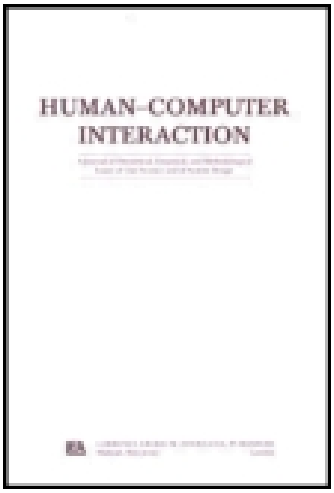

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Making Things Visible: Opportunities and Tensions in Visual Approaches for Design Research and Practice

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Making Things Visible: Opportunities and Tensions in Visual Approaches for Design Research and Practice

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Visual approaches for conducting research during the design process often give voice to people and ideas that might otherwise remain obscured. Recent and increasing interest in visual research techniques has coincided with technological advances such as camera phones and visually oriented mobile applications. As a result of this close association between digital technologies and image-based research techniques, there are multiple opportunities and challenges within human–computer interaction (HCI)

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design practice to employ these strategies to improve user experiences. This article provides an overview of current visual approaches to research highlighting the role technology has played in facilitating and inspiring these techniques. A series of case studies are presented that provide a basis for understanding a breadth of visual approaches in HCI design practices as well as serve as a point of entry to a critical and reflective discussion about the use of these approaches in different circumstances. Based on these reflections, three value statements are offered as a means to encourage the use of these visual approaches more broadly and critically in HCI design studies.

1. INTRODUCTION

Many researchers are attracted to visual approaches because of a belief that they have the ability to give voice to people and ideas that might otherwise go unnoticed or unnoted when eliciting and analyzing data. Much of the work in this area has been motivated by questions such as, Do you see what I see? Can you see what I see? How can I see what you see? For several decades, sociologists and anthropologists have used photography and video as tools for ethnographic inquiry. Techniques such as Photovoice, participatory video, and collaborative drawing have been particularly effective in engaging community members in dialogue and encouraging them to become active research partners. Researchers have also discovered that visual modes of dissemination such as art exhibits, film screenings and web sites (cf. Mitchell, 2011) can engage members of the broader community in ways not available through more traditional venues for scholarly publication.

This recent rise of visual studies across a range of social science research communities has coincided with increasingly available digital imaging technologies.

The general public has a greater familiarity with photography and video techniques due to readily available mobile phone cameras and increasingly inexpensive point-and-shoot digital cameras, making it easier and more feasible to engage community members in visual techniques for data elicitation and collection.

These digital tools empower researchers to make increasingly sophisticated decisions about what is made visible, how the previously invisible comes to light, and who has access to the newly revealed. In fact, many of us have turned to visual approaches such as sketching, photography, and visualization for conducting research, exploiting the process of making things visible to implicitly and explicitly push the boundaries of design practice. In recent years, trends such as the Quantified Self movement (Wolf, 2010), social media venues such as Flickr and WikiMedia and SnapChat, and visually oriented programming environments such as Scratch (Resnick et al., 2009) and Processing (Fry, 2008) have all flourished. In each of these cases, technology is increasing the scope and altering the nature of what we can make visible to ourselves and to the users of our products.

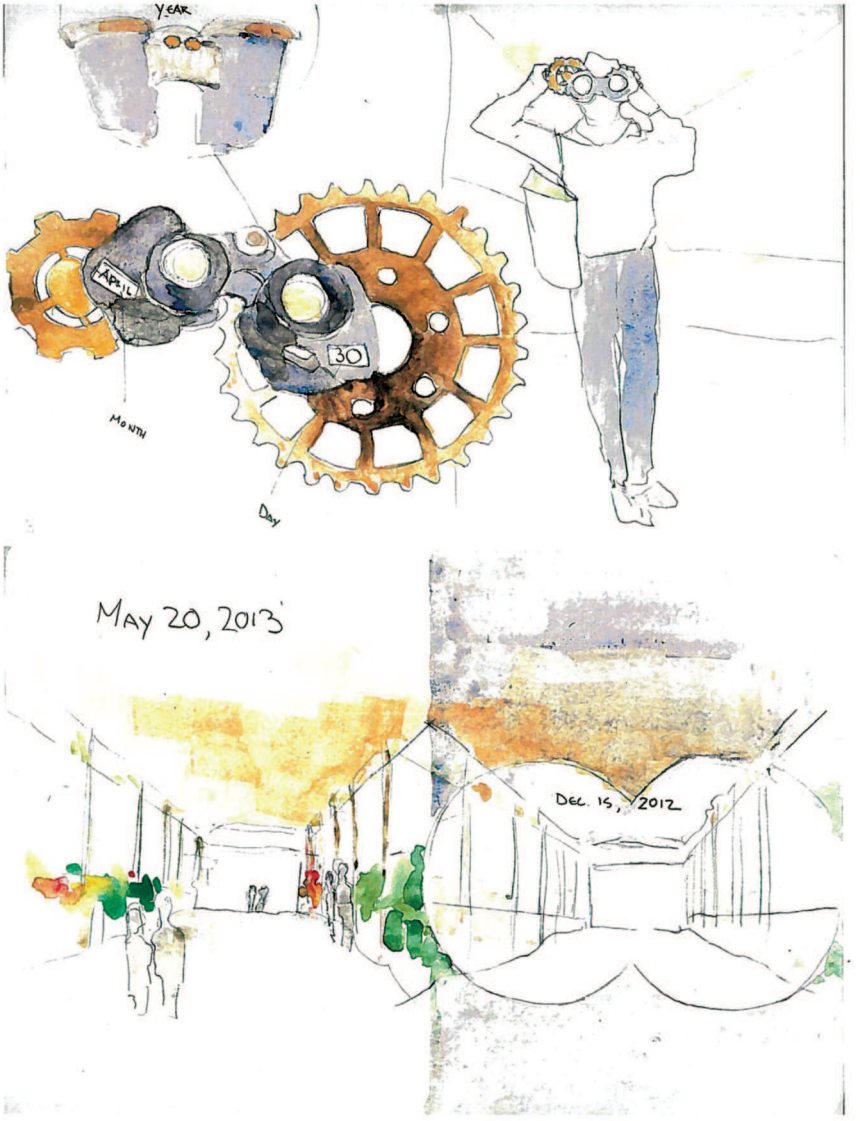
When applied in the domain of human–computer interaction (HCI), visual approaches ask us to become consciously, ethically, and socially aware of the choices we make as designers regarding what we make visible and how we make things visible. In this article, we associate this process with a reflective design practice (Sengers, Boehner, David, & Kaye, 2005). We use examples from our own design research practice to frame a discussion of opportunities and tensions presented by incorporating visual approaches into HCI design. For example, we examine the use of sketching as a way to provoke conversations rather than propose solutions (Figure 1), we consider the notable lack of images indicating social interaction in a user-generated collection of photographs documenting health and wellness decision points (Figure 2), and we explore unintentional disclosures made possible when personal information is collected across a number of channels (Figure 3) and aggregated in a single visualization.

This article begins with a general discussion of visual research practices across the social sciences where arguments for and against these techniques have been the most clearly articulated. Next, we discuss examples of visual approaches in HCI research and offer three detailed cases from our own design research practice. These cases serve as a basis for reflecting on a series of tensions that can emerge when visual approaches to research are embedded in the technology design process. This leads us to identify three value statements that are intended to encourage critical and reflective use of visual approaches in HCI design research and practice.

