Persuasive Anxiety: Designing and Deploying Material and Formal Explorations of Personal Tracking Devices

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Self-tracking refers to the use of computational sensing devices that track data about user behavior to provide self-knowledge. Self-tracking devices are often designed to function transparently, with minimal user awareness of the tracking process. Although effective from an information-processing perspective, this invisibility can also background issues of materiality and user experience. Further, research on self-tracking has shown that devices are often abandoned, can cause user anxiety, and reflect hegemonic social norms. Self-tracking is an emerging technology and skilled cultural practice, but its central issues—the space of design possibility, the nature of user needs/ experiences, and sociopolitical implications—remain unclear. We present *Persuasive Anxiety*, a project informed by research through design, critical design, and design deployment studies. We report on the design and longitudinal deployment of three designs—Candy Camera, Melody Bot, and Fractured View—to spark critical dialogue about self-tracking. The project helped reveal some the relationships between self-tracking and destructive social norms, as well as how they might be mitigated; the emergence of self-tracking as a performative cultural skill; and the possibility of bringing digital

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content authoring tools/research into a closer dialogue with self-tracking to give self-trackers greater agency over this cultural practice.

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1. INTRODUCTION

Personal data-tracking technologies, inheriting the ubiquitous computing vision of which they are a part, are often characterized as fading into the background, "capturing data from everyday life both continuously and unobtrusively" (Sellen et al., 2007, p. 81). They feature "compact, inexpensive, self-activating sensors … to let us capture most of our lives easily and passively" (Czerwinski et al., 2006, p. 46). They promise "lifelong automated data collection of personal data" (Li, Dey, & Forlizzi, 2011, p. 413). According to this vision, personal data collection has little to no physical presence, requires little to no human intervention, and works continuously and at the scale of a lifetime. This is a vision that becomes increasingly feasible with new developments in the engineering of sensing and display technology (e.g., Yokota et al., 2016). And yet, perhaps because of the intimate nature of these devices—their ability to track and report all of our movements to ourselves and others, with diverse implications—these technologies remain present to

mind in spite of their disappearing qualities, and not always in positive ways. Personal informatics technologies have led to experiences of anxiety and even product abandonment (Khovanskaya, Baumer, Cosley, Voida, & Gay, 2013; Lazar, Koehler, Tanenbaum, & Nguyen, 2015; Patel & O'Kane, 2015; Purpura, Schwanda, Williams, Stubler, & Sengers, 2011).

The notion that personal informatics devices are invisible arguably reflects an underlying commitment to an information-processing metaphor: They collect information, process it, present it, and then the user perceives, makes decisions about, and acts on the information in ways that the technologies can sense, thus perpetuating the cycle. What matters, in this view, is not the physical device but the flow of information. Yet devices do have a physical form, and as Fogg (2002) noted, attractive and aesthetically pleasing persuasive technologies can be perceived as intelligent and reliable by virtue of the "halo effect"—creating associations between the device's attractiveness and general goodness. In other words, product semantics contribute to product experiences. But perhaps this point is too easily overlooked when the product by its nature is supposed to *disappear*: What are the semantics of an unseen product? Complicating this picture is that many dimensions of personal informatics are not best described in terms of information processing: self-image, body shame, the experience (and consequences) of being watched, the knowledge that one ought to and/or is failing to comply with this or that normative code (e.g., 10,000 steps a day). These issues get at the *experiential* qualities of a health, productivity, or similar regimen.

We begin our project by asking, What happens if we replace disappearing devices and the information-processing metaphor and instead build on an approach to personal informatics, also explored in the research literature, that foregrounds design materiality, active interpretation, and user experience and performativity? To do so, we developed a collection of nine designs, called Persuasive Anxiety, which blends research through design and critical design methodologies to help us explore alternative design values. The designs all focused on tracking consumption nominally for health and behavior change. However, they experimentally embodied values unlike those that dominate the space today. For example, instead of the Bauhaus-inspired modernist aesthetic of Fitbits and smartphone apps, we opted for organic materials (including feathers, sugar, and plant textures), connotative and stylized forms (including 1950s gumball machines, the *Alien* movies' visual style, and action figures), and biomimetic interaction styles.

As a part of that project, we built and deployed three of the designs: Candy Camera, Melody Bot, and Fractured View. All of them reflected three interrelated design tactics that emerged in our design activities aimed at subverting hegemonic and anxiety-inducing qualities common in personal informatics. All proposed self-tracking practices not involving quantitative measures. We deployed these designs in homes for 6 months, each home receiving two of the three. Cognizant of particular difficulties with deployments of design prototypes serving a critical purpose, we also were proactive about the deployment design itself. We met 12 times each with the research participants in their homes. As is typical of deployment studies, during these meetings we conducted interviews and observations. We also did additional design work to support participants in their critical engagements with the designs, as we explain in more detail next. Our goal in

the deployment was to see how people came to integrate these designs in their everyday lives, how they came to interpret them, and how these interpretations challenged and/or reinforced present understandings of personal tracking devices in the literature today.

As we expected, by radically changing the material form, product semantics, and core functionality of personal tracking devices, participant understandings of self-tracking were defamiliarized, opening up complex and wide-ranging conversations about self-tracking and its roles in contemporary life. We found that our use of webcams—initially intended as a more holistic and qualitative tactic of self-tracking than step- and calorie-counters—invoked among users expectations about digital content authoring (specifically image creation, manipulation, and presentation). We found that the notion that tracking is or ought to be quantitative and compliance driven—in spite of our best efforts to subvert both expectations—was remarkably persistent and yet creatively realized. We found that participants wanted greater creative control over how they perform self-tracking as a "technology of the self" (Foucault, 1988).

Combined, these three results suggest that our participants blurred the distinction between self-tracking and self-representation, as others have already found (e.g. Lupton, 2014). Further, this blurring revealed different attitudes and behaviors concerning the ways that users cede (to the device) or assert (for themselves) the power of self-representation using tracked data as a material—and they did so in ways that couple tightly with particular design decisions. This work explores that tension—between self-representational content that is mechanically and/or algorithmically captured, and self-representational content that is personally created, enacted, and performed—to better understand experiences of anxiety with self-tracking and gain insights into new design tactics and strategies in this space.

2. LITERATURE REVIEW

The focus of this work was on the use of design practice as a means to examine different problems and potentials within the practices of personal informatics. Personal informatics covers a number of technologies that "help people collect personally relevant information for the purpose of self-reflection and gaining self-knowledge" (Li et al., 2010, p. 558). The information collected frequently comes in the form of data points about some behavior or activity that the user wants to track. This approach has had considerable success in a number of domains, including fitness, weight loss, and financial planning. One concern of particular interest to this work is the abandonment of personal informatics devices over time.

2.1. Abandoning Personal Informatics Devices

Researchers have noted that self-tracking devices are often abandoned; they seek to understand barriers that stand in the way of the often long-term patterns of use (Lazar et al., 2015; Patel & O'Kane, 2015). These barriers include finding data that does not fit

with the users' concept of self, lack of usefulness in the data collected, and an excess of extra work introduced by the tracking process (Lazar et al., 2015). Eventual abandonment may be part of the desired use of personal informatics devices, for example, when users meet a goal (Lazar et al., 2015; Rooksby, Rost, Morrison, & Chalmers, 2014). Other times, abandonment happens because the product has unintended consequences. In a study focused on fitness trackers in the setting of a gym, Patel and O'Kane (2015, p. 2928) found that "some participants suggested that they avoided information to evade the feelings of shame and disappointment of not being able to meet a goal." Thus, the barriers to use relate to the idea of self-tracking as being anxiety causing in the way that being presented with an unflattering vision of the self. This can be particularly problematic, as it can involve trading one problem for another or could even result in users becoming worse with regards to the behavior they were trying to correct (Calvo & Peters, 2013).

The topic of anxiety became a focal point for us. Informed in part by health sciences as well as feminist research on the body (e.g., Satinsky, Reece, Dennis, Sanders, & Bardzell, 2012), we speculated that self-tracking devices' unintended participation in hegemonic norms might be a source of anxiety. More specifically, we suspect that the ability of such devices to provide ever higher resolution, their external/objective qualities, and their ability to be used as evidence of compliance with health and with social (and often hegemonic) norms all contribute to this anxiety. We decided to tease forward the topic of anxiety, to treat it as a design material, and to play with it speculatively. Because anxiety is an embodied emotion, and the self is a body, we also wanted to focus on the embodiment of personal tracking devices, that is, their materiality and form.

2.2. Materiality and Form

There have been a few investigations that focus on materiality within the context of personal informatics. For example, Khot et al. explored the use of physical materials as a representation of tracked data, with the focus on investigating the output of tracking through the perspective of materiality (Khot et al. Khot, Lee, Aggarwal, Hjorth, & Mueller, 2015). The researchers equipped participants with a Polar H7 heart rate monitor. The Polar H7 is a band worn across the abdomen, and it tracks information about heart rate. The researchers used those data to generate 3D printed objects that represented activity through various transformations on objects, such as a histogram, flower, frog, and ring (Khot et al., 2014), as well as food rewards (Khot et al., 2015). The results showed how these data-objects created autotypographies—"a physical map of memory, history, and belief" (González, 1995, p. 134)—that were "driven mainly by the aesthetic rather than the embodied information in the artifacts" (Khot et al., 2014, p. 3842). The concepts of "autotypographies" and the material qualities of the devices and representations inspired our approach.

Similarly, some work has focused on how the use of tangible user interfaces (TUIs) in personal informatics could make self-monitoring more enjoyable: "TUIs can remind people to insert data, motivating users in doing tasks usually perceived as repetitive and burdensome" (Federico, 2015). In addition, TUIs can add new affordances to the process of

interacting with personal informatics device (Rapp & Cena, 2015), allowing for new means by which data can be collected and manipulated. The materiality of interfaces seems to affect the way that personal informatics devices are used and how data are consumed, and thus represents a design opportunity. In our own work, we seek to leverage the material expression (Wiberg, 2016) of different forms and materials: holistically formal qualities, physical sensations, historical and genealogical connotations, affordances, and conventions to contribute to participants' willingness for long-term engagement with the personal informatics devices more frequently and more reflectively.

