think it affects their perception of research. I think it has all sorts of impact on them - and not negative ones.

> Q: It's actually interesting because I think that students, one of the things I'm seeing is that they don't acknowledge how much the leadership of CENS affects them. As a whole they see themselves as very autonomous decision-makers.
>
> AL: Yes. They sort of are, and that's part of the character of the institution, but it's also not the complete story.

The complicated relationship between mentors and students at CENS obscures the possibility of leaders' values serving as levers in CENS design.

Navigating institutional mandates

Values levers were often deployed by people close to design, whether colleagues like statisticians, outside users, or leaders and mentors. But CENS designers were also influenced by agents farther from design, including administrators responsible for the responsible conduct of research at UCLA. The university imposed its own ethical mandates on CENS design, enforced through the oversight of the Institutional Review Board (IRB), a board set up to monitor research ethics at UCLA. CENS leaders voluntarily decided early during participatory sensing research that CENS researchers should send campaigns which involved human subjects to the IRB for review.

CENS designers had a sometimes rocky relationship with UCLA's Institutional Review Board. CENS leaders were proactive about approaching the IRB, and actively informed it of sensing developments as well as campaigns such as *PEIR*. The IRB was, in turn, relatively hands-off with CENS projects. The IRB considered most lab projects to be technical pilots or services, rather than human subjects research, because the project data was not analyzed to draw generalizable conclusions about human behavior. Only a handful of CENS projects qualified for review by the IRB, and most of those received an 'Exempt'

status from the board. It is only projects that explicitly drew conclusions about mobility patterns or mobile phone usage that qualified for full review by the IRB. But though it was infrequent, designers considered getting IRB approval undesirable or even painful, because it required paperwork, could take quite a bit of time to secure approval, and therefore slowed down the pace of testing and implementation.

About three years ago, CENS hired A. to oversee the logistics of data collection campaigns: distributing and keeping track of phones, recruiting subjects, and organizing focus groups. As one of her primary duties, A. was also the person who interfaced with UCLA's Institutional Review Board (IRB). She found IRB staff to be helpful and willing, and felt the institution was a good influence on the student designers. As she put it:

> So far I've liked talking to the IRB, I think they seem very logical and very willing, they understand that there's limitations and frustrations. And it actually helps to have statements that they've made, to be able to say to [students], this is what I've heard. … And you know everyone thinks "I'm doing the right thing." So I always bring up the examples that IRB puts in their training program. Well people who did this must have thought they were doing the right thing, can you please think about that? … And once you see it click, you can see it almost click, and they go yeah....

The Director agreed with A.'s perception of the influence of the IRB. In her interview, the Director related:

> I thought that [interaction with the IRB] has been an extremely valuable process. As many jokes as I make about the paperwork, or whatever anybody else says, I believe in the role of the IRB.
>
> The approach that we took with the IRB was to be proactive rather than wait for them to come and have questions. I was happy with that. I think, and this is sort of generally how I feel about regulations and things like that, is to try to understand the principles that exist and to work over time to make that mapping into new areas based on a set of principles that generated the IRB in the first place. I felt like that was a successful engagement and in general the approach that CENS took worked well, as opposed to sort of coming and having problems later with doing all the stuff without IRB approval. It

> has generated a significant staff burden and impact on students, but I think it was good. I'm pleased with that.

The Statistics Lead also agreed on the influence of the IRB.

> I think [working with the IRB] is an exceptionally valuable step. The process may be onerous, but I think that at very least, the fact that the students are aware that they have to do it. Again, I go back to [the art school projects] where people didn't stop and think about what it is they're doing. Once people start to have an honest discussion of what the data mean and what these kids have actually done, I think everyone in the room got a little queasy, so the not thinking about that sort of thing up front leads to that kind of queasiness that at very least this [IRB] process will avoid. … I think that the benefit is really there.

Much like the establishment of the internal review form, the Statistics Lead valued the procedural nature of IRB applications as a values check for students.

For all of the positive influence ascribed to the IRB by CENS leaders and staff, review by the Board also generated resistance, particularly among students and design staff. One memorable email from staff member B., as he began the required IRB training, read: "I just started the course and I'd like to announce that this certification is complete butt." This sentiment, with its harsh and dismissive mockery, was not unusual in the lab. One day, I had to walk straight through the middle of a fight between the staff member A and graduate student T. to reach my desk. They were arguing, loudly, about the consent documents for the graduate student's participatory sensing pilot. T. was clearly annoyed about the amount of information given to participants. "It's too much!" he argued. "People see this and go, what is all this stuff?!"

A. was good at negotiating these negative attitudes and helping students fill out the paperwork to secure IRB approval. At the same time, she loudly expressed frustration with student attitudes towards the IRB. As she narrated it to me:

> [I feel] the need to be a kind of oversight, against the "I'm just handing out a phone that's testing a technology. What's the big deal?" kind of response. … [CENS students have] forgotten by this point, they've lost sight of some of...the human subject training. And so I find myself having to go back and remind them of some of the reasons behind this... We're talking about the fact that you're asking someone else to collect data. [The IRB is] here not necessarily to judge what you're doing. They really aren't here to try to make your life more difficult. They're about protecting the people that you're asking to help get you data and assure that their rights are protected and unfortunately there had been abuses in the past that have led to requiring regulatory oversight, not necessarily every time, but we are trying to stay within these policies and to protect UCLA from any liability or any issues that may arise and so it is important to sort of honor and respect these requirements. I try and make them feel like I'm here to help them facilitate that, not to make it a burden on their life.

She had a practice-based approach to help meet this attitude challenge:

> I will help you fill in the blanks [in the paperwork] but I need you to have a go so you can at least get a sense and understanding of what this is all about. So there is a few cases where you have to repeat this process and I also feel like I'm listening to their frustrations and that's fine right? I can absorb that. I can manage that and if they want to vent that's perfectly understandable because I know the concept of research and the way it flows. It's sort of counterintuitive to have to go in to a regulatory process in that approach because they get an idea and they just want to jump and run with it. It's very hard to have to be the one to say, "No, I'm sorry. We have to back up a bit." … I've discovered in all these things I've done that the more you're upfront with people, "I'm sorry there's going to be some things you'll have to take into consideration." They may grumble, but at least there's no surprise later.

But the paperwork – and in some sense, interacting with A., who was not a designer herself – made these discussions administrative tasks, rather than tasks central to design decision-making. The IRB served as a hurdle to be cleared, and students offloaded much of the writing required to A. In this way, the IRB functioned very differently than other values levers, which brought values discussions into design meetings. Instead, the IRB became associated with paperwork, not design work. Graduate student T. explained the outside nature of the IRB as follows:

> I feel like actually, as a system designer, the burden shouldn't fall on me to get IRB approval. Not to say that my system shouldn't get IRB approval, but I feel like somebody else should handle that... Because I don't know how to put this, but I am designing a system and I am really concentrating on designing the system and then this is like another process and it is a little bit outside of my... I do not do this on a regular basis. … So that's what I found really frustrating and that's why I always hesitated to want to work on it…

IRB requirements occasionally inspire students to reexamine the security of their data or their collection procedures, but most often, the engineers express frustration and resentment about the administrative overhead rather than appreciation for the questions raised. Graduate student T. continued:

> The second [frustrating aspect] is that I feel like [the IRB staff] do not really understand... They never will understand the system and the things that they are concerned about just make me sad. They are concerned about things like these forms that we have to fill out afterwards and stuff like that… I found the fact that they approved [a particular project] to be extremely funny. Just because it is like the most invasive of all the things that we could do, you know. And they didn't care. The only gripe that they had was some stupid form thing that we were not storing in a locked cabinet. So that obviously shows that they have no clue what is going on. So now I have no respect for them. And now that is why I really cringe whenever I have to deal with it… Like if you understood the system properly then I would have more respect for you, and then I will put more time to actually do the application. But now that I know that you do not know what you're talking about, then why put the effort into it.

This attitude was fairly prevalent, shared by most of my staff and graduate student interview subjects. Even one CENS leader had negative opinions about his interactions with the IRB. The Co-PI put it this way:

> So that's the first time I got exposed to [the IRB], and I wish I could say that the experience was pleasant but it was not. I think it was not, in part because of the unpredictability … I find IRB to be rather clueless on things. I mean, things which I wouldn't expect that anyone reasonably well-versed in current technology should be concerned about, they're not.

The IRB's intervention at CENS serves as a values lever, but it's unclear how much impact this lever has had on design. The combination of outsider status and perceived lack of understanding sometimes frustrated the IRB's effectiveness. What values they IRB applied, and how, were obscured by translational issues and lack of respect.

Values worker advocacy

The IRB was an example of a values lever applied from outside of the design space. A quite different sort of lever was my own intervention at CENS. I deployed my own values levers as a member of the development team at CENS. I tried to deploy an explicit focus on, and advocacy for, anti-surveillance values as part of my role at CENS. As the Area Lead described the role:

> I think that there's a reasonable amount of questioning about, "should we do stuff?" Honestly I think that your role has formalized that, right? In some sense that you're there and you're asking those questions and if you don't actually ask those questions then there's sort of unspoken implicit permission that it's okay.

As a values worker – someone explicitly hired to consider values issues in design – I engaged in a number of activities that helped to deploy values levers. These were tailored to different parts of the design process. During high-level design meetings, specific advocacy was a useful tool. I explicitly raised issues of privacy, consent, equity and forgetting in group meetings, where the large and often interdisciplinary groups meant systems were discussed at the relatively high level of plans and goals. This is the "questioning" or advocacy role that the laboratory leader quoted above described. I played this role in projects ranging from *PEIR* to *AndWellness*. Designers came to recognize this as my job. When I asked them to

describe my role during interviews, I got responses like this one from postdoctoral scholar M.:

> I know that you are interested in issues of privacy and public policy…. You must have questions that you ask and then you are always questioning about the campaigns.

Graduate student I. put it this way:

> You hang around in the meetings and take lots of notes and speak up on various privacy issues.

And from G., who sat at the desk next to me for over a year:

> So as far as I know you are involved with ethical issues around the privacy of the data, and not only the data, the other aspects of the kind of pervasive applications on Smart Phones.

I also worked with students on the more specific, lower-level details of design in projects such as *PEIR*, *AndWellness*, and the Personal Data Vault. This often took the form of working one-on-one via email or in person with a student who was wrestling with a particular system implementation. I worked with graduate student L. on specific filtering mechanisms for the Personal Data Vault, and graduate student T. on privacy preserving data alterations in *Biketastic*. I would ask students to describe the planned data flow and brainstorms what inferences could be made or problems might arise. We would then work together to translate potential solutions into technical implementations. I describe ways of working across high-level conversations as well as the nitty-gritty of design work in "From design principle to technical specification," below.

Another intervention which spanned design, incorporating high-level planning alongside granular work on systems themselves, was to organize and lead projects in cooperation with designers to address anti-surveillance issues head on. These projects ranged

from writing technical reports to be used in design to working with computer scientists to design privacy protections for our systems, such as the Personal Data Vault. I will talk more about the ways that we worked together to translate anti-surveillance values into concrete design decisions, and the tools that resulted, in the next section.

Students had a variety of reactions to my work in the lab. Because they were talking to me, they could not be expected to be completely honest. As a result, negative evaluation of my work wasn't articulated. But what was honest – and interesting – were the ways that my presence offloaded the work of ethical decision-making in the design process. As M., the postdoc, put it:

> It's a relief. Just because there is an expert in an area that is obviously just as important as the technology design. But usually we don't have anybody who is an expert. So the stuff that comes with having an expert. And I guess the one thing that I can say is: it's also relief that we don't have to think about it. Meaning like we know that somebody who knows what they're doing is thinking about this problem and so it's nice, because normally when we have to think about the problems that we know nothing about we just hack solutions together. So the relief part comes from it's like we are not going to hack to get the solution for this.

L., who was particularly interested in privacy research, said:

> I think it's really useful for me especially. Because especially as a computer scientist, to develop any system related to privacy is really hard, because it's just too sensitive a topic. So having a social scientists itself is really helpful, because people can say "this is said by a social scientist," so people cannot really complain about it [laughter]. So I think personally that having the social scientist itself is really powerful. … Our social scientist defines, you know, what kind of things does this system support. So I just need to build the system based on those. So it really makes it easy.

A last activity that allowed me to deploy values levers was to explicitly ask students about the anti-surveillance values they ascribed to, and how they addressed those values in design. During our interviews, as specific anti-surveillance values came up (which they often

did – the students knew of my interest, after all) I would ask: Are you concerned about [privacy/consent/equity/ forgetting]? The responses I got were quite often yes. G. responded, "I can envision that putting some of this stuff together can lead to systems that can be very invasive, privacy invasive." Graduate student M. answered: "If I'm going somewhere and I don't want anyone to know, I think: I need to turn off this application, or leave my cell phone…" I would then follow up to ask the students how they had addressed the particular issue – privacy, consent, equity, or forgetting – in their design process. This was a harder question to answer. Graduate student I. responded:

> We initially were going to have the Privacy Data Vault system, but it vanished basically. Like that's kind of gone to the wayside unfortunately, so we're interfacing the phone directly to the database.

Staff member K. responded:

> Not in our first prototype but our second prototype, we're going to have full authentication and security.... There's a lot of background set up for that, so we did not have time to get to that for the first rollout.

Asking directly about values in design tended to produce answers that referred back to my projects: the definitional project of participatory privacy regulation, or the technical project of the Personal Data Vault. Clearly my work had come to be associated with direct contemplation of anti-surveillance values. While my presence seemed to increase the amount of discussion of anti-surveillance values, it also helped move responsibility for those design decisions away from engineers and into the work of a social scientist.

Gaining funding

Resources and funding were also values levers at CENS, as they can encourage practices that foster attention to values. Larger, better funded participatory sensing projects

like *AndWellness* had correspondingly large development teams. Because the teams were large, they required formal weekly planning meetings and fairly clear lines of communication. Anti-surveillance values tended to come up in these meetings, due to a variety of factors. CENS leaders were often in these meetings, as was I. In addition, the discussions fostered by a larger group of people tended to reveal worries and opinions, which then become design concerns.

The design of larger systems contrasted to projects like *WhatsInvasive* and *Biketastic*, which had little or no initial funding and only two or three developers. Design meetings for these projects were informal and often spur-of-the-moment. Leaders and team members communicated about these projects largely over email. The less complex systems (which harbored less obviously sensitive personal data) were perceived to need less planning in advance. And fewer ethical concerns surfaced in the discussions of the small working teams.

Funding also dictated the trajectory of projects. Funding guaranteed graduate students to work on a project, full-time staff to concentrate on duties unwanted by or unsuited to graduate students, and resources such as phones and server space to devote to a project. Funding also facilitated interaction with clients and community members, including allowing a staff member to organize focus groups and providing incentives for participants in pilot tests. For example, both *PEIR* and *Biketastic* ended due to a lack of external funding.

Several CENS leaders addressed the tensions around resources, project maturity, and values discussion in our interviews. The Director described it this way: "I feel like we're just unfortunately below critical mass to be generating more of those [values-based projects]." The Area Lead felt similar constraints around financial resources to support the kinds of

projects that would engender social, and particularly artistic, values. When I asked him to describe how he chose projects, he said:

> I mean they're driven largely by funding. At least the CENS projects have been largely driven by funding. So the ones where I have the most interaction are ones where there are CENS resources involved. … The things that I have the most investment in are some of the stuff that REMAP has done, some of the interaction that CENS has had with the Filipino Workers Center and stuff like that. I wish that I could do more with those projects. They are, for whatever reason, sort of under-resourced at CENS and I haven't been able to advocate for them in a way where there were more resources and that's been a disappointment to me. Those are the ones where I could see more involvement.

That said, the Area Lead also had strong opinions about why the grant-based funding model specific to university research was an important one for the values-based design practice he hoped to foster:

> The university is one of the few places that you can put that stake in the ground. … Damn it, this is important and maybe there are some things that we shouldn't do. … I think in this case the university shouldn't, or somehow doesn't, have a profit motive and doesn't have a short term return motive. … But it has a freedom to propose unpopular perspectives and alternate perspectives and I think it's one of the few places that can afford to or is charged in a way with doing that.

But he continued to be challenged to be able to support projects, even in this model outside of the marketplace:

> I definitely have an interest in the cultural and expressive roles of these technologies, but it was difficult to get traction for that at CENS and externally, not mindshare, but financial traction. … Now that I know the culture of CENS I think it wasn't that there was as lack of interest, it's just there was no mechanism for them to justify investigating [artistic applications].

The Director addressed the idea that the funding landscape needed to change to support diverse projects. In fact, she felt she could be an agent for that change. As she described it:

> Part of it is actually influencing the field so that there become funding opportunities. It sounds corrupt, but funding opportunities already have a certain mindset and if you just respond to what comes, you're not moving the field along. So I end up talking a lot. I go out and I give tons of talks and in some sense don't hold anything back. I talk about our latest ideas and I'd say, in several rounds career-wise, that has had influence on the field. We don't always end up with the most publications in it. We don't always end up even with the most funding in it, but it feels like that's also part of my, or our, function and in the end, it has caused there to, over time, be opportunities to get funding that probably wouldn't have been there otherwise. … I'm not setting [the agenda], but I'm trying to influence it, not for some personal gain reason, but for the same reason I want to do the work is the same reason I want there to be funding to do the work.