2. VISUAL APPROACHES TO RESEARCH IN THE SOCIAL SCIENCES

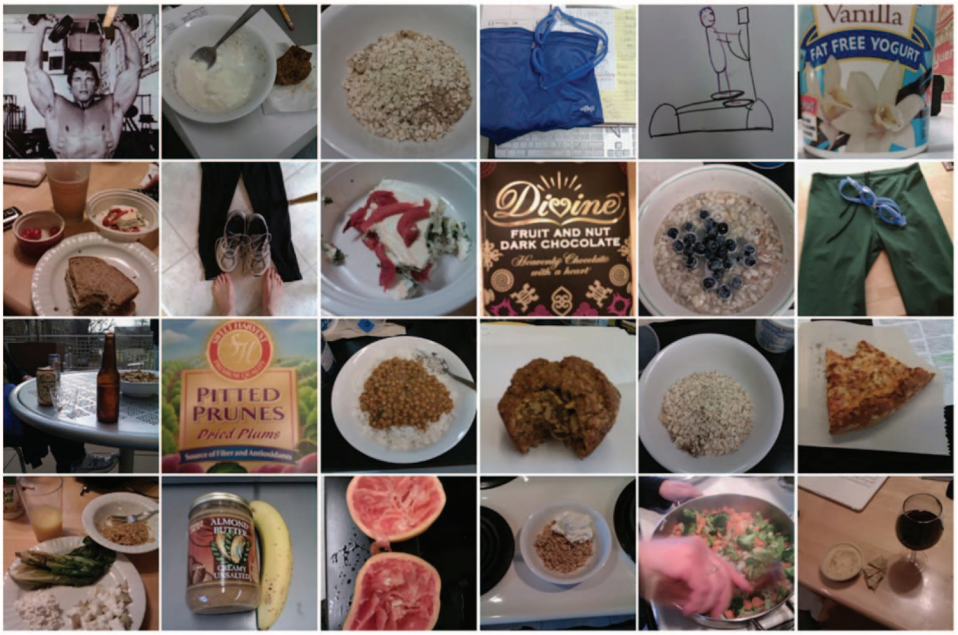
Although digital technologies have increased the accessibility of tools available to designers to explore visual approaches, these techniques are not new. Since the

FIGURE 1. Sketch of a speculative design based on user-generated images and concepts.



advent of affordable still and video cameras, visual research methods have been used in a range of disciplines beginning with art, design, and art history and extending into anthropology and sociology. However, this has not been a seamless multidisciplinary exchange. Feeling that artistic critical discourse was neglecting to expand as rapidly as what he calls "the domain of images," Elkins (1999) urged art historians to take a wider view of visual studies, to extend and adapt the practice of interpreting art images to include a broader scope of visual content, in particular scientific images and maps. Cultural studies scholars like Rose (2007) and Van Leeuwen and Jewitt

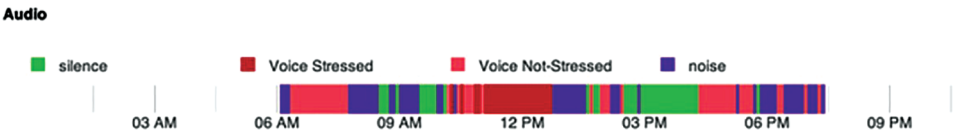
FIGURE 2. Participant-created photographs of health and wellness decision points.



(2001) took on this challenge by introducing social semiotic methods for the analysis of images, offering guidelines for building coding schemes and establishing reliability for image interpretation in social science research.

Claudia Mitchell's (2011) focus on participatory visual methods stresses the imperative for research subjects to be deeply involved in the research process, complicit in both the collection and the interpretation of visual data. For example, photography has been used not just as a means to document a setting or environment; when the camera is placed in the hands of the informant, it becomes a way to amplify participant reflection and voice (Liebenberg, Didkowsky, & Ungar, 2012). Visual techniques, such as Photovoice and participatory video, attempt to enable agency and empowerment in order to cultivate self-reflection in both researcher and informant. When informants become collaborators, they also take ownership of research outcomes, they become invested in doing research "properly" (whatever that might mean), and they become more engaged in the process of dissemination.

FIGURE 3. Detail of visual representation of personal information highlighting audio channel.



Images are used in these situations because of actual and perceived benefits of visual modes of communication. Visual representations are generally considered more accessible across populations (Mathison, 2009; Rose, 2007). Images in these contexts are thought to have the ability to give voice to people or ideas that might otherwise be silent, and images are often associated with a higher truth-value (Latour, 1987, 1990; Mitchell, 2011, p. xii) in certain circumstances. Linguistic anthropologists have shown that the use of graphic representations in collaborative contexts can be a means to build consensus and mutual understanding (Ochs, Gonzales, & Jacoby, 1996; Streeck & Kallmeyer, 2001). Because of these attributes, visual research techniques have consistently and effectively been used to engage informants in the research process. In particular, these methods provide opportunities to bring participants through to the interpretation and synthesis stages of working with data in ways not possible with other methodologies.

Although the growing body of literature focused on visual methods (Harper, 2012; Kress & van Leeuwen, 1996; Margolis & Pauwels, 2011; Mitchell, 2011; Pink, 2012; Rose, 2007) helps to support the rigorous use of these research techniques, many of the techniques being developed still lie outside the norms of traditional research reporting and presentation. Of interest, although the use of photography in particular has been common for several decades, it has only been in recent years that a growing number of handbooks, conferences, and journals have appeared that seriously consider image-oriented forms of inquiry as a valid means of social science research (Elkins, 2003). Many scholars still struggle to have their visually oriented research output recognized alongside other more traditional scholarly publications.

Within the domain of HCI, acceptance of visual approaches to conducting design research has been more open. Visual methods have long played an established role in the ideation phases of HCI design (e.g., Buxton, 2007; Gaver, 2011; Tversky et al., 2003). Coinciding with increased interest in technology-enabled visual research practices, however, theoretical discussions regarding the nature of affordances, materiality, and sociotechnical phenomena have challenged those working in the HCI domain to consider a range of perspectives on agency and the impact of technology (e.g., among others: Dourish, 2010; Latour, 1992; Yates & Orlikowski, 1992). According to visual studies scholars Rose and Tolia-Kelly (2012), visuality is inextricably embedded in this discussion, evidenced by a growing body of scholarship that positions the process by which things are made visible as a critically important aspect of sociotechnical systems (e.g., Amann & Knorr-Cetina, 1988; Dumit, 2004; Latour, 1990; Ochs et al., 1996; Vertesi, 2012). In highlighting the relationship between visuality, materiality, and technology, Rose and Tolia-Kelly are not claiming to have discovered a new phenomenon. Rather, they are attempting to draw attention to practices deeply embedded in the ways in which we come to understand the world around us. This includes the practice of technology design.

As we discuss in the remainder of this article, when visual approaches are used not just for ideation and concept development but also as a means for reflecting on design practice and involving participants in design thinking, tensions can emerge.

For example, notions of "confidentiality" and "anonymity" are quickly problematized in practice when participants are asked to show and reveal the world from their perspective. Observation, interview, or focus group transcriptions can be edited to replace names with pseudonyms. When reporting the narratives of informants, adjustments can be made to protect the identities of those involved. However, when people take photographs of their home or family, it is much more difficult to guarantee the protections we are used to providing as researchers. The following three cases are used to bring to the surface such tensions that are introduced into design practice through the adoption of visual approaches to research.

3. VISUAL APPROACHES IN HCI RESEARCH: THREE CASES

Often when research techniques or methods are examined, it is to debate what constitutes valid and replicable practices. For example, issues related to interpretation of image-based data require particular attention to systematicity and transparency (Mathison, 2009). It is also important to remain aware of the effects of aesthetic and stylistic conventions when considering how both community-generated visual materials and our own visual representations of data can influence various stages of the design process. And when the line between the roles of participant and researcher blurs, as is the case in many studies that rely on user-generated images, criteria for evaluation of research output can become confounded by competing goals.

We touch on these issues as we walk through a series of HCI projects that use visual approaches, in addition to addressing the ways that these techniques support or challenge reflective design practice. As we delineated in the introduction, applying a lens of visual materiality to the domain of technology design requires us to become consciously, ethically, and socially aware of the choices we make as designers regarding what we make visible and how we make things visible. We see this activity as being closely aligned with reflective design practices. Sengers et al. (2005) identified six principles of reflective design:

1. Designers should use reflection to uncover and alter the limitations of design practice.
2. Designers should use reflection to reunderstand their own role in the technology design process.
3. Designers should support users in reflecting on their lives.
4. Technology should support skepticism about and reinterpretation of its own working.
5. Reflection is not a separate activity from action but is folded into it as an integral part of experience.
6. Dialogic engagement between designers and users through technology can enhance reflection.

These principles reflect many of the core values just described regarding the reasons why social scientists have turned to visual approaches as part of their research methodologies: a desire to make new things visible, a call for democratization of the research process, and a commitment to give voice to ideas and people who might otherwise go unnoticed. Through three illustrative cases, we highlight some of the ways in which, building on these shared values, visual approaches support reflective design thinking by both designers and user/participants.

