

People often endeavor to better understand themselves and their habits as a first step toward changing behaviors, increasing awareness, or simply satisfying a curiosity. Personal tracking apps and devices launched with the promise of helping people achieve this self-understanding by documenting what might be forgotten or surfacing what might be unobservable. Though today's tracking tools certainly help some individuals better learn aspects of their lives such as eating (e.g., *MyFitnessPal*, *Lose It!*), personal finances (e.g., *Quicken*, *Mint*), and exercise (e.g., *Fitbit*, built-in pedometers in modern phones), the technology often fails to support the level of self-understanding that people desire. Many people encounter a fundamental barrier: systems ignore the reality of everyday use of ubiquitous technology, assuming that people are highly motivated, unwavering in their diligence, and have the expertise necessary to analyze their data.

I study **how and why people use tracking technology today, create models and frameworks generalizing those findings, and implement and evaluate novel systems** which resolve needs surfaced by the models and frameworks. These projects have received a Best Paper Award (CHI 2017) and two Honorable Mentions (CHI 2015, CHI 2017). But more importantly, the models and frameworks have informed how other researchers think about and frame their work, and the design insights from my work have been disseminated to practitioners and informed their design choices.

Through my research, I envision a world where a novice can be their own expert by identifying what they need to track to answer a question they have about their habit or their body, finding a tool that supports collecting data that can help answer that question, drawing accurate conclusions from the data collected, and receiving encouragement and advice from others along the way. To do this work, I draw on theories and techniques from **Human-Computer Interaction (HCI)**, particularly from ubiquitous computing, social computing, and persuasive technology. I use human-centered design methods, understanding people's needs through interviews and surveys, designing and evaluating different options through online studies, and implementing and deploying novel systems.

Helping People Find Value in Their Tracking

People track for many reasons, often struggling to get value from their data because apps and tools rarely convey more than simple totals or correlations. To better understand how technology can help people find value in their tracking, I first developed a model characterizing how people use personal tracking tools in their daily lives, explaining the challenges people encounter and suggesting opportunities for systems to help people get more value from tracking. I then used this model to implement and evaluate two designs that demonstrate how to better surface interesting and actionable insights to people who are reflecting on their data or who have lapsed in their tracking.

A new conceptual model: understanding how people track

Early understandings of why and how people use personal tracking tools were based on studying the practices of early adopters who primarily tracked for self-improvement [1,12]. Though these understandings offer useful perspectives on how and why people may track, they ignore many of people's tracking goals and the challenges they encounter using tracking tools. To understand how people who are not early adopters or experts use tracking technology, I surveyed and interviewed people across three tracking domains (physical activity, location, finances), then synthesized people's everyday lived experiences into a new theoretical model of how people use tracking tools [10]. The

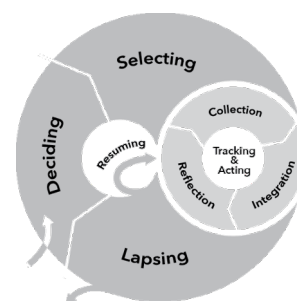


Figure 1. The lived informatics model describes how people use personal tracking tools across different reasons for tracking. It surfaces points in the tracking process where designs can better support people's needs.

model I developed unifies people's varied tracking motivations (e.g., behavior change, curiosity, receiving rewards from insurance providers) into a process of deciding to track, selecting a tool, tracking and acting, lapsing, and possibly resuming tracking. The model exposes opportunities for designs to better support people at different stages of their tracking process. For example, designs can help people identify what data they need to collect and select appropriate tools to do so, gather actionable insights from the collected data, and encourage resuming tracking after a lapse. I explored the latter two opportunities in my dissertation research, and have future plans to explore the former.