As participatory sensing progresses to more mature design and projects, some of these issues will be addressed. However, developers working on small-scale and amateur projects may be challenged to rethink the design process and put equal emphasis on personal data and systems.

From Values to Technical Specifications

Values levers such as working on interdisciplinary teams, experiencing internal testing, designing around constraints, seeking user feedback, advocacy from leaders and a values worker, navigating institutional mandates, and gaining funding help drive the translation process from anti-surveillance values of interest into design principles: things that can be made concrete in design. Paying attention to this process helped answer my third research question: How do anti-surveillance values affect technology development? The process of transforming social values like privacy into design principles is part political, and part translational. It's a progression of recruiting people (particularly influential people) to ideologies, and then translating those ideologies into design principles. A variety of values levers are influential in this process.

The process between value and design principle can feel difficult to systematize. As the Area Lead expressed:

> I want to say in the design process it's been ad-hoc. … By the time we're in the design process we're not really questioning the original intent of the project. So there's some meta-design selection process where I think there is a sifting that happens where we're making some ethical decisions about what are projects we're going to work on and what we're not. We're not doing surveillance. We're not doing military. There's high level decisions that are happening almost in an unspoken way, but sometimes spoken.
>
> So by the time that we're in a real project the questions come up when people choose to raise them or when there are clear IRB issues. There's a sensitivity to participation in the role of the user that's come over time that I notice in [the grad students]… a sense that users are important as customers, as people. Ad-hoc isn't necessarily a criticism, because I don't know that structured ethical review of projects is reasonable in a university setting.

Indeed, a structured ethical review of projects often had negative consequences, such as those produced by the IRB. The Area Lead also mulled over the difficulty of moving from values to principles:

> … I think other than that sort of ad-hoc structure one of the things that's interested me is some of the early writing you did [on design principles]. I've been trying to push for us to articulate principles for the same reason that it sorts of works, I think it worked okay in the IRB case is that projects change, technology trajectory changes. If we can figure out principles we can reason from, not from nothing, but from sort of basic principles. I think that's valuable.

Ad-hoc as it is, the process of moving from values to design principles and then to technological features was an important one to understand. At CENS, the first step was identifying and justifying relevant social values, such as privacy, consent, equity and forgetting. The second was translating those values into design principles. I will illustrate how the CENS team defined principles of local control, legibility, long-term engagement and parsimony to respond to anti-surveillance values. The final step is translating those principles

into technology features, such as user interface considerations, data retention procedures, or secure data storage.

The first step in this process – identifying and justifying relevant social values – was an ongoing advocacy process. Sometimes this involves giving presentations to spark discussions on troubling topics, such as surveillance powers enabled by participatory sensing or the undefined legal status of the personal data our lab collects. Justifying values frameworks to lab leaders was fairly easy; the majority of the laboratory faculty members hold concern for privacy, participation and social justice among their core values. Students showed more variable concern for these values, although most were receptive to their importance in ongoing discussions. I will illustrate the process, and the challenges, of moving from values to design principles by relating the story of CENS' first, and most thoroughly addressed, values challenge: that of privacy.

Example: defining privacy

The first major challenge CENS faced in incorporating anti-surveillance values into design was defining what "privacy" would mean in CENS systems. Trying to operationalize an abstract anti-surveillance value into principles that could be incorporated into our system incorporated both definitional and cross-disciplinary work. The definition of privacy we developed was the product of collaborative work with the Director, the Area Lead, the Statistics Lead, a UCLA Law School professor, and me. The team began with an "information privacy" approach, defining privacy as an individual process of decision-making about sharing and withholding information. Our approach fused perspectives from the technical and ethical privacy literatures into a framework we called *participatory privacy*

regulation (PPR). PPR stemmed from the observation that negotiations of privacy occur in all phases of the research process. Control over capture was part of defining data collection requirements. Decisions about data resolution were part of presenting project results. Data sharing and retention were implicated in decisions about research outputs and goals. The process of negotiating privacy was indelibly a part of research. Privacy regulation as *participatory* therefore explicitly stated that decisions about personal disclosure boundaries were part of engagement in research or system design. Privacy regulation as a *process* meant that decisions to withhold or disclose information were more complicated than could be addressed by a single transaction, an on/off switch, or pre-set system settings. People controlled access to the self, or access to information about the self, according to context. Such decisions were intimately tied to the identity a person assumes (e.g., parent, boss, friend) and the people and places with which she interacted. Privacy therefore acquired specific, variable, and highly individual meaning in specific circumstances and settings.

The team's PPR approach argued that participatory sensing systems should be designed so that people could negotiate social sharing and discretion much as they did in non-instrumented settings. Participation in the entire sensing process could help users understand a system's information flow, weigh the costs and benefits of sharing information, and make informed, context-specific decisions to disclose or withhold data. Allowing user discretion and autonomy in these functions could help researchers and participants build trust in each other and their technology.

Once we had a working definition of privacy, we needed to define how our systems would support that definition. We outlined three principles that we hoped would encourage *participatory* approaches, fusing values of privacy, consent and participation. These were

developed over the course of writing several papers for computer science as well as policy conferences. After many iterations, the four principles were finalized as:

Primacy and empowerment of participants. Taking a stronger stance than consent to data collection, participants should retain control over their raw data. Participants own their raw location data and any annotations to that data (photos, sound clips, co-location data, etc.) and should be able to make and revoke decisions to share subsets of the data. Framed this way, participants were not just subjects of data collection, but took the role of investigators (when they contract with self-analytic services) or co-investigators (when they contribute their data to larger research initiatives.) As such, they should have input into how data is collected, processed, stored, and discarded.

Longitudinal engagement of individuals throughout the data life cycle. Participatory sensing service interfaces should encourage participants to engage with the data from the point of collection through analysis, long-term retention, or deletion. Privacy decisions about sharing and retaining data can occur at many points in the sensing process, and systems should enable the continued engagement of participants necessary to allow them to change their data practices as their context changes. Stronger than notice, the crux of engaging individuals with decisions about their data was refusing to put data in a black box. Instead, collecting high-quality data, analyzing, learning from the data, and making ongoing choices about the data, became the goals of sensing.

Data legibility. Participatory sensing systems can help participants make sense of, and decisions about, their data by visualizing granular, copious data in ways individuals can understand. Methods to improve data legibility included visualizing data using tools such as maps, charts, icons, pictures, or scales. Data legibility also included showing users who has

accessed their data and how frequently, and showing participants where their data goes and how long it remains accessible. System features should increase participants' understanding of complex risk and help them make better decisions about data capture, sharing, and retention. Legibility was a stronger interpretation of data access, and can fortify participants to be better data stewards.

Parsimony. Parsimony focused on capturing data that is relevant to specified research objectives while minimizing the capture of peripheral information. Parsimonious capture targeted the data needed for research and new knowledge creation, but limited the possibilities for the invasion of participant privacy through retention of nonessential personal data. Minimizing capture also created a discrete, understandable data set, helping participants comprehend and consent to sensing campaigns.

As we developed these principles over time, we tried to ensure that our approach responded to each of the primary values concerns raised by surveillance. The following matrix of values design principles shows the ways in which we mapped particular design principles to the anti-surveillance values of interest.

	Privacy	**Consent**	**Equity**	**Memory**
Local control	X	X	X	
Legibility		X	X	
Long-term engagement	X	X		X
Parsimony	X			X

Figure 4.4: Anti-surveillance values and design principles

From design principle to technical specification

Transforming a design principle like participant primacy into a technical affordance was yet another translational and interdisciplinary process. It proceeded by using design

principles to imagining tweaks to a system, a data flow, or an entirely new kind of software or architecture. Though in my role of values advocate, I could be quite influential in helping to define design principles, moving from principle to feature was something I could not do alone. Instead, I needed graduate students and staff to engage with the design principles and brainstorm suggestions for how they could be achieved.

The least successful example of this translation, in fact, was from early in my work at CENS, when I tried to envision this translation on my own. I lacked the necessary language, and the right understanding of CENS design, to affect technical outcomes. I worked quite hard to map design principles to technical specifications in an early technical report I prepared for the group (Shilton, Burke, Estrin, Hansen, & M. B. Srivastava, 2008). A chart I made summarizing design implications of participatory privacy regulation is reproduced below:

Campaigns & Privacy

Data Life Cycle	**Participant Decision**	**Participant Action**	**Design Implication**
1. Capture ↓	Participant decides when to enable capture.	Participant turns phone on/off or turns capture software on/off.	UI on phone to enable/disable capture.
2. Storage ↓	Participant employs a pseudononymous username.	Participant registers a username that does not reveal identity.	Authentication system allows for pseudonyms as usernames.
	Participant decides to delete some captured data from their collection.	Participant views data via UI and elects to delete data.	UI and data store enable deletion of data at any granularity.

3. Processing ↓	Participant decides to be discrete with third party data.	Participant blurs, masks, declines to share, or deletes third party data.	UI allows easy masking, altering, and deleting.
4. Sharing ↓	Participant decides to share selected with designated people or processing programs.	Participant uses UI to select data for sharing, and to select desired recipients.	Data tore allows for feed customization, in-network sharing, or other selective sharing features.
5. Republishing ↓	Participant decides to alter data resolution before sharing to protect identity or confidentiality.	Participant uses UI to aggregate, limit or alter data to republish at a lower resolution.	UI and data store allow for resolution control. System also allows republishing.
6. Retention ↓	Participant decides their data should be deleted at the end of their campaign participation.	Participant uses UI to set generate metadata indicating internal retention period.	System complies with retention data through automatic deletion of 'expired' data.
	Participant monitors data shared with external applications.	Participant checks up on retention agreements with third parties by executing a hash.	System enables hash to compare data sets, monitor and negotiate with outside programs.
7. Reuse	Participant decides some of their data may be reused by future campaigns.	Participant uses UI to create reuse metadata.	System enables automatic enforcement of internal reuse policies.

Figure 4.5: A failed mapping of privacy features for campaigns

Perhaps this interpretation was too linear, failing to capture the intricacies of the design process. Perhaps a text-heavy chart was a bad way to present the translation between design

principles and technical specifications. Perhaps I did not share and promote it properly. But as far as I know, no one referred to this chart, or my definitions, during design.

I was able to be part of much more successful translations when I worked directly on CENS design teams. Perhaps the most successful example of a system that responded directly to anti-surveillance values, and the design principles of participatory privacy regulation, was the effort to develop the Personal Data Vault (PDV). In early CENS systems, personal data flowed from a participant's phone directly to a sensing application provider (in this case, CENS servers). This positioned application developers as powerful personal data aggregators. That model struck the team working on privacy issues as backward. We began work on the Personal Data Vault (PDV) explicitly intending to democratize the process. The vault is built to sustain the participatory privacy regulation principles we had defined. We hoped that a vault architecture would help individuals foster as sense of ownership over their personal data, treating the data as resources to be collected, monitored, and shared judiciously(Shilton et al., 2009). We also intended that the vault provide a place for individuals to reflect on their data, transforming data collection from an outside gaze into a process of self-reflection, awareness and identity building. We imagined an inference engine, which might help users understand what data the vault had shared, and what might be inferred about them by others from those shared data. In this way, the vault can serve not just a data diary, but as a tool to track and peer into the data others may be holding about an individual.

L., a senior graduate student, assumed responsibility for the vault and tailored her computer science dissertation to focus on advanced privacy filters that would allow data vault users to better match sharing preferences to their daily lives and realities. Both a new

postdoctoral scholar, I., and graduate student, C., started working on PDV-like implementations as part of their research. The leadership team also brainstormed systems that would allow vault users to negotiate with third parties to reveal less granular data, and vault mechanisms that would allow users to send machine-generated data for time periods in which they wished not to reveal real location data (Mun et al., 2009).

The translational effort needed to translate the participatory privacy regulation design principles into features of the PDV often took place at high-level design meetings focused on planning and goal-setting. One such meeting involved a call between the Director, a senior graduate student, myself and teams working on similar data vaults at Stanford, Rutgers, and the University of Southern California. Translating between design principles and technical specifications was a huge part of the call. An example of such a conversation is below:

> [Stanford researcher]: Is access [to data in the vault] constrained on identity?
>
> [Rutgers researcher]: In the privacy world, purpose should be associated with access instead of identity.
>
> [USC researcher]: This brings up question of how you track usage or purpose.

The team then spent some time discussing using the existing technical standard OpenID to manage identity, but left the question of how to track information usage or access purpose aside.

A different example took the form of another multi-institution collaboration, this one with a lab at MIT. The lab was developing policy languages that could be a tool to turn our design principles into concrete action within the vault. The MIT team created programs that would allow users to set rules or policies. These rules gave the vault permission to, for

example, send subsets of personal data to third-party applications. During the discussion, the Area Lead raised the question of how expressive the code authored by MIT would be. He asked "Can it do, say, resolution control? Could it do things like sparse sampling, adding noise, or sending fake data?" The MIT collaborators replied that their language wouldn't be able to do this directly. The CENS team would have to provide both data (for example, fake data) and the relationships between the data (that is, insert instead of real data in X or Y scenario) to the MIT software. This conversation helped us understand the capabilities and limitations of their language.

Translation conversations also took place one-on-one, in person or over email, as we discussed concrete changes to a system. For example, the struggle with how to translate and implement data legibility played out in an email exchange between me and the lead PDV graduate student. L. wrote to me:

> While the USC folks and I are working on PDV development, we're kinda confused about what roles the inference tool should have... The inference tool has to work for improving data legibility. But in what sense? We want to make it something more than just a data visualization. But we're having trouble designing it, especially from the user's point of view.
>
> So I went back to your paper [about design principles] and tried to re-think it. You mentioned something about totality: The tools must be capable of analyzing the totality of user's sharing decisions, to enumerate potential policy violations, and make what-if analyses about proposed data sharing policies. I understand what this statement means, but couldn't identify good usage scenarios... So I wonder if you had any good usage scenario in mind when you wrote this part.

I wrote back to try to clarify:

> Let's see.
> Usage scenarios for the inference engine. How about:
>
> A person is participating in both *PEIR* and *AndWellness*, both using a data vault. She shares her commuting routes between 9 am and 5 pm with *PEIR*,

> and she shares her geo-tagged EMAs (but not routes) with *AndWellness*. The basic visualization would of course show the routes shared with *PEIR*, and the locations shared with *AndWellness*. But the inference engine might mash these up, pointing out that non-commute routes could be inferred were *PEIR* and *AndWellness* to combine their data sets. … A user running both would want to be aware of this possibility, and depending on their sensitivity, might want to change their EMA sharing so that it was just between 9 and 5 too. … A more complicated example might mash up Facebook status updates ("At Pizzeria Mozza for dinner!") against limited *PEIR* data and EMA data to show inferred routes.
>
> … The idea is to help people who are participating in multiple applications keep track of all of those different sharing scenarios… Maybe we could brainstorm together a little more?

To which L. replied:

> I like the example. Yes, it's a good start. We could come up with more examples and think about ways to generalize them to be implemented systematically.

This process of translation between design principle and technical specification can easily be held up by a lack of fit between interests, or simply a lack of resources. An example of a failure to translate our principles into design features has been difficulty implementing our principle of data legibility. Good interface design is the lynchpin of this design principle, but the CENS team has not had the resources or visualization expertise to design user interfaces. As the Director explained in an interview:

> All of our user interface visualization design piece is completely arbitrary and unaddressed and probably introduces noise into our process continually. If we had more resources, we would solve that problem.

The Statistics Lead also expresses this difficulty around data analysis and visualization. As he put it in an interview:

> The hardest thing is to figure out what the appropriate level of analysis is for a lot of the projects. I feel like some of them have analysis, some of them just put stuff on a map, not that there's anything wrong with that, but there's

> work that could be done there that hasn't been done that I'd like to see some staff folks try and do….
>
> I think again that we could be well served by having a few more usability or interface people floating around, if I answer it from a practical standpoint to begin with. I think that there could be some more of that.

These comments illustrate that the process of translating from design principle to technological feature is often a question of having the right people, with the right skill sets, to work on the design and implementation.

From Values Levers to Critical Technical Practice

This chapter has traced design at CENS, starting from the nature of product development at CENS through the various values levers that manifested during CENS design. It has explored the diverse laboratory practices that deploy those values levers, and the agents that can intervene at all levels of design. The next chapter will explore the implications of these findings for establishing a critical technical practice in the design of pervasive sensing systems.

Chapter 5: Discussion – Values Levers and Critical Technical Practice

Values discussed and adopted during CENS design included privacy, consent and participation, power and equity, and forgetting. But they also included competing values such as efficiency and innovation values. This chapter discusses how *values levers* – practices and agents that pry open discussions about values in design and help build consensus around social values as design criteria – influenced CENS design and helped the team negotiate between competing values. The chapter also details how anti-surveillance values affect technology development when values levers are effective, and values are agreed upon, translated into design principles and eventually into technological features.

Values Important in Design at CENS

My first research question asked: what social values are discussed and agreed upon by the design team during participatory sensing design at CENS? My analysis focused on anti-surveillance values: privacy, consent, equity, and forgetting. But it also documented other values of importance at CENS: innovation, creativity, efficiency and practicality. Sometimes values focused on innovation or utility were in tension with anti-surveillance values, particularly when designers were faced with deadlines for papers or pilot testing.