Each case presents a design project recently conducted at Cornell University's Interaction Design Lab along with discussion of related work in the HCI domain to reveal some of the tensions inherent in utilizing visual approaches. Several projects coming out of Interaction Design Lab have applied visual approaches to design problems focused on the use of technology—especially mobile applications—to promote reflective practices. Three representative cases are presented in order to explore specific benefits and challenges associated with visual approaches to design thinking. We examine:

- Sketching
- Photographic content analysis
- Visualization of personal informatics

Each case explicates how the use of visual approaches enabled designers to make visible important aspects of design thinking. Each case also serves as a point of entry to a range of HCI research that also makes use of these visual approaches. This survey enabled us to identify three critical and reflective characteristics of visual approaches to design practices related to visual narrative, visual disclosure, and visual representation of data. These are described and discussed throughout the remainder of this article.

3.1. Sketching

Sketching is one of the more common visual methods deployed in HCI research and design (e.g., Hearst, 1998; Landay & Myers, 2001), and substantial effort has focused on developing computational systems to support sketching (cf. Johnson, Gross, Hong, & Yi-Luen Do, 2007). As discussed by Tversky et al. (2003), design sketches are frequently associated with the ideation process, and, in fact, most designers are trained to some degree or another in sketching according to a specific set of aesthetic or technical requirements. Making visual sketches of concepts is often used early on in design process for such purposes as providing rough outlines for ideas without the need for minute details (Buxton, 2007) or exploring speculative ideas or concepts (Gaver, 2011).

A variety of research has examined the role of sketching in collaborative HCI design. Van der Lugt (2002) conducted an experimental study to investigate the benefits of sketching for idea generation during design meetings. They concluded that sketching supports the reinterpretation process while improving access to earlier ideas that might have been lost during an iterative work cycle, basing this claim on

the persistence of the drawn object as a reminder or stimulus for further thought. Bastéa-Forte and Yen (2007) created a collaborative sketching system using tablet PCs with styluses and a shared digital canvas to be used during brainstorming sessions. Although their system resulted in less time spent sketching during interactions, it did help equalize contributions from meeting participants (compared to traditional face-to-face methods). They concluded that the sketching system increased awareness of the quality and number of ideas contributed. "Microsketching" is a method for producing rapid prototypes developed by Forlizzi and DiSalvo (2009) for use in collaborative design contexts. Their approach to user interviews involved combining drawings of a single feature or detail of an interface combined with ethnographic probes. This and other work collectively describes the various purposes sketching can serve in collaborative contexts and the values it can provide in the design process.

Sketching can also serve as a form of exploratory prototyping (e.g., Wyche, Aoki, & Grinter, 2008), providing close connections among the observation, interpretation, and communication of data. Similar to design workbooks (Gaver, 2011), these sketched prototypes do not depict systems or devices that necessarily should, or in some cases even could, actually be implemented. Rather, this approach uses speculative sketching as a means of supporting a reflective dialog (J. Snyder, 2013, in press) between researcher and participant, between designer and user. The case presented here describes one instance of our experiences with using sketching in this way.

Project: Farmers Market

The first study we profile explored the potential impact of sustainability interventions into the environment and culture of a long-standing community farmers market in Ithaca, NY. Although one of the motivations for this study was to explore the implications of designing in support of sustainability—buying locally grown food arguably reduces environmental impact due to shorter transportation distances—it also considered how sustainability fits into the larger sociocultural context of the market. To do so, a cultural probe (Gaver, Dunner, & Pacenti, 1999) was delivered in the form of a weeklong diary assignment with a different prompt and activity for each day (Figure 4). Visual design concepts influenced the creation of diary activities to engage participants' imaginations, many of which involved asking participants to create drawings in response to prompts. Responses collected through diaries included drawings, reflective statements, and recorded observations. Based on these responses, designers created sketches for a series of speculative design concepts, such as a map comparing prices at the farmers market with prices for fresh produce at local grocers or a pair of augmented reality style "timenoculars" (Figure 1) that would allow the wearer to view the market as it was at different times in the past (see more examples next). Some of these sketches were exhibited on posters at the farmers market, and some were presented back to study participants in focus groups to elicit conversations about how their experiences of the market might change as the result of these designs

FIGURE 4. Diary instructions.

being implemented. For more details on the methods and study design, see Baumer, Halpern, Khovanskaya, and Gay (2014).

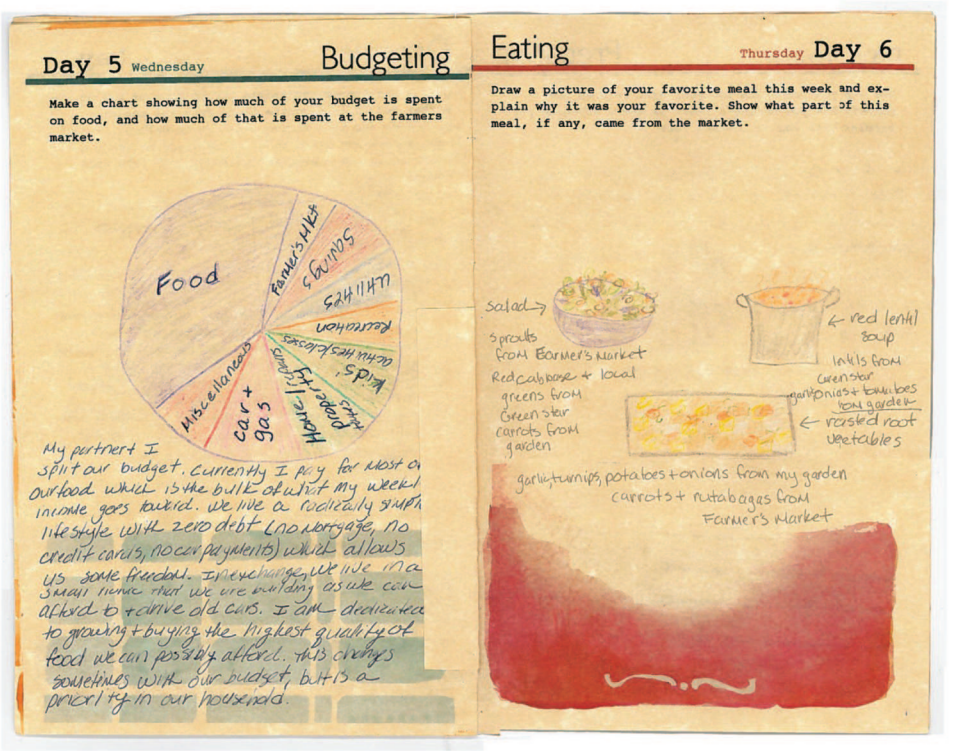
Visual methods played three distinct roles in this work. First, some of the diary prompts asked participants to create drawings, maps, or other visual artifacts. These images helped give voice to participants' experiences and perspectives in unique ways. For example one participant's depiction of the stressful aspects of visiting the market (Figure 5) conveyed subtleties of her subjective experience in a richer way than if she had verbally described the market as "stressful" or "crowded." Second, the design of the study materials themselves—from the recruitment material to the diary pages to the concept sketches—maintained a consistent look and feel (Figure 6). This

FIGURE 5. Participant's depiction of stress at the market.

consistency is a definitional characteristic of cultural probes. Following Gaver et al. (1999), in contrast to scientific approaches, cultural probes "don't emphasize precise analyses or carefully controlled methodologies; instead, [they] concentrate on aesthetic control" (p. 24). This aesthetic control thus serves as a designerly analog to scientific methodological control, creating a consistent visual language that both unifies the entire experience of participation in the study and reinforces the speculative nature of the design concepts.

Third, and the point on which this section focuses, the process of generating design sketches and presenting them back to study participants represents, we argue, a form of speculative prototyping. Significant work in HCI has explored the value

FIGURE 6. The look and feel of study materials served as a cultural probe.



of, various approaches to, and the impacts of prototyping (e.g., Dow, Glassco, Kass, Schwartz, & Klemmer, 2010; Halskov & Nielsen, 2006; Houde & Hill, 1997; Rudd, Stern, & Isensee, 1996). In contrast to such previous work, this project does not use prototyping as a step toward implementing a functioning computational device or system. Rather, it uses sketching-as-speculative-implementation as a means of exploring the edges of a design space in a manner that both is reflective and may help elicit conversations among study participants, as described next. This approach both bears closer resemblance to, and is inspired by, work from Wyche et al. (2008), who used design sketching both to work through interpretations of ethnographic data and to elicit data from study participants. We also draw inspiration from Gaver's (2011) design notebooks, which similarly explore fanciful or whimsical ideas rather than concrete design recommendations.