2.3. Research Through Critical Designs

To both reexamine personal informatics as a practice and investigate the possibilities of form within that practice, we adopted a research through design (RtD) approach infused by critical design. RtD is a form of inquiry "where the end product is an artifact— where the thinking is, so to speak, embodied in the artifact, where the goal is not primarily communicable knowledge in the sense of verbal communication" (Frayling, 1993, p. 5). In other words, RtD uses design processes, prototypes, and products as a research method (Bardzell, Bardzell, & Hansen, 2015; Gaver, 2012; Zimmerman, Forlizzi, & Evenson, 2007). Critical design uses the language of design to ask questions, provoke, and explore alternative futures (Bardzell & Bardzell, 2013; Dunne & Raby, 2013). Critical design is a form of research through design that seeks to challenge norms, to defamiliarize, and to stimulate debates (Dunne & Raby, 2001). Unpacking the notion of criticality in design, Bardzell and Bardzell (2013) wrote,

> A design research project may be judged "critical" to the extents that it proposes a perspective-changing holistic account of a given phenomenon, and that this account is grounded in speculative theory, reflects a dialogical methodology, improves the public's cultural competence, and is reflexively aware of itself as an actor—with both power and constraints—within the social world it is seeking to change. (p. 3304)

Neither research through design nor critical design prototypes are intended as consumer products. Instead, such prototypes are key components of a research methodology—to contribute to design research within a given situation or domain. As such, these prototypes "may counter conventions of utility and efficiency, profit and taste" (Mazé & Redström, 2009, p. 3) and employ satire and other literary conventions (Dunne & Raby, 2013) as a means to encourage critical engagement. Such designs have to walk a line between being realistic and plausible enough to be recognizable as designs, and yet novel or estranging enough to provoke the kinds of responses that generate debates and create the sorts of insights or surprises that inform future design.

This balance, especially in the case of critical design, which seeks to be more provocative than research through design in general, introduces a methodological issue: To achieve their purpose, critical designs require from those who engage them a response that has a certain degree of aesthetic sophistication. That is, people cannot "use" critical

designs like they might use more conventional products—they cannot just test them out. Critical designs instead require rather special "users" who understand up front the designs' estranging purposes, who can read such purposes and their significances in the formal and material qualities of the design itself, who can imaginatively place themselves in a world where such a design actually is viewed as functional and desirable, and who can articulate these reactions in a way useful to design research. This rules out simplistic reactions, be they positive or negative, such as, "That's stupid!" or "That's so cool!"— neither generates debate or brings to light underlying issues, possibilities, or desiderata. Further, aesthetic responses often develop over time—through repeated engagement, reflection, conversations with others, and so on—and so critical design study participants need the opportunity to develop that thinking, and that in turn means that they need a reason to do this work after the initial novelty of the design has passed.

All of this is a known problem in critical design, which historically has been shown in museums to an art world crowd and thus failed to generate the kind of user experience engagement and data that we want. In our work, we sought to engage in a research through critical design process to help us think critically and deeply about the intermingling of anxiety, self-tracking, and hegemonic social norms; we wanted to use deployments as a methodology to engage participants in helping us interpret and imagine design implications of these issues and allowing the sense-making process to unfold over time.

3. METHODOLOGY: DESIGN AND DEPLOYMENT

Our research methodology is research through design, infused by critical design, and enriched by a longitudinal deployment of the designs in six homes. Persuasive Anxiety included nine designs, but most of them used materials in a manner that created beautifully aesthetic pieces that were, nonetheless, fragile and more suited for display in exhibitions. However, three of the designs were created to be more stout in their construction, and we duplicated and deployed those designs. In this section, we offer accounts of the design process of the three designs that were part of the deployment and of the design of deployment study and resulting data analysis.

3.1. Designing Objects of Persuasive Anxiety

To investigate how participants appropriate personal informatics tools and systems for identity work and how these tools and systems help shape interpersonal and community relationships, we used an RtD approach, informed by critical design. We designed and fabricated nine designs initially as objects to think with, exploring different forms, materials, and conceptions of selfhood and tracking. We then chose three of these designs to take forward into a deployment: Candy Camera, Melody Bot, and Fractured View. Through the deployments and ongoing contact, we were able to coexplore with our study participants the assumptions, values, ideologies, and behavioral norms inscribed in personal informatics devices.

Design Concepts and Key Tactics

We began the design process with a critical question: What would personal informatics devices look like if they avoided measurement? Many approaches to tracking are quantitative and map to a normative standard (Khovanskaya et al., 2013), a combination that we hypothesized contributed to anxiety—and so imagining alternative design strategies became central to our research question. To explore how personal informatics might work without measurement, we scoped our inquiry to weight loss. We then generated a number of design concepts based on two common approaches to weight loss: eating fewer calories and burning more calories through exercise. In addition to these direct causes of weight gain, we also considered how stress and anxiety themselves could be the cause of weight gain through behaviors such as emotional eating. From these, we generated a number of design concepts that avoided quantitative measures, including a mirror that would replace the reflection of the user with a more fit body as incentive to work out, a special set of utensils that would break apart in the user's mouth when used outside of designated mealtimes, and a doll that when squeezed would become thinner and remain that way for an extended time. The problem with these concepts, however, was that although they avoided overt measurement, they also showed preferential treatment for one body form over another.

Iterating on the mirror concept, two key insights arose. First, it was all too easy to perpetuate hegemonic norms through any means of reflecting the user. Second, defamiliarizing such reflections can reveal assumptions and attitudes in surprising ways. We came to the idea that we would replace quantitative personal tracking with *photographic personal tracking in a defamiliarizing way*. We had thus come upon a design tactic that offered the potential to deemphasize measurement, avoid hegemonic judgments, and still reveal new insights. To do so, we would leverage the availability of inexpensive cameras and microcontrollers as well as the language of design.

But we still had some practical problems. Developing deployable designs featuring still and video cameras raised issues concerning surveillance and privacy: We knew that we ran the risk of generating new user anxieties while pressing the tolerances of our ethical review board. This has been recognized as a concern for personal informatics (Purpura et al., 2011). To explore self-tracking in ways that do not ratchet up existing anxieties, we asked, How can we make the presence and function of our cameras transparent? This led to the design tactic of *material transparency*: Not only would the cameras remain visible, but their visibility would be foregrounded as a formal and material aesthetic choice.

There also the issue of how the cameras might be used. Because our concept was to track users with images rather than numbers, we needed to couple the images and whatever was being tracked. We obviously could not reproduce fully functioning and overly complicated digital cameras, such as Nikon and Canon cameras, because they would separate image making from tracking. This led to the design tactic of coupling image making and behavior tracking through *extremely limited controls*.

Having arrived at this concept and these three tactics, we began to iterate on individual concepts toward realized designs. Here we present the three design artifacts that we eventually deployed, including key design decisions made along the way (Figure 1).

FIGURE 1. Top to bottom, Candy Camera, Melody Bot, and Fractured View.

Candy Camera

The Candy Camera is a traditional-style gumball machine that has been retrofitted with a web camera, LCD screen, and Raspberry Pi board. Its name is a whimsical play on the title of the TV show *Candid Camera*. Turning the machine's crank, in addition to releasing a gumball or similar snack, causes the camera to capture an image, which is then added to an automated slideshow that is displayed in the LCD screen. Images in the slideshow are played continuously for anyone near the machine to see. Taking its form from candy machines that were common in America around the 1940s and 1950s, this design introduces a playful element to the tracking process both through its form and by incorporating it into a fun, albeit possibly unhealthy, activity. Compared to the frequently more sedated colors and utilitarian forms used in tracking devices such as the Garmin vívosmart or the Fitbit, this vintage-styled device is bright red and has fluting and ornamentation that is more befitting of a device that has a fun purpose.

In terms of the visibility of the camera and the screen, both were affixed to the form in a manner that would fit the aesthetic of the machine to some degree but also make

them stand out. Rather than incorporating them into the design of the original candy machine, they were positioned to follow the lines of the device but largely just added on, up to and including leaving the wires that connect different elements visible. This was done to play with the visible language of the two devices, juxtaposing machine aesthetic (e.g., Šimbelis, Lundström, Höök, Solsona, & Lewandowski, 2014) with the more traditional form of the candy machine. Functionally, the camera is positioned on the top of the machine, pointing it at the direction of the head of a person of average height who is using the device at arm level. This meant not only that the camera would be highly visible in use but also that it would have a greater chance of capturing headshots. The screen is placed inside the front half of the glass bowl of the device, directly below the camera and in front of all the candy. To maintain a documentary feel, the camera provides no indication of the images that it will capture; it offers no previews. In addition, the images are displayed out of sync with the capture process. This means that when a new image is added, it is placed at the end of the slideshow and shown only after the slideshow loops back around and starts over. This means that the users will not see the image they have just captured, shifting the focus from the current visit to the machine to reflection on the accumulated history of prior visits.

Melody Bot

The Melody Bot is a figurine that video records users ambiently while they work at their computer. Its purpose is to generate music videos of the sedentary user, which it does when the user imports any MP3 audio file to its application. It works such that the device captures video in clips, which are analyzed for pixel-level movement and stored to the connected computer. When an audio file is imported into the application, a custom beat-detection algorithm counts the peaks and valleys in the audio file's waveform. The video clips are computationally cropped to the length of time between beats, and then matched to the song, with the segments that have the most movement being matched to the sections of the song with the highest density of peaks and valleys. The result is a video of the user at their computer with jump cuts between minor movements creating a representation of movement, even dancing, even though the user was in fact sedentary at their computer.

Although the software application is designed to be unobtrusive, the web camera itself is designed to draw more attention to itself in a fun and playful way. Initially, the design was intended to present a human form that was neither fat nor thin and neither male or female. In short, a kind of androgynous caricature of a human that users could project themselves onto—similar to McCloud's (1993) description of how abstraction in cartoons facilitates similar projection. After several different sketches, the ultimate form that we chose was similar to Munny (http://sites.kidrobot.com/munnyworld/) designer toys, with a slightly pudgy, humanoid form. In place of a human head, however, the figure has a CRT monitor with the camera placed front and center, looking forward. Details such as this, or the emphasis on the posterior of the character, were chosen to play with the notion of anthropomorphized technology. The whole figurine is made of clear epoxy

resin, in order to reveal the functioning parts of the camera, with the printed circuit board and wires cast directly into the head directly. In this way, the more human and even possibly cute form of the design is juxtaposed with the frequently hidden visual aspects of computing. The playful and human form is intended to create a feeling of an inoffensive or even friendly companion who is keeping an eye on its user, whereas the more functional aspects of the camera become a reminder that it is not a person but rather a machine that is doing the watching. Similar to Candy Camera, the application offers no means to preview what it will capture.

The collected videos are edited in such a way as to incorporate the visual language of both music videos and action films. The beat-detection system was created to focus on smaller spans of music between beats, meaning that cuts are generally quick. The result is a juxtaposition between the representation of self as sedentary and the music and editing of action sequences, with the goal of simultaneously introducing humor into the process, as well as creating a point for consideration in the unusual and jarring nature of the combination of form and content.

Fractured View

The Fractured View is a stressball-like object with an embedded camera and array of force-sensitive resistors. When squeezed, it takes a picture, but users never see that image directly. Instead, it is distorted. The length and amount of force from the squeezing are used to create a single numeric representation of the squeeze. This number is then fed into a modified version of Daniel Shiffman's (n.d.) *Explode* Processing script. The script "explodes" the image into three dimensions, using data derived from the force sensors. The more forcefully the Fractured View is squeezed, the more the picture is exploded. Because the Fractured View takes pictures only when it is squeezed, it is impossible to have unexploded images from it. Relieving stress thus becomes an act of documentation, where the documentation itself is distorted—or expressively "colored"—by the amount of stress subjectively experienced.