CENS designers valued privacy, consent, equity, and sometimes even forgetting. But they also faced significant competing values that at times outweighed ethical principles. There were technical limitations on the projects and system features that designers could pursue. The team worked with a limited number of phones to distribute to pilot testers, and those off-the-shelf phones had restricted features. Team members faced pressures to move their design process along quickly, and sometimes values-based design was seen as an

impediment to quick progress. Students eager for success as academics faced stringent deadlines and pressure to publish their ideas before anyone else did. The constant pressures of technical innovation often combined to make a slower, stickier, values-oriented design process unattractive.

CENS' focus on balancing real-world products with research produced a very particular design environment focused on building rather than documenting, and new ideas rather than rigid design requirements. In this sort of environment, features needed to collect personal data (such as capture and upload mechanisms) were implemented much more quickly than those needed to limit collection, restrict sharing, or delete data. When I ask graduate students about this issue, their response would hinge on the definition of "functional." Their efforts were primarily focused on building a functional prototype. But it was clear that their definition of "functional" included personal data capture, but not necessarily data protection or deletion.

This description is consistent with the broader literature on anti-surveillance values such as privacy and forgetting. In social and political debates, these values are often pitted against utility and efficiency (Agre, 1994; Blanchette & Johnson, 2002). Some have labeled this a false dichotomy, and sought theoretical perspectives that don't trade privacy against efficiency (Cohen, 2008; Johnson, 2000). But within CENS design, it was common for engineers to see anti-surveillance values as supplemental, second-order design criteria. A "functional" system did not *need* to include anti-surveillance protections.

Why basic functionality does not, in the opinions of many CENS designers, include anti-surveillance values is difficult to fully diagnose. We can speculate as to why anti-surveillance values are more difficult to incorporate into design than innovation values.

These are more political and therefore perhaps more controversial. But perhaps just as importantly, anti-surveillance values are less native to the current culture of computer science design. In understanding the relative weights of anti-surveillance values at CENS, Star and Griesemer's (1989) definition of boundary objects proved useful. A boundary object is something understood and shared in the work of a diverse group. Part of the challenge of changing the design conversation at CENS was finding values-oriented boundary objects or concepts to which designers could quickly relate, and around which they could cooperate. The relative ease or difficulty of finding such objects points to the relative straightforwardness of incorporating some values (such as privacy) and struggle to incorporate others (e.g., equity) into design. The concept of "privacy" proved to be an accessible boundary object at CENS. There are classes and conferences in the CS community devoted to topics of privacy and security. From early in my tenure at CENS, it was clear that designers recognized privacy as a computer science concern. Though we often understood the term differently, privacy gave us a place to start a discussion. Privacy as a preexisting value, as well as a boundary object within the discipline of computer science, made it easier to open a door to talking about values such as consent, equity, and forgetting. But these values proved much harder to operationalize in the design setting. An ongoing challenge for values advocates in design will be finding commonality and boundary-spanning possibilities for these more difficult value concepts.

Design Practices and Their Influence

While the most basic definition of a participatory sensing system at CENS never came to include anti-surveillance protections, many processes and agents within design did

promote anti-surveillance features. These features, such as data filtering and scrubbing, data retention limits, and use of the Personal Data Vault, were incorporated into multiple CENS projects. This observation engages my second research question, which asked: how did design practices and participants influence consideration of anti-surveillance values?

Analysis of the ethnographic data suggests that design practices emphasized some values and not others. Similarly, agents with particular agendas – from laboratory leaders to me in the role of anti-surveillance advocate – engaged particular values. These processes and agents employed *values levers* to build consensus around and act upon anti-surveillance values.

Inherent and introduced values levers

While previous literature on values in design has suggested that values help construct the day-to-day work of design, my dissertation illustrates that the opposite is also true: the routinized practices of design work shape the values incorporated into new technologies. The findings from CENS suggest that values levers, including working on interdisciplinary teams, experiencing internal testing, designing around constraints, seeking user feedback, advocacy by leaders and a values worker, navigating institutional mandates, and gaining funding, promoted social values in design.

Some of these values levers were inherent to design at CENS, part of the already-existing landscape of design activities. Interdisciplinary conversations encouraged focus on personal data, leading to discussions of privacy, consent, equity and forgetting. This process was illustrated at CENS when statisticians and information studies participants refocused design conversations on data use and practices. Internal testing of participatory sensing technologies similarly encouraged a focus on personal data, and particularly the inferences

that could be drawn with such data. This activity was demonstrated when students discovered privacy, consent and equity concerns while testing their applications and those of their colleagues. Designing around values constraints made values into technical challenges, and inspired new forms of technical creativity to reach values goals. This practice was demonstrated by CENS projects such as the Personal Data Vault (PDV). And gaining funding served as a values lever within CENS design, as well. Gaining funding increased team size and resources, promoting more focus on personal data and resulting discussion of values. This relationship was illustrated by the contrast between values discussions on small projects like *Biketastic* and larger, better-funded projects such as *AndWellness*.

Other values levers were introduced to the lab by purposeful design activities. Laboratory leaders made a conscious decision to seek user feedback, leading to examples like *AndWellness*, when user focus groups opened up new and nuanced discussions of values such as privacy. Agents such as values workers and leaders used a combination of laboratory procedures and advocacy techniques to advance anti-surveillance values. CENS leaders demonstrated this by advocating for values such as privacy, and instituting procedures, such as the CENS Human Activity Data Collection Worksheet, to encourage better privacy-oriented data practices. I intervened as an advocate for anti-surveillance values by raising values issues in design meetings, drafting values-based policies for design, and interviewing designers about their values and values-based actions. And institutional regulatory bodies such as the IRB did, in some cases, enforce procedures that demanded attention to values in design. UCLA's IRB certainly fostered discussion of consent, in particular, at CENS. But the IRB also lost designers' respect by failing to fully understand the implications of participatory sensing data collection.

Figure 5.1 illustrates the combination of inherent and introduced values levers in design at CENS. Each activity leveraged a particular experience that helped to articulate anti-surveillance values, make them prominent and important, and build consensus around these values as design criteria.

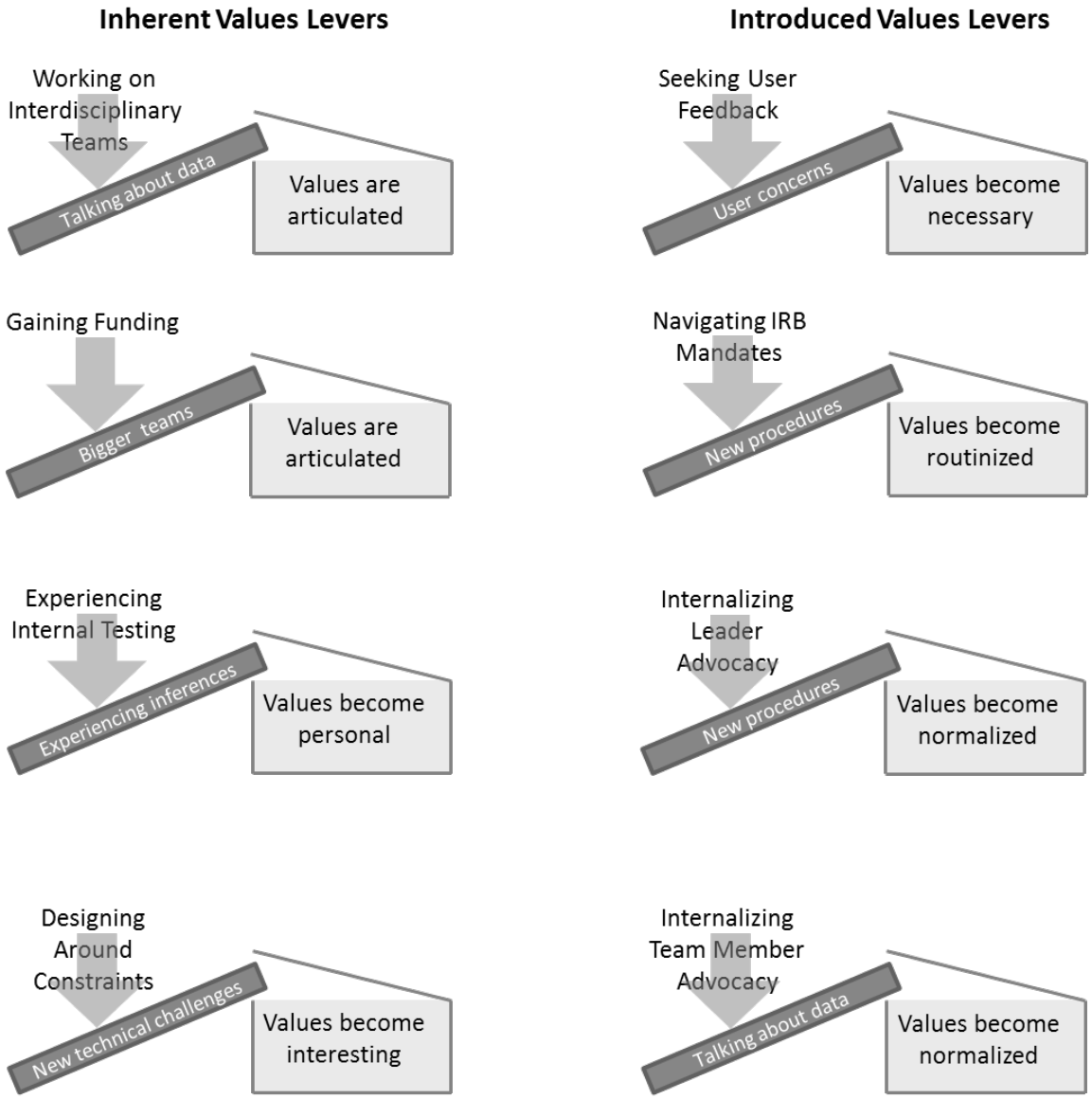


Figure 5.1: Inherent and introduced values levers in design

These levers changed the equation of which values were incorporated into CENS technology, helping to promote social values alongside market and innovation values. Working on interdisciplinary teams, experiencing internal testing, designing around constraints, seeking user feedback, leader advocacy, and the intervention of a values advocate all had demonstrable impact on design decisions.

Characterizing effective values levers

The ethnographic data also point to at least one values lever – navigating institutional mandates – that needed further refinement to effectively change design. This raised a question: what features made for an *effective* deployment of values levers? Why could my own insertion of levers as a values worker be declared effective, while the role of the IRB was less obviously so? Analyzing the values levers deployed at CENS suggests that effective deployments result in: 1) changes in the design conversation; 2) changes in the perception of usefulness of social values in design; and 3) values-based modifications to the technologies themselves.

An effective values lever, whether in the form of a person like a values advocate or a practice like internal testing, changed the topic of conversation, making values such privacy, consent, equity and forgetting a part of regular design meeting discussions. For example, over the last two years, privacy and consent have become regular topics in design at CENS. Privacy is invoked by internal testing as well as refocusing on personal data through interdisciplinary conversations. Student designers regularly wrestle with consent as they fill out the Human Activity Data Collection Worksheet for all new participatory sensing projects. Laboratory leaders required activities, such as internal testing, that focused

designers on the data. Advocates and leaders led discussions of the creativity that arose from values-based design constraints like privacy.

The observation that effective values levers changed the topic of design conversation confirms theories posited by authors such as Los (2006) and Friedman and Nissenbaum (1997a) in the surveillance literature. Without the intervention of values levers, algorithms and databases are often discussed as if they are ethically neutral. As Los writes:

> The technicistic approach that prevails in global surveillance culture and likely affects programmers, managers and users of surveillance systems removes these systems' codes and scripts from the scope of moral reflection. These truncated, de-humanized and de-socialized scripts appear as 'given' and acquire a very positivistic air (Los, 2006, p. 89).

By focusing on "neutral" code, developers risk neglecting ethical inquiry by placing values-based inquiry out of the scope of their design practice. Values levers, however, change the focus of conversations, emphasizing moral values within discussions about systems.

Beyond changing the topic of conversation, effective values levers did work that concretely contributed to the process of technology development. This helped change the engineers' perception of the usefulness of social values to design. By making values something that directly applied to design and even opened up new spaces of creativity, values became agreed-upon design criteria. For example, privacy became a major driver for creation of the Personal Data Vault. Social equity became a driver for community-based campaigns like the Boyle Heights Project. Internal testing served as one values lever that did concrete design work. When CENS students ran their colleagues' location-tracking programs over the weekend, or answered sensitive survey questions, they gained new respect for privacy as a design criterion. For CENS designers, experiencing the data quite often meant experiencing inferences that could be drawn from that data, and therefore the values

concerns raised by that data. A practice meant to check new products for usability and bugs had the unanticipated result of encouraging researchers to reflect on the sensitivity of the personal data in their systems. Internal testing fostered a focus on the personal data that was distinctive within the design process. The kinds of data under request (including location as well as questions about eating, sleeping and exercise habits) surfaced concrete surveillance and privacy concerns in a way that constructing algorithms for abstract data processing had not.

The emphasis on finding values levers that do concrete, contributive work within design is new within the values in design literature. While authors such as Manders-Huits and Zimmer (2009) and Rabinow and Bennet (2008) have explored values intervention techniques, this dissertation is the first to specify ways in which values interventions can be viewed as tools for design, not just as tools for promoting values in design.

The final indicator of an effective values lever was finding and documenting values-based modifications to the technologies under production. At CENS, these took a wide variety of forms. They were sometimes as simple as anonymization measures built into battery use monitoring software. Sometimes values were engaged in a more complex way, such as in the complicated sharing filters developed as part of L.'s computer science dissertation. Finding such values-based modifications are an important part of the values in design theoretical framework established by Friedman (2006) and Nissenbaum (2009c). Finding these technologies at CENS confirms the values in design perspective that social values are inscribed into technological objects.

From Values to Technology: Structuring the Laboratory

My third research question asked: How do anti-surveillance values affect technology development? The answer to this question lies in the process of translation from social value to values lever to design criteria.

At CENS, anti-surveillance values were translated by agents and design processes into values levers. Deploying these values levers during design then helped create what Collier and Lakoff (2005) refer to as a "regime of living":

> A given regime provides one possible means … for organizing, reasoning about, and living 'ethically' – that is, with respect to a specific understanding of the good … They suggest important elements of how such situations are organized ethically through a process that combines principles of ethical reasoning with concrete practices in specific contexts (2005, p. 31).

A regime of living is a cohesive ethical orientation, a sense of how things "should" be done. At CENS, values levers helped to create an anti-surveillance-oriented regime of living. The levers encouraged an environment in which questioning how anti-surveillance values relate to daily design was a feature of the lab's work. Existing design agents, such as leaders or institutional regulators, deployed these values levers. And design practices such as internal testing and interdisciplinary work created values levers that were integral to the design process. Together, values levers deployed by agents and laboratory practices helped foster a critical technical practice: the process of questioning design as it happens, with the goal of building pro-social, carefully considered technologies (Agre, 1997b).

At CENS, this regime of living influenced the three step process of translating abstract values into concrete design criteria. Values levers were employed along all three steps, as illustrated in the diagram below:

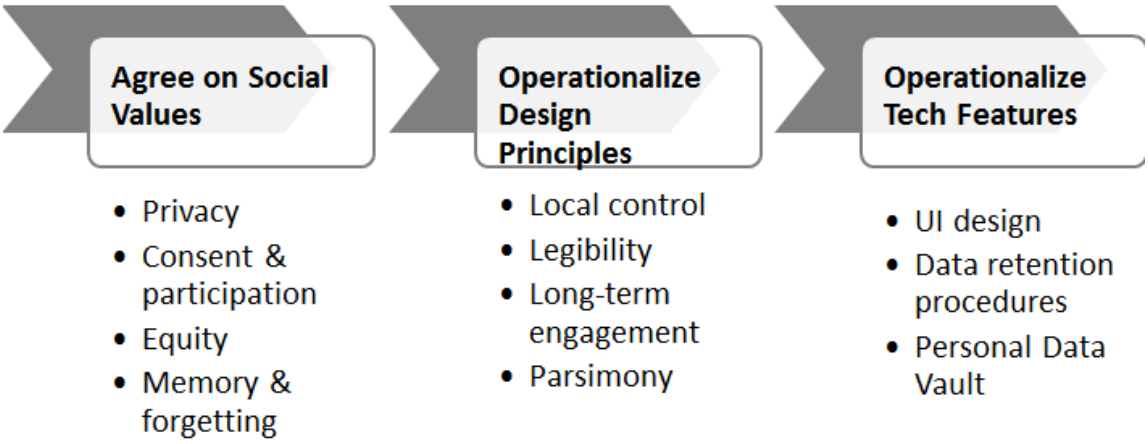


Figure 5.2: From values to technology features

But in order for these practices and agents to deploy values levers, the design lab had to be structured to allow for and encourage their presence. The structure a design lab is given by its membership and its daily work practices matters to the process of translating between social values and technological features. It is laboratory structure that makes space for the agents and processes explored here.