In the work described here, sketches helped to provoke conversations among community members during a phase of the design process that does not always incorporate users' perspectives and reflection. Rather than focusing on refining specific functionality, this prototyping exercise asked users to reflect on how their experience of the market would be influenced by the existence of the proposed tools, technologies, and experiences. Focus group participants were encouraged both

to imagine themselves using the speculative designs and to respond to each others' reactions; at the market, posters with sketches were accompanied by markers and Post-It notes and a prompt that read "Your Thoughts?. . . "

The speculative sketches leveraged themes from the diaries into more fully developed concepts. For example, inspired by market visitors' sometimes stressful accounts of their experiences, designers developed a concept for a set of ropes and poles that would respond to crowds by automatically reconfiguring itself to alleviate crowding and allow for optimal foot traffic flow through the market space (Figure 7). Another design concept drew on the locality of the food at the market, which is sometimes described as farm-to-table. Inverting that theme, designers suggested a system they deemed Table-to-Farm. Market visitors would snap photos of a meal they had prepared with food from a vendor, and these photos would then be displayed on small LCD screens near that vendor's stall at the market (Figure 8).

The visuality of these sketches had several ramifications. First, although considerable thought was given to the actual functionality of the designed interventions, the sketches themselves were rendered in a provisional, conceptual, and speculative style, which was intended to encourage creativity in imagining experiences of use. Buxton (2007) similarly describes the value of presenting design concepts with a purposefully "roughed-up" presentation to signal that the design is still open to change. Second, the sketches' aesthetic matched that of the diaries from which inspirations were drawn, both maintaining the aesthetic control just described (Gaver et al., 1999) and reinforcing the unified experience for any diary participants who happened to see the posters at the market. Finally, these speculative renderings included specific material details on which participants drew in their responses. For example, responses to the ropes-and-poles design were mixed; Post-It notes contained such responses ranging from "Yes! Makes things orderly," to "I kind of like the feeling of disarray at the market, it gives character," to "No! Like cattle in a chute? No! No!" This example points to challenges in both interpretation and representation in working with the

FIGURE 7. Ropes and poles.

FIGURE 8. Table-to-Farm.

visual data. Despite the compelling nature of the experiences depicted in Figure 2, the variety in responses suggest that "stressful" is not a word all visitors would attribute to the market, or perhaps that the stressful atmosphere is in part constitutive of the market experience as a whole.

During the focus groups, participants also commented that, beyond the functionality, the aesthetic of the ropes-and-poles felt out of place. The sketch, they said, seemed to depict a metal and plastic construction reminiscent of a department store or an airport. One participant suggested that poles made out of wood with twine running between them may fit better at the market. This example demonstrates how the visuality of the sketches helped draw attention to, and elicit responses about, the sociocultural aesthetic of the market, an aspect not anticipated in advance.

The Table-to-Farm concept garnered similarly ambivalent responses. Although participants appreciated the concept of being able to connect back with the farmers from whom they bought the food, they objected to the form that connection took, specifically with respect to the LCD screens. One focus group participant described how she often goes to the market to avoid such media technologies, for example, she pointedly leaves her phone in the car. Placing LCD screens around a farm stand would inject into the market the very thing she goes there to escape. Thus, the visual

representation helped elicit a possible implication not to design technology (Baumer & Silberman, 2011), a situation in which a technological intervention may be not only unwanted but also potentially detrimental.

Finally, a key tension emerged around perceptions of the purpose of these sketches. Despite being labeled and described as "speculative" and "conceptual," many study participants interpreted the sketches as proposals for objects or systems that might actually be implemented and deployed at the market. Indeed, a number of market visitors objected, sometimes vociferously, to the changes to the market the designs seemed to imply. Although efforts were made to mitigate such concerns and reassure visitors that none of the speculative designs would actually be implemented, this temporary confusion raises important tensions about the interpretation of visual images and how different meanings can be ascribed to them by study participants, researchers, and others.

In sum, we suggest that showing study participants concept sketches in this way represents a type of sketching-as-speculative-implementation, provoking conversations not only about envisioned usage but also about aesthetics and materiality. These conversations go beyond the look-and-feel (cf. Houde & Hill, 1997) to consider broader sociocultural ramifications. Although actually implementing functionality through prototypes certainly has value, we suggest that there also may be unique value in the sketching-as-speculative-implementation process described here. Using these stylized renderings allowed participants to attend not only to the functioning of the conceptual design but also to the material details and social impacts of the implementation. By contrast, more traditional prototyping—wire frames, paper prototypes, and so on (e.g., C. Snyder, 2003)—is more likely to elicit comments about the logic and flow of the interaction design than about, say, the kind of paper on which the prototype is presented. This case suggests that a sketching-as-speculative-implementation approach can help by addressing materiality sooner in the design cycle, giving implicit cues that may impact perceptions of a system's purpose, its functionality, and the position that it occupies in larger sociotechnical arrangements. However, it also draws attention to some of the challenges and tensions that may emerge, particularly with respect to the interpretation and meaning of such images. We consider these tensions further in the discussion.

3.2. Photographic Content Analysis

Perhaps more than any other visual technique, the evolution of photography as a research tool within HCI research reflects the dramatic influence of technology on our relationship with images. Transitions from print film to digital storage and from disposal cameras to ubiquitous camera phones have made it possible for a more diverse group of researchers to collect images as a primary source of data. This has coincided with a transition from photography-related research primarily concerned with building interfaces for taking, editing, organizing, and sharing digital photographs (e.g., Wilhelm, Takhteyev, Sarvas, House, & Davis, 2004) to recognizing the impact that social issues, context, and authorship can have on the adoption of those tools

(Dourish & Mazmanian, 2012). A combination of social media and digitization has radically influenced the ways in which we think about media production and craft practices (Wiberg et al., 2013). As a result of this evolution, within HCI photography has become not just a use case but also a research domain (Pedro & Suryanarayan, 2012), a research tool (Clarke, Wright, Balaam, & McCarthy, 2013) and a research inspiration (Ljungblad, 2007), sometimes all of these in the very same study (Hall, Jones, Hall, Richardson, & Hodgson, 2007).

The evolution of digital photography has also influenced the relationship between researcher and participant. For example, it is not uncommon for researchers to distribute digital cameras to informants and to ask them to document their lives (or an aspect of their lives) for a day, a week, or a month (cf. Baber, Cross, Khaleel, & Beale, 2008; Brown, Sellen, & O'Hara, 2000; Liu, Huh, Neogi, Inkpen, & Pratt, 2013). Some researchers have even developed contextual photography tools that the user wears around his or her neck and that will automatically take a certain number of photos during the day at regular intervals (Hodges et al., 2006; Lindley et al., 2009; Ploderer, Leong, Ashkanasy, & Howard, 2012). Approaches like these magnify data collection capacity in at least three dimensions. First, participants can provide researchers with access to new facets of their lives. Second, events and situations can be documented from multiple perspectives. Third, these studies often result in hundreds, if not thousands, of photographs per participant, often documenting the most unremarkable of experiences (Bourke, McCarthy, & Smyth, 2011; Gemmell, Williams, Wood, Lueder, & Bell, 2004). Increased capacity across these three areas translates to a higher resolution representation of the user experience.

