Vernacular Visualization Practices

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ABSTRACT

In this essay, I define and discuss *vernacular visualization practices*: the creation and use of data-driven visual representations by individuals untrained in design or data science, in contrast to formal or expert visualization practices. Vernacular visualization practices reflect local and situated resources, requirements, evaluation criteria, and final outputs. In these contexts, individuals sometimes choose to make design choices that differ from those vetted by experts. These differences surface opportunities for deeper understanding of visualizations in communicating data-driven information to diverse audiences and among stakeholders with heterogeneous expertise and needs. To support this argument, I discuss the origins of the concept of vernacular visualization practices, highlight related trends in human-computer interaction (HCI) research, and then briefly describe some methodological approaches for studying them.

Keywords: Vernacular visualizations, adaptive design, grounded design, social semiotics.

1 INTRODUCTION

Visualizations, of one form or another, are the means by which many of us will discover, interact with and use the vast amounts of data that are accumulating at our fingertips. The expansion of open source development environments, like R, D3 and Processing, and web portals for enterprise products such as Tableau are greatly expanding the number and types of people who can create visualizations [1], [2]. As a result, an increasingly diverse group of people are seeing, making, and using data visualizations in a range of contexts.

In many cases, these visualizations play important roles in communication and coordination among stakeholders with substantially different types of expertise, experience, and values. For example, in my own work I have explored the creation and use of visual representations to support public engagement in science [3] as well as the ways in which the visualization of personal health data plays a role in the long term management of chronic conditions [4]. In order to respond to the needs of increasingly diverse users like these, it has become critically important to understand the ways that communicative practices, prior knowledge, social norms and conventions, and different types of digital and data literacies influence collaborative and coordinated sense-making mediated by visualizations.

Information visualization researchers, traditionally focused on technical requirements, have been challenged to keep up with these shifts [5]–[7]. Many visualization systems are designed for specialized audiences in order to support sophisticated analytic activities and are evaluated in terms of how well they support these tasks [8], [9]. Understandably, analytic requirements often

drive information visualization research, however there are a host of other sociotechnical factors that can influence the design and use of visual representations of information and data in communicative contexts. Changes to visualization development environments and consumption scenarios have resulted in an awareness that traditional, formal approaches to system evaluation, based on the time it takes a user to perform specified tasks, may not always adequately measure the full range of cognitive and communicative activities associated with using visual representations of information [2], [10], [11].

I argue that viewing these trends in terms of *vernacular visualization practices* can contribute to evolving user-centered design principles for visualization systems that serve this broadening range of contexts. *Vernacular* refers to practices that are situated and local, resulting from immediate needs rather than virtuosity [12]–[14]. The idea of vernacular visualization design practices does not replace more specialized and targeted insights regarding best practices for effective analytic systems. Instead, it highlights adaptive and informal practices that augment and add to existing frameworks for understanding the role and impacts of data-driven visual representations. To support this argument, I will discuss the origins of the concept of vernacular visualization practices, highlight related trends in human-computer interaction (HCI) research, and then briefly offer some methodological approaches for studying them.

2 VISUALIZING DATA IN EVERYDAY LIFE

2.1 Non-experts

Vernacular visualizations can communicate complex ideas to diverse audiences, educate the public, and stir debate [1], [5], [15]. Viégas and Wattenberg [12], who introduced the term “vernacular visualization”, use the word or tag cloud as an exemplar of systems for visually representing information that are created by and for non-expert users (in contrast to those developed by experts for specialized audiences). They explain: “A tag cloud is truly a ‘vernacular’ technique – one that does not come from the visualization community, and that violates some of the golden rules of traditional visualization design” [12, p. 52]. In fact, word clouds have been heavily criticized for having “glaring theoretical problems” [12, p. 51]. Many information visualization researchers have faulted them for being analytically oversimplistic and even misleading, reflecting a shallow understanding of visual principles, and the source of inappropriate physical or material associations between concepts that are inherently abstract [16].

Yet, there are many people who love them, use them, remember them, and share them. Hearst and Rosner have defended the word cloud, showing that a distinction can be made between *analytic value* and *social or communicative value* [17]. Words clouds *do* have worth, just not the kind typically attended to by information visualization researchers.

In coining the term “vernacular visualization,” Viégas and Wattenberg challenged the information visualization field to think about the ways in which the rapid expansion of data presentation practices could influence the work of formally trained system designers and developers. An essential facet of this influence includes the ways in which communication and coordination

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within vernacular contexts can serve as both design requirements and evaluative criteria. Viégas and Wattenberg, and a growing number of other visualization researchers, have steadily been working on ways to reconcile these day-to-day practices with other sophisticated and specialized advances being made in the field.