The structure of the CENS laboratory enabled values levers to flourish. CENS leaders took interdisciplinarity seriously, and structured the design laboratory to support it. Leaders hired social scientists and statisticians, and encouraged these outsiders to become full members of design teams. They assigned space and equipment side-by-side with computer scientists and electrical engineers. They solicited readings for both design meetings and classes from outside disciplines. They repeatedly invited public health, urban planning, and information studies students and faculty to join the team. They took small steps to overcome what Rabinow and Bennett (2008) referred to as the "hierarchy of power and privilege" between computer science and outside disciplines.

Similarly, CENS leaders encouraged laboratory practices that enabled values levers in design. Internal testing was one of those practices. Because it was sometimes an unpopular burden to students, leaders took it upon themselves to continually reinforce the importance of internal pilot tests. Leaders took steps such as providing administrative support to assist with pilot testing, and requiring students to test their colleagues' projects. Leaders also structured the lab to encourage work with users. Grants were written to support pilot tests with sample user populations. Administrative support was allocated to organizing user focus groups, making user involvement viable and possible.

The laboratory structure was also influenced by another important factor: funding for design activities. Funding was a crucial, but difficult to manipulate, variable in fostering a design environment open to values levers. Money could restrict or expand value-centered design practices by affecting the availability and interplay of levers such as values advocates, interdisciplinary teams, and internal testing. The declaration that money is important is hardly surprising, but the ways in which it affects values in design are intricate and worth discussing. As I illustrated in Chapter 4, larger, better-funded participatory sensing projects had correspondingly large development teams. Evidence from meetings and interviews showed that it was large teams that spent more time considering the values implications of their work. The discussions fostered by a larger, interdisciplinary group of people tended to reveal ethical worries and opinions, which then become design concerns. Funding also guaranteed that there were staff members in place to support long-term engagement with users and clients. These engagements supported values like local control and participation. Finally, funding enabled the long-term intervention of an ethics advocate. A grant focused on ethics in engineering allowed me to immerse myself in the CENS design process.

Funding also provided legitimacy and security for my project, providing both financial means and outside justification for the importance of the project.

There has been little literature focused on the role of funding in values in design, although it was hinted at in the foundational work by Friedman and Nissenbaum (1997a). The importance of funding to values levers in design at CENS indicates that studying funding cycles and pathways, and their effect on the values expressed during design, may be an interesting avenue for future work.

Making Anti-Surveillance Values Integral

My fourth research question asked: How can designers as well as outside advocates make anti-surveillance values an integral part of design? The answer to this question, like the others, lies in the structure of design work. The structure of the CENS lab enabled a variety of actors and design practices at CENS to deploy successful values levers. These levers were not always deployed intentionally. Three of the deployments I described formed values levers as unintended consequences of other design activities: working across disciplines, working with users, and testing sensing technologies for bugs. Other deployments, however, were more intentional, including those by laboratory leaders and me in the role of a values worker.

When compared, the values levers with the most impact at CENS shared a critical feature in common. They all functioned *inside* the design environment, making values discussion part of the culture and ideology – the "regime of living" – of design. The only values lever explored in Chapter 4 with ambivalent effects on design was the intervention by a true outside force: UCLA's Institutional Review Board. The reasons it was critiqued and

ignored by CENS designers focused almost entirely on its outsider status. Integrating values levers inside of design seems to be necessary to foster a critical technical practice.

Evidence from CENS suggests that internalizing values levers in the design process can be done in one of several ways. It can be accomplished by inserting actors such as a values advocate or interdisciplinary teammates into design to deploy values levers, such as attention to personal data or direct advocacy for certain values. It can also be achieved by using techniques to move actors and processes, such as values constraints, users, and institutional authorities, closer to design.

Inherent values levers

Two of the most successful values levers – experiencing personal data and inferences through internal testing, and focusing on personal data through working with interdisciplinary teams – were inherent to CENS design. They were *unintentional* values levers, and served to focus designers on values as an uninterrupted part of their design practice. Such internal values levers are extremely valuable, because they reinforce the point that social values are a part of design. They do not suffer from seeming alien to design, as advocacy and design requirements sometimes do. The argument cannot be made that they come from agents who don't understand the technologies or design practices, because the values arguments come from the designers themselves. These internal practices may be some of the most important to encourage as part of a critical technical practice.

Introduced values levers

Values levers need not be inherent to the design process. They can be introduced by outsiders, if they can effectively be moved inside design. The most obvious example of

moving a lever from outside to inside design at CENS was the role of the values advocate. In this case, the importance of being able to shift from an outsider to an insider on the design team could not be overstated. To be effective, I had to become a full member of the design team. Indeed, many of the problems with values consultants or advocates explored in previous values in design literature stem from lack of acceptance by the scientific or technical team (Manders-Huits & Zimmer, 2009; Rabinow & Bennett, 2008).

For values levers that depend upon outsiders – social scientists, ethics boards, or even funding bodies – one persistent challenge is negotiating unequal power and design expertise. Outsiders, particularly social scientists, face a challenge that Rabinow and Bennett (2008) describe as the "hierarchy of power and privilege." These authors were involved in a bioethics collaboration with biologists and genetic scientists. As they wrote of the intellectual work of the lab:

> There was basically no effort made to do any of the background work that was required to make sense of some of our technical or scholarly terms. … Despite the [funding] mandate, there was an often polite, but unbending refusal to make this engagement mutual – it seemed to be taken for granted as natural that members of the [social science] team were conversant with the molecular biology and eager to learn more of the chemistry and engineering. No reciprocity emerged nor was it encouraged (or discouraged) by the other PIs, it simply was not considered. What remained therefore was a hierarchy of power and privilege (Rabinow & Bennett, 2008, p. 8).

The intellectual work of science and engineering, as Rabinow and Bennett found, too infrequently includes values analysis, ethical debate, or humanistic conversation. Rabinow and Bennett suggest that the solution to increasing values discussions in science lies in "rethinking relations among the life sciences, human sciences, and ethics" (Rabinow & Bennett, 2008, p. 9).

I respect and understand Rabinow and Bennett's call for rethinking relations, but I have taken a different approach to values interventions at CENS. In many ways, my work has accepted the hierarchy of power and privilege between my field and that of CENS students and leaders. I have done this because I had a fundamentally instrumental goal. If outsiders from less powerful social science disciplines want to change design, we need to work within the existing realities of design.

At CENS, working within design meant joining problem-solving discussions rather than simply observing; authoring papers with designers; making presentations both to the designers in meetings and alongside the designers at conferences; and otherwise participating in the academic work of the design lab. A byproduct of my ethnographic method was the luxury of spending a lengthy amount of time at CENS. Such a long (indeed, unsustainable) commitment, however, is not a requirement for a successful values intervention. My primary motivation for a multiple-year stay was ensuring validity of my ethnographic research methods, not building influence as an ethics advocate. I began deploying values levers (although I didn't think to call them that at the time) after an initial stay of only a month or two, beginning almost immediately with an active role drafting privacy policies for the *PEIR* project. What was much more important than the length of lab tenure was the *density* of time spent in the lab: regular attendance at weekly meetings, use of a work station in the lab, and immediate availability for ad-hoc meetings and casual interactions. As the Director responded when asked why the values advocate relationship worked:

> It's a kind of respect. It's a kind of respect, but it's also engagement. There's a balance of respect and engagement, because you gained respect by becoming engaged.

Ultimately, engagement was much more important than length of stay in the lab. This finding suggests that the values advocate role could be adapted to the time constraints of consultants or senior researchers with months, rather than years, to spend on a project. But such advocates may need to rearrange their work, consulting, or research schedules to allow total immersion in a design lab during those critical months.

Beyond immersion in the lab, I made a concerted effort to take part in the design work of the lab. Though I cannot code or design systems, I tried to find ways to be useful to the daily work of the participatory sensing team. I helped organize focus groups with users and suggested social science methods to bolster system evaluations. I coauthored a number of papers with other CENS students. And in addition to joining existing projects, I started CENS projects of my own. I spearhead an ethics education grant that funded a course on values in design. I organized an ongoing exploration of legal implications of participatory sensing. I've pursued grants with team leadership so that ethics projects might continue after I leave. Fully joining the work of academic labor helped make me part of the team, instead of an outside values consultant. Such work also helped me maintain the blessings of lab leadership and the respect of coworkers.

At times, full membership in the design team seemed compromising as a values advocate. Indeed, the lengthy period that I spent in the design lab, necessary for ethnographic validity, heightened the problems of values compromise. There is a large literature in sociology discussing the relative advantages of insider versus outsider status, and the line between participant-observation and participation (Lofland et al., 2006). In my work as a values advocate, this tension was reflected in moments where my core anti-surveillance values began to slip. For example, I once surprised myself by suggesting a change to

AndWellness to encourage continuous location tracking, rather than selective geo-tagging. Such a change hardly fulfilled the value of parsimony that I claimed to espouse.

While there were obvious problems with such ethical compromise, there were also benefits. Moments like these illustrated to designers that my principles were not rigid, and that sometimes other design values (in this case, a new, valuable outcome that wouldn't have been possible without the continual location trace) outweighed anti-surveillance values. Such examples helped me avoid the label of a nag or hopeless idealist, and instead emphasized the cooperative nature of cross-disciplinary work.

But advocates must balance a lack of rigidity with strategies to ensure that core values are not compromised. One strategy stemmed from my experience with the positive influence of reporting to my dissertation committee, comprised primarily of social scientists. Because I was beholden to this committee, I was careful not to let my core values slip too far. Advocates embedded in a design lab can benefit from external supervisors who are equally concerned with core values. This might take many forms, but would best be comprised of discipline-appropriate experts in applied ethics and values in design. In addition, advocates should cultivate a community of values-minded peers. Attending conferences or professional development focused on core values will reiterate their importance, help advocates find strategies for dealing with concerns, and help embedded researchers or consultants continue to be strong advocates.

Because the literature investigating values interventions into design is emergent, many of these findings are new. The importance of moving values levers from outside to inside design is perhaps intuitive, but it has not been discussed in the values in design

literature or science and technology studies literature in any depth. Further investigation and testing of ways to integrate values levers into design is needed.

Remaining Structural Challenges

Of course, a well-structured design laboratory where values levers reside close to the daily work of engineering only addresses one facet – design – of just, equitable technologies. As the literature reviewed in Chapter 2 suggests, there are significant constraints beyond the laboratory that affect the social impact of participatory sensing technologies. The surveillance and STS literature reviewed in Chapter 2 suggest at least two challenges that remain unaddressed in the CENS laboratory. The distributed control of sensing technologies suggests structural challenges to CENS' social justice goals. And the distributed nature of personal data collection suggests difficult theoretical questions about the value of self-monitoring and discipline. These challenges are unaddressed by the values in design perspective, but important to consider in the larger social question of pervasive personal data collection and social justice.

Challenges of distributed collection and control

One of the central features of participatory sensing is that control over the sensing technologies is meant to be distributed in nature. Competition among mobile carriers, content hosts such as Google, Facebook and Amazon, and small-scale start-ups will all challenge anti-surveillance ethics. If personal data is indeed the "new oil," as the World Economic Forum recently claimed (*Personal data: the emergence of a new asset class*, 2011), economic competition among personal data collectors may eclipse anti-surveillance values as corporations and governments race to control this flow of data. CENS demonstrated ways

in which time and resource pressures already push against anti-surveillance values. Without wide adoption of values levers and concern for values in design, distributed collection and control of personal data will challenge anti-surveillance values.

Challenges beyond fair information practices

Pervasive computing applications like participatory sensing are largely unregulated. For decades, the Codes of Fair Information Practice have served as national voluntary standard for data privacy, protecting personal information collected by governments and corporations (Waldo et al., 2007). The Codes demand notice of data collection, choice and consent, access for data subjects, integrity and security, and enforcement and redress (U.S. Department of Health, Education, and Welfare, 1973).

Participants in sensing certainly deserve notice and awareness, choice and consent, access and participation, integrity and security, and enforcement and redress. But the distribution of these data beyond governments and large corporations complicates application of fair information principles. The Codes assume organizations to be the data collectors, and individuals to be the data subjects. This may not be the case in many participatory sensing applications. Individuals may intend their data collection for their own purposes and use. The data collected by community groups might be cooperatively analyzed and widely shared. By enabling dispersed data collection and sharing, participatory sensing collapses the role of data collectors and data subjects. Fair data practices begin to lose their coherency when the roles of data subjects and collectors become blurred. Which parties are responsible for ensuring notice, access, security and redress? New guidelines are needed to

help sensing developers and legislators answer these questions and encourage anti-surveillance values in design.

As explored in Chapter 2, scholars of mediated environments suggest that privacy negotiation becomes a dynamic and ongoing process that relies heavily on user engagement with data and ongoing sense-making: what data am I sharing now, with whom, and what do they say about me? In participatory sensing, understanding privacy as engagement and control of data specifies that privacy decisions take place throughout the sensing process, from deciding to turn on a sensor to making post-facto decisions to delete data. Participatory sensing participants invested in their data will have reason to explore, understand, and make privacy decisions. In previous work (Shilton et al., 2009), the CENS ethics team has called this principle *local control*. Participants should also be able to understand what the data mean and reveal about them. We called this principle *transparency*. Participants should have the ability to make and revoke data sharing and withholding decisions over time, as the context of their privacy needs change. We called this principle *long-term participation*. Each principle has roots in an individual right to manage one's image and identity, and consequently the data that increasingly are part of that identity (Phillips, 2005a).

The Codes of Fair Information Practice do not support these principles well, because they do not adequately promote data subjects' engagement with their own data. Notice is not enough to spark investment. Access is not enough to promote understanding. And redress is not enough to support long-term changes in context and subsequent privacy needs. Participant primacy, data legibility and longitudinal engagement can expand the Codes of Fair Information Practice to support systems that improve users' ability to make sense of, and regulate decisions to share or withhold, data.

Self-discipline and empowerment

Participatory sensing and pervasive personal data collection also raise questions about social change. What will the social impacts of new regimes of personal data collection be? Even when based on values such as privacy, consent, and equity, CENS data collection is still self-surveillance. Surveillance scholars such as Vaz and Bruno (2003) have documented the ways in which self-tracking or self-surveillance practices often focuses upon deviance in the body or the community that social pressures dictate must be rectified. CENS projects such as *AndWellness* assume an agenda of healthier eating or better adherence to wellness practices; projects such as *Mobilize* seek to document community blight alongside positive attributes. Though there are few studies of data-intensive self-tracking, there are signs that such practices can become obsessive forms of self-discipline. Entries on self-quantification blogs such as "The Quantified Self" discuss not only the joys and discovery of self-tracking, but also obsessive behaviors surrounding weight and exercise that self-tracking can feed (Carmichael, 2010). In this light, participatory sensing can be seen as an heir to Foucault's vision of surveillance over individuals. In *Discipline and Punish* (1979), Foucault describes the historical transition from exiling the mad or the sick to "institutions for measuring, supervising and correcting the abnormal… to brand [the individual] and to alter him…" (1979, pp. 199-200). Foucault's concern for techniques and institutions for measuring and supervising extends to participatory sensing, no matter how distributed the architecture or deep the community participation.

Similarly difficult to discuss, but important to recognize, are challenges created by CENS' laudable goals of using participatory sensing to benefit underserved or marginalized populations. This focus creates an uncomfortable question. Is the CENS emphasis on using

participatory sensing tools with marginalized or at-risk populations (such as HIV positive young men or urban high school students) actually increasing the surveillance of these populations? Could sensing projects compound instead of address structural inequalities? If anti-surveillance values falter, or if police or immigration authorities subpoena CENS data, has the social experiment actually increased the vulnerability of these populations to control and discipline? Increased personal data gathering among marginalized communities could risk amplifying what Gandy (1993) refers to as the 'panoptic sort': segmenting people according to their social address.

CENS' focus on participatory projects attempted to mitigate concerns about power and equity, but it is also important to note that participatory projects do not have an unblemished social history. As Cooke and Kothari (2001) write in *Participation: The New Tyranny?* participatory methods are sometimes used by governments or corporate interests to validate development projects that serve to control, rather than empower, marginalized populations. Cooke and Kothari use their edited collection to document economic development projects in which ritualistic notions of "participation" became a cynical means to justify manipulation of marginalized populations. Similar critiques have arisen of the practice of incorporating participatory methods into the design of geographic information systems (Elwood, 2006). In addition, participatory processes add work – sometimes lots of work – for participants. Participants once protected by features such as confidentiality under IRB-approved traditional research projects must now be actively involved in managing and organizing their own data. Participation demands volunteer effort, and therefore may privilege those with time and resources to spare. Constant self-reflection on the motivations behind participatory sensing, and honest appraisal of who benefits from sensing, will be

necessary to ensure that participation is not a puppet, and that participatory sensing continues to serve social justice interests.