Originally, we intended the form of the Fractured View to represent different perspectives on body form. We started with a pudgier form, similar to the Melody Bot, which when squeezed would become a thinner, but more distorted, form. Introducing a camera to the design replaced physical distortion with visual image distortion, which made the connection to body form became more tenuous. However, it also placed emphasis on the squeezing motion, something that could be mapped onto stress.

Similar to the Melody Bot, the Fractured View uses its form expressively and metaphorically to introduce an element of fun. We wanted the design to play with both creative and destructive aspects of explosiveness. Plants such as touch-me-nots (*Mimosa pudica*) and the squirting cucumber (*Ecballium elaterium*) use explosions that scatter seeds as a response to being touched: The threat to a plant becomes a strategy of self-perpetuation, which seemed a particularly apt metaphor. Thus, a plant pod form was chosen for the Fractured View, the creative explosions of which can reflect emotional anxiety and creative release simultaneously.

Of the three designs, the camera in the Fractured View is the least visible. This was due to a practical and aesthetic reasons. In terms of practicality, by building the camera into the design's liquid latex shell, it is physically secure within a design that will be handled roughly. It also causes the orientation of the camera to be occluded, making the resulting images even more difficult to predict. Aesthetically, covering the bulk of the camera further emphasizes the organic feel of the device. Rather than looking like a camera, the Fractured View foregounds its squeezability.

In all three of these designs, the function, form, and use of cameras as materials propose different ways that personal informatics devices could be imagined in terms of material, functional, and (self-) representational qualities. But how would users respond to them, live with them?

3.2. Designing the Deployment Study

As noted earlier, our goal was not to develop serious commercial product concepts but instead to explore the meanings and possibilities of personal tracking through the materials, styles, and forms of design, and we believed that engaging members of the public would help us see beyond our intentions and open us to a deeper and more critical engagement with the underlying issues: self-tracking, anxiety, hegemony, computation, and design.

We conducted a longitudinal deployment study for a duration of 6 months, from October 2013 to September 2014, in six households in a midwestern U.S. college town. The deployments were staggered by 1 month each. We began with the first home in October 2013, with a new home added in November, another in December, and so on, until we had six by March of the following year. Each home received two of the three designs. Because the Melody Bot and the Fractured View both require a USB connection, and we didn't want to monopolize users' USB ports, no home received both. The first three households received the Candy Camera and the Melody Bot, and the last three households received the Candy Camera and the Fractured View. Participants were recruited by announcing the study via e-mail distribution lists and through referrals. We visited each household two times a month during the deployment study, where we observed and conducted up to 2 hr of interviews and artifact probe activities to make visible participants' experiences and sense-making process with the designs (explained next).

We conducted a pilot study to rehearse and troubleshoot the deployment study procedures. We then took the first six participants who expressed interest in participating in deployment study proper. Household 1 had two members: Kelly, an interaction designer in her early 30s, and her husband, Andrew, a research associate in the local university's biology department, also in his early 30s. Household 2 was home to Leslie, a mid-40s administrator at the local university and semiprofessional photographer who lived with her teenage son, Jared. Household 3 had Sarah, an early 30s doctoral student majoring in leisure studies, and her husband, Dale. Household 4 was home to Ben, a writer, and his wife, Karen, who were both in their 60s. They were often joined by their daughter Eva, who lived locally by herself and visited her parents often. Household 5 had

two members: Jessica, an administrator at the local university in her late 30s and her grade-school-age son, Larry. Finally, the sixth and largest household comprised Jack, a mid 30s K-12 educator and freelance designer; his wife, Laura, who also worked in K-12 education; their two grade-school daughters; and their son. All households were within a 20-mile radius of the local university, were Caucasian, and were middle class.

We carefully developed the first encounter with the designs to foster positive first impression and generate interest. We worked with a graphic designer to create a Quickstart Guide for each design. The graphic designer transformed the three designs into stylized cartoons, and they became the centerpiece of each guide. Each of the six-page visual guides employed a humorous tone to pique curiosity and invite engagement. It provided installation tips, instructions for use, and troubleshooting advice for common technical issues and concluded with a hotline for any emergency. The guide was also color-coded to visually connect the guide to the design, as well as other design-specific elements in the study, such as the probes we describe next (Figure 2). We also worked with a printing company to create a custom box and housing materials for all three designs. The custom box took on the same visual language as the Quickstart Guide, with the same cartoons and color scheme to ensure consistency. Each design, along with the QuickStart Guide, was carefully placed in the customized box and hand-delivered to each of the households during our first visit to create an unboxing experience (Figure 3).

Informed by our prior experience deploying critical designs (Bardzell, Bardzell, Forlizzi, Zimmerman, & Antanitis, 2012), we proactively found ways to foster participant engagement with the designs over time. We made a series of artifact probes to distribute

**FIGURE 2. Excerpt for the Quick Start Guide for Melody Bot.**
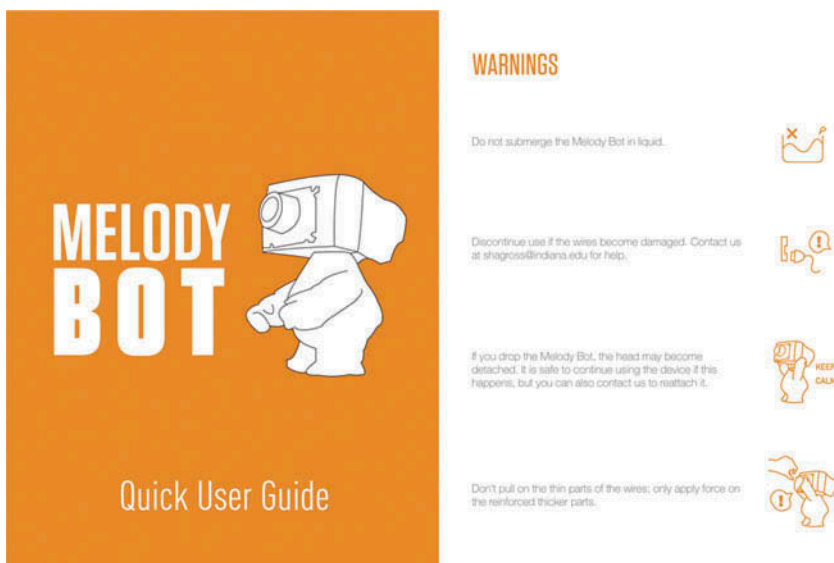
over the 6 months to encourage interaction with the three designs. We intended these probes to be both research tools to stimulate reflections about the designs and common household items to fade into the participants' everyday lives. For example, we created "mission" coasters made with cardboard with the designs in stylized cartoons on one side and fun and easily accomplished tasks on the other (Figure 4). These coasters were given to the participants as "gifts from the research team" during one of our visits. The participants were encouraged to use the coasters as often as they wished and felt most comfortable. We then collected the filled-out coasters and used them as conversation starters with the participants during the subsequent visits.

Another artifact probe we created for the deployment study was somewhat transgressive, with the goal of gauging how participants sense-make issues of privacy around personal informatics tools and systems. In one of the later visits during the deployment, rather than replenishing the Candy Camera with different kind of candies as on previous visits, we mixed into the candy custom pill capsules instead. Each clear pill capsule contained a small scroll of paper with unique information about the participants that had been collected off the Internet by members of the research team using only the participants' names and addresses. The messages were specifically selected to highlight the amount of information about the participants that was freely available online, ranging from questions about property value (e.g., "How do you feel about your house being worth $20 thousand less than your neighbors'?") to questions about friends and relations

FIGURE 3. First encounters with the designs through unboxing experiences.

FIGURE 4. A sample of the mission coaster as artifact probe.
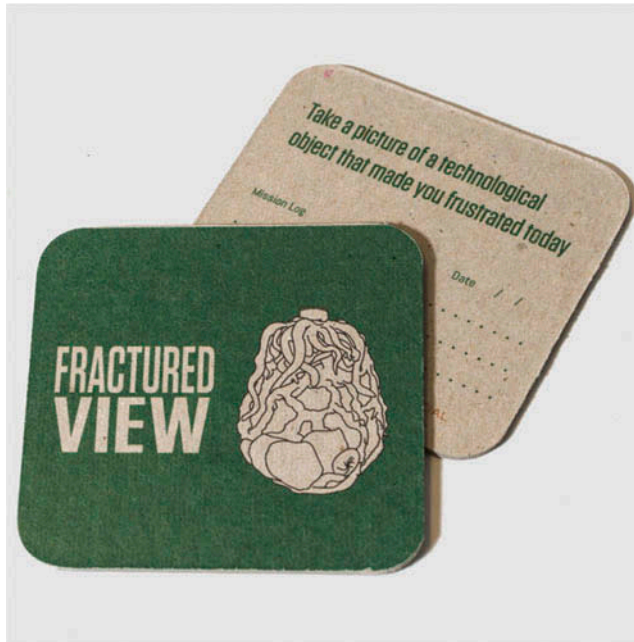
(e.g., "Your friend Joan is getting married; were you invited to the wedding?"). The objective was both to reinforce the theme of surveillance and to create anticipation each time participants interacted with the Candy Camera ("What else had they found out about me?"). To capture reactions, we provided a scrapbook for each household. The participant-curated scrapbook became a conversation starter in our subsequent visit.

In addition to creating and using artifact probes to engage participants long term, we also developed a secure, participant-only, password-protected website. The website was created to engage the participants in the co-construction of research activities (Bardzell & Bardzell, 2011); in this case, the automated data—videos and images as a result of the use of the three designs—were captured and stored on the web server and populated on the website so that participants knew what was recorded. They had the option to remove anything that they did not want to be shared with the research team; in addition, they could comment and reflect on the data in the text box associated with each piece of the data. At the conclusion of the deployment study, the participants and research team reviewed and reflected on 6 months' worth of participant-generated data together.

Once all six deployments concluded, we turned to data analysis. To understand how participants sense-made around and with the three Persuasive Anxiety designs, we first used Carspecken's (1996) low-level open coding to categorize the transcriptions of the interviews, participant-generated reflections of the automated images and videos, and data from probe activities. Briefly, in this form of analysis we labeled specific speech acts

with a minimum amount of interpretation, focusing specifically on what was said and emergent themes across participants. Following this, these themes were used to develop richer interpretations of exemplary remarks, reflections, and media of note through discussions and affinity diagrams between researchers. We chose Carspecken's data analysis method because it allowed us to work through the quantity of data that we had collected across the longitudinal study while allowing us to critically and thickly describe exemplary data. In what follows, we present the results of that analysis, focusing on how these designs were experienced as tracking devices and how our design tactics of transparency and limited control, as described earlier, were experienced by users.