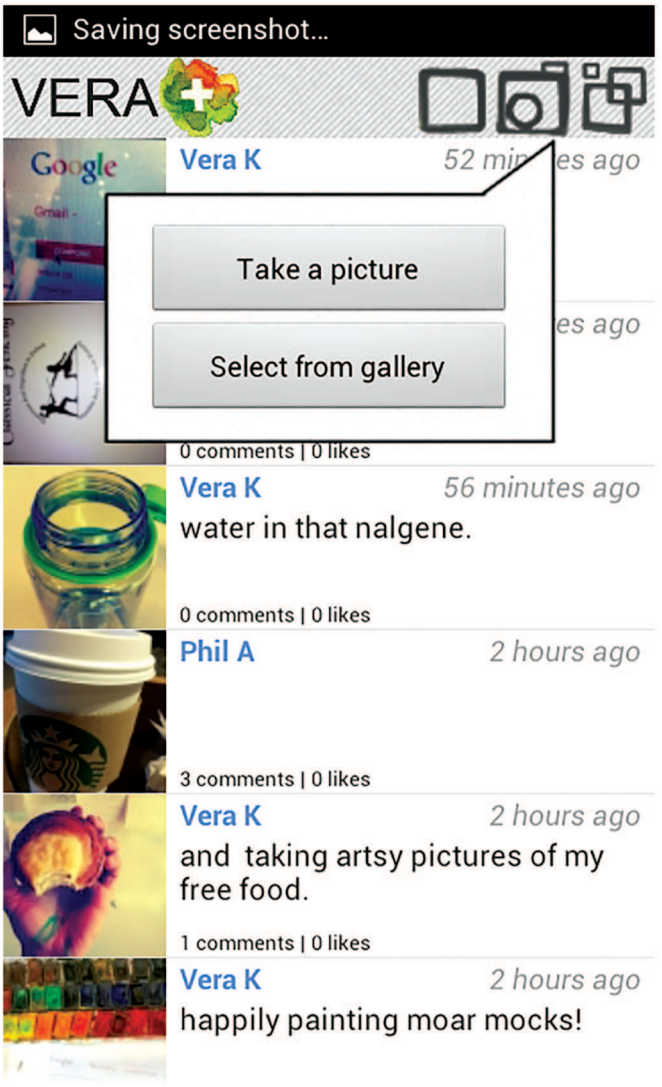
In terms of reflective design practice, one of the challenges of working with these image collections is a lack of differentiation regarding what is more or less important, either to the researcher or the participant. How do we sift through the mundane to get to the rich moments that inspire reflection? How does one tell the difference between "interesting" and "boring" when the goal is to capture the moments between anticipated activities? How can viewing seemingly endless galleries of images documenting the most ordinary of experiences help users reflect on their lives in ways that are not only productive to us as designers but also meaningful to the users as participants in the design process? It follows that in the evolving realm of user-generated content, old categorizations of, for example, professional/amateur, personal/public, candid/posed, artistic/snapshot, are no longer as useful as they once were. For HCI researchers, this means that we need to create new ways to describe what, how, and why users are creating the images that they are posting (Carter & Mankoff, 2005).

From a reflective design perspective, the magnified capacity offered by user-generated digital photography is an opportunity to observe changes in our perceptions of authorship, artistry, and self-representation, and these collections of images can help us to understand the limits of the analytic and practical infrastructures we have created to support our research (Carter & Mankoff, 2005). We use a recent study involving the content analysis of a collection of user-generated photographs to explore tensions related to these issues.

Project: VERA

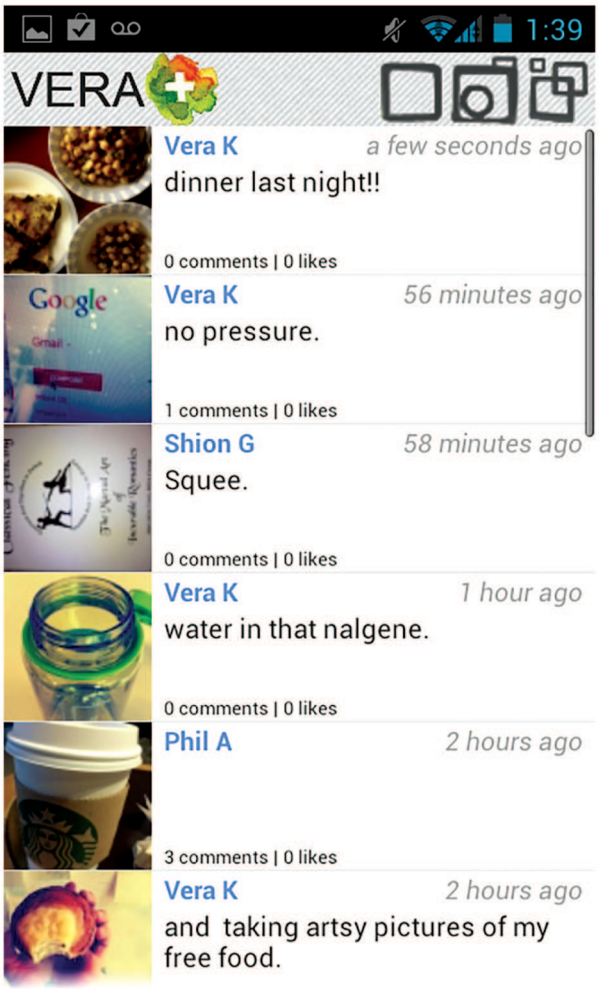
VERA is a mobile phone application designed to encourage health and wellness by providing users with a platform to visually document and share daily choices regarding health behaviors in real time. The VERA system enables users to document and share momentary health decisions made throughout the day using a mobile phone or web interface. Status update creation (Figure 9) begins with the user documenting a health decision by taking a photo or selecting one from an existing gallery. When a status update is created, the user provides details about

FIGURE 9. Status update using VERA.



the decision (a binary "I did this" or "I did not do this" indicator, a subjective healthiness rating on a 7-point Likert scale, and an optional text caption) before completing two measures—one for affect (Pollak, Adams, & Gay, 2011) and the other for stress (Taylor, Welch, Kim, & Sherman, 2007). The VERA application passively records other associated data including timestamp and location (as latitude and longitude), as well as location and timestamp data about the photo if it was not taken in the moment of status update creation. The ability for users to see and comment on the choices made by their fellow participants is an important component of most VERA deployments. Status updates, including image, name of user, timestamp, and optional caption, are visible to all those in a user's peer group (as defined by the application) through a newsfeed view (Figure 10). User can add a comment or +1 ("like") to any update. A series of deployments of the

FIGURE 10. VERA newsfeed view.



application have been launched in the field with several diverse user populations ranging from new mothers to college students to employees in wellness clubs (Baumer et al., 2012).

One of the primary motivations for designing the VERA system was to learn more about the effects of social influence on health and wellness decision making. Rich in-application activity logs; user-generated captions and comments; pre- and posttest surveys; and, in several cases, semistructured interviews have provided data for researchers to analyze during cycles of system implementation and evaluation to better understand how social sharing of health choices affected user behaviors and perceptions. Textual analysis of captions and comments combined with statistical analysis of affect and stress measures suggest that the open endedness of the system allowed users flexibility and freedom in defining what counts as health, and social aspects of the interactive features of the system compounded both the positive and the occasionally negative impacts of this openness.

However, the images themselves had not previously been the focus of concentrated analysis. Analysis of participant-generated images was undertaken to determine if the visual narratives evident in the image-based data confirmed the social awareness reflected in other forms of data collected during the use of the VERA interface (i.e., captions, comments, affect metric). In focusing on visual content, the photos were analyzed in isolation from associated textual data (e.g., the caption and comments) and metadata (e.g., affect, stress, and location).

VERA participants were encouraged to develop their own approaches to visually documenting health-related behaviors. Deployments of the system typically generate large numbers of images (recently, 3,106 images for a 2-week, 55-user study). We took a grounded approach to analysis of a subset of these images, generally informed by Charmaz (1983, 2009), who advocates an iterative and flexible, though still structured, approach to inductive analysis of qualitative data. We were also guided by the approaches to content analysis delineated by visual studies scholars such as Van Leeuwen and Jewitt (2001) and Rose (2007), who have codified visual analysis as a social science research practice distinct from art historical image analysis. The approach to visual analysis used by Liebenberg et al. (2012) served as a practical model of the merging of Charmaz's grounded approach and these accepted image analysis techniques.

Exploration of the user-generated photographic data followed an iterative three-step process: (a) initial open coding, (b) focused coding, and (c) analytic search. For initial coding, we examined four sets of photographs collected over a 3-week period by each of the most prolific participants in an early run of the tool. The diary/journal nature of the data allowed researchers to examine longitudinal visual trends over time. Initial and focused coding yielded a descriptive scheme that characterized the user-generated photographs in terms of content and composition as well as the degree to which social relationships were explicitly or implicitly expressed within the images.