But though it has undeniable disciplinary and perhaps social sorting effects, participatory sensing does more than just brand and alter the individual. Data collection for and by the self, or the community, targets social norms to which the subject agrees or even desires. Though these desires may be socially constructed and enforced, this does avoid the totalitarianism that occurs in a panoptic scenario, when subjects under surveillance feel the need to conform to norms with which they do not identify and would not choose (Vaz & Bruno, 2003). Indeed, participatory sensing has the potential to do more than simply help individuals comply with consensual social norms. Its focus on participation in defining data collection and understanding the meaning of sorting and analysis could enable individuals to identify that they are in fact the subject of such social pressures. This is where participatory sensing diverges from Foucault's disciplinary visions: it recognizes the agency of individuals within the mechanisms of surveillance. Participatory sensing does not deny that social forces press on deviant bodies or construct neighborhoods as blighted. But through a focus on participation, it proposes that individuals can learn to recognize such pressures through ongoing interactions with the realities and limits of personal data collection. By becoming directly involved in the very real messiness of surveillance, individuals have much more agency to stop and start surveillance, and to believe, ignore, or even challenge the resulting branding.

Towards Generalizability

This dissertation followed the values in design perspective laid out by Friedman et al (Friedman, 1997; Friedman, Kahn, et al., 2006), including a conceptual investigation of what values respond to social concerns such as surveillance, an empirical analysis of the ways these values are discussed and weighed during design, and a description of how these values affected technology design at CENS. A major question unaddressed, however, in the values in design literature is what factors encourage engineers – consciously or not – to prioritize some values over others in their work. Running parallel to this question is how to make engineers' values choices, and particularly social values choices, conscious and purposeful. For example, although inserting an ethics advocate onto the design team is one of the most common interventions discussed in the values in design literature, it is one of the hardest to replicate. As with any successful collaboration, the success of a values advocate depends upon personalities, a fit between interests and subject matter of the lab, and the acceptance of lab leaders (Manders-Huits & Zimmer, 2009; Rabinow & Bennett, 2008). The values in design literature continues to struggle with how to replicate individual successes in new settings.

And in many ways, the CENS setting was truly exceptional. Studying values in participatory sensing design turned out to be a case where values were particularly visible. Anti-surveillance values such as privacy and consent rose to the surface of design very quickly due to the user-facing nature of the technologies under development, and the collection of recognizably personal data. CENS leaders were aware of, and committed to, anti-surveillance values from the beginning of design, and their attention helped make these concerns quite visible. CENS also had a preexisting commitment to interdisciplinary work,

incorporating statisticians and social scientists into the team. This further increased the visibility of social values during design, as I described in Chapter 4. Values advocacy, and enabling values levers, will likely be much more difficult in other design settings. By presenting a single case study, this dissertation raises new questions of how to replicate the success of the various values levers described in CENS design.

Learning from this particularly visible design case, however, gives those studying values in design a new advantage: concrete activities to look for in design environments. Because social values were visible and important at CENS, I have been able to define the concept of values levers, and explore their effectiveness and implications for design. Similar levers may well be present in other design environments, though they may be harder to see. By examining the ways in which membership and practices of a laboratory relate to the values expressed in design, this dissertation attempts to overcome one limit of the values in design literature to date: that of replicability. Close attention to the *people and practices* that made values levers successful presents a new contribution the existing literature. While literature on values in design has previously suggested that values help construct the day-to-day work of design, my dissertation illustrates that the opposite is also true: the routinized practices of design work shape the values incorporated into new technologies. Attention to lab membership and practices can provide insights into what levers might be replicated in other design settings.

Next Steps

Science and technology studies literature provide a great wealth of theoretical and empirical research into influences on technology design. STS, policy, law and information

studies provide theoretical perspectives on ethical challenges posed by information systems, surveillance, and recently, ubiquitous computing and participatory sensing. By combining empirical techniques developed for design settings with theoretical perspectives on values, my work investigates a gap between these literatures: how social values unfold in a ubiquitous computing design setting, and design practices and agents that create space for building consensus around, and acting on, those values. Investigating this relationship between social values and design furthers our understanding of values in the age of pervasive computing, and also encourages new kinds of collaboration between social science and system design.

This dissertation remains, however, a single case study. Future comparative work will be important to establish whether values levers such as internal testing, working on interdisciplinary teams, designing around constraints, seeking user feedback, values advocacy from leadership and values workers, navigating institutional mandates, and gaining funding similarly encourage social values as part of the work of technology design. Comparison with industrial design settings, which differ dramatically in structure and culture from academic laboratories, might be most revealing. Qualitative comparative analysis might be one route to determining the generalizability of the values levers I have developed here (Babbie, 2007). Another technique might be conducting a negative case analysis (Lofland et al., 2006) by finding a design situation in which anti-surveillance ethics are devalued. Examining the structure of that setting might support (or refute) the validity of the values levers established here.

Further research is also needed to investigate the assemblage of participatory sensing beyond the design setting. Conceptual and legal analysis could explore the effects of national

telecommunications policy on participatory sensing infrastructures. And studying user adoption will be critical to understanding how the values materialized in CENS technologies are deployed and altered in use.

Another area of inquiry that remains for future work is to examine participatory sensing under values lenses not related to surveillance. Participatory sensing doesn't only challenge privacy, consent, equity and forgetting, but a number of other social values. Democracy and democratic participation are invoked by the "bottom-up" nature of data collection. Openness of data and software are ongoing values engaged in CENS design. Environmental sustainability, accessibility, and economic empowerment are all issues mentioned in CENS publications and rhetoric. Conceptual investigations of how participatory sensing engages these values, or reanalysis of the data presented here to find values levers that affect these issues, might be rewarding next steps.

Chapter 6: Conclusions

Privacy by design, values-sensitive design, baking values in: these design movements declare that social values are inherent in new technologies, affecting their affordances and use. This dissertation has studied *how* values become a part of technologies. Anti-surveillance values became material in CENS participatory sensing technology through a process of building consensus around specific values such as privacy, consent, equity, and forgetting; and then translating those values into technological features. This process was supported and enabled by values levers: practices and design activities that opened new conversations about social values, and encouraged consensus around those values as design criteria. The routinized practices of design work shaped the values incorporated into CENS technologies.

This finding is important because building anti-surveillance features into technology is of increasing importance. The nature of personal data collection is changing. Consider the individual tracking his own weight loss statistics using an online application, or the community group that bands together to document pollution released by a chemical plant in the neighborhood. Individuals may intend their data collection for their own purposes and use. The data collected by community groups might be cooperatively analyzed and widely shared. By enabling dispersed personal data collection and sharing, mobile sensing collapses the role of data collectors and data subjects. Traditional privacy protections like the Codes of Fair Information Practice (Waldo et al., 2007) begin to lose their coherency when the roles of data subjects and collectors become blurred. Individual or small-scale data collectors may not know to follow voluntary fair information practices, or may simply face a lack of resources to devote to professional data management practices. Data management codes developed for organizations, dependent upon best-practice security, and supervised by

privacy officers become tenuous in a future where single developers or small teams create prolific data sharing applications. Making anti-surveillance values a critical part of design practice may be a more tenable approach.

The role of values levers at CENS, both inherent to design and introduced, suggests that a laboratory's membership and design practices are critical to the values incorporated into design. To "bake in" anti-surveillance values such as privacy, consent, equity and forgetting, funders and leaders must structure laboratories to enable and encourage values levers, which facilitate these values becoming criteria for design. This conclusion suggests that those in a position to shape development laboratories – academic leaders and funders both – can have enormous influence on values in design. Explicitly and purposefully considering how to construct design group membership, rules, design activities, and daily work practices requires a shift in perception by both leaders and funders. To facilitate this shift, this chapter offers suggestions for the design community and the technology policy community. In this chapter, I draw upon the analysis of practices and agents that promote and impede anti-surveillance values in design at CENS to suggest how the structure of design laboratories might encourage social values in design. I have organized these structural recommendations into two sections for different stakeholders: *Design Recommendations* for the engineering, computer science and information science communities, and *Policy Recommendations* for social scientists, advocates, and funders.

Design Recommendations: Deploying Values Levers

The first set of recommendations for encouraging social values in design focuses on structuring design laboratories so that values levers can flourish. At CENS, discussion and

action on anti-surveillance values were enabled by two very specific design practices: internal testing and working on interdisciplinary teams, both of which fostered careful attention to the personal data passing through participatory sensing systems. Similarly, discussion and action were encouraged by explicit advocacy by an outside advocate as well as laboratory leaders, and lab rules and procedures designed to materialize the influence of those agents.

Attention to personal data

Attending to collections of personal data as part of design practice was an ongoing challenge at CENS and in computer science design generally. But work practices that facilitate attention to the sensitive data collected in participatory sensing, its meanings, and its potential uses, can encourage anti-surveillance values in design. Internal testing, though insufficient for testing user interfaces, can be a powerful tool for redirecting designer attention to the data. Rewarding students for testing their own software, and that of colleagues, can promote a design culture in which sensitive data is taken seriously. Good data management practices – descriptive metadata, secure storage, and reuse policies – may also be a part of attention to data. Building such data management practices into the work of design is an ongoing challenge (Borgman et al., 2007a; Mayernik et al., 2007). Further work in this area might help to make attention to and interaction with personal data an even more powerful values lever in design.

Encouraging interdisciplinarity

Including statisticians and a social scientist in design at CENS provided a values lever by sparking conversations using the lingua franca of participatory sensing: personal data.

Industrial laboratories have long known that interdisciplinarity can encourage good design; CENS provides a case study in which interdisciplinary encouraged *values* in design.

Interdisciplinarity is a matter of recruiting and hiring a diverse workforce, but also of encouraging sometimes difficult cross-disciplinary conversations, and paying attention to uneven power dynamics between disciplines. Statisticians should be not just consultants brought in for data analysis, but full members of the design team. Social scientists must be welcomed as contributors although they may struggle to understand the intricacies of a system diagram. Giving social scientists, ethicists, or statisticians physical space in the laboratory is an important first step. Just as important is taking their contributions seriously and attempting to reach across lines of hierarchy and privilege by engaging material and perspectives from other disciplines.

Reciprocation for this acceptance is also important: non-coding team members must do work that contributes to the life of the laboratory. For social scientists trained in values concerns and information ethics, operationalizing values in design can be a critical design role. Helping design teams move from abstract values of importance, like privacy or equity, to technological features, was a process of translation well-suited for individuals trained in thinking about the socio-technical nature of design. And such work contributed directly to design, making social values directly useful to design.

Working with users

CENS was fortunate to have an organizational culture that valued client collaboration and user input. Leaders emphasized and approved projects with committed outside partners, and encouraged students to work with those partners. However, the time

and motivational pressures that make participatory design challenging for students indicate that such design practices will continue to face hurdles. If a focus on user-centered or participatory design is critical to deploying values levers in design, more accessible methods that appeal to both designers and user groups will be necessary. Designers must work hard to find a match with users who have the time and interest to invest in the design process. At the same time, users must be open to quirky interfaces, occasional bugs, and technical limitations. And project leaders (as well as administrators and funders) must reduce time pressure on students and accept participatory design as a generator of innovation and not a chore. Funders must also recognize the importance of long-term community-researcher partnerships – a problem in much of participatory research and participatory design (Cargo & Mercer, 2008; Horowitz et al., 2009).

Finding the creativity in the constraints

Laboratories that incorporate user perspectives must allow for a slower design pace in order to foster this element of a critical technical practice. Similarly, it is important to embrace the slower design pace that values constraints sometimes impose on design. Though concerns such as privacy and consent may seem to slow down design progress, they also open spaces for new technical creativity. Recognizing that innovation sometimes comes from constraints is a design philosophy that laboratory leaders and values advocates can encourage on their teams.

Policy Recommendations

Laboratory leaders and embedded values advocates are not the only agents who can have a positive influence on values in design. Policy – whether internal rules adopted by

design laboratories or funding agencies, or national approaches to regulating participatory sensing data – can also affect how participatory sensing technologies are built. In this section, I address two aspects of policy: actions that can be encouraged by funding agencies such as the National Science Foundation and the Defense Advanced Research Projects Agency; and guidelines for both laboratories and national technology policy to enact anti-surveillance values.

Funding values in design

The findings from CENS design suggest recommendations for encouraging values levers using funding mechanisms. Funders interested in promoting values in design might consider setting aside money to support cooperative, user-centered design projects. Creating explicit requirements to cooperate with users, and providing financial backing for the logistics and long-term engagement necessary to make this happen, would be invaluable to opening up public participation in controversial technology design.

Funders can simultaneously encourage disciplinary diversity in design efforts. Supporting proposals that pair computer scientists with statisticians and social scientists can provide a solid foundation for discussion of data and data sensitivity. Funders might also consider funding particularly controversial data collection projects at levels that support larger project teams (including paid staff dedicated at least in part to personal data management) and a sustained, mature design process.

Strengthening organizational norms

Making a critical technical practice part of the organizational norms surrounding design can have an impact on when and how values levers are deployed. Institutionalizing

rules closer to design – closer even than the IRB – may be one important way of taking action. Setting internal policies and design requirements, like those of local control, long-term participation and transparency discussed in the next section, can help to strengthen norms around considering values and ethics as part of design.

Reforming IRBs may be another way of encouraging a critical technical practice. Building review boards that can confidently review the risks of large personal data sets, technological storage, and access requirements, and that can navigate the shifting borders between design and human subjects research, is an area of critical need. Computer scientists have not traditionally served on institutional review boards. But as computer science research increases its scope into human subjects data collection, IRBs will need to incorporate the technical expertise of engineering faculty and data analysis and inference expertise of statistics faculty.

Supporting participatory information values

Funding values in design and reform of IRBs won't be sufficient to ensure that pervasive sensing technologies are built in pro-social ways. This dissertation suggests anti-surveillance values and levers can function as guidelines for developers, but that rules – particularly federal policy – may also be necessary values levers.

National policy could support participatory information principles such as local control, transparency, and long-term participation through a variety of means. Funding open-access, interoperable data vault projects; hosting such vaults; or providing financial and regulatory incentives to encourage vault start-ups could provide support for local control of data. Local control through vault architectures would provide an alternative vision to current

data flow architectures: data stores owned and operated by the same entities that build applications and provide data services. Local control architectures can slow the proliferation of vertically integrated personal data sets, keeping data control separate from companies or governments with interest in mining that data.

National policy could also encourage a lay public understanding of mobile sensing privacy, security and risk. Technology users often underestimate or misunderstand data sharing and security risks (Camp, Asgharpour, Liu, & Bloomington, 2007). Data literacy will become an increasingly important knowledge set as applications for collecting and sharing data proliferate. Policymakers can engage traditional and media, educators, and civic groups to get citizens interested in, and talking about, participatory sensing. This will help to move discussion of data use decisions into the public sphere. Public discussion and debate of social issues engendered in participatory sensing technologies can fortify both individual understanding and democratic decision-making. It can also subject sensing systems to both academic and lay reflection and critique (Calhoun, 2000). This debate might take place in the popular media, or increasingly within online settings and communities of interest. Education reforms – whether in school curricula or job training programs – could also help to improve individuals' *data literacy* – the knowledge needed to interact with and draw conclusions from quantitative data. Fostering such literacy can help participants feel that their data are accessible, and encourage long-term participation with data.

Finally, regulation could mandate accountability and audit mechanisms to help users interpret where their personal data are flowing and who might have access. Audit mechanisms could be as simple as logs that reflect what data a phone or vault has sent to third party applications. A more complete form of feedback could trace the trail of data use

outside the vault. Such a mechanism could begin to address individuals' lack of control once their data have left their phone or vault. This would require third party applications to log sharing or transformation of data back to the vault, according to terms agreed upon when an individual (or the vault on her behalf) contracts with the application. Audit mechanisms might go so far as to require accountability for data use from third party applications. A third party auditor or periodic certification of third parties might serve as an even stricter implementation of accountability (Shilton et al., 2009).

Helping individuals understand the data practices of the participatory sensing services to which they subscribe will also help participants make better sharing decisions. A voluntary or regulated system of application labels could help participants understand levels of risk inherent in location-aware services. If an application adheres to best practice data practices, it might be certified as a "fair data" application. In much the same way that voluntary and regulated labels such as "fair trade" and "organic" increase the transparency of food products for consumers, labeling could help individuals contract with trusted sensing service providers. Best practices might start with the Codes of Fair Information Practice, and grow to include anonymizing data when possible, collecting minimal information, visualizing and explaining data analysis and aggregation procedures, and supporting audit trails and data retention limits.

Conclusion

Surveillance has moved beyond governments and firmly into the private – and now even the participatory – spheres. In his book *Surveillance Society*, Lyon (2001) writes:

> Surveillance is diffusing decisively into society at large, although it should be noted that this does not mean that the capacity to answer back has now exceeded the power of state surveillance upon its citizens (p. 33).

This suggests that, one day, "the capacity to answer back" could be realized. We have not reached that point in 2011, but the emergence of participatory sensing brings us closer to such a possibility.

Though this dissertation has argued that anti-surveillance values *should* be an important part of pervasive data collection design, it does not ask whether such values will be dominant or even prevalent. It focuses on how anti-surveillance values are to be incorporated at all. The conclusions drawn from one academic design laboratory will not hold true for all design situations. This dissertation, with its ethnographic data, cannot argue that values levers *cause* consideration of anti-surveillance values or values-based technological innovation. It cannot rule out other contributing factors. But it does provide a description that points to values levers as an important element in design, and explains how surveillance concerns affect the design of data collection technologies. Values levers have served as necessary (but not sufficient) conditions for anti-surveillance values to be incorporated into CENS design. They may also be generalizable to other pervasive data collection technologies. We should not assume practices that focus designers on personal data, encourage creativity from constraints, integrate user feedback, incorporate advocacy by leadership and the values advocate, and bolster team size and resources are the only, or even the primary, values levers in pervasive sensing design. But there will be comparable values levers in all design settings, and they can be found by paying attention to practices and agents at work in design.