4. FINDINGS: LIVING WITH PERSUASIVE ANXIETY

Throughout the experience of living with the designs, the participants addressed many of the material, functional, and formal qualities of the designs. Here we focus on how participants viewed these qualities in terms of making connections to other playful artifacts, how these became a part of the use of the designs in terms of tracking and self-knowledge, and how the styles of interaction related to surveillance.

4.1. Interpretative Play

When introducing the devices, we gave participants a brief overview of how the devices functioned (e.g., squeeze the Fractured View to take a distorted picture), as well as a brief and open-ended description of how the devices fit within the space of personal tracking. In other words, participants were told that we were interested in how the devices might be used to track activities, but we did not give specific details about how the functions of the devices might connect to the tracking process. Reasonably, this left many participants confused regarding how they might use these strange technological devices.

For Kelly and her husband, Andrew, who received the Candy Camera and the Melody Bot, the idea of using technology for fun was an easy association. Both work with technology for their jobs as an interaction designer and bio informatics educator, respectively. Sarah and her husband, Dale, who also received the Candy Camera and Melody Bot, were also familiar with the idea of recreational technology, with Sarah working on a PhD in recreation with a focus on media. Leslie and her teenage son, Jared, also received the same two designs; they were not into recreational technology but did have a strong relationship with a specific form of technology. A middle-aged administrator at the local university, Leslie both professionally and recreationally would engage in artistic activities, particularly focusing on photography as a means of self-expression.

For the second set of deployments (all of which involved the Candy Camera and the Fractured View), participants were equally experienced with recreational technology but a little less actively engaged. Jessica is a late 30s administrator for the local university who

lives with her adolescent son, Larry. Larry plays a number of video games both for recreation and as part of his education (which Jessica helps with by installing and playing Minecraft), and Jessica works with computers but does not engage with them much beyond the role of work. Jack and Laura, a late-30s couple who live with their three children, have a similar connection between work and computing, with Jack having worked in a number of roles that involve design and engineering through computers, as well as working as a teacher at a local high school where Laura works. Like Jessica, they were not necessarily critical of technology in general but were not as excited by it as Kelly, Andrew, Sarah, and Dale.

Ben and Karen were arguably most removed from the rest of the participants, both in age (they are in their 60s) and in their comparatively little experience with technology. Ben works as a freelance writer and Karen is retired, having previously worked as an archeologist. As a conversation with them details, they have mixed feelings regarding the role of technology more generally:

> Ben: "I dream, I have these … what are they called, Luddite? I have these dreams of if I didn't have to earn a living and I didn't have to do this, this, and this, could I just buy all of my things with cash? I might like having a TV and a DVD player but I could just get rid of the Internet. I could have a landline. I just think 'how can I get technology out of my life?'"
>
> R1: "What don't you like about technology?"
>
> Ben: "Cause it takes up time, it requires … I don't like … I hate getting a new computer and having to … I hate the learning curve. Technology just seems to be full of learning curve after learning curve after learning curve. I have to keep …"
>
> Karen: "It breaks down in six months and you have to buy a new one or it is obsolete."

Both Ben and Karen later would go on to describe how they do not necessarily hate technology but that they find it gets in the way quite a bit and that they have a high preference for technological tools that facilitate the work they want to do, but do not see computers as a source of recreation.

The participants, then, reflected a wide range of attitudes, and these attitudes influenced how the participants initially interpreted the stylistic elements of the designs that we gave them. In particular, as a sometimes positive, sometimes negative attribute, they referred to the overall toylike appearance of the designs.

For the participants who were accustomed to thinking of technology in playful terms, it was easy to associate the style of the designs with fun and play. As Kelly described,

> I think it appears more child-like in nature, both devices actually. Which I'm attracted to, I like stuff like, I've got a Pee-wee Herman doll there. I like stuff that but I don't know if other 30 year olds do. … Maybe I'm weird.

In this description, the Candy Camera is presented as being fun and enjoyable, as well as something that fit into Kelly's own kitsch friendly stylistic sensibility: "I think it totally fits MY aesthetic because I'm kind of kitschy and eclectic."

Although he enjoyed the playful nature of the Candy Camera, Kelly's husband, Andrew, saw the style of the Melody Bot as something a bit more daunting: "I haven't used that thing [Melody Bot] at all, it terrifies me. … I'm not a creative type, I feel that that involves more creativity and I'm not there, that's not where I live." Just from the visual appearance of the design, Andrew felt that it was something that had to be used creatively and thus chose not to use it. Kelly had a similar reaction to the device in her own process of using it:

> I guess for the first video, just sitting here using my computer, I didn't quite know what to do to be captured on camera. Like what Andrew said, there's this element of feeling like you need to be creative in the content you are creating.

The expectation that they themselves need to be "creative" with the Melody Bot was surprising and interesting to us: People don't generally speak that way about their Fitbit. It suggests that the Candy Camera was seen as not only a self-tracking device but also as a digital content (i.e., digital image) authoring platform.

Sarah had a more social reaction to the Candy Camera:

I've noticed that when I have people over I'm interacting with the Candy Camera more. Um, it's almost like a feature piece—come do this, check this out kind of a thing. So it seems a little bit easier to interact with in a playful way. I feel like it's my office up stairs—it's business. So I feel like when I interact with the camera upstairs [Melody Bot], I'm doing business right now. … Its not as playful. … It feels like a capturing me doing my work as compared to down here this thing is capturing us having fun." For Sarah, the Candy Camera's location and its fun elements made it a compliment to the atmosphere of her living room compared to the Melody Bot that was tethered to her office. However, she also saw great potential for fun in the Melody Bot, subsequently requesting that we install it on her new laptop so that she could bring it downstairs as well.

For participants who received the Fractured View, the description and use of the design were a little more complicated. As Jessica initially described the design, "It looks cool, but I'd like to see how it works when it gets hooked up. … It's squishy—it looks either like a facehugger [referencing the *Alien* films] pod thing or a Jurassic plant." Prior to using the device, Jessica simply saw it as something cool and something displaced in space or time. As she began to use it more, it began to take on a more creative role: (in reference to the ability of the Fractured View to relieve stress) "I think the Fractured View would help because it was a creative outlet and I could fracture things and some people and it made me feel better." Here the ambiguous form of the design, the distortions introduced by interacting with it, and the ability to figuratively fracture things and people combine into a complex experience. As Jessica described later, "I think it, probably more than just a stress ball, more like a creative outlet reduces stress and you don't think about what you're doing or think about other things than what you're doing at the moment." For Jessica, the interweavings of different stylistic elements created an experience that was

not only enjoyable but also capable of relieving stress in the fullness of how different elements related.

In both cases, the physical form of the devices invited participants to think of them as tokens of their lifestyles, to read their stylistic and expressive qualities accordingly. But they are also computational objects. For Ben and Karen, the fun of the device was in some ways tainted by the more digital elements. As Ben stated, "I like the gumball machine, but I have to admit it feels a little bit contaminated by the technology. … I feel weird. I want to be excited, but I don't care." For Ben and Karen, the device both represented something playful, but perhaps something slightly unsettling as well—the technology "contaminates" the gumball machine. For Ben and Karen, the dark connotations of computational surveillance and the physical form of the gumball machine were reconciled in a bit of humor: They physically propped the Candy Camera up on the table using several hardcover books on the CIA and NSA.

Although Jessica found the Fractured View to be a complex, interesting, and even fun design, her reaction to the Candy Camera was more in line with what Ben and Karen described.

Jessica: "Um, well … that [Candy Camera] looks friendly and playful but I think that's evil. Um … and that [Fractured View] looks evil but its actually friendly and playful. I think its opposite in actual functionality."

R2:   "Okay, why is it evil?"

Jessica: "Well you can't control it. It takes a picture and you have to change your surroundings to control the picture. And this you control it entirely because you can delete it if you don't like the picture but that one you're stuck with. … I don't think of it as surveillance. It just captures the moment and you have some control but not very much control."

R2:   "Not surveillance but it's evil still?"

Jessica: "It's still evil yeah. yeah cause it looks … anything that looks that playful and friendly has to have something bad."

For Jessica, the juxtaposition of the playful form and the function of the Candy Camera resulted in it being evil in nature. What makes it "evil," however, is the way that automation, control, and presentation come together in the objects. One object has a happy presentation, but its automation forces the user to change to accommodate it; the other has a sinister presentation but actually gives the power of control over to its user. Both objects "lie" but only one is "evil."

As we explained earlier, when we chose to use cameras as a central data collection mechanism for our self-tracking devices, we were thinking about disrupting the tendency of self-tracking devices to use cognitively thin, automated, quantitative measures (such as step counters). We anticipated and hoped that the enriched data that photographic images provide would lead to different experiences of self-tracking, which they did. We did not expect the extent to which our participants not only grasped the creative and performative possibilities of the cameras but indeed read them as *expectations* the devices placed on their users. Of course, it is known that users

sometimes "perform" for MyFitnessPal or Fitbit, but we witnessed the activation of a sophisticated cultural practice—photographic snapshots, digital image editing—as an unconsciously assumed component of self-tracking. Participants then filled in what that might mean for them (e.g., the need to "be creative," to perform socially, to perform self-tracking differently in the home office than in the living room). This creativity and performance was not without a more anxious component, however; with participants being "terrified" by the designs, feeling they are "contaminated," or simply outright evil. As we show in what follows, many of their most critical reactions (here in the sense of criticizing the designs themselves, rather than in the sense of critiquing underlying ideologies of self-tracking) had to do with the specific ways that our designs limited their expressive ability to author themselves.

4.2. Quantitative and Compliance-Oriented, with Room for Fun

Although our designs proposed certain conceptions of what personal informatics and self-tracking might look like, of course all of the participants already had some notions of personal data tracking devices and what people use them for. Their interpretations—both initially and over time—can be understood as a conversation between these two conceptions of personal informatics. For Jessica, Leslie, and Jack, the concept of tracking was not new, but it wasn't something that they actively pursued in digital form. For example, when attempting to better manage his finances, Jack described using more traditional methods as opposed to a site like Mint.com, a site where users input financial information in order to track and visualize their spending: "It was more like pen and paper, just being better about budgeting: spending less and paying more on (credit cards); spending a lot less and paying a lot more." For Jack, the act of tracking was more of a matter of discipline combined with the analog balancing of income versus expenses.

Sarah was far more interested in the Quantified Self movement as a concept but also found herself divided about whether it was something that she was actually interested in pursuing.

> I think it's interesting the whole quantified self, you know, we're starting to track everything that we do. I kinda don't want to know, part of me is like, I don't know. I wore a pedometer for years and then the first week of school here I wore it and, I don't know what I did, I caught it on my sleeve or something and it broke in half, the clip came off of the device itself and I haven't gotten another one.