Evaluating a novel design: visual cuts to surface actionable insights

Today's apps and devices can often satisfy a person's initial curiosity about how much they walk per day or where they go in a month, but fail to surface actionable insights into how they might improve or adjust their habits. To understand what people are curious to learn from their data, I surveyed people experienced in physical activity tracking, uncovering a set of trends people want to identify and correct (e.g., the impact of commuting and weather on exercise). I developed *visual cuts*, or visualizations of tracked data with captions that suggest an opportunity for improvement or a potentially interesting trend in the data, for each of 13 trends [5]. I recruited participants to collect four weeks of location and activity data using the *Moves* lifelogging app, which collects location data and supports people in tagging the places they visit (from *Foursquare's* place database) and their transit mode (walking, running, biking, transit). Compared to insights identified by current tracking tools, participants felt the visual cuts through their *Moves* data helped them find patterns in their data more easily and discover factors that influenced their behavior. Participants each preferred a different set of cuts based on what they were most interested in and what trends were salient in the data they collected. These individual preferences led to the recommendation that designs should offer people a set of visualizations, rather than try to infer what is most actionable or informative.

In a later study, I applied visual cuts to work-break data logged by information workers, surfacing insights around when during the day people take breaks and how those breaks impact their productivity [3]. Participants found visual cuts valuable for understanding their break habits and finding opportunities to change their breaks to make their days more productive or enjoyable. This second demonstration of the benefit of visual cuts suggests the technique could help people find value from tracked data in other domains.

Evaluating a novel design: presenting tracked data to people who have lapsed

Tracking tools can encourage and support people even after they have stopped tracking. Systems today can send lapsed people insights from their data through notifications, or summarize the data they collected previously when they return. However, a challenge is that people have varied perspectives on their tracking experiences. Some feel guilty for stopping, others feel tracking was not beneficial, and some feel a mix of both [4]. Despite these different views, I demonstrate that reviewing the collected data can support people regardless of whether or not they want to return to track. I combined my technique of *visual cuts* with techniques from *persuasive technology* to frame information to create visualizations which offered a recommendation or insight aligned with their perspective on their tracking experience (e.g., felt guilty for abandoning tracking, felt it was not valuable, more mixed). I conducted an experiment where people who had abandoned their Fitbits were asked to rate visualizations of their own data, randomly paired with different framing techniques. After reviewing their data, participants who felt guilty over abandoning stated they were encouraged to resume tracking. Those who felt tracking was not worthwhile stated they learned about their habits from reviewing the data and appreciated that the visualizations did not encourage them to return.

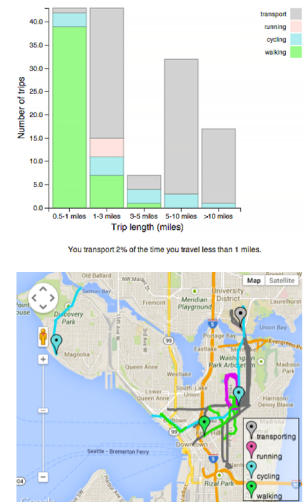


Figure 2. The visual cuts technique surfaces trends people find interesting and actionable in the location and activity data they collect.

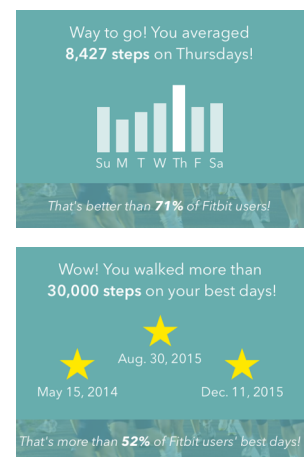


Figure 3. I designed methods of framing tracked data to motivate or inform people who lapsed in tracking.

Helping People Find Support Through Their Tracking

Tracking apps often include features for sharing on social networking sites like Facebook and Twitter. Though people use these features hoping for advice, accountability, or to celebrate achievements, their posts to social networks often receive little or no response. I developed a framework characterizing the range of techniques used by social features in tracking apps, enabling application designers to create more engaging social features by systematically identifying and evaluating design choices. I then used the framework in two design explorations, examining how a design can help people tell the story behind data they collect and how a design can help foster a community around tracked data.