Participatory sensing will coexist with broad data surveillance by corporations and governments, and may be used towards pernicious ends. But with its emphasis on participation and targeted collection, participatory sensing may simultaneously give people their own way to use tools and platforms of surveillance. Participatory sensing, when developed with a focus on anti-surveillance values, can emphasize learning, messiness, and experimentation rather than rigid categories and conformity. As CENS matured and values levers became part of design practice, the lab's projects suggested that pro-social goals were possible. Designers and users began working together and using sufficiently mature technologies to ensure local control of personal data, participation by affected community members, and transparency of the sensing process. The lab's efforts illustrated that laboratory structures and agents can foster interest in anti-surveillance values at the design level, and a willingness to address conditions that can foster pro-social sensing technologies. CENS also demonstrated that the structure of laboratories can help to make anti-surveillance values like privacy, consent, equity and forgetting priorities in design. By fostering interdisciplinary laboratories with strong leadership, good data practices, and values advocates, just and equitable systems can be built by design.

Appendix: Code Definitions

A.1 Academic Status: Category to mark each subject's place in the academic hierarchy.

A.2 Disciplines: Category to mark disciplinary background of subject, as well as subject's primary colleagues.

A.3 Interactions with ethics advocate: Category to describe subject's interactions with the ethics advocate.

Exposure to advocate: Amount of interaction that subject has had with advocate.

Always/seldom/never in meetings.

Frequent/infrequent/no interaction with advocate.

Quality of exposure to advocate: Subject indicates feelings re advocate interactions.

Expresses appreciation/Expresses frustration.

A.4 Institutional ethics: Category to describe subject's interaction with ethical rules imposed by the university.

Exposure to IRB: Amount of interaction subject had w/ IRB procedures.

Frequent/ Some/ None.

Avoidance: Subject has taken steps to avoid dealing with IRB requirements.

Compliance: Subject talks about adhering to the rules laid down by the IRB.

Frustration: Subject expresses frustration with institutional ethical rules.

Institutional mandates: Subject identifies rules that they must follow.

Loopholes: Subject points out ways to get around IRB mandates.

Liability: Subject discusses legal repercussions for not following institutional rules.

Paperwork pipeline: Subject discusses paperwork necessary to comply with IRB.

A.5 Mentorship: Category to describe subject's interaction with bosses, leaders, or other influential figures.

Identifies individual mentor: Who?

Amount of mentorship: How much?

Frequent/infrequent/none

Quality of mentorship: Descriptions of the mentoring relationship.

Conflict between students & mentor: Describes tensions with mentor.

A.6 Internal testing: Category to describe subject's experiences with CENS technologies.

Amount: How frequently the subject has tested CENS technologies.

Frequent/infrequent/none.

Learned from testing: Subject indicates something discovered during testing process.

Normalized tech use: Subject gives example of becoming accustomed to tech feature.

A.7 User and client interaction: Category to describe subject's experiences working with users (consumers of CENS technologies) and clients (collaborators who help plan deployments).

Amount: How frequently has the subject interacted with users or clients?

Frequent/some/none.

Learned from users: Subject indicates something new they learned from a user.

Learning from clients: Subject indicates something new they learned from a client.

A.8 Funding: Category to describe subject's relationship with project funding.

Funding concern: Subject expresses fear of losing funding, or concern with how funding availability affects their project.

Funding source: Subject names sources of project funding.

Resource limitations: Subject discusses limits on physical, financial or human resources.

B.1 Identification of Agency: A category to highlight instances where subjects identify power, action and agency on the part of actors.

Design constraints: Subject identifies limits imposed by the design process.

Designer agency: Subject identifies their power as decision-makers.

Lack of agency: Subject expresses a lack of power or autonomy.

Limits on agency: Subject recognizes constraints on their individual autonomy.

Relinquishes responsibility: Subject doesn't take responsibility for their actions, or assigns responsibility to another agent.

Technological agency: Subject assigns power to a technological system.

Technological limits: Subject recognizes the constraints of a technological system.

Technological optimism: Subject expresses hope or assurance that technology can solve problems.

User agency: Subject identifies the users' power as decision-makers.

B.2 Expressing Ethical Issues: A category to mark subject's identification of or grappling with values or social issues.

Confusion about ethical issues: Subject expresses uncertainty about right, wrong, or social goods.

Consent: Subject discusses gaining permission from users.

Concerns about data control: Subject discusses issues surrounding control of personal data.

Data representation: Subject discusses concerns about how personal data is displayed in system or to users.

Environmental concerns: Subject expresses concern for the environment or environmentalism.

Ethical analogies: Subject draws comparisons between two ethical issues.

Ethical justification: Subject provides a rationale for their behavior based in ethics.

Identifies ethical issue: Subject identifies that an issue they face is one of values, morals or ethics.

Intercultural ethics: Subject identifies issue that might be different in other cultures.

Parsimony: Subject discusses minimal data retention or targeted data collection.

Participation: Subject discusses ways to involve users in the sensing process.

Persistent memory: Subject discusses concerns about, or ideas for, retaining information indefinitely.

Power differences: Subject identifies differences in power between actors in lab, clients, or users.

Privacy: Subject discusses the term privacy or concerns about who can see what data.

Surveillance: Subject discusses concerns about watching others, tracking others, or controlling others through data collection.

Trust: Subject discusses role of trust in users, designers, or systems.

Usability: Subject discusses role of interface, interaction design, or other usability issue.

B.3 Expressing Values: Attitudes: A category to mark statements that indicate personal values that a subject professes to hold or consider during design.

Accessibility: Subject professes to care about user friendliness or legibility.

Behavior change: Subject cares about using data to change a user's behavior.

Choice: Subject professes to care about giving a user or designer choices.

Deadlines: Subject professes to care about academic or lab due dates.

Efficiency: Subject professes to care about working in fastest/most effective way.

Equity: Subject professes to care about equality between people or fairness.

Flexibility: Subject professes to care about system interoperability, changeability, or modularity.

Idealism: Subject expresses belief in an ideal or goal.

Individualism: Subject expresses a belief in the importance of being individual or responsible for own actions.

More data: Subject expresses a belief that collecting large quantities of data will produce new knowledge.

Quantitative data: Subject expresses a belief that collecting quantitative data will produce new knowledge.

Sharing: Subject expresses a belief that free giving and taking of data can produce new knowledge.

Utility: Subject expresses belief that usefulness of product is important.

B.4 Enacting Values: Actions: A category to mark statements that indicate ways that the subject has acted on the values they hold.

Access control: Subject has built mechanisms to control who can see what data.

Creativity: Subject talks about new ideas stemming from values concerns.

Data hiding: Subject talks about ways of scrubbing, altering, or masking data.

Data responsibility: Subject talks about responsiblity for data management.

Data storage: Subject talks about building, maintaining a database or other store.

Data verification: Subject talks about ways to verify veracity or accuracy of data.

Design process: Subject talks about everyday work of building sensing technologies.

Obscuring identifiers: Subject talks about hiding the identity of sensing participants.

B5. Motivations: A category to mark statements that indicate why subjects took the action that they did.

Data purpose: Subject talks about why they are collecting data.

Identifies ethical motivation: Subject talks about taking action on a value.

Reliability: Subject talks about veracity or accuracy of data as a motivation.

Security: Subject talks about safeguarding data as a motivation for their work.

Bibliography

Ackerman, M. S., & Cranor, L. F. (1999). Privacy critics: UI components to safeguard users' privacy. *Conference on Human Factors in Computing Systems CHI'99* (pp. 258-259). ACM Publications.

Acquisti, A., & Grossklags, J. (2008). What can behavioral economics teach us about privacy? *Digital Privacy: Theory, Technologies, and Practices* (pp. 363-377). New York and London: Auerbach Publications.

Agile software development. (2011). *Wikipedia.org*. Online encyclopedia. Retrieved 19:06:22, from http://en.wikipedia.org/wiki/Agile_software_development.

Agrawal, R., & Srikant, R. (2000). Privacy-preserving data mining. *2000 ACM SIGMOD International Conference on Management of Data* (pp. 439-450).

Agre, P. E. (1994). Surveillance and capture: two models of privacy. *The Information Society*, *10*(2), 101-127.

Agre, P. E. (1997a). *Computation and Human Experience*. Cambridge, UK: Cambridge University Press.

Agre, P. E. (1997b). Toward a critical technical practice: lessons learned in trying to reform AI. In G. C. Bowker, L. Gasser, S. L. Star, & B. Turner (Eds.), *Social science, technical systems, and cooperative work: Bridging the great divide*. Hillsboro, NJ: Erlbaum.

Agre, P. E. (1998). Beyond the mirror world: Privacy and the representational practices of computing. *Technology and privacy: The new landscape* (pp. 29-61). Cambridge, MA and London: The MIT Press.

Albrechtslund, A. (2008). Online social networking as participatory surveillance. *First Monday*, *13*(3).

Allen, A. L. (2003). *Why privacy isn't everything: feminist reflections on personal accountability*. Lanham, Boulder, New York and Oxford: Rowman & Littlefield Publishers, Inc.

Altman, I. (1977). Privacy regulation: culturally universal or culturally specific? *Journal of Social Issues*, *33*(3), 66-84.

Andrejevic, M. (2007). *iSpy: surveillance and power in the interactive era*. Lawrence, KS: University Press of Kansas.

Angus, A., Papadogkonas, D., Papamarkos, G., Roussos, G., Lane, G., Martin, K., West, N., et al. (2008). Urban social tapestries. *Pervasive Computing, IEEE*, *7*(4), 44-51.

Anthony, D., Kotz, D., & Henderson, T. (2007). Privacy in location-aware computing environments. *Pervasive Computing*, *6*(4), 64-72.

Babbie, E. (2007). *The Practice of Social Research* (Vol. 11). Belmont, CA: Wadsworth.

Bandura, A. (1977). *Social learning theory*. New York: General Learning Press.

Bannon, L. (2006). Forgetting as a feature, not a bug: the duality of memory and implications for ubiquitous computing. *CoDesign*, *2*(1), 3-15.

Bell, Genevieve. (2006). No More SMS from Jesus: Ubicomp, Religion and Techno-spiritual Practices. In P. Dourish & A. Friday (Eds.), *UbiComp 2006: Ubiquitous Computing* (Vol. 4206, pp. 141-158).

Bell, Gordon, & Gemmell, J. (2007). A digital life. *Scientific American*, (March), 58-65.

Bell, Gordon, Hey, T., & Szalay, A. (2009). Beyond the data deluge. *Science*, *323*(5919), 1297-1298.

Bellotti, V. (1998). Design for privacy in multimedia computing and communications environments. *Technology and privacy: The new landscape* (pp. 63-98). Cambridge, MA and London: The MIT Press.

Beniger, J. (1986). *The Control Revolution: Technological and Economic Origins of the Information Society*. Cambridge, MA and London: Harvard University Press.

Berman, F. (2008). Got data?: a guide to data preservation in the information age. *Communications of the ACM*, *51*(12), 50-56.

Blanchette, J.-F., & Johnson, D. G. (2002). Data retention and the panoptic society: the social benefits of forgetfulness. *The Information Society*, *18*(33-45).

Boast, R., Bravo, M., & Srinivasan, R. (2007). Return to Babel: emergent diversity, digital resources, and local knowledge. *The Information Society*, *23*(5), 395-403.

Boles, F. (1991). *Archival Appraisal*. New York and London: Neal-Schuman Publishers, Inc.

Borgman, C. L. (2007). *Scholarship in the digital age: information, infrastructure, and the internet*. Cambridge, MA and London: The MIT Press.

Borgman, C. L., Wallis, J. C., & Enyedy, N. (2007). Little science confronts the data deluge: habit ecology, embedded sensor networks, and digital libraries. *International Journal on Digital Libraries*, *7*(1-2), 17-30.

Borgman, C. L., Wallis, J. C., Mayernik, M. S., & Pepe, A. (2007). Drowning in data: digital library architecture to support scientific use of embedded sensor networks. *ACM/IEEE Joint Conference on Digital Libraries 2007*. Presented at the ACM/IEEE Joint Conference on Digital Libraries 2007, Vancouver, BC.

Bowker, G. C., & Star, S. L. (2000). *Sorting Things Out: Classification and Its Consequences*. Cambridge, MA and London: The MIT Press.

Braman, S. (2006). *Change of state: information, policy, and power*. Cambridge, MA and London: The MIT Press.

Brunton, F., & Nissenbaum, H. (2011). Vernacular resistance to data collection and analysis: a political theory of obfuscation. *First Monday*, *16*(5). Retrieved from http://firstmonday.org/htbin/cgiwrap/bin/ojs/index.php/fm/article/view/3493/2955.

Buchanan, T., Paine, C., Joinson, A. N., & Reips, U.-D. (2007). Development of Measures of Online Privacy Concern and Protection for Use on the Internet. *Journal of the American Society for Information Science and Technology*, *58*(2), 157-165.

van der Burg, S. (2009). Imagining the Future of Photoacoustic Mammography. *Science and Engineering Ethics*, *15*(1), 97-110.

Burke, J., Estrin, D., Hansen, M., Parker, A., Ramanathan, N., Reddy, S., & Srivastava, M. B. (2006). Participatory sensing. *World Sensor Web Workshop*. Presented at the World Sensor Web Workshop, Boulder, CO: ACM.

Burkert, H. (1998). Privacy-enhancing technologies: Typology, critique, vision. *Technology and privacy: The new landscape* (pp. 125-142). Cambridge, MA and London: The MIT Press.

Byrne, E., & Alexander, P. M. (2006). Questions of ethics: Participatory information systems research in community settings. *Proceedings of the 2006 annual research conference of the South African institute of computer scientists and information technologists on IT research in developing countries* (pp. 117-126). Somerset West, South Africa: South African Institute for Computer Scientists and Information Technologists.

Calhoun, C. (2000). Social theory and the public sphere. *The Blackwell Companion to Social Theory* (Second., pp. 505-544). Malden, MA: Blackwell Publishing.

Camp, L. J., Asgharpour, F., Liu, D., & Bloomington, I. N. (2007). Experimental evaluations of expert and non-expert computer users' mental models of security risks. *Proceedings of WEIS 2007*. Presented at the WEIS 2007, Pittsburgh, PA.

Camp, L. J., & Connelly, K. (2008). Beyond consent: privacy in ubiquitous computing (Ubicomp). *Digital Privacy: Theory, Technologies, and Practices* (pp. 327-343). New York and London: Auerbach Publications.

Campbell, A. T., Eisenman, S. B., Lane, N. D., Miluzzo, E., & Peterson, R. A. (2006). People-centric urban sensing. *Proceedings of the 2nd annual international workshop on Wireless internet*. Boston, MA: ACM.

Capurro, R. (2007). Intercultural Information Ethics. *Localizing the Internet. Ethical Issues in Intercultural Perspective*. (Vol. 4, pp. 21-38). Munich: Fink.

Capurro, R. (2005). Privacy. An Intercultural Perspective. *Ethics and Information Technology*, *7*, 37-47.

Cargo, M., & Mercer, S. L. (2008). The Value and Challenges of Participatory Research: Strengthening Its Practice. *Annual Review of Public Health*, *29*, 325-350.

Carmichael, A. (2010, April 5). Why I stopped tracking. *The Quantified Self*. Weblog, . Retrieved August 22, 2010, from http://www.kk.org/quantifiedself/2010/04/why-i-stopped-tracking.php.

Carroll, J. M. (2003). *HCI Models, Theories, and Frameworks: Toward a Multidisciplinary Science* (1st ed.). San Francisco, CA: Morgan Kaufmann.

Castells, M. (1999). Flows, Networks, and Identities: A Critical Theory of the Informational Society. *Critical education in the new information age*. Lanham, MD: Rowman & Littlefield Publishers, Inc.

Catalani, C., & Minkler, M. (2009). Photovoice: A review of the literature in health and public health. *Health Educ Behav, 37*(3), 424-51.

Cheng, J. (2011, April 21). How Apple tracks your location without consent, and why it matters. *ars technica*. Blog. Retrieved April 23, 2011, from http://arstechnica.com/apple/news/2011/04/how-apple-tracks-your-location-without-your-consent-and-why-it-matters.ars.

Cohen, J. E. (2008). Privacy, Visibility, Transparency, and Exposure. *University of Chicago Law Review*, *75*(1), 181-201.

Collier, S. J., & Lakoff, A. (2005). On regimes of living. In A. Ong & S. J. Collier (Eds.), *Global assemblages: technology, politics and ethics as anthropological problems* (pp. 22-39). Malden, MA: Blackwell Publishing.

Cook, T. (1991). *The archival appraisal of records containing personal information: A RAMP study with guidelines*. Paris: General Information Programme, United Nations Educational, Scientific and Cultural Organization.

Cooke, B., & Kothari, U. (2001). *Participation: the New Tyranny?* London and New York: Zed Books.