Kelly had a complex relationship with tracking. On one hand, she was interested in personal tracking systems, and actually began to use MyFitnessPal as well as other tracking systems toward the end of the study. However, as part of her job she also worked on an application for tracking employees on the job and giving them feedback, describing it as "basically a snooping application, kind of Big Brother-esque." Although this system did not qualify as a personal informatics device, these concepts of "snooping" and "Big Brother" were common in her thinking about her personal information.

Devices that capture data were not inherently problematic, but who had access to that data was an important concern.

Sarah's relationship with this kind of tracking, in general, was quite complex as well, as is indicated by her conceding that she may not want to know the results. However, in spite of this she did express interest in getting an iWatch as a replacement for her broken pedometer. Partially this may have been due to the specific limitations of the pedometer as well, as she pointed out, "It didn't really matter at that point, I know how much I walk on average," combined with a desire to not have her life reduced to one specific number: "Um, I don't like to use a scale. I avoid a scale like the plague. Because that one to me is the ultimate judgment. Like, its not supposed to be about the weight, it's supposed to be about how I feel." In this way, Sarah seemed to be quite similar to the people who have been part of other studies focused on people who abandon personal informatics technology (e.g., Lazar et al., 2015; Patel & O'Kane, 2015): For a number of different reasons the devices seemed appealing but also presented a number of difficulties with regards to long-term use.

Of all the participants, Ben and Karen were the most critical of tracking devices and systems, both analog and digital:

Karen: "Yeah, I mean, I think I'm kind of guessing, but my guess is that a lot of people who use these health apps are … they don't like what they get; they don't like the results. So they develop this kind of weird relationship with their recorder or their technology. They have this idea that they're using it to be healthy, but they're pissed off at it."

Ben: "Like the bathroom scales."

Karen: Karen: "Exactly."

Although not necessarily opposed to the idea of tracking as a means to an end, these two saw the devices as becoming a kind of antagonistic force to the user. The technology or device in question becomes a relationship rather than a means to an end, with the actual results of the tracking process not necessarily living up to expectations or goals. Similar to Sarah, they saw tracking devices as a way to reach a goal but were more critical of such devices in terms of their actual ability to deliver on such a promise.

For some of the participants, the role of the devices as a personal tracking system were strongly tied to the notion of counting action, in spite of the use of images rather than numeric representations. As Jack and Laura described, attributes of the device as a whole became something to be counted and measured:

Jack: "Well with a scale, my mass translated, translates into that thing on that meter, the analog … kind of meter. For that [the Candy Camera], the feedback I get is the line on the glass bowl, like the level of candy that's remaining. …"

Laura: "I think when, not so much when we filled it with the peanuts but when it still had Skittles in it sometimes the camera would be like 'ugh, I don't want

it to take my picture because then I'd know how many Skittles I'm eating. …'"

Jack: "In the picture you could tell who has been eating the supply of Skittles. If it was full of Skittles and I was primarily the one who was on the screen, then I would be a little concerned that I was over consuming my portion of the allotted Skittles."

Both the qualitative and quantitative measure of candy and pictures became a means of tracking. For a household with three children, this became a way of telling not only how many candies had been eaten but also who had been eating them. Whereas Jack and Laura saw this counting exercise in more rough-cut terms, Kelly could see how moving from uses of the machine to caloric intake could be useful:

I could see someone kind of mapping out their day and what they're eating. … I'm trying to count calories actually right now so I could see how … I could work the Candy Cam into my day, my calorie allotment based on the number of pieces that comes out if I was going to be that specific. So counting calories would be one thing that you could log and track with the machine.

So whereas Jack was interested in such things as keeping his children from getting too much candy and watching a more broad idea of sugar intake, Kelly saw the way that the Candy Camera dosed candy as a means of calorie tracking. Sarah incorporated similar counting processes into her actual use of the design:

I would say I've used it more than … that is a lot of M&M's to be gone out of that machine um yeah and I would try to go several days without going near it and all of a sudden it would be like five times in a row. So I've just decided that every day I'm at least going to do one, so it's not bingeing.

The design gave Sarah an indication of how many candies she had eaten and, comparing that amount to the amount her husband was eating, had noted an increase. Bypassing the specific amount of calories, she saw it more as a means to have candy but not overindulge. Similarly, Jack would see the images on the Candy Camera as a kind of "warning": "Well I guess, with, you know, wigging out if I'm on the screen. If I see several pictures of myself on the screen I might be hesitant to turn the dial." By connecting the pictures to the amount of candy consumed, and then reflecting upon that, the device effectively made Jack consider his actions, even if it did not always act as a deterrent. Kelly and Andrew had similar reactions:

Andrew: "Well I will say this, it will prevent me from … knowing that you are time stamping it in some ways, it does prevent me from going to it like five times in a row. Like, ah I don't want these guys to know I'm mawing on all of these jelly beans. I have to go and run a mile now."

Kelly: "I don't think these two are very judgey."

Andrew:

> "No, but you know, there is an aspect of that, like you're being counted how, you're being binned, you're being put into a bin of how often you ate Jelly Bellies that day."

Within this, the main concern was less about how many candies were eaten, necessarily, but the sort of interpersonal and intrapersonal reactions that would determine how that information is socially interpreted. Andrew references how we (the researchers) might interpret the eating of candy and how that served as a kind of judgmental part of the design. Alternately, Laura saw the designs as better, in this regard, than other options:

> I think if it instead flashed a number that showed you how many times you've eaten Skittles that day, that would be worse. The pictures, I mean its playful and fun too which brings it that positive aspect of it instead of just being like ten servings of Skittles.

For Laura, the pictures provided a more fun kind of means of tracking—one that could be counted but also could be simply a funny source of entertainment. It is, perhaps, similar to how Sarah describes her experience with scales:

> Um, I don't like to use a scale. I avoid a scale like the plague. Because that one to me is the ultimate judgment. Like, its not supposed to be about the weight, it's supposed to be about how I feel.

For these participants, data brings associations of being evaluated, graded, and judged. But such judgment may be necessary, given that Jack and Sarah both also had spoken favorably about using different means of tracking in their lives. Although it may not be as judgmental to some participants, for Kelly the lack of numeric representation actually hurt how effective the devices could be:

> That information (the photos) is not as useful—the pictures of people getting candy over and over again… isn't as useful as augmenting those pictures with more data about when we're doing it and how often, and how much calories.

For Kelly, the lack of abstraction (and perhaps even judgment) of the photos, compared to some sort of numeric representation, made them less useful as a form of tracking.

Comparing these responses, the responses to the images as a form of tracking seem to emphasize counting in one form or another. Even those who embraced the more interpretive nature of the photos still spoke of the act of tracking as being tied to some sort of measurement, be it the number of photos of a particular individual or the visible level of candy in the Candy Camera.

One of the issues with the Candy Camera was a feeling of lack of control over the device. In attempting to come to grips with the device, Jessica described how she

could use it in a way that broke from the idea of treating the device as an evil tool of punishment:

> I changed the way I'm thinking about the Candy Cam. Its not a punishment tool its to shock the other end of it. So if I can come up with something creepy at the … on the camera then its a successful candy gram.

Rather than a mugshot of a person who was taking candy, here the picture becomes a deliberate message to the next person, an action that deliberately takes control of the picture-taking event. This notion of making a picture (active), as opposed to having a picture taken (passive) was not unique to Jessica either, with Kelly and Andrew discussing how the design could be used to scare the next person to get candy, Laura capturing images of her Jean-Luc Picard stuffed doll, and Ben and Karen taking pictures of the camera taking pictures of them.

In contrast to the Candy Camera, however, participants had very different reactions to the Melody Bot, with regards to its functioning as a tracking system. For Laura, it was a matter of the quantity that she would use the Melody Bot:

> Now if it had turned on automatically, the minute I, then you probably would have a lot more footage because of those instances where I was just on real quick or say I hadn't showered yet. Then you would have a lot more because it would just … there it is. That would have changed things, I think, a little bit.

For Laura, the Melody Bot would have gathered more video, regardless of whether she wanted it to or not. Sarah had similar sentiments, regarding the use of the design as a tool for tracking time at the computer:

> I'm hoping that the camera sitting there will make me more productive. I almost wish that as soon as the computer turned on the camera would automatically start capturing image. I feel like it would be more of an accountability tool for me.

The idea of the design as an "accountability tool" here becomes connected to the idea that the data the Melody Bot collects should be complete and rigorously collected.

Although the designs did not fit readily into the style of personal informatics devices, in terms of their ability to rigorously collect quantitative data, this did open up the space for a different kind of tracking. As Sarah related while looking over all of the images from the Candy Camera,

> Based on seeing the pictures come up and looking through the website pictures it was one of those things of "wow! there's more pictures of me … still in my pajamas or in my very lounge-around-the-house kind of clothes." My hair pulled back and just … lazy is what I call it. Actually that's what Dale calls it too. And realizing that I needed to take care of myself a little bit more. Um. But there's a few … there's quite a few pictures of me coming home from working out where I look the same. But I'm grabbing M&M's as soon as I walk in the door.

So while the control of starting and stopping the Melody Bot led Sarah to use it less for tracking, the automatic nature of the Candy Camera helped her to observe something about her behavior. This observation was not specifically tied to the candy-dispensing function of the design but rather to a more abstract collection of actual behavior, observations from family, and the function of the design.

One of the more interesting findings of the deployment was that participants kept coming back to notions of tracking as fundamentally quantitative and compliance based, in spite of our strong and obvious efforts to undercut both of these notions. Participants even managed to turn our designs into quantitative trackers, albeit somewhat crude ones (e.g., using images from the Candy Camera to help count calories). The material styles of the designs gave participants license to reimagine self-tracking with a flair for fun, but the functional purpose—losing weight, maintaining accountability, doing the right thing—never entirely left the conversation. This result underscores the experiential complexity of weight loss and similar regimens, in that participants not only comply with or fail to comply with them—dealing with the accompanying frustration and anxiety that can come with noncompliance—but also interpret them, appropriate them, perform them, and make fun of them. All of this suggests that there is room for personal informatics to lighten up, that the sober data collection and earnest information presentations of something like Fitbit can accommodate more than their current slick consumer interfaces and gamification strategies; they can also accommodate humor, reflection, and irony.

4.3. Awareness and Frustration From Camera Control and Visibility

We referred earlier to two design tactics: One was to call attention to the cameras, an effect achieved by stylizing them with transparency. The other was to tightly couple interactive controls with the task of tracking, an effect achieved by taking away much of the control of using the cameras. Both tactics turned out to be significant.

Putting computer-controlled cameras in people's homes was meant to highlight issues of surveillance, but we also wanted participants to have absolute control over what the cameras captured and to know that they had this control. There proved to be good reason for our precautions, because all of our participants expressed some degree of negative feelings toward the capacities of technology to be used for purposes of surveillance. Even Leslie, who was more understanding of the ambient capture of images in public spaces due to her background in photography, expressed offense at data collection and sharing practices common on social media:

> I started a Pinterest pages board for the School of Ed, and all of a sudden it started changing everything to German. And it's because somehow it found everything about me on Facebook and saw that I was writing in German on messages or something, and I was pissed. I'm like, "You know what? That's not right." … and really I just thought that was too aggressive and it turned me off of Facebook a little bit. I was like, you know nobody needs to know; I'll say if I speak German or not.