A new design framework: how tracking tools support sharing

Although many research applications have introduced sharing features to help people receive support or advice, people often do not receive the response they hoped for or choose not to share [13]. I synthesized what approaches to sharing tracked data taken by research applications into a unified design framework [7]. The framework categorizes designs according to six dimensions that impact how the sharing feature will be received: data domain, preprocessing, sharing trigger, persistence, post content, and audience. Enumerating these dimensions provides a language for describing the design of sharing features and enables application designers to isolate a design choice to evaluate. A more structured approach can help designers identify what design choices foster good social experiences around sharing personal data.

I demonstrated the utility of the design framework through an empirical investigation of what people want to see their contacts tweeting via running apps. In an analysis of tweets generated by the running app RunKeeper, tweets with text written by the runner received more replies and favorites than tweets with only automatically generated content. I conducted an experiment where people read tweets generated to represent characteristics, common and uncommon, in the tweets we observed online. Participants said they were more interested and would be more inclined to offer support to people whose tweets that explained the importance of a run, such as stating the run accomplished a milestone or that it was harder than usual due to the weather. These findings prompted me to study how designs can best support two aspects of the framework: (1) helping people create and share better *content* which explains the importance of a tracked moment, and (2) creating an *audience* interested in that content through a community with a shared goal.

Evaluating a novel design: Telling the story through collected data

To help people create and share better content, systems must help people explain the importance of a moment. I believe a moment's importance is usually related to the larger story which motivated them to collect the data, such as hitting a major milestone on a journey to save money or overcoming a temptation toward a goal of weight loss. To understand how systems can help people tell interesting and meaningful stories to themselves and others through the data they collect, I designed, developed, and evaluated a mobile app named Yarn [9]. Yarn supports stories of accomplishment, such as training for a running race or working on a home DIY project. I designed a set of *visual templates* in Yarn intended to support people's varied motivations for sharing. The visual templates augment visual data (personal photos, maps of runs), with numeric data (time worked, distance traveled) while emphasizing the sharing motivation. About two-thirds of the participants who used Yarn for four weeks shared during the study (over Facebook, over SMS, or in-person). Participants felt they would want to share stories once they were close to completion, or with communities who were working on similar accomplishments.



Figure 4. Survey participants felt they would be more inclined to respond to tweets from the running app RunKeeper which explained the importance of the run.



Figure 5. Yarn uses visual templates to help people create story content that aligns with their sharing motivation.

Evaluating a novel design: Sharing with an interested audience

Even when moments explain the story behind tracked data, it can still be hard to relate to for people who have never collected similar data. I sought to explore how a system can foster an interested audience by creating cohorts of people with similar tracking interests and goals. I explored this design goal in the domain of food tracking by designing an app named Food4Thought for sharing photos of food to a private Facebook group [6]. Food4Thought gave people in the cohort the same daily challenge to complete, such as “*eat something high in fiber*,” This design created a community working toward similar accomplishments and provided a topic of conversation, integrated into a platform people are already motivated to check. The low-burden approach to food entry contrasts with current calorie-based food journals, where it can be hard to identify and enter what and how much is eaten [2]. In a three-week quantitative experiment where participants with similar goals (e.g., eat healthier, lose weight) were randomly assigned to either the social condition or a non-social condition, participants in the social condition completed more challenges and cited cases where they learned of foods which completed challenges from their peers. Both conditions provided an increase in mindfulness of food choices, demonstrating how the technique can encourage people to make healthier food choices.



Figure 6. Food4Thought used a private Facebook group to create a community of people with similar health goals, providing the members interesting daily challenges to foster conversation.

Future work

My research **aligns tracking technologies with people’s motivations and preferences**. I plan to continue empirical work on how technology can better align with people’s needs as new tracking tools are introduced and become more ubiquitous, such as fine-grained personal energy usage or accurate methods for monitoring food consumption. I will also continue researching design opportunities uncovered by my formative work in helping people find from tracking, both alone and with the help of others. I have also begun exploring challenges around identity and inclusion in personal tracking, and expect to continue this emphasis. Studying these problems will benefit from collaborations in disciplines such as public health, medicine, economics, psychology, and feminist and gender studies.