2.2 Vernacular scenarios

I have deployed this vernacular framing to study the role that the creation and use of visual representations of data and information play in collaboration, coordination, and communication among people with disparate expertise and experiences [3], [4], [16], [18], [19]. The following scenarios provide some examples of the ways that diverse audiences come together through visualization practices:

- A patient pours over updates to her online electronic health record, including her latest set of test results. She has multiple chronic health conditions that she has wrestled with for many years. The patient and her doctor often refer to test results like these as they try to plan a course of treatment that satisfies both of their goals: the patient wants a high quality of life and the physician is assessing the risks and benefits of recent experimental drug trials. The patient is feeling overwhelmed and frustrated as she scans the visualizations. Her physician's notes about the various numbers, charts, and graphs, which reference a conversation that began in the exam room the previous day, seem to be overly optimistic, which confuses the patient. They look at the same data visualizations, but each has a distinct interpretive lens.
- Members of a coastal community are concerned about the health of the marine habitats they call home. An environmental scientist seeks to collect detailed information about marine wildlife along a long portion of the coast as part of a collaborative effort to assemble a rigorous dataset related to the impacts of climate change. The scientist launches a citizen science project with the hopes of both engaging the public in science and also collecting the needed data. Through much trial and error, the scientist learns that visualizations of the data collection process are an extremely effective tool to train volunteers in the process of making careful and accurate observations of wildlife on their beaches. Data-driven visualizations also enable the researcher to share the results of climate science being performed with the public. The volunteers see their data reflected in the complex graphs. They do not always understand the details, but often become more invested in the project as they see patterns of impacts through the visual representations provided by the scientist [3].
- A person diagnosed with bipolar disorder, a serious mental illness characterized by extreme shifts in mood, practices therapeutic self-tracking as a means to self-manage her chronic condition. She only sees her psychiatrist once every 3 months due to her restricted health care coverage and the limited resources of the public mental health clinic where she receives treatment. She is diligent about this tracking, which she documents through a combination of MS Excel spreadsheets and hand-drawn charts in a paper journal. She brings all of this information to her regular appointments in order to help her clinician fill in the blanks between visits. Even though her medical

team cannot add these documents directly into her electronic health record, they make notes and discuss emergent patterns. Visualization, in the form of Excel charts and graphs, the journal, and sketches made during their face-to-face encounters, enable the patient and her clinician to posit trends, agree on interpretations of symptoms, and collectively make sense of the impacts of a recent change in medication [4], [20]–[23].

My research explores scenarios like these, showing that visual representations can support social interactions by scaffolding intersecting vernacular (e.g., local, situated, everyday) literacies and, in the process, helping to create *common ground* among stakeholders [18], [19], [24].

2.3 Adaptive design

The term “vernacular visualization” owes a debt to the field of architecture, where the value of studying vernacular or “folk” building techniques has been recognized by architectural scholars for decades [14], [25], ranging from traditional Japanese family homes [13] to Ugandan security gates [26]. Across these contexts, folk builders innovate by repurposing and re-contextualizing existing materials and ideas in order to address their individual challenges and needs [14]. Untrained in the discipline of architecture, these vernacular designers make decisions based on their deep understanding of local resources, pain points, and aspirations.

Hubka uses the study of barn buildings in the northeastern region of the US to illustrate the perhaps surprising richness of everyday design practices [14]. At first inspection, these barn structures appear identical and homogeneous; however further scrutiny reveals rich and diverse customizations, fabrications, and alterations. Hubka argues that the reward for this closer examination is a wealth of information about the lived experiences of the builders. Idiosyncratic refinements correspond to specific localized needs. He describes these highly individualized approaches to problem solving as distinctly different from the motivations of professional architects to innovate in order to conceptually or intellectually advance their craft.

A similar perspective is reflected in an approach to the design of human-computer interactive systems advocated by Thomas Moran [27]. Moran defines “everyday adaptive design” as “pervasive activity engaged in by people as they adapt resources at hand to their everyday lives” [27, p. 15]. He contrasts this to “professional design” practices performed by trained professionals and “generic design” activities undertaken by non-designers acting in the role of designer during the interactive system development process. “Adaptive design” occurs after technology has been designed and built, during set up, installation, training, maintenance, upgrades, repair and reconfiguring. One only needs to search the internet for “life hacks” to see evidence of this type of design practice.

A connection can be drawn between everyday adaptive design and Hubka's New England barns, designed and built on a particular model, but adapted in use to optimize for particular vernacular contexts. Implicit in acknowledging the work of vernacular or everyday designers is the notion that users and professional designers (i.e., expert or formally trained builders) approach the innovation process using distinctly different knowledge, skills and practices [28].