Corburn, J. (2003). Bringing local knowledge into environmental decision making: Improving urban planning for communities at risk. *Journal of Planning Education and Research*, *22*, 120-133.

Cuff, D., Hansen, M., & Kang, J. (2008). Urban sensing: out of the woods. *Communications of the ACM*, *51*(3), 24-33.

Curry, M. R., Phillips, D. J., & Regan, P. M. (2004). Emergency response systems and the creeping legibility of people and places. *The Information Society*, *20*, 357-369.

Dearden, A., Lauener, A., Slack, F., Roast, C., & Cassidy, S. (2006). Make it so! Jean-Luc Picard, Bart Simpson and the design of e-public services. *Proceedings of the ninth conference on participatory design: Expanding boundaries in design*, *1*, 67-76.

Dodge, M., & Kitchin, R. (2007). "Outlines of a world coming into existence": pervasive computing and the ethics of forgetting. *Environment and Planning B: Planning and Design*, *34*(3), 431-445.

Dodson, S. (2003, October 9). The internet of things. *The Guardian*. Retrieved from http://www.guardian.co.uk/technology/2003/oct/09/shopping.newmedia

Donner, J., Verclas, K., & Toyama, K. (2008). *Reflections on MobileActive 2008 and the M4D Landscape*. MobileActive.org and Microsoft Research India. Retrieved from http://mobileactive.org/files/DVT_M4D_choices_final.pdf.

Dourish, P. (2001). *Where the action is: the foundations of embodied interaction*. Cambridge, MA and London: The MIT Press.

Eagle, N. (2008). Behavioral Inference across Cultures: Using Telephones as a Cultural Lens. *Intelligent Systems, IEEE*, *23*(4), 62-64.

Eisenman, S. B., Lane, N. D., Miluzzo, E., Peterson, R. A., Ahn, G. S., & Campbell, A. T. (2006). MetroSense Project: People-Centric Sensing at Scale. *Proceedings of the ACM Sensys World Sensor Web Workshop*. Presented at the ACM Sensys World Sensor Web Workshop, Boulder, CO: ACM.

Eisenman, S. B., Miluzzo, E., Lane, N. D., Peterson, R. A., Ahn, G. S., & Campbell, A. T. (2007). The BikeNet mobile sensing system for cyclist experience mapping. *Proceedings of the 5th international conference on Embedded networked sensor systems* (pp. 87-

101). Presented at the 5th international conference on Embedded networked sensor systems, ACM.

Elwood, S. (2006). Critical issues in participatory GIS: Deconstructions, reconstructions, and new research directions. *Transactions in GIS*, *10*(5), 693-708.

Ernst, W. (2002). Beyond the Rhetoric of Panopticism: Surveillance as Cybernetics. *CTRL [SPACE]: Rhetorics of Surveillance from Bentham to Big Brother* (pp. 460-463). Cambridge, MA and London: The MIT Press.

Ess, C. (2009). *Digital media ethics*. Cambridge, UK and Malden, MA: Polity Press.

Federal Communications Commission. (n.d.). 9-1-1 Service. *Public Safety and Homeland Security Bureau*. Retrieved April 13, 2009, from http://www.fcc.gov/pshs/services/911-services/.

Fienberg, S. E. (2006). Privacy and confidentiality in an e-commerce world: Data mining, data warehousing, matching and disclosure limitation. *Statistical Science*, *21*(2), 143-154.

Fire Eagle. (n.d.). . Retrieved April 12, 2009, from http://fireeagle.yahoo.net/.

Fish, A., Murillo, L. F. R., Nguyen, L., Panofsky, A., & Kelty, C. M. (2011). Birds of the internet - towards a field guide to the organization and governance of participation. *Journal of Cultural Economy*, *4*(2), 157-187.

Fisher, E. (2007). Ethnographic Invention: Probing the Capacity of Laboratory Decisions. *NanoEthics*, *1*(2), 155-165.

Forsythe, D. E. (2002). *Studying Those Who Study Us: An Anthropologist in the World of Artificial Intelligence* (1st ed.). Palo Alto, CA: Stanford University Press.

Foster, I., Kesselman, C., & Tuecke, S. (2001). The Anatomy of the Grid: Enabling Scalable Virtual Organizations. *International Journal of High Performance Computing Applications*, *15*(3), 200 -222.

Foucault, M. (1979). *Discipline and Punish: The Birth of the Prison*. New York: Vintage Books.

Foucault, M. (2002). The Eye of Power: A Conversation with Jean-Pierre Barou and Michelle Perrot. *CTRL [SPACE]: Rhetorics of Surveillance from Bentham to Big Brother* (pp. 94-101). Cambridge, MA and London: The MIT Press.

Foucault, M. (2007). *Security, Territory, Population: Lectures at the College de France 1977--1978* (1st ed.). New York: Picador.

Franklin, S., & Roberts, C. (2006). *Born and Made: An Ethnography of Preimplantation Genetic Diagnosis*. Princeton, N.J. and Oxford: Princeton University Press.

Freiwald, S., & Swire, P. (2009, April 17). Phone Tracking Should Require a Warrant. *ACSBlog: The Blog of the American Constitution Society*. Retrieved April 21, 2009, from http://www.acsblog.org/ip-and-tech-law-phone-tracking-should-require-a-warrant.html.

Friedman, B. (Ed.). (1997). *Human values and the design of computer technology*. CSLI Lecture Notes. Cambridge and New York: Cambridge University Press.

Friedman, B., Kahn, P. H., Hagman, J., & Severson, R. L. (2006). The watcher and the watched: Social judgments about privacy in a public place. *Human-Computer Interaction*, *21*, 235-272.

Friedman, B., Kahn, P. H., & Borning, A. (2006). Value sensitive design and information systems. In D. Galletta & P. Zhang (Eds.), *Human-Computer Interaction and Management Information Systems: Applications* (Vol. 6). New York: M.E. Sharpe.

Friedman, B., & Nissenbaum, H. (1997). Bias in computer systems. In B. Friedman (Ed.), *Human values and the design of computer technology* (pp. 21-40). Cambridge and New York: Cambridge University Press.

Frikken, K. B., & Atallah, M. J. (2004). Privacy preserving route planning. *Proceedings of the 2004 ACM workshop on privacy in the electronic society* (pp. 8-15). Presented at the 2004 ACM workshop on Privacy in the electronic society, Washington DC, USA: ACM.

Galloway, P. (2004). Preservation of digital objects. *Annual Review of Information Science and Technology*, *38*, 549-590.

Gandy, O. H. (1993). *The Panoptic Sort: A Political Economy of Personal Information*. Boulder, CO: Westview Press.

Ganti, R. K., Pham, N., Tsai, Y.-E., & Abdelzaher, T. F. (2008). PoolView: stream privacy for grassroots participatory sensing. *Proceedings of the 6th ACM conference on embedded network sensor systems* (pp. 281-294). Raleigh, NC, USA: ACM.

Gillespie, T. L. (2010). The politics of "platforms." *New Media & Society*, *12*(3).

Girard, M., & Stark, D. (2005). Heterarchies of value: distributing intelligence and organizing diversity in a new media startup. In A. Ong & S. J. Collier (Eds.), *Global assemblages: technology, politics and ethics as anthropological problems* (pp. 293-319). Malden, MA: Blackwell Publishing.

Goldberg, I. (2008). Privacy-Enhancing Technologies for the Internet III: Ten Years Later. In A. Acquisti, S. Gritzalis, & C. Lambrinoudakis, Sabrina de Capitani di Vimercati (Eds.), *Digital Privacy: Theory, Technologies, and Practices* (pp. 3-18). New York and London: Auerbach Publications.

Goldman, J., Shilton, K., Burke, J., Estrin, D., Hansen, M., Ramanathan, N., Reddy, S., et al. (2009). *Participatory Sensing: A citizen-powered approach to illuminating the patterns that shape our world*. Washington, DC: Woodrow Wilson International Center for Scholars.

Google Latitude. (n.d.). Retrieved April 12, 2009, from http://www.google.com/latitude/intro.html.

Gould, J. D., & Lewis, C. (1985). Designing for usability: key principles and what designers think. *Communications of the ACM*, *28*(3), 300-311.

Great Backyard Bird Count. (n.d.). Retrieved April 15, 2009, from http://www.birdsource.org/gbbc/.

Green, N. (2009). Mobility, memory, and identity. In G. Goggin & L. Hjorth (Eds.), *Mobile technologies: from telecommunications to media* (pp. 266-281). New York and London: Routledge.

Green, N., & Smith, S. (2004). "A spy in your pocket"? The regulation of mobile data in the UK. *Surveillance & Society*, *1*(4), 573-587.

Gregory, J. (2003). Scandinavian Approaches to Participatory Design. *International Journal of Engineering Education*, *19*(1), 62-74.

Guston, D. H., & Sarewitz, D. (2002). Real-time technology assessment. *Technology in Society*, *24*(1-2), 93-109.

Hara, N., & Rosenbaum, H. (2008). Revising the Conceptualization of Computerization Movements. *The Information Society*, *24*(4), 229-245.

Hayes, B. (2008). Cloud computing. *Communications of the ACM*, *51*(7), 9-11.

Hayes, G. R., Abowd, G., Davis, J., Blount, M., Ebling, M., & Mynatt, E. (2008). Opportunities for Pervasive Computing in Chronic Cancer Care. *Pervasive Computing*

2008, Lecture Notes in Computer Science (Vol. 5013, pp. 262-279). Heidelburg: Springer-Verlag.

Hayes, G. R., Poole, E. S., Iachello, G., Patel, S. N., Grimes, A., Abowd, G., & Truong, K. N. (2007). Physical, social and experiential knowledge in pervasive computing environments. *Pervasive Computing*, *6*(4), 56-63.

Hayles, N. K. (1999). *How We Became Posthuman: Virtual Bodies in Cybernetics, Literature, and Informatics* (1st ed.). Chicago & London: University Of Chicago Press.

Herkert, J. (2001). Future directions in engineering ethics research: Microethics, macroethics and the role of professional societies. *Science and Engineering Ethics*, *7*(3), 403-414.

Hey, T., & Trefethen, A. E. (2005). Cyberinfrastructure for e-Science. *Science*, *308*(5723), 817-821.

Hollander, R. (2001). Mentoring and ethical beliefs in graduate education in science. *Science and Engineering Ethics*, *7*(4), 521-524.

Hong, J., & Satyanarayanan, M. (2007). Security & privacy. *Pervasive Computing*, *6*(4), 15-17.

Horowitz, C. R., Robinson, M., & Seifer, S. (2009). Community-Based Participatory Research From the Margin to the Mainstream: Are Researchers Prepared? *Circulation*, *119*, 2633-2642.

Huey, L., Walby, K., & Doyle, A. (2006). Cop watching in the downtown Eastside. *Surveillance and Security: Technological Politics and Power in Everyday Life* (pp. 149-165). New York and London: Routledge.

Iachello, G., & Hong, J. (2007). End-user privacy in human-computer interaction. *Foundations and Trends in Human-Computer Interaction*, *1*(1), 1-137.

Iachello, G., Smith, I., Consolvo, S., Chen, M., & Abowd, G. (2005). Developing privacy guidelines for social location disclosure applications and services. *Proceedings of the 2005 symposium on Usable privacy and security* (pp. 65-76). Pittsburgh, Pennsylvania: ACM.

Institute for Applied Autonomy. (2006). Defensive surveillance: Lessons from the Republican National Convention. *Surveillance and security: Technological politics and power in everyday life* (pp. 167-174). New York and London: Routledge.

John, L. K., Acquisti, A., & Loewenstein, G. (2009). *The Best of Strangers: Context Dependent Willingness to Divulge Personal Information* (Working Paper). Pittsburgh, PA: Carnegie Mellon University. Retrieved from http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1430482.

Johnson, D. G. (2000). *Computer Ethics* (3rd ed.). Upper Saddle River, NJ: Prentice Hall.

Johnson, D. G. (2007). Ethics and Technology "in the Making": An Essay on the Challenge of Nanoethics. *NanoEthics*, *1*(1), 21-30.

Johnson, D. G., & Wetmore, J. M. (Eds.). (2008). *Technology and Society: Building Our Sociotechnical Future*. Cambridge, MA and London: The MIT Press.

Joseph, A. D. (2007). Works in progress: security and privacy in pervasive computing. *Pervasive Computing*, *6*(4), 73-75.

Kang, J. (1998). Privacy in cyberspace transactions. *Stanford Law Review*, *50*, 1193-1294.

Kang, J., & Cuff, D. (2005). Pervasive Computing: Embedding the Public Sphere. *Washington and Lee Law Review*, *65*, 93-146.

Kelty, C. M. (2008). *Two Bits: The Cultural Significance of Free Software*. Durham, NC: Duke University Press.

Kensing, F., & Blomberg, J. (1998). Participatory Design: Issues and Concerns. *Computer Supported Cooperative Work (CSCW)*, *7*(3), 167-185.

Ketelaar, E. (2002). Archival Temples, Archival Prisons: Modes of Power and Protection. *Archival Science*, *2*, 221-238.

Khan, V.-J., & Markopoulos, P. (2009). Busy families' awareness needs. *International Journal of Human-Computer Studies*, *67*(2), 139-153.

Kinkade, S., & Verclas, K. (2008). *Wireless Technology for Social Change: Trends in Mobile Use by NGOs*. Washington, DC and Berkshire, UK: The UN Foundation - Vodafone Group Foundation Partnership.

Kling, R., & Iacono, S. (1988). The mobilization of support for computerization: the role of computerization movements. *Social Problems*, *35*(3), 226-243.

Knorr Cetina, K. (1999). *Epistemic Cultures: How the Sciences Make Knowledge*. Cambridge, MA: Harvard University Press.

Krause, A., Guestrin, C., Gupta, A., & Kleinberg, J. (2006). Near-optimal sensor placements: maximizing information while minimizing communication cost. *Proceedings of the 5th international conference on information processing in sensor networks* (pp. 2-10). Nashville, Tennessee, USA: ACM.

Landecker, H. (2007). *Culturing Life: How Cells Became Technologies*. Cambridge, MA and London: Harvard University Press.

Lange, P. G. (2007). Publicly private and privately public: Social networking on YouTube. *Journal of Computer-Mediated Communication*, *13*(1).

Lassiter, L. E. (2005). *The Chicago Guide to Collaborative Ethnography*. Chicago & London: The University of Chicago Press.

Latour, B. (1991). Technology is society made durable. In J. Law (Ed.), *A sociology of monsters: Essays on power, technology, and domination* (pp. 103-131). London and New York: Routledge.

Latour, B. (2007). *Reassembling the Social: An Introduction to Actor-Network-Theory*. Oxford, UK: Oxford University Press.

Latour, B. (2008). A cautious prometheus? A few steps toward a philosophy of design (with special attention to Peter Sloterdijk). In F. Hackne, J. Glynne, & V. Minto (Eds.), *Proceedings of the 2008 Annual International Conference of the Design History Society* (pp. 2-10). Presented at the 2008 Annual international Conference of the Design History Society, Falmouth, UK: Universal Publications.

Latour, B., & Woolgar, S. (1979). *Laboratory Life: The Social Construction of Scientific Facts*. Princeton, N.J. Princeton University Press.

Lenhart, A., & Madden, M. (2007). *Teens, Privacy and SNS*. Washington, DC: Pew Internet & American Life Project.

Lessig, L., & McChesney, R. W. (2006, June 8). No Tolls on the Internet. *The Washington Post*, A23.

Lievrouw, L.A., & Farb, S. E. (2003). Information and Social Equity. *Annual Review of Information Science and Technology* (pp. 499-540). 37: Information Today.

Lievrouw, L. A. (1989). The invisible college reconsidered: bibliometrics and the development of scientific communication theory. *Communication Research*, *16*(5), 615-628.

Lofland, J., Snow, D., Anderson, L., & Lofland, L. H. (2006). *Analyzing Social Settings: A Guide to Qualitative Observation and Analysis*. Belmont, CA: Wadsworth/Thomson Learning.

Los, M. (2006). Looking into the future: surveillance, globalization and the totalitarian potential. In D. Lyon (Ed.), *Theorizing Surveillance: The panopticon and beyond* (pp. 69-94). Devon, UK: Willan Publishing.

Love, S. (2005). *Understanding Mobile Human-Computer Interaction (Information Systems Series)*. Amsterdam and Boston: Butterworth-Heinemann.

Luebke, D. M., & Milton, S. (1994). Locating the victim: An overview of census-taking, tabulation technology, and persecution in Nazi Germany. *IEEE Annals of the History of Computing*, *16*(3), 25-39.

Lyon, D. (2001). *Surveillance Society* (1st ed.). Buckingham and Philadelphia: Open University Press.

Madden, M., Fox, S., Smith, A., & Vitak, J. (2007). *Digital footprints: online identity management and search in the age of transparency*. Washington, DC: Pew Internet & American Life Project.

Mahoney, M. S. (2004). Finding a history for software engineering. *Annals of the History of Computing*, *26*(1), 8-19.

Manders-Huits, N., & Zimmer, M. (2009). Values and pragmatic action: the challenges of introducing ethical intelligence in technical and design communities. *International Review of Information Ethics*, *10*, 37-44.