Social media was a common target for participant concerns over surveillance, as were video cameras at institutions such as banks and places of employment. As Kelly described,

> I don't like cameras out, like at work, there are cameras all over the building. I'm not a big fan of that. It's not like I try to do something funny, because I know the systems guys are going to see it on tape.

Generally, these descriptions highlight the issues of control and visibility that emerged in our design process.

The tactic of limiting control over the devices as a tactic of tightly coupling tracking and image-making had mixed reviews. As Karen described, her daughter Eva found the lack of control to be troubling:

> We talked about the problems with the cameras on both of them, and [Eva] said because of the problems with the cameras, she just felt like they weren't interactive. She wasn't interacting, they weren't interacting with her at all in that the sort of photo booth aspect of that one [Candy Camera] … just taking pictures. The camera aspect of this one [Fractured View], you need to know where the camera is focusing. Without that it loses the point of being interactive, I guess, is what she was talking about.

In this case, although the controls on the cameras were limited to orient participants toward using the designs as tracking, that did not prevent them from wanting to use the cameras in other ways. This became more complicated in relation to the nature of images:

> Eva: "I think the taking of photos raises more privacy concerns than other interactive devices."
>
> Karen: "Because while it's impossible to do, the control of one's image is the site of a lot of ethical concerns whereas other forms of data. … If you can see how people have interacted with the device but they're not personally identifiable, I guess that doesn't seem to raise the same kind of privacy confidentiality concerns, and then people are less likely to be offended when they aren't personally identifiable, but also because people are just sensitive about pictures of them."

As Jessica pointed out, control was not just about the capturing of images but also about what could be done with them after they were captured:

> I like the Fractured View better than the Candy Camera. … The control aspect, I can control this I can't control that. I'm the one taking pictures with this one and that one is taking the pictures. I think if it [Fractured View] was streaming [its images] like that it would be fine if it had a slideshow. Cause I would be the one, if I didn't want to see the picture I could just delete it, and it wouldn't be of me it would be of something else.

So even if the images from the Fractured View displayed its images in a manner more similar to the Candy Camera, Jessica would still prefer it because it allowed her to delete unwanted images, whereas the images captured by the Candy Camera could not be accessed.

Overall, participants found the level of control over the cameras to be problematic—either offering too little in terms of interaction or, as Sarah described earlier, offering too much control to properly function as a tracking device. However, this level of control did not frequently lead to feelings of surveillance. Alternately, the visibility of the cameras did raise some concerns. As Laura and Jack described, in reference to the Candy Camera,

Laura: "I mean, just kind of everybody has kind of the same reaction which is what?"

Jack: "Why is there a camera on it? A lot of people think its a video camera for some reason, I mean we know it's not, but they say things like 'are you worried about someone watching you?'"

In this case, the camera became an alert to visitors to Laura and Jack's house. Although having a DSLR or other recognizable camera lying around did not raise concern, nor presumably the cameras in either of their laptops, the prominent display of the Candy Camera's camera made it stand out and, as such, attract both attention and concern over monitoring. Here, our self-disclosure, contrasted with the lack of it on laptops, aroused suspicions.

Sarah and Laura had similar reactions. Sarah described the Candy Camera as "staring at her," which, toward the beginning of the study, made her very aware of its presence. Laura similarly saw the camera as a kind of eye: "But what's weird is this little eye is always out in the room. This makes me more unsettled than that. Yeah, yeah, it took me a couple days to kind of go 'It's okay, it's not really looking at me right now.'" In both instances, seeing the camera made participants wonder if it was seeing them.

Karen also had a similar reaction, but more focused on the technology:

It's an eye—the camera is like an eye. I felt the same way when I had a webcam on me. When i first got a laptop there was a webcam built in and I added one to my thing at work. Cameras without shutters, I guess. I think it's kind of a pop culture thing, though, you know? The eye of Sauron, yeah.

Although the form of the camera certainly played a role in this designation, particularly with regards to the shape of the all-seeing eye of the villain from *The Lord of the Rings*, the emphasis on the shutter and the general functioning of a web camera as opposed to a DSLR or other shuttered camera is notable. Just as other participants had concerns over the possibility of it consistently recording, the particulars of the type of camera created an association here as well.

Our findings suggest that both the visibility/self-disclosure and limited controls tactics were significant and that the latter was imperfectly realized from a user experience standpoint. That is, the transparency of the cameras called attention to them in ways that were (overall, if not universally) what we wanted: to raise questions of surveillance without making subjects actually feel threatened by them. But in establishing a tight coupling of tracking and image-making through limited controls, we went too far: The designs introduced frustration through their interface. If the Melody Bot was terrifying because of its perceived demands of creativity, it and the rest of the designs caused distress in their inability to fluidly allow participants to comply with that demand. Combining this with the interpretive and appropriative aspects of self-tracking, these results suggest that we could have made the cameras more functional without losing their powers of self-tracking.

5. DISCUSSION

We return to the knot of questions that motivated this project: How can human–computer interaction (HCI) researchers and designers better understand and design for the experiential qualities of personal tracking? How best to take seriously the ways such devices pose threats to human vulnerabilities and contribute to anxiety? What are some concrete design implications of conceiving personal tracking in a material, qualitative, and hermeneutic frame, rather than a disappearing, quantitative, compliance frame? Is is possible to engage users in conversations that critically and/or speculatively reimagine what personal tracking could be?

As we explained earlier, we used research through design, inflected by critical design, as a methodology to approach answers. That is, the design process itself—with its iterative concepting, sketching, internal crits, and material prototyping—was a tool of inquiry. It led us to several dead ends. These included design concepts that seemed likely to perpetuate hegemonic norms, such as body thinness. Another problematic direction involved design concepts that were overly dark; for example, we had several designs that explored slow suicide as a design metaphor for the deleterious effects of consumption. This metaphor helped us think critically about ways that the language of design can critically interrogate consumption, but we realized that if one of our eventual goals was deployment in people's homes, then such design concepts went too far. Similarly, several of our design prototypes were constructed from fragile materials, which were perfectly acceptable in our lab, but we realized that they could not be deployed without radically changing them. Each of these dead ends nonetheless raised specific design considerations to our awareness, encouraging discussions and reflections that ultimately did lead in more positive directions. Above all, our research through design approach helped bring to clarity for us some ways that specific design choices engage (for better and/or worse) three concerns pertaining to personal tracking: the perpetuation of hegemonic norms, connotations of surveillance, and the pragmatics of coupling digital interfaces to an embodied practice of getting healthy (however construed).

In what follows, we reflect on our efforts to counter hegemonic norms in self-tracking, on our discovery of the potential for content authoring tools to enrich self-tracking as performance of the self, and on how particular data forms—sensors and quantitative measures versus digital photos and videos—participate in and shape self-tracking.

5.1. Designing In/Against Hegemonic Norms

The issue of hegemonic norms was an ethical concern that several members of the research team brought to the project, and we suspected it is a key reason for the abandonment of self-tracking devices. Specifically, we were suspicious that technologies putatively designed and used to promote health were also more subtly engaged in affirming and perpetuating hegemonic beauty norms, thinness in particular, resulting in feelings of not measuring up. Further, these norms are gendered, affecting women more than men—as beauty industry marketing and bulimia/anorexia statistics alike attest. This suspicion was foundational to the project as a whole: We were interested to decouple personal tracking from a compliance model of health, to disrupt a deficit conception of health, that is, a notion in which users understand themselves as failing to comply with a clearly articulated definition of a healthy lifestyle and needing to "fix themselves" in order to make up that difference. Doing so, we hoped, might reveal ways to decouple self-tracking from experiences of anxiety.

But as we mentioned earlier, it is extremely difficult *not* to participate in the perpetuation of such norms. Many of our design concepts were as bad as or even worse than commercial technologies in terms of perpetuating norms. A key issue is that tracking inevitably leads to some form of representation of the self, and it is all but impossible not to hold up such representations against one ideal or another (e.g., a body mass index or a human model in a fashion magazine). The hegemonic norms problem is, as far as we can tell, intractable: So pervasive and overdetermined in social life, we found no way to avoid it, and instead we sought tactics to mitigate it. Our primary tactic was to track using digital photographs and video, that is, to represent users with photographic images of themselves, taken in playful situations and with defamiliarizing means of representation. We anticipated that many users would see the images and worry about whether they failed to meet this or that hegemonic beauty criterion ("Do I look fat?"), but at least that interpretation would come from themselves (or their participation in a social world where such practices are ubiquitous), and they would not be baked explicitly into the system.

Participants did indeed offer such responses, but as our results showed, they also critiqued them. As critical theorist Theodor Horkheimer and Adorno (1997) pointed out with regard to mass consumer culture decades ago: We know we're being duped, that is, we as consumers understand that demand is manufactured through consumer manipulation—but we desire stuff anyway. Something similar seems to hold for self-tracking: Participants are aware of hegemonic norms and the danger such norms represent to themselves—but they still want to be thin. We cannot design away that desire to be thin, to have a body that is attractive according to normative social standards of human physical beauty. What we *can*

design is technology that renders the conflicted ethics of self-tracking more present to users' awareness. Perhaps this is trading one form of anxiety for another, but it helps people not only to know themselves but also to be more cognizant of the lenses through which they know themselves. We chose photography-based tracking for that purpose, and it worked more or less as we expected (i.e., it defamiliarized self-tracking in terms of thin, quantitative measures), but it also worked in another way that we had not expected (i.e., by reframing self-tracking as multimedia self-authoring).

5.2. Sensors to Self

An obvious design problem was how to couple interaction with our devices to the user's lifestyle goals by means of self-tracking. One of the strengths of the dominant commercial personal tracking model today, exemplified by Fitbit, is that it tightly couples interaction, tracking, and a well defined conception of healthy living. It uses sensors to produce quantitative data, which it visualizes for users in relation to a normative quantitative model (e.g., one should walk 10,000 steps/day, should climb 10 staircases a day, should consume fewer than 1,800 calories per day, fewer than 200 carbs per day, etc.). Although we wanted to imagine alternatives to the emphasis on quantitative data and compliance models, we still wanted a tight coupling of interaction, self-tracking, and an understanding of healthy living. The question was how to concretize that in the language of design.