It has been over a decade since Moran advocated for everyday adaptive design practices as a “worthwhile focus for design research” [27, p. 16]. In that time, within the HCI community there has been growing interest in topics related to adaptive

practices including: everyday design, e.g., [29], [30]; creative needs of the public, e.g., [31]–[33]; material properties of restoration and repair, e.g., [34]; the democratization of innovation, e.g., [35], [36]; and DIY and hacker culture, e.g., [37]–[40].

Studies of everyday adaptive design show the benefits of expanding the domain of technology design research to include the potentially idiosyncratic and highly individualized activities of non-expert communities [28]. For example, Wakkary and Maestri [30] and Bardzell, Rosner and Bardzell [31] looked at localized design work to examine the ways in which quality is assessed in the absence of formal evaluation procedures and heuristics. Tanenbaum et al. [36] highlight the ways in which maker communities have created demand for new types of tools and literacies. Torrey, Churchill and McDonald's work looking at the online search practices of crafters [32] reveals that the process of "learning how" can be used to expand models of information seeking behavior to accommodate the blend of material and virtual experience involved in many types of craft tutorials. Work in this area also provides important reminders that as sociotechnical practices unfold in the real world, systems (and the activities they were designed to support) do not remain static [41], supporting Moran's claim that exploring the theory and practices of adaptive design will help interactive system developers "to develop design methods, adaption techniques, and 'pliant' technologies" [27, p. 16].

This framing of the broadening scope of visualization practices connects the growing body of research in HCI looking at everyday design and the democratization of technology with research in the information visualization field focused on human-centered approaches to system development and evaluation (e.g., [1], [2], [42], [43]).

2.4 Values in the design of visualizations

The process of generating visual representations of information has been treated primarily as a technical endeavor driven by scientific standards of objectivity [44]–[46]. However, other factors can also influence the technology design process:

"...values held by designers affect how information technologies are imagined; how systems handle data, create categories, and draw inferences; and what affordances are available for user interaction. All of these decisions affect the social consequences of emerging technologies." [47, p. 375]

In this context, values refer to "what a person or group of people consider important in life" [48, p. 69]. Values of an individual or a community can greatly influence which design problems are given priority, how resources to solve those problems will be allocated, and the metrics by which solutions will be evaluated. This is as true for expert designers as it is for vernacular designers.

Design studies in other areas of computing, such as software design [48], [49], infrastructure design [47], [50], [51], game design [52], and accessibility design [53], [54], show that reflective examination of the values that motivate decisions made during the technology development process, not just the technical outcomes, can lead to a better understanding of both current contexts of use and responsible development of future systems [55], [56]. The values evident in vernacular visualization practices, as observed in practices of adaptation, repurposing and pragmatic invention, will provide important signposts for

understanding the mechanisms of innovation in informal design contexts [57], [58].

3 METHODOLOGICAL FRAMEWORKS

Information visualization researchers have steadily introduced an increasing range of techniques for measuring a wider spectrum of user experiences, such as: grounded approaches that lead to a situated understanding of contextual aspects of use [59]; reflections on the visualization design process [7], [60]; focused attention on insight generation [42], [61] and sense-making processes [62], [63] over task completion; and evaluation of the impacts of a visualization on narrative interpretation [16], [64], [65].

While these studies acknowledge the richness of the visual experience and importance for information visualization researchers to think beyond traditional time and error models of system evaluation, they often fail to position visualization practices within iterative and coordinated communication processes [18], [66]. In my research, I address this gap by drawing on three qualitative methodological frameworks for performing situated and contextual analysis of vernacular visualization practices.

3.1 Image-enabled communication practices

Advances in image-making tools have greatly increased our opportunities for using images to collaborate. While information visualization research often focuses on building systems to generate visual representations of large data sets, a small but growing subset of studies focuses on collaborative aspects of information and data visualization. Situated analysis of the creation and use of visualizations in social contexts helps us to understand the communication acts associated with image-making in collaborative contexts and how individuals use the image within the context of social practice (i.e., cognitively, discursively, physically, emotionally).

Visualizations, analogue or computational, reflect our intentions, priorities, and values just as other types of communication do. This is especially true in collaborative contexts where visual representations of information have the ability to transcend disparate vocabularies and synchronize frames of reference. Interactional sociolinguistic concepts of conversational involvement and coordination can provide a framework for multimodal analysis of social interactions that included the creation and use of visual representations of information in a variety of forms, from digital visualizations to sketches on a whiteboard.