We found that overt depictions of social experiences or relationships with others were far less present than anticipated. Upon close inspection of the photographs, the effects of social awareness evident in the nonvisual data (Baumer et al., 2012) are not reflected in the visual data. For example, meals were depicted as solitary

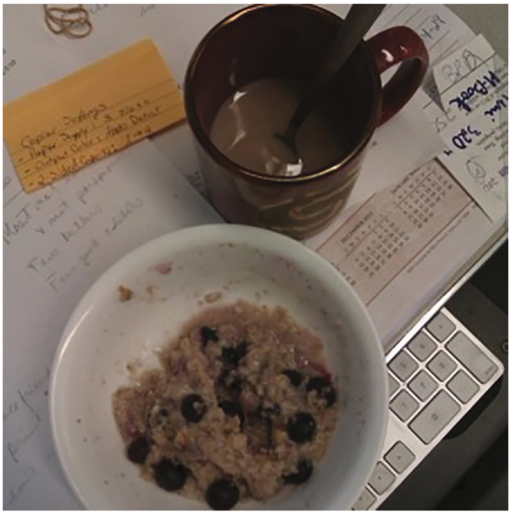
events. Activities such as walking, running, or going to the gym were shown from a solitary perspective. For the few instances where the existence of others was evident, suggestions of social interactions appeared by way of multiple place settings at a table, two pairs of snow-covered hiking boots, or multiple shadows cast on a sidewalk. This finding contrasted with both interview data and the presence of sociality in health behaviors in the captions and comments (e.g., a picture of a toy-laden living room free of humans with the caption "playing with my kids is a workout"; comments on statuses about running that allude to running with others; and references to going to the gym, which typically involves seeing and possibly interacting with other people).

On reflection, we identified two possible reasons for this discrepancy. One, participants had (quite properly) strictly adhered to the Institutional Review Board exhortation to not take pictures of self or others, especially children. This is one explanation for the prevalence of activities with pets, especially dogs, which we came to see as a possible proxy for other relationships taking place off-camera. This observation also served as an opportunity to learn (or learn again) that different media carry distinct challenges in terms of balancing the protection of participants with collection of rich, unbiased data (Carter & Mankoff, 2005). In this case, the unique ability of photographs to capture a likeness resulted in this mode of data collection carrying a particular type of methodological burden. In fact, the ability of photographs to disclose information, sometimes unintentionally is both an argument for using photographs as evidence of social awareness and presence and an argument against using this type of data.

Others have also encountered this hazard of working with user-generated photos and video (Baber et al., 2008; Carter & Mankoff, 2005; Lindley et al., 2009). In our case, our parameters for ensuring privacy might have actually created an unintentional skew or bias in the information provided through the photographs. This also spurred us to recognize that although having a participant use photography to document his or her experiences can provide a researcher with a more detailed, vibrant view of an informant's world (Clark-Ibañez, 2004), we as researchers can say or do things (implicitly or explicitly) that diminishes or possibly even negates the power of this tool. Instructions related to privacy have different implications when carried out in the form of a written diary versus a digital photograph.

A second explanation for less overt representations of social activities is related to the single-image status update (rather than a series of images documenting a single event or a short video clip recording a moment in time). Our timeline interface for performing analysis enabled us to step back and take a longitudinal perspective on the visual data, similar to the approach taken by researchers analyzing multimodal discourse (Baldry & Thibault, 2006; Norris, 2004). In doing this, it became possible to (re)construct visual narratives that reflected implied social activities and relationships. For example, many participants submit photographs of meals where a dish or cup was placed on top of a pile of paperwork (Figure 11), marking a solitary meal eaten while working. In the rare cases where a more social context was evident, the presence of others was typically implied rather than explicitly documented. For

FIGURE 11. Bowl and cup sitting on top of paperwork, illustrating explicit nonsocial context.



example, we came to recognize large quantities of food (Figure 12) or footprints (Figure 13) as markers of social context. These narratives are supported by interview data but became evident in the photographs only when they were carefully viewed in a sequential manner. Visual norms (i.e., what eating alone looks like) emerged through the analytic process and viewing the images in sequence enabled

FIGURE 12. Table full of desserts, illustrating implied social context.

FIGURE 13. Footprints in the snow, illustrating implied social context.

us to construct explanatory narrative around anomalous images like the table full of desserts.

A second observation emerging from the visual analysis of VERA images was that the vast majority of images depicted scenes or actions from a close field of view, displaying little context, particularly in the home or at the workplace. It is interesting to reflect on the HCI work being done in the area of contextual photography (e.g., Baber et al., 2008; Bourke et al., 2011; Ljungblad, 2007) and the importance that location-based information can play in making visual data more meaningful to both user and researcher. The lack of contextual information evident in the VERA images also raises the issue that health related decision making might not be as holistic an experience for participants as it could be. Based strictly on the images submitted through the VERA application, participants tended to compartmentalize the events they chose to depict, focusing on plates of food and workout gear. In contrast to comments made by participants during exit interviews where they talked about using the social aspects of the application to reflect on their choices and to achieve goals, there were few photographs that could be categorized as aspirational or inspirational, or images that one might interpret as representing health in a more experiential and holistic way. One notable exception was a participant who photographed a calendar with the date of an upcoming running competition circled, conveying a sense of anticipation and future goals. The practical and pragmatic perspectives evident in the photographs are in stark comparison to both interview data, and many of the status update captions and associated comments, raising the issue of which media is more reliable as a data source. We return to these issues in the discussion.

3.3. Visualization of Personal Informatics

Although the connections between HCI design research and visual methods are more explicit when visual artifacts such as sketches or photographs are employed in the ways just described, these methods can also be applicable for research projects that involve the collection and analysis of nonvisual data, for example, sensor data streams or event logs. A wide variety of techniques have been developed within the HCI community for transforming heterogeneous data into interactive visual representations (Heer, Bostock, & Ogievetsky, 2010; Plaisant, Carr, & Shneiderman, 1995; Shneiderman, 1996). These techniques aim to make complex patterns that are typically not visible or obvious more accessible. The resulting visual representations can be used as part of HCI practice, helping practitioners to make sense of data as they are being collected. In some cases, such visualizations can also facilitate a conversation between the HCI practitioner and the people who provided the data. Like photographic content analysis, this class of techniques is typically incorporated into HCI research late in the process, as it is oriented around making sense of data or eliciting feedback about the accuracy of data or additional information about the context in which data were collected.

One specific example of how nonvisual behavioral data can be collected, aggregated, and presented visually can be found in a research area that has come to be known as personal informatics. Personal informatics are a class of systems that combine visualization techniques with emerging mobile sensing technologies and ubiquitous access to information and are designed to help people collect and reflect upon their own behaviors, habits, and routines (Li, Dey, & Forlizzi, 2010, 2011; Wolf, 2009). These systems are often motivated in service of "knowing oneself," that is, to collect data that can be used to set goals and make changes, such as improving adherence to an exercise regimen (Li, Dey, & Forlizzi, 2009) or identifying environmental sources of disruption during sleep (Kay et al., 2012). In our research, we have also adopted these systems as research tools, giving us the opportunity to explore patterns and causality in everyday behaviors, often in consultation with the informants, themselves.

Transforming nonvisual data into visual representations opens up many new possibilities for interrogating relationships in large data sets, but it also raises a number of issues for HCI researchers. Evaluating the selection, implementation, and effectiveness of an information visualization for supporting a particular task or group of users is a known challenge (Plaisant, 2004) and a topic of ongoing discussion within the HCI and information visualization research communities (cf. the proceedings of the BELIV workshop series; http://www.beliv.org). Often, personal informatics systems are built using graph- or chart-based representations of quantitative data. These design choices can lead to concerns about whether such representations might impose a bias on the way data are "read" and the literacy skills required by informants to make sense of the representations during retrospective interviews (Shneiderman, 2000). Furthermore, because one of the benefits of personal informatics is that they can be used to reveal patterns in data that might otherwise not be visible, practitioners need to take additional steps to consider the kinds of unintentional disclosures that

might result from collection and visual analysis of participants' data. These concerns become particularly acute when combined with the automatic or continuous collection of sensor data. In designing systems that support personal informatics, we have begun to look at the role that social, behavioral, and physiological data collected throughout the day might play in helping people to make more informed decisions about their health and well-being.

Project: SESAME

SESAME (a ***S****tress* ***E****xperience* ***S****ampling* ***A****nd* ***M****easurement* ***E****xperiment*) is part of a broader research initiative to understand the role that pervasive and mobile technologies can play in supporting healthy living. This project is inspired by the rise of personal informatics technologies (Li et al., 2010, 2011; Wolf, 2009), but instead of focusing on capture and quantitative analysis of low-level physical actions (e.g., number of steps taken) or physiological indicators (e.g., blood pressure), the research aims to understand how technology can provide a resource for reflecting on trends of more complex psychological phenomena, such as stress. The increasingly pervasive sensing capabilities of computational devices provide a valuable opportunity for continuously and non-intrusively measuring stress levels. These data can be used to facilitate self-reflection on patterns of stress embedded in daily routines or caused by various internal or external environmental factors. Biometric sensing devices are also being adopted by medical professionals and incorporated into long-term clinical treatments and behavioral interventions that are designed to improve healthcare outcomes (Chatterjee & Price, 2009).