My work to date has been funded by the National Science Foundation and the Intel Science and Technology Center for Pervasive Computing. I expect to apply for funding for my future research from the NSF Cyber-Human Systems and Smart and Connected Health programs. As the NSF expands to more applied aspects of research, I envision opportunities to collaborate with domain experts to explore the human aspects of personal tracking in other domains. Though I am not a security expert, I see opportunities to collaborate with others to study security and privacy perspectives around tracked data through the Secure and Trustworthy Cyberspace program. I see similar opportunities to collaborate around tracking in public spaces through the Smart and Connected Communities program. I also expect the design implications of my research to impact commercial products through awards like the Google Faculty Research Awards as well as ad-hoc connections with teams in industry.

Supporting the decision to track and the selection process

My existing work has examined how designs can better support the tracking, acting, and lapsing stages of tool use. I plan to expand this research by studying how designs can better help people at other stages of the tracking process. There is a promising opportunity for technology to guide people through the stage of *deciding* to track by helping them define their goals for tracking to be specific and measurable, no matter whether they are trying to change their behavior or satisfy a curiosity. I am also excited

to explore how designs can help people in the *selecting* phase identify what data they need to collect and what tracking tool or method will be best for them. I plan to start this exploration in a small set of tracking domains, as people's goals are often impacted by the domain they are tracking in [11]. I hope to extend these domain-specific explorations into domain-agnostic design principles for goal-setting and data-selection, drawing on my experience developing theoretical models and design frameworks across tracking domains.

Opportunistic storytelling with tracked data

Storytelling often occurs as people bring up topics in conversation, rather than through updates in a feed as supported by most social computing systems. I plan to explore how social computing systems can support storytelling through data naturally as the topic arises. For example, I am interested in exploring algorithmic approaches to succinctly summarize the important moments in someone's story to date, such as a short video or animation which can be shown in-person on a phone when the topic arises. I am also interested in extending my work on how designs can create cohorts of people with similar tracking interests to support people in the storytelling space. I look forward to designing an online community to help people follow the progress of other telling similar stories, using tracked data to compare their experiences to those of others.

Designing inclusive tracking technologies

My interest in understanding people's everyday tracking needs led me to study how people track their menstrual cycles, an essential aspect of health tracking prevalent long before technology [8]. Colleagues and I uncovered that the design of most apps for menstrual tracking assume the gender and sexual identity of the person tracking (female, heterosexual), their aesthetic preferences (pink), the length of their cycle (about 28 days), and their reasons for tracking (for conception). These assumptions result in app designs that make the people using them feel excluded, and in some cases can remind people of unpleasant struggles with infertility. I plan to continue studying and advocating for the inclusivity of personal tracking tools around gender and in other areas. For example, I would like to design physical activity tracking tools to be flexible to geographic and socioeconomic constraints around how one can exercise, or to design representations of tracked data appropriate for varied levels of education.

Summary: helping tracking tools meet people's needs

I am excited to develop guidelines to help designers of tracking tools understand and meet people's needs. My research builds recommendations for designing across tracking domains, but remains informed by people's domain-specific goals and design needs. In addition to collaborating with other HCI, ubiquitous computing, and social computing researchers, my interest in personal tracking across domains will enable collaborations across disciplines where tracking can help people monitor and improve themselves.

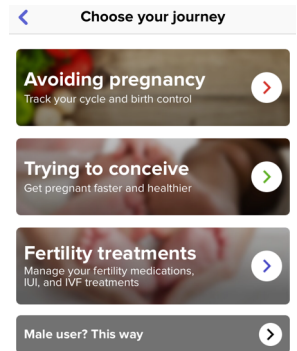


Figure 7. Many apps for tracking menstrual cycles make assumptions about the gender or sexual identity of the person tracking, such as the *Glow* app pictured here. These assumptions can make people feel excluded.