Our solution, as we have shown, was to use consumer cameras, but that decision introduced other challenges. One was how picture taking and viewing can serve as the basis of self-tracking. Consumer cameras have been ubiquitous for decades, a trend that has exploded in recent years thanks to mobile phones and social media, and in streaming video thanks to Skype and similar technologies. Coinciding with this trend has been a steady increase in features: Even consumer Canon and Nikon DSLR cameras have hundreds of features, and many of these are being translated into mobile phone cameras and their built-in photo managers. In other words, consumer photography already has established interfaces, skilled practices, and social connotations. These features, uses, and connotations all threatened to confuse our intended use of the cameras for personal tracking.

In short, we were proposing a new kind of computational interface for this kind of tracking (i.e., cameras), and we were proposing to strategically limit users' interactions with cameras in a way that users had never done so before. We came up with a design tactic that sought to limit the scope of our otherwise open-ended choices by severely limiting interactive controls. The hope was to establish a tight mapping between computational interface and health practice. No image previews were available on any of our designs. Common tasks, such as photo management, editing, and presentation (e.g., in the form of albums), were all taken away. Positioning of subjects within the frame was all but impossible in the Candy Cam, short of physically moving the whole device, and it was difficult in the other two designs as well. None of the designs offered in-device previews: All images could be seen only on a separate display (though in the case of the Candy Camera, this display was built into the design itself).

The deployment once again helped us evaluate the tactic and our implementation of it in the designs. On one level, we were successful: Data clearly show that users understood how this coupling worked. They understood that turning the crank on the Candy Camera took a single picture and placed it into an automated and uneditable slideshow and that the slideshow revealed their behavior with the gumball machine over time. They understood that Melody Bot produced a time-compressed representation of their sedentary computer work (humorously in the form of a music video). They understood that the Fractured View was a stressball with a camera in it and that they were supposed to use it to "explode" stressful aspects of their environment.

But on another level, our implementations of this tactic were less than successful. Most users expressed frustration with the limited controls. They described situations where they wanted to do X, but Y happened instead. Helpfully, none of these criticisms was about improving the devices as photographic equipment (which was one of *our* concerns): No one complained about their inability to creatively manipulate depth of field or wanted to create Candy Camera profiles to be used in street versus landscape photography. Instead, the complaints generally suggested ways that the devices' controls could be opened up in a way that supported their use in personal tracking.

This is an interesting result because it has implications for future design work in self-tracking. The key reaction is that participants saw the devices as digital content authoring tools but not in a generic sense (e.g., the way that Photoshop or Instagram allow image editing in a broad range of contexts). They were interested in *performing self-tracking with digital photo authoring*. That is, they intuitively wanted to link cultural practices around photography (taking snapshots, posing, image editing, curating, presenting images to others) with cultural practices around self-tracking (systematically collecting health-related data about the self, subjecting that data to analysis in order to discover hidden aspects of the self, revealing ways to intervene upon the self to improve, and finally performing an improved and healthier self).

From a critical design methodological perspective, this notion of performing self-tracking with digital photo authoring was interesting because it suggested to us that a key strategy participants had for making sense of these estranging designs was to mobilize and synthesize a number of concepts and cultural practices that had hitherto been separated. That is, these concepts and cultural practices were familiar to them already, but not in the particular way they became juxtaposed in order to make sense of, and make use of, our critical designs. This novel juxtaposition of familiar practices led to the articulation of new "user needs and requirements" (as it were) if such practices were to be realized beyond the fictional world of the critical design. Back in this world, we realized that there was an interesting design space that seriously integrates self-tracking with creative multimedia authoring (digital images, animation, robustly customizable avatars, social media, etc.).

5.3. A Tale of Two Self-Tracking Regimes

The diverse ways that participants understood, lived with, and performed our designs over time informed our understanding of ways that self-tracking, design decisions, and anxiety are entangled. Reactions from participants highlighted the ways that being observed, and the anticipation of feeling judged, can lead to anxiety, as can the demand to perform for the devices.

From a theoretical perspective, we tend to understand self-tracking as a "technology of the self." Technologies of the self, a concept developed by philosopher-sociologist Michel Foucault (Bardzell, Bardzell, Zhang, & Pace, 2014; Foucault, 1988; for an application in HCI, see Bardzell, Bardzell, Zhang, & Pace, 2014), refers to the many techniques that individuals enact on themselves to understand themselves (Foucault's examples include confession, psychoanalysis, hygiene regimens, and learning how to be a better sexual partner). Such practices do not only represent the self, but they come to *constitute* the self, that is, they are used to bring a new self into being. Given both the stakes (i.e., the constitution of the self) and the rapidity of changes in technologies of the self (i.e., the rise of self-tracking as a cultural practice), it is not surprising that anxiety is a common outcome.

Our subjects helped us see that self-tracking contributes to self-care in a few specific ways. We explore this through a comparison, informed by Foucault's notion of technologies of the self, of two self-tracking regimes—that of Fitbit and MyFitnessPal, on the one hand, and our webcam-based approach, on the other. In developing this comparison, we hope to reflect qualities of self-tracking in general and then hone our focus on the medium-specificity of different self-tracking technologies.

First, computer-supported self-tracking adds a *level of granularity, or heightened resolution, to self-understanding*. A Fitbit presents user's stepcount for the day, week, or lifetime of enrollment in the service; on MyFitnessPal a user can trace the ups and downs of his neck thickness across months or years. If self-trackers worry that they are too lazy or sedentary, the stepcounts not only answer yes or no but also do so at a very high resolution. Similarly, most of us who worry about our figures don't commonly focus on our necks—bellies, thighs, butts are far more commonly of concern. Now, though, MyFitnessPal has made fat necks a thing, and high resolution data—attractively visualized—are there to help users see what they could not have before.

Although our use of cameras in many ways replaced thin, quantitative measures (such as step counts) with thick, qualitative measures (images of the self in moments of eating, stress, or extended sedentary behavior), their outcomes (i.e., collections of photographic/video images) still contributed toward that granularity. Participants could see how often the husband versus the wife reached for the Skittles, the distribution of use of the gumball machine, and how long a session sitting at the computer lasted. Such patterns can be, and clearly were, interpreted at a high level of resolution. It is also worth reiterating that our participants found ways to link these images to quantification—by counting the images or certain features of the images and by linking their interpretation of the images with more traditional forms of self-tracking that they were doing alongside the study.

Second, self-tracking introduces *a sense of objectivity, that is, it provides external evidence of the self*. We might contrast this with one of Foucault's favorite examples: the practice of confession. Confession depends on awareness of guilt, memory, and possibility other abilities such as empathy, imagination, and regret—subjective capacities and states. In the booth, with penitent and priest, there is little externalized—all hinges on the first-person verbal narrative of the penitent. But a year's worth of Fitbit data are much more objective. The story of the user's physical activity is in the system— distributed across local devices, the cloud, data-mining algorithms, user interpretations, and what users disclose to others (knowingly, through the interface's linkages to social media, and unknowingly with their data being bought and sold). The externality of these data makes self-delusion more difficult and encourages self-trackers to hold themselves to account for that record of data.

Our participants helped us understand how a collection of photographs also offers an external account of their behavior. The photo collections answer questions such as the following: What times in the day do I snack? How is my posture in long sessions at the computer? Who in the household made fuller use of the creative possibilities of the devices? And as with the Fitbit data, the externalized aspect of the photo collections means that not only can an individual user gaze at herself through her data but so can anyone with access to that data, including us. That opens up not only a concern to be accountable to oneself but also the possibility of being held to account by others. Presumably, such social accountability is experienced by some as anxiety.

Third, *data from self-tracking are commonly compared with a goal or ideal or norm*. A man of this age and height and weight according to the chart is "normal" or "overweight" or "obese." A woman of height H wanting to lose weight at rate R should limit herself to N calories. Also well known is that these goals tend to reflect not only the health sciences but also social norms: 2,000 calories is too much for person P to eat (from a health standpoint), and P lacks self-control (from the standpoint of social prejudices). Walking fewer than 10,000 steps in a day not only is suboptimal for weight loss but also suggests to some that P is lazy. Although it was possible for our participants to critique the intermingling of health/medical goals and social norms, no one, including us, was ever able actually to disentangle them.

The use of photography for self-tracking likewise participated in these dynamics, but in a way that reflected its medium. When Sarah sees how often she is dressed down in the photos, she calls herself "lazy" and adds, "actually, that's what [my husband] calls it, too." We did not intend the devices to be used as fashion trackers, or "how put-together am I?" trackers, but emergently that is what they became for her. They did so because the photos captured more than when/what she snacked on but also what she was wearing and how her hair looked at the time (recall that regimens of hygiene are also a technology of the self). And her additional reference to her husband—"what he calls it, too"—has her see herself normatively through her husband's eyes through the device's photo- graphic representations of her—the tracker criticizes her failure to adhere to regimes of hygiene by borrowing her husband's voice.

6. CONCLUSION: PERSUASIVE ANXIETY

We know from prior research—and we saw it again in our study—that people perform for their self-trackers. Indeed, that is one of their purposes—to encourage certain types of performance, for example, to take that extra 1,000 steps or to eat one less scoop of ice cream to stay below a target. But the blurry relationship between health goals and social norms, as well as the gap between what sensors sense and what actually happened, creates ambiguity. That can be read as a technical flaw, but instead we argue that it opens up *a performative space for self-tracking*. In other words, users are aware that trackers don't quite capture "reality," and they often actively and creatively make use of that gap. Numerous websites can be found that suggest ways to trick Fitbit into counting more steps. A recent news report found that Fitbit users who don't have their trackers with them don't exercise, because it won't count anyway. One Reddit poster reported his discovery that Fitbit counted his masturbating as steps, which led to a seriocomic thread about how to interpret and make the best use of that fact.

Our goal is not to decry this performative space for self-tracking and to call for applications that shut it down; the pervasiveness of social norms suggests to us that it can't be shut down anyway. Rather, our study suggests to us that users actually want tools to support their self-tracking performances—this was the one functionality that they consistently criticized our designs as seeming to promise but not actually delivering.

In other words, the three qualities of self-tracking just characterized—increased resolution in data about the self, the externality/objectivity of that data, and self-tracking data's blurry simultaneous mappings onto both medical models and social-hegemonic norms—are not just qualities of an interface; they are increasingly part of our contemporary condition. It is becoming a cultural skill to collect and interpret self-tracking data (much like Instagramming or "vaguebooking" are emerging as cultural skills). As those skills improve, demand to support those practices is growing, although it is difficult to perceive let alone articulate at this stage.

Stated more analytically, we saw our participants were practicing and/or developing skills as follows:

- *Performing for the system.* This refers to ways that users craft what the system tracks and how it does so. This can include hiding things from the system (e.g., not reporting a snack to MyFitnessPal), lying to the system (e.g., allowing the system to count masturbation as walking), or creatively posing for the system (e.g., staging a certain shot for the Candy Camera). For now, users have little direct control over how sensor data become information and knowledge—it is mostly blackboxed and even proprietary in the case of commercial products like Fitbit.
- *Performing for the self.* People self-track to learn about themselves (e.g., behavior, hidden patterns), of course; this learning is not cold and objective but rather is motivated—it is subordinated to a drive to be a better self. Technologies of the self are often creatively stylized; for example, almost all of us cut/groom our hair, but we all do so differently. How we will stylize our self-tracking self-performances

remains an open research question, but our study at least gave us glimmers into what this might become.