We developed and deployed SESAME to carry out a field study specifically designed to investigate two aspects of personal health informatics: (a) the relative accuracy of various means of collecting data about stress levels throughout the day, and (b) participants' responses to different types of visual representations of this stress data. The focus of this research project was not to develop novel information visualization techniques but to utilize established classes of visual representations as a way both to help the members of the research team to make sense of a complex and interrelated data set. It also sought to foster conversations with study participants about the accuracy of the data collected by the system and the utility of reflecting on stress in the context of daily activity. In this sense, a visual approach was taken in order to investigate forms of self-representation. In addition, information visualizations are well suited to examining multiple streams of data over time, providing a multidimensional view of participants' day-to-day experiences. Because we were using the visualizations as a conversation prompt with study participants, it was also helpful that these types of visual representations are commonly used in consumer products like the Fitbit and the Nike FuelBand.

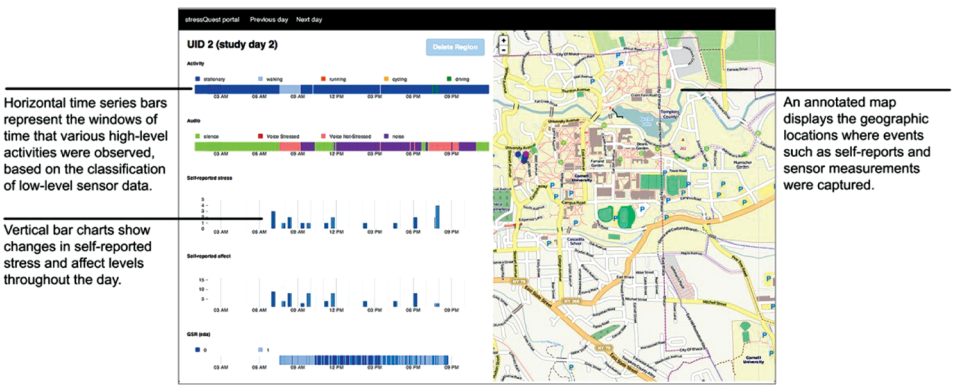
SESAME was built on a smartphone platform, which participants carried during the study and used to record a variety of data about their everyday behaviors as well as their psychological state. These data included activity levels, geographic location, and stress level, determined both through ecological momentary assessment surveys

(Moskowitz & Young, 2006) of stress (Taylor et al., 2007) and mood (Pollak et al., 2011) and through continuous, computational classification of the audio environment surrounding the phone as *silence*, *non-human-voice noise*, *stressed voice*, or *not-stressed voice* (Lu et al., 2012). We also asked participants to wear an electrodermal activity (EDA) monitoring device, which provided an empirical indication of physiological arousal (Poh, Swenson, & Picard, 2010). At the end of a roughly 10-day data collection period, participants were shown and invited to explore a personal informatics-inspired interface visualizing the data collected about them (Figure 14).

Data from the self-report questionnaire and the passive sensors were displayed along a series of 1-day timelines, stacked above one another on the left side of the interface for ease of comparison. Self-report data were presented as bar charts, with taller bars representing higher stress and positive affect levels. Audio profile, activity, and EDA information were displayed as a linear sequence of colored blocks filling the time associated with each sound type, activity, and EDA state. EDA was processed into two features, aroused and not aroused. A map displayed the geographic locations where data were collected by the system and helped to provide a sense of context linking a person's surroundings to their self-reported and automatically inferred stress levels.

Our personal informatics-inspired approach to making everyday stress and activity data visible in SESAME served as useful common ground when discussing and interpreting the data collected during the study with participants at the study's conclusion. The tool also played an important role in other aspects of the research process as well. Members of the research team relied heavily on the visual representations generated by the system for iteratively refining the machine learning and data processing algorithms used to classify and interpret low-level sensor data. By examining visualizations of participants' data side by side as they arrived in our research database, we were able to find gaps in the data coverage or, more commonly, identify instances in which the deployed smartphone apps were having trouble connecting

FIGURE 14. An overview of SESAME's visualization portal, illustrating the visualization techniques employed to represent different facets of the data collected during the study.



to and uploading sensor data to our server. The visual representations were also valuable for helping us to "tune" the level of granularity of the underlying sensor data presented to participants prior to the final interviews.

However, perhaps even more compelling in the context of the discussion here, the visualization tool also served as a valuable means for presenting data back to the study participants as part of the debriefing and exit interview process. In general, participants expressed enthusiasm at having the opportunity to reflect back over their activity, location, and stress data to see the relationship among fleeting facets of their everyday experience and how they related to one another (or did not, particularly when they expected to see stronger correlations between, e.g., a particular location and an anticipated stress level). In terms of reflective design practice, the visualizations allowed us to participate in a dialogue with users regarding the impact of the technology on their day-to-day experiences in a way that examining raw data would most not have allowed.

Anticipated by Li et al. (2011) and contemporary personal informatics systems, several participants made inferences across modalities, particularly drawing on location or activity, or both, to make better sense of what was happening at the time the interface showed them having experienced periods of higher or lower stress. When our interfaces showed something unexpected or confusing, some participants explained that they felt that the source of these discrepancies must have been caused by the technology—failures in data collection or problems with our classification of the data—whereas others assumed the data must be correct and worked hard to construct narratives to make sense of it. Many of the participants drew on multiple features of the visualization in an effort to construct these narratives. For example, in a visualization similar to the one shown in Figure 14 in which the circles on the map were colored in a range from green (not stressed) to red (very stressed), a participant observed:

> It is really interesting that it is showing a lot of red circles in the morning and then it becomes green. I think that it makes sense. That day, I was traveling to New York City and I had my boy friend's dog with me. I was a bit stressed until I got in the bus after securing the dog in the carrier. After I got in the bus I was more relaxed.

These narratives often became jumping-off points for more substantive discussions about the daily routines and stressors encountered over the course of a typical day. Although skilled interviewers would likely have been able to help guide participants through this kind of self-reflection, we found that using the visual representations of the data—particularly when examined in light of day-to-day variations—as a catalyst for the conversation helped participants to open up and share concrete stories about their experiences throughout the week, often with a great degree of enthusiasm. They also provided us with an opportunity to learn more about the assumptions and expectations that users brought to the technology we were developing.

Being able to guide participants visually through their data enabled us to have conversations with them about problems that we were seeing with the output of our (relatively complex) machine learning algorithms, which they might not otherwise have been able to see or fully comprehend. For example, when walking through several days' worth of visualizations, we noticed that one participant's voice-based stress inference was peaking somewhat consistently during mealtimes, whereas the skin conductivity (arousal) measure indicated a low likeliness of stress. The members of the research team did not know how to interpret this finding—typically, we would have expected to see a stronger correlation between these two physiological measures associated with stress. When we pointed out this issue to the participant during the interview, he laughed and explained that mealtimes were often also used to catch up on watching movies; the action movies that he preferred to watch often featured tense dialogue, which was apparently being detected by the audio-based stress classifier but that the algorithms were (incorrectly) attributing to the participant. This instance made us aware that visual approaches carry distinct risks and rewards related to the representation of the self. The user immediately recognized himself (or at least his habits) in the data, and this had an impact on his perception of the value of the system.

Although SESAME could well have surfaced even more critical privacy concerns, given the personal nature and automatic collection of the data that we collected, participants did not widely express discomfort during their review of the visualizations. When specifically asked about it, one of the participants reasoned, "The question is, do you believe in the values of the app? Here, I feel like the app is helping me be aware of and control my stress." This might not be the case in all such studies, and it should be noted that the participants in this study were not strangers to the researchers. Dynamics of trust and disclosure will continue to evolve with this project. For example, to engage participants in the research process to an even greater degree, we have begun development of a tool that will allow users to view visualizations of their data before submitting it to the research team for analysis, providing them with the opportunity to mark regions of data from one or more sources to be redacted over a particular period. This is similar to the approach taken by Kay et al. (2012) in their study of sleep habits (2012). Visual representations of complex sensor streams can provide easily intuited representations of the data directly to the participant enabling him or her to flag aspects of their personal information for exclusion from the study. It will be interesting to see if people are more, less, or equally likely to share data when they can see a cross-channel representation of their daily activities. Interjecting this moment of interactivity in the data collection process will also provide an opportunity to ask participants to reflect on the version of themselves reflected in the aggregated visualization.