References

1. Eun Kyoung Choe, Nicole B. Lee, Bongshin Lee, Wanda Pratt, and Julie A. Kientz. Understanding Quantified-Selfers' Practices in Collecting and Exploring Personal Data. *CHI 2014*, 1143–1152. <http://doi.org/bbpd>
2. Felicia Cordeiro, Daniel A. Epstein, Edison Thomaz, Elizabeth Bales, Arvind K. Jagannathan, Gregory D. Abowd, and James Fogarty. Barriers and Negative Nudges: Exploring Challenges in Food Journaling. *CHI 2015*, 1159–1162. <http://doi.org/bbdt>
Best Paper Nomination, Top 5% of Submissions
3. Daniel A. Epstein, Daniel Avrahami, and Jacob T. Biehl. Taking 5: Work Breaks, Productivity, and Opportunities for Personal Informatics for Knowledge Workers. *CHI 2016*, 673–684. <http://doi.org/cfbt>
4. Daniel A. Epstein, Monica Caraway, Chuck Johnston, An Ping, James Fogarty, and Sean A. Munson. Beyond Abandonment to Next Steps: Understanding and Designing for Life after Personal Informatics Tool Use. *CHI 2016*, 1109–1113. <http://doi.org/bjjd>
5. Daniel A. Epstein, Felicia Cordeiro, Elizabeth Bales, James Fogarty, and Sean A. Munson. Taming Data Complexity in Lifelogs: Exploring Visual Cuts of Personal Informatics Data. *DIS 2014*, 667–676. <http://doi.org/bbng>
6. Daniel A. Epstein, Felicia Cordeiro, James Fogarty, Gary Hsieh, and Sean A. Munson. Crumbs: Lightweight Daily Food Challenges to Promote Engagement and Mindfulness. *CHI 2016*, 5632–5644. <http://doi.org/bjh8>
7. Daniel A. Epstein, Bradley H. Jacobson, Elizabeth Bales, David W. McDonald, and Sean A. Munson. From “nobody cares” to “way to go”! A Design Framework for Social Sharing in Personal Informatics. *CSCW 2015*, 1622–1636. <http://doi.org/bbks>
8. Daniel A. Epstein, Nicole B. Lee, Jennifer H. Kang, Elena Agapie, Jessica Schroeder, Laura R. Pina, James Fogarty, Julie A. Kientz, and Sean A. Munson. Examining Menstrual Tracking to Inform the Design of Personal Informatics Tools. *CHI 2017*, 6876–6888. <http://doi.org/cfbv>
Best Paper Award, Top 1% of Submissions
9. Daniel A. Epstein, Koko Nakajima, Mira Dontcheva, James Fogarty, and Sean A. Munson. Yarn: Using Personal Data to tell Stories of Accomplishment by Aligning Shared Content with Sharing Goals. *Under Submission*.
10. Daniel A. Epstein, An Ping, James Fogarty, and Sean A. Munson. A Lived Informatics Model of Personal Informatics. *UbiComp 2015*, 731–742. <http://doi.org/bdsr>
11. Ravi Karkar, Jessica Schroeder, Daniel A. Epstein, Laura R. Pina, Jeffrey Scofield, James Fogarty, Julie A. Kientz, Sean A. Munson, Roger Vilaradaga, and Jasmine Zia. TummyTrials: A Feasibility Study of Using Self-Experimentation to Detect Individualized Food Triggers. *CHI 2017*, 6850–6863. <http://doi.org/cfbw>
Best Paper Nomination, Top 5% of Submissions
12. Ian Li, Anind Dey, and Jodi Forlizzi. A Stage-Based Model of Personal Informatics Systems. *CHI 2010*, 557–566. <http://doi.org/bh8zsb>
13. Mark W. Newman, Debra Lauterbach, Sean A. Munson, Paul Resnick, and Margaret E. Morris. “It’s not that I don’t have problems, I’m just not putting them on Facebook”: Challenges and Opportunities in Using Online Social Networks for Health. *CSCW 2011*, 341–350. <http://doi.org/bcvgg7>