Markey, E. (2011, April 21). Letter from Congressman Markey to Steve Jobs. Retrieved from http://markey.house.gov/docs/apple_ios_letter_04.21.11.pdf.

Marx, G. T. (1998). Ethics for the new surveillance. *The Information Society*, *14*, 171-185.

Marx, G. T. (2002). What's new about the "new surveillance"? Classifying for change and continuity. *Surveillance & Society*, *1*(1), 9-29.

Marx, G. T. (2006a). On privacy. *Progressive Librarian*, (27), 23-31.

Marx, G. T. (2006b). Soft surveillance: The growth of mandatory volunteerism in collecting personal information--"Hey Buddy Can You Spare a DNA?" In T. Monahan (Ed.), *Surveillance and Security: Technological Politics and Power in Everyday Life* (pp. 37-56). New York and London: Routledge.

Mayer-Schoenberger, V. (2007). *Useful void: the art of forgetting in the age of ubiquitous computing* (Working Paper No. RWP07-022). Cambridge, MA: Harvard University.

Mayernik, M. S., Wallis, J. C., Borgman, C. L., & Pepe, A. (2007). Adding context to content: The CENS deployment center. *Annual Meeting of the American Society for Information Science & Technology*. Presented at the Annual Meeting of the American Society for Information Science & Technology, Milwaukee, WI.

McGregor, J., & Wetmore, J. M. (2009). Researching and teaching the ethics and social implications of emerging technologies in the laboratory. *NanoEthics*, *3*(1), 17-30.

McKemmish, S., Gilliland-Swetland, A., & Ketelaar, E. (2005). "Communities of memory": pluralising archival research and education agendas. *Archives & Manuscripts*, *33*(1), 146-174.

Medina, E. (2006). Designing freedom, regulating a nation: socialist cybernetics in Allende's Chile. *Journal of Latin American Studies*, *38*, 571-606.

Miluzzo, E., Lane, N. D., Eisenman, S. B., & Campbell, A. T. (2007). CenceMe - Injecting Sensing Presence into Social Networking Applications. *Lecture Notes in Computer Science*, *4793*, 1-28.

Monahan, T. (2006a). Questioning surveillance and security. *Surveillance and Security: Technological Politics and Power in Everyday Life* (pp. 1-23). New York and London: Routledge.

Monahan, T. (2006b). Counter-surveillance as Political Intervention? *Social Semiotics*, *16*(4), 515-534.

Monahan, T. (Ed.). (2006c). *Surveillance and security: Technological politics and power in everyday life*. New York and London: Routledge.

Monash University School of Information Management and Systems. (2006, June 16). Trust and Technology Project: Building archival systems for Indigenous oral memory. Retrieved from http://www.sims.monash.edu.au/research/eirg/trust.

Muller, M. J. (2003). Participatory design: the third space in HCI. *Handbook of HCI*. Mahway, NJ: Erlbaum.

Mun, M., Estrin, D., Burke, J., & Hansen, M. (2008). Parsimonious mobility classification using GSM and Wi-Fi traces. *Proceedings of the Fifth Workshop on Embedded Networked Sensors (HotEmNets)*. Presented at the Fifth Workshop on Embedded Networked Sensors (HotEmNets), Charlottesville, VA.

Mun, M., Reddy, S., Shilton, K., Yau, N., Boda, P., Burke, J., Estrin, D., et al. (2009). PEIR, the personal environmental impact report, as a platform for participatory sensing systems research. *Proceedings of the International Conference on Mobile Systems, Applications,*

and Services. Presented at the International Conference on Mobile Systems, Applications, and Services, Krakow, Poland.

Nguyen, D. H., & Mynatt, E. (2002). *Privacy mirrors: understanding and shaping socio-technical ubiquitous computing systems*. Georgia Institute of Technology.

Nieusma, D. (2004). Alternative Design Scholarship: Working Toward Appropriate Design. *Design Issues*, *20*(3), 13-24.

Nissenbaum, H. (1998). Protecting Privacy in an Information Age: The Problem of Privacy in Public. *Law and Philosophy*, *17*(5-6), 559-596.

Nissenbaum, H. (2004). Privacy as contextual integrity. *Washington Law Review*, *79*(1), 119–158.

Nissenbaum, H. (2009). *Privacy in Context: Technology, Policy, and the Integrity of Social Life.* Stanford, CA: Stanford Law Books.

Nokoscope. (n.d.). Retrieved April 20, 2009, from https://dev.nokoscope.com/eb2/.

Novobilski, A. (2002). Pervasive/Invasive Computing; Two sides of the location-enabled coin. *Proceedings of the International Conference on Parallel and Distributed Processing Techniques and Applications* (Vol. 3, pp. 1063-1067). Presented at the International Conference on Parallel and Distributed Processing Techniques and Applications, CSREA Press.

Nuechterlein, J. E., & Weiser, P. J. (2005). *Digital Crossroads: American Telecommunications Policy in the Internet Age*. Cambridge, MA and London: The MIT Press.

Office for Protection of Research Subjects. (2007, March 30). UCLA Investigator's Manual for the Protection of Human Subjects. Retrieved from http://www.oprs.ucla.edu/human/manual/TOC.

Office of the Secretary of the National Commission for the Protection of Human Subjects of Biomedical and Behavioral Research. (1979). *The Belmont Report: Ethical Principles and Guidelines for the Protection of Human Subjects of Research*. Department of Health, Education, and Welfare.

Ottinger, G. (In press). From providing solutions to participating in problem solving: transforming engineering identities through undergraduate EJ projects. *Technoscience, Environmental Justice, and the Spaces Between: Transforming Expert Cultures through Grassroots Engagement*. MIT Press.

Palen, L., & Dourish, P. (2003). Unpacking "privacy" for a networked world. *CHI 2003* (Vol. 5, pp. 129-136). Ft. Lauderdale, FL: ACM.

Perlman, R. (2005). *The Ephemerizer: making data disappear* (Technical Report No. TR-2005-140). Boston, MA: Sun Microsystems Labs.

Perry, J., Macken, E., Scott, N., & McKinley, J. L. (1997). Disability, inability and cyberspace. In B. Friedman (Ed.), *Human values and the design of computer technology* (pp. 65-89). Cambridge and New York: Cambridge University Press.

Personal Privacy in an Information Society: The Report of the Privacy Protection Study Commission. (1977). Retrieved from http://epic.org/privacy/ppsc1977report/.

Personal data: the emergence of a new asset class. (2011). Geneva, Switzerland: World Economic Forum. Retrieved from http://www3.weforum.org/docs/WEF_ITTC_PersonalDataNewAsset_Report_2011.pdf.

Philip, K., Irani, L., & Dourish, P. (2010). Postcolonial Computing: A Tactical Survey. *Science, Technology & Human Values*.

Phillips, D. J. (2002). Negotiation the digital closet: online pseudonyms and the politics of sexual identity. *Information, Communication & Society*, *5*(3).

Phillips, D. J. (2003). Beyond privacy: Confronting locational surveillance in wireless communication. *Communication Law and Policy*, *8*(1), 1-23.

Phillips, D. J. (2004). Privacy policy and PETs: the influence of policy regimes on the development and social implications of privacy enhancing technologies. *New Media & Society*, *6*(6), 691-706.

Phillips, D. J. (2005a). From privacy to visibility: context, identity, and power in ubiquitous computing environments. *Social Text*, *23*(2), 95-108.

Phillips, D. J. (2005b). Texas 9-1-1: Emergency telecommunications and the genesis of surveillance infrastructure. *Telecommunications Policy*, *29*(11), 843-856.

Pinch, T. J., & Bijker, W. E. (1984). The Social Construction of Facts and Artefacts: or How the Sociology of Science and the Sociology of Technology might Benefit Each Other. *Social Studies of Science*, *14*(3), 399-441.

Pinch, T. J., & Bijker, W. E. (1989). The social construction of facts and artifacts: or how the sociology of science and the sociology of technology might benefit each other. *The Social Construction of Technological Systems*. Cambridge, MA and London: The MIT Press.

Rabinow, P., & Bennett, G. (2008). *Ars Synthetica: Designs for Human Practice*. Houston, TX: Rice University Connexions web site. Retrieved from http://cnx.org/content/col10612/1.2/.

Raento, M., & Oulasvirta, A. (2008). Designing for privacy and self-presentation in social awareness. *Personal and Ubiquitous Computing, 12*, 527–542.

Rambaldi, G., Chambers, R., McCall, M., & Fox, J. (2006). Practical ethics for PGIS practitioners, facilitators, technology intermediaries and researchers. *Participatory Learning and Action*, *54*(April), 106-113.

Reddy, S., Shilton, K., Burke, J., Estrin, D., Hansen, M., & Srivastava, M. B. (2008). Evaluating Participation and Performance in Participatory Sensing. *UrbanSense Workshop, SenSys 2008*. Presented at the Sensys, Raleigh, NC, USA: ACM.

Reddy, S., Shilton, K., Denisov, G., Cenizal, C., Estrin, D., & Srivastava, M. (2010). Biketastic: Sensing and Mapping for Better Biking. *ACM Conference on Human Factors in Computing Systems (CHI)*. Presented at the ACM Conference on Human Factors in Computing Systems (CHI), Atlanta, GA: ACM.

Roberts, S. (2004). Self-experimentation as a source of new ideas: Ten examples about sleep, mood, health, and weight. *Behavioral and Brain Sciences*, *27*(2), 227-288.

Rule, J. B. (2004). Toward strong privacy. *University of Toronto Law Journal*, *54*(2), 183-225.

SETI@home. (n.d.). Retrieved April 15, 2009, from http://setiathome.ssl.berkeley.edu/.

Schuler, D., & Namioka, A. (1993). *Participatory Design: Principles and Practices*. Hillsdale, NJ: Lawrence Erlbaum Associates.

Shapiro, S. (1998). Places and spaces: the historical interaction of technology, home, and privacy. *The Information Society*, *14*(4), 275.

Sheehan, K. B. (2002). Toward a typology of internet users and online privacy concerns. *The Information Society*, *18*(1), 21-32.

Shilton, K., Burke, J., Estrin, D., Hansen, M., & Srivastava, M. B. (2008). *Achieving participatory privacy regulation: guidelines for CENS urban sensing* (Technical Report). Los

Angeles, CA: Center for Embedded Networked Sensing, UCLA. Retrieved from http://escholarship.org/uc/item/7617924b.

Shilton, K., Burke, J., Estrin, D., Hansen, M., Govindan, R., & Kang, J. (2009). Designing the Personal Data Stream: Enabling Participatory Privacy in Mobile Personal Sensing. *The 37th Research Conference on Communication, Information and Internet Policy (TPRC)*. Presented at the The 37th Research Conference on Communication, Information and Internet Policy (TPRC), Arlington, VA.

Shilton, K., Burke, J., Estrin, D., Hansen, M., & Srivastava, M. (2008). Participatory privacy in urban sensing. Presented at the MODUS 2008, St. Louis, Missouri.

Shilton, K., Ramanathan, N., Reddy, S., Samanta, V., Burke, J., Estrin, D., Hansen, M., et al. (2008). Participatory design of sensing networks. *Proceedings of the 10th Conference on Participatory Design* (Vol. II). Presented at the PDC 08, Bloomington, IN: ACM.

Shilton, K., & Srinivasan, R. (2007). Participatory Appraisal and Arrangement for Multicultural Archival Collections. *Archivaria*, *63*, 87-101.

Shneiderman, B., & Plaisant, C. (2005). *Designing the user interface: strategies for effective human-computer interaction* (Fourth.). Boston, MA: Pearson Addison-Wesley.

Singh, M. (2009, March 7). Why is deep packet inspection (DPI) essential for wireless networks? *Mobile Handset DesignLine*. Retrieved April 12, 2009, from http://www.mobilehandsetdesignline.com/215801091?printableArticle=true.

Sismondo, S. (2004). *An Introduction to Science and Technology Studies*. Malden, MA: Blackwell.

Souza, C. de, Froehlich, J., & Dourish, P. (2005). Seeking the source: software source code as a social and technical artifact. *Proceedings of the 2005 international ACM SIGGROUP conference on Supporting group work* (pp. 197-206). Sanibel Island, Florida, USA: ACM.

Spradley, J. P. (1980). *Participant Observation*. New York: Holt, Rinehart and Winston.

Srinivasan, R. (under review). Re-thinking the Cultural Codes of New Media: The Question Concerning Ontology.

Srinivasan, R. (2004). Knowledge architectures for cultural narratives. *Journal of Knowledge Management*, *8*(4), 65-74.

Srinivasan, R. (2007). Ethnomethodological architectures: information systems driven by cultural and community visions. *Journal of the American Society for Information Science and Technology*, *58*(5), 723-733.

Srinivasan, R., & Shilton, K. (2006). The South Asian web: an emerging community information system in the South Asian diaspora. *Ninth Conference on Participatory Design: Expanding boundaries in design* (Vol. 1, pp. 125 - 133). Trento, Italy: ACM.

Star, S. L. (1999). The ethnography of infrastructure. *American Behavioral Scientist*, *43*(3), 377-391.

Star, S. L. (2010). This is not a boundary object: reflections on the origin of a concept. *Science, Technology, & Human Values*, *35*(5), 601-617.

Star, S. L., & Griesemer, J. R. (1989). Institutional ecology, "translations" and boundary objects: amateurs and professionals in Berkeley's Museum of Vertebrate Zoology, 1907-39. *Social Studies of Science*, *19*(3), 387-420.

Steel, E. (2010, March 15). Exploring Ways to Build a Better Consumer Profile. *Wall Street Journal.com*. Retrieved from http://online.wsj.com/article/SB10001424052748703447104575117972284656374.html.

Strickland, L. S., & Hunt, L. E. (2005). Technology, security, and individual privacy: New tools, new threats, and new public perceptions. *Journal of the American Society for Information Science and Technology*, *56*(3), 221-234.

Suchman, L. (1995). Making Work Visible. *Communications of the ACM*, *38*(9).

Suchman, L. (1997). Do categories have politics? The language/action perspective reconsidered. In B. Friedman (Ed.), *Human values and the design of computer technology* (pp. 91-105). Cambridge and New York: Cambridge University Press.

Suchman, L. (2007). *Human-Machine Reconfigurations* (2nd ed.). New York: Cambridge University Press.

Suchman, L., Blomberg, J., Orr, J. E., & Trigg, R. (1999). Reconstructing Technologies as Social Practice. *American Behavioral Scientist*, *43*(3), 392-408.

Surie, A., Perrig, A., Satyanarayanan, M., & Farber, D. J. (2007). Rapid trust establishment for pervasive personal computing. *Pervasive Computing*, *6*(4), 24-30.

Swarthout, A. M. (1967). Eavesdropping as violating right of privacy. *American Law Reports 3rd* (p. 1296). 11: West Group.

Thurm, S., & Kane, Y. I. (2010, December 18). Your Apps Are Watching You. *Wall Street Journal.com*. Retrieved from http://online.wsj.com/article/SB10001424052748704694004576020083703574602.html.

U.S. Department of Health, Education, and Welfare, U. S. D. of H. (1973). *Records, Computers, and the Rights of Citizens*. Cambridge, MA: MIT Press.

UCLA policy 991: protection of human subjects in research. (2009). Office for the Protection of Research Subjects, UCLA. Retrieved from http://www.adminvc.ucla.edu/appm/entry_policies.asp?vSection=public/991.htm.

Vaananen-Vainio-Mattila, K., & Ruuska, S. (2000). Designing mobile phones and communicators for consumers' needs at Nokia. *Information Appliances and Beyond: Interaction Design for Consumer Products* (pp. 169-204). San Francisco, CA: Morgan Kaufman and Academic Press.

Vallero, D. A. (2008). Macroethics and engineering leadership. *Leadership and Management in Engineering*, (October), 287-296.

Vaz, P., & Bruno, F. (2003). Types of Self-Surveillance: from abnormality to individuals "at risk." *Surveillance & Society*, *1*(3), 272-291.

Vredenburg, K., Mao, J.-Y., Smith, P. W., & Carey, T. (2002). A survey of user-centered design practice. *Proceedings of the SIGCHI conference on Human factors in computing systems: Changing our world, changing ourselves* (pp. 471-478). Minneapolis, Minnesota, USA: ACM.

Waldo, J., Lin, H. S., & Millett, L. I. (2007). *Engaging privacy and information technology in a digital age*. Washington, D.C. The National Academies Press.

Weil, V. (2001). Mentoring: Some ethical considerations. *Science and Engineering Ethics*, *7*(4), 471-482.

Westin, A. F. (1970). *Privacy and freedom*. New York: Atheneum.

Windhausen, J. J. (2006). *Good fences make bad broadband: preserving an open internet through net neutrality* (White Paper). Washington, DC: Public Knowledge.

Wolf, D. L. (1996). *Feminist Dilemmas In Fieldwork*. Boulder, CO: Westview Press.

Yao, M. Z., Rice, R. E., & Wallis, K. (2007). Predicting user concerns about online privacy. *Journal of the American Society for Information Science and Technology*, *58*(5), 710-722.

Zittrain, J. (2008). *The Future of the Internet--And How to Stop It*. New Haven & London: Yale University Press.