- *Performing for other people.* Because self-tracking represents the self, people understandably want some control over those representations—their granularity as well as what they imply ("I've been athletic/lazy this week")—as these representations become visible to others. Already Fitbit and MyFitnessPal can link to social media accounts and gamification tactics create mini-competitions between friends. With our designs, this was manifested in the visibility of images/videos to others in the household, including family members residing in the house, as well as visiting friends. Our study suggested that the social dimensions were extremely important—that users thought a lot about them and staged them in certain ways—so again, this seems to be an important issue for future research.

These three points all stress ways that users assert agency over the devices and the practice of self-tracking. But alongside of this impulse for more control is its opposite: the desire/need to cede control to the device. A major reason to turn to Fitbit and MyFitnessPal is because it generates data automatically, uploads it to the cloud, visualizes it for the user. Its externality and automation is key to the discovery of patterns that a user can't see herself and the power of confrontations with those representations.

In other words, we infer that devices have to be compatible with both sides of this tension: the desire to *cede to the device* the power to represent the user and to *assert for oneself* the power to represent oneself. Our inference from our critical design study is that current commercial self-tracking devices might be too narrow and too prescriptive in the room they provide for users to manage this tension. Further, as users' cultural skills to live in an era of self-tracking increases, there will be increased demand for more individually definable control over what is ceded to the device and what is asserted as the user's prerogative. Theoretically informed notions of selfhood could support this research; we used Foucault, but we can easily imagine symbolic interactionism and many other theories also working well.

Finally, we want to keep in the foreground our concern about hegemonic social structures shaping self-tracking as it becomes part of our lived environments and an increasingly sophisticated cultural practice, or technology of the self. Our concern is that self-tracking runs the risk of *reproducing* hegemonic regimes. Indeed, the dangerous, if apparently coincidental, harmony between medical health recommendations concerning obesity and destructive social expectations of thinness shows that the reproduction of hegemonic regimes is already in full swing. It strains credulity to believe that the market success of Fitbit, for example, reflects *only* a new consumer commitment to fitness according to modern medical science.

We believe that any time lived environments and social practices are in a moment of emergence and fluidity—and we believe self-tracking is in such a moment—there is at least *some* possibility of intervening, of actively resisting the reproduction of hegemonic norms. It is unlikely, to the say the least, that self-tracking devices will bring an end to hegemonic social norms and their symptoms. But it seems reasonable to ask, How might designers of self-tracking devices and systems take seriously the threats of bulimia,

anorexia, self-loathing, and body shame that consume so many of us? How can we design in such a way that cleaves fitness from body shame? Our critical design study suggests that one promising design tactic is to support active and creative performances of the self (rather than foreclosing them through ever-tighter data-to-knowledge loops), and one way this can be done is by linking the HCI research and design work on self-tracking to that of multimedia content authoring, informed by work on the self and selfhood from social media research.

NOTES

[1]All names have been changed to maintain anonymity.

REFERENCES

Bardzell, J., & Bardzell, S. (2013). What is critical about critical design? In *Proceedings of the CHI 2013 Conference on Human Factors in Computer Systems*. New York, NY: ACM.

Bardzell, J., Bardzell, S., & Hansen, L. (2015). Immodest proposals: Research through design and knowledge. *Proceedings of the CHI 2015 Conference on Human Factors in Computer Systems.*. New York, NY: ACM.

Bardzell, J., Bardzell, S., Zhang, G., & Pace, T. (2014). The lonely raccoon at the ball: Designing for intimacy, sociability, and selfhood. *Proceedings of the CHI 2014 Conference on Human Factors in Computer Systems*. New York, NY: ACM.

Bardzell, S., & Bardzell, J. (2011). Towards a feminist HCI methodology: Social science, feminism, and HCI. *Proceedings of the CHI 2011 Conference on Human Factors in Computer Systems*. New York, NY: ACM.

Bardzell, S., Bardzell, J., Forlizzi, J., Zimmerman, J., & Antanitis, J. (2012). Critical design and critical theory: The challenge of designing for provocation. *Proceedings of the CHI 2012 Conference on Human Factors in Computer Systems*. New York, NY: ACM.

Calvo, R. A., & Peters, D. (2013). The irony and re-interpretation of our quantified self. *Proceedings of the 25th Australian Computer-Human Interaction Conference: Augmentation, Application, Innovation, Collaboration*. New York, NY: ACM.

Carspecken, P. F. (1996). *Critical ethnography in educational research: A theoretical and practical guide*. Hove, UK: Psychology Press.

Czerwinski, M., Gage, D. W., Gemmell, J., Marshall, C. C., Pérez-Quiñones, M. A., Skeels, M. M., & Catarci, T. (2006). Digital memories in an era of ubiquitous computing and abundant storage. *Communications of the ACM, 49*(1), 44–50. doi:10.1145/1107458

Dunne, A., & Raby, F. (2001). *Design noir: The secret life of electronic objects*. New York, NY: Springer Science & Business Media.

Dunne, A., & Raby, F. (2013). *Speculative everything: Design, fiction, and social dreaming*. Cambridge, MA: MIT Press.

Federico, S. (2015). A tangible personal informatics system for an amusing self-reporting. *Proceedings of the UbiComp 2015 International Joint Conference on Pervasive and Ubiquitous Computing and Proceedings of the XX 2015 International Symposium on Wearable Computers*. New York, NY: ACM.

Fogg, B. J. (2002, December). Persuasive technology: Using computers to change what we think and do. *Ubiquity*, *5*, 89–120.

Foucault, M. (1988). *The care of the self*. New York, NY: Vintage Books.

Frayling, C. (1993). *Research in art and design*. London, UK: Royal College of Art.

Gaver, W. W. (2012). What should we expect from research through design? In *Proceedings of the CHI 2012 Conference on Human Factors in Computer Systems*. New York, NY: ACM.

González, J. A. (1995). Autotopographies. In Mark J. Driscoll (Ed.), *Prosthetic territories: Politics and hypertechnologies* (pp. 133–150). Boulder, CO: Westview Press.

Horkheimer, M., & Adorno, T. W. (1997). *Dialectic of enlightenment*. New York, NY: Continuum.

Khot, R. A., Hjorth, L., & Mueller, F. F. (2014). Understanding physical activity through 3D printed material artifacts. *Proceedings of the CHI 2014 Conference on Human Factors in Computer Systems*. New York, NY: ACM.

Khot, R. A., Lee, J., Aggarwal, D., Hjorth, L., & Mueller, F. F. (2015). Tastybeats: Designing palatable representations of physical activity. *Proceedings of the CHI 2015 Conference on Human Factors in Computer Systems*. New York, NY: ACM.

Khovanskaya, V., Baumer, E. P., Cosley, D., Voida, S., & Gay, G. (2013). Everybody knows what you're doing: A critical design approach to personal informatics. *Proceedings of the CHI 2013 Conference on Human Factors in Computer Systems*. New York, NY: ACM.

Lazar, A., Koehler, C., Tanenbaum, J., & Nguyen, D. H. (2015). Why we use and abandon smart devices. *Proceedings of the CHI 2015 Conference on Human Factors in Computer Systems*. New York, NY: ACM.

Li, I., Dey, A., & Forlizzi, J. (2010). A stage-based model of personal informatics systems. *Proceedings of the CHI 2010 Conference on Human Factors in Computer Systems*. New York, NY: ACM.

Li, I., Dey, A. K., & Forlizzi, J. (2011). Understanding my data, myself: Supporting self-reflection with ubicomp technologies. *Proceedings of the CHI 2011 Conference on Human Factors in Computer Systems*. New York, NY: ACM.

Lupton, D. (2014). Self-tracking cultures: Towards a sociology of personal informatics. *Proceedings of the Australian Computer-Human Interaction Conference on Designing Futures: The Future of Design*. New York, NY: ACM.

Mazé, R., & Redström, J. (2009). Difficult forms: Critical practices of design and research. *Research Design Journal*, *1*(1), 28–39.

McCloud, S. (1993). *Understanding comics: The invisible art*. Northampton, MA: Kitchen Sink Press.

Patel, M., & O'Kane, A. A. (2015). Contextual influences on the use and non-use of digital technology while exercising at the gym. *Proceedings of the CHI 2015 Conference on Human Factors in Computer Systems*. New York, NY: ACM.

Purpura, S., Schwanda, V., Williams, K., Stubler, W., & Sengers, P. (2011). Fit4life: The design of a persuasive technology promoting healthy behavior and ideal weight. *Proceedings of the CHI 2011 Conference on Human Factors in Computer Systems*. New York, NY: ACM.

Rapp, A., & Cena, F. (2015). Affordances for self-tracking wearable devices. In *Proceedings of the 2015 International Symposium on Wearable Computers*. New York, NY: ACM.

Rooksby, J., Rost, M., Morrison, A., & Chalmers, M. C. (2014). Personal tracking as lived informatics. *Proceedings of the CHI 2014 Conference on Human Factors in Computer Systems*. New York, NY: ACM.

Satinsky, S., Reece, M., Dennis, B., Sanders, S., & Bardzell, S. (2012). An assessment of body appreciation and its relationship to sexual function in women. *Body Image*, 9(1), 137–144. doi:10.1016/j.bodyim.2011.09.007

Sellen, A. J., Fogg, A., Aitken, M., Hodges, S., Rother, C., & Wood, K. (2007). Do life-logging technologies support memory for the past?: An experimental study using sensecam. *Proceedings of the CHI 2007 Conference on Human Factors in Computer Systems*. New York, NY: ACM.

Shiffman, D. (n.d.). Explode. *Processing*. Retrieved from https://processing.org/examples/explode.html

Šimbelis, V., Lundström, A., Höök, K., Solsona, J., & Lewandowski, V. (2014). Metaphone: Machine aesthetics meets interaction design. *Proceedings of the CHI 2014 Conference on Human Factors in Computer Systems*. New York, NY: ACM.

Wiberg, M. (2016). Interaction, new materials & computing–Beyond the disappearing computer, towards material interactions. *Materials & Design*, 90, 1200–1206. doi:10.1016/j.matdes.2015.05.032

Yokota, T., Zalar, P., Kaltenbrunner, M., Jinno, H., Matsuhisa, N., Kitanosako, H., … Someya, T. (2016). Ultraflexible organic photonic skin. *Science Advances*, 2(4), e1501856. doi:10.1126/sciadv.1501856

Zimmerman, J., Forlizzi, J., & Evenson, S. (2007). Research through design as a method for interaction design research in HCI. *Proceedings of the CHI 2007 Conference on Human Factors in Computer Systems*. New York, NY: ACM.