4. DISCUSSION

Visual approaches are easily spotted because they involve image-based forms of expression such as photography, drawing, video, graffiti, and maps. Visual sociologists

such as Rose (2007) and Harper (2012) pointed out that it is important to understand that these artifacts are, in fact, markers of complex relationships embedded in the ways in which information is represented and interpreted through the research process, whether that happens within the boundaries of design practice or social science inquiry. In terms of the former, visual approaches help us not only to provide tools to users that enable them to reflect on their own experiences but also to see new dimensions in our own design practices (Sengers et al., 2005). The three cases presented in this article offer examples of the ways in which this can happen.

The visual is more than simply a "semiotic register" (Jackson, 2012, p. 43) or a one-for-one encoding of ideas that could just as easily be expressed with words. "Doing the visual" means drawing attention and awareness to distinct social and material experiences that characterize our interactions with each other and the world around us (Rose & Tolia-Kelly, 2012). It involves being aware of what we choose to make visible (and to whom) through the technologies we design, contemplating how we go about making things visible through the design choices we make, and taking responsibility for understanding the implications of these decisions. These are the principle components of visual materiality.

It is worth noting that although in each of these studies the visual techniques utilized were part of the original research design, the practice of doing the visual within the design process presented unanticipated opportunities for both participants and researchers. Explicitly and consciously doing the visual as a design practice can provide new channels for learning about user needs and experiences, creating innovative products, and more effectively measuring the impact of interactive tools. However, as we have seen from the three cases highlighted here, visual approaches are not without challenges, both practical and conceptual.

In the farmers market study, cultural probes were used to stimulate participants to think about the relationship between a local market and technology. Researchers were interested in the open endedness of sketching as a data collection medium, believing it to be flexible, accessible, and tactile. They also used sketching to develop user-generated responses into more articulated speculative designs, creating visual stimuli for further discussion with their participants. In practice, these sketches did in fact allow participants to attend to the material details and social impacts of these conceptual designs, as opposed to solely focusing on functionality. However, the drawings also introduced tensions with respect to interpretation and meaning. The researchers expected that the loose and open nature of the sketches would reflect the provisional and speculative state of the proposed designs. Some participants read the images differently, interpreting the tactile and representational qualities of the drawing to mean that they were more concrete, "real" designs that would be implemented. They constructed narratives from individual images, filling in the blanks and responding to the picture in an imagined context of which the designers had little or no control. The conversation thus provoked was undeniably influenced by the choice to present the speculative designs as sketches.

Visual narrative also played an important role in the analysis of photographs collected via the VERA system. By taking a longitudinal perspective on a series of

images taken over time, researchers recreated social narratives through careful examination of objects, patterns, characters, and settings in user-generated photographs. With the VERA study, the researchers sought to understand what exactly was being made visible through the images documenting health and wellness decision points and to contrast this with social narratives evident in other modes of data collected. Careful attention was given not to speculate or to invent but instead to rely solely on the visual evidence in the photos to construct an understanding of both content and context. Although photographs have a distinct ability to capture a likeness or a setting, it can also be difficult to control the information that they disclose. In this study, tensions related to visual disclosure had two dimensions. First, by comparing the information being conveyed through the photographs to other forms of data collected, system designers were able to fully appreciate that different media show different realities. Inferences across modalities introduce challenging questions regarding the reliability of any one type of data when making choices about tool functionality. Second, although the participants in the farmers market study implicitly acknowledged the absence of contextual narrative surrounding the speculative designs depicted in the sketches created by designers, longitudinal analysis of the VERA images revealed systematic gaps in the stories being represented within the photographs, specifically an absence of social interactions and other people. Articulating these issues of visual disclosure embedded in the VERA system enabled designers to uncover and address limitations of their tool, one of the principles of reflective design practice (Sengers et al., 2005).

In the third case describing SESAME, both visual narrative and disclosure played a role in the ways in which designers deployed information visualizations of personal health data. However, another aspect of doing the visual influenced reflective experiences to an even greater extent. Visualization practices are about creating representations. In this case, sensor data was visualized to create a representation of the self for study participants. For the designers, the goals of the study were to (a) determine the accuracy of various means of collecting data about individual experience of stress over time and (b) to evaluate participant responses to different types of visual representation of these data. For the participants, the study was intended to help them to see themselves in new ways. Although tensions between these two sets of objectives could have kept the practical reflections of designers (e.g., How well is our system working?) segregated from the self-reflective observations of the participants (e.g., Is that really how I experienced my day?), visualizations were used to integrate these reflective processes. The question of reliable self-representation became a vehicle for conversations among designers and participants. If a representation did not "look right" to participants or if a participant was not able to construct a plausible narrative across the summary visualizations that designers made available to them, designers used this as important evaluation feedback regarding the performance of their system. In this way, tensions around the design of accurate and reliable visual representations were seen as a productive by-product of the visualization process.

The cases presented in this article in no way present an exhaustive picture of the range of visual approaches applied within HCI design practice. We offer them as examples of the ways in which we can think about social and material tensions

introduced into the design process through the adoption of visual approaches. As we have argued throughout this article, these techniques are not new. However, if applied reflectively, they have great potential as tools for navigating the ever-changing sociotechnical landscape in which we as designers move.

5. CONCLUSION

In summary, we synthesize across these cases to offer three statements regarding the value and challenges of utilizing visual approaches in reflective HCI design and research, highlighting tensions we discovered in our own work through doing the visual. In presenting cases from our own design research practices we illustrate the ways in which an awareness of the following tensions can help the HCI community better utilize visual approaches:

- *Visual narratives* can help us to develop reflective design practices by giving voice to underrepresented ideas or people. Sketching, photography, and video have become standard tools for creating visual narratives in HCI design practice, however new data collection methods are making visualizations also a key tool in utilizing this visual approach. Visual narratives help designers take advantage of these techniques to develop new perspectives for understanding the forces at play in the deployment and adoption of technology, especially by drawing potential users into the design research process. However, visual narratives can also highlight gaps within and around our data collection methods, and challenges can arise when researchers and study participants interpret such narratives differently. In order to use visual narratives effectively, research protocols and methodologies should be evaluated across all channels of data collection and participants should be engaged in the design research process from start to finish, not just during the ideation phase.
- Stakeholders can become engaged in the design process through the practice of *visual disclosure* through techniques such as photography and information visualization. Novel, emergent, and unanticipated information can be revealed when participants are asked to reflect on their own experience through visual representation, creating unique opportunities for designers to identify themes and patterns not originally anticipated. Unintended disclosure, however, can also present challenges. Understanding the scope of what is believed to be disclosed versus what is actually disclosed, conducting systematic analysis across cases that involve varying levels of unintended disclosure, and addressing ethical concerns about control over disclosure all become potentially provocative challenges. Increasingly larger and diverse data sets make the task of grappling with visual disclosure more complex but also more vital. Tapping into the benefits of visual disclosure as a design tool may require negotiations with Institutional Review Boards and collaborative approaches to working with participants to determine the appropriate level of disclosure for a given situation.

- *Visual representations* of data provide a means to make complex patterns that are typically not visible or obvious more accessible. This process often involves a tight coupling of observation, interpretation, and communication. The visual artifact is simultaneously analytic tool, interpretive framework, and presentation vehicle. This coupling can give the impression of being closer to the origin of ideas or phenomena, especially when documenting activities and interactions that are ephemeral or fleeting. It can also make it difficult to disentangle discrete aspects of design output in terms of evaluating systems for efficacy, functionality, and usability. In terms of maintaining a reflective design practice and an open conversation with users, the immediacy provided by visualizations can be both advantage and confound. It is important to recognize that visual encoding always involves a degree of data reduction, requiring reflection and conscious decision-making on the part of designers.

This article provides an overview of current visual research methodologies highlighting the role technology has played in facilitating and inspiring these techniques. Visual methods continue to develop across a number of disciplines because they allow researchers to—literally—make things visible. Although statistical analysis and traditional forms of evaluation might have broader followings and more commonly understood procedures for validation, working with visual data has the potential to build bridges between researchers and users supporting reflective design practice in new ways.

NOTES

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