In order to establish a methodology for examining image-making as an information-driven communicative practice, I conducted a qualitative study examining face-to-face conversations involving the creation of *ad hoc visualizations* (i.e., "napkin drawings") [18], [19] (Figure 1). Through analysis of verbal, non-verbal and visual communication practices, I draw attention to several key functions of image-making within conversations, some more closely associated with the image artifact, others more specifically related to the activity of image-making. Findings show that the activity of image-making contributes to the maintenance of conversational involvement in ways that are not always evident in the drawn artifact. Findings identify affordances of visualization practice related to both the material visual object (artifact) and the performance of communication acts (activities) [67].

Figure 1. Pair co-creating an ad hoc visualization during a face-to-face conversation.

This analytic framework helps to delineate vernacular or local visual encoding systems and practices, classifying not just what is depicted but also: 1) what those depictions mean to community members and 2) what the act of depicting enables them to do, understand, describe, and/or communicate.

3.2 Grounded Design

In a recent study [4], my team and I adapted *Grounded Design* methodology [68] in order to explore the implications of visualization conventions associated with the display of personal information for people who self-track as a means to manage bipolar disorder (BD), a chronic serious mental illness (SMI) [4]. We worked with individuals diagnosed with BD to 1) better understand sense-making challenges related to the representation and interpretation of personal data and 2) probe the benefits, risks, and limitations of participatory approaches to designing personal data visualizations that better reflect their lived experiences.

Issues of social identity, attitudes towards self-disclosure, and potentially biased approaches to what is considered "typical" or "normal" are critical factors when designing visualizations for personal informatics systems. This is particularly true when working with vulnerable populations like those who self-track to manage serious mental illnesses like bipolar disorder (BD).

Rohde et al. [68] explain that empirical design research is inherently entangled with social practice. Design concepts and prototypes exist in an environment that is dynamic, contingent, unpredictable, and organic. Any empirical contribution to a shared knowledge base that results from design research must acknowledge and be considered in terms of how an information technology (IT) artifact is created within and appropriated into dynamic, real-world social contexts. This recognizes that the sociotechnical contexts in which IT artifacts are introduced and exist are continually changing, evolving, and emergent.

In order to accomplish this, Grounded Design inquiry is guided by a set of focusing questions that correspond to a series of design research activities [68, pp. 169–170], including: (1) an ethnographic **context study** to help researchers understand the design context from the perspective of community members in order to cultivate a shared understanding of the problem space and nature of requirements and restrictions; (2) a period of **co-design** to enable stakeholders (researchers in collaboration with community members) to *work on* IT artifact(s) that respond to these needs; (3) **appropriation** of IT artifacts into social practice, enabling stakeholders to *work with* the IT artifact(s); and (4) the creation of a **design case study** that represents a conceptual

Figure 2. Examples of timelines drawn by individuals diagnosed with bipolar disorder, representing their experiences with mental illness over time.

reconstruction of the change process enacted by the intervention of the IT artifact within the specific problem space.

Resonant with Grounded Design, D'Ignazio and Klein's work on Feminist Data Visualization highlights six conceptual design imperatives [69] for supporting inclusion and combating disciplinary bias in the creation of data visualizations: 1) rethink binaries, 2) embrace pluralism, 3) examine power dynamics and aspire to the empowerment of all individuals, 4) consider context, 5) legitimize embodiment and affect, and 6) make labor visible.

Participatory and iterative methods guided by both the Grounded Design methodology and D'Ignazio and Klein's principles [69] enabled us to explore the benefits and limitations of a series of speculative visual representations of personal data for individuals living with BD. Specifically, we focused on four primary design inquiry activities:

- **Identify sense-making challenges** related to interpreting and using personal data in the context of BD;
- **Deploy participatory design techniques** that enable participants to share knowledge and insights and associate self-knowledge with diverse visual imagery;
- **Synthesize participant-generated imagery** to identify common themes including visual motifs reflecting participant experiences and sense-making challenges related to the interpretation of personal data; and
- **Create and assess speculative sketches** that build on these visual themes and draw on vernacular data practices to represent personal data in ways that are more akin to lived experiences.

These activities were performed through 1) two interviews with each participant, including a series of visual elicitation tasks, described below; 2) engaging with a professional graphic artist to transform common themes into exploratory visual encoding schemas; 3) and a third interview in which participants responded to these visual encoding schemas.

The collaborative design activities that we developed for this work fostered candid conversations between researchers and individuals with BD about the challenges of managing a life-long mental health condition, the participants' existing self-tracking and data-reflection practices, and the strengths and weaknesses of several speculative personal visualization designs.

One of the common self-tracking challenges described by participants was reconciling an internal version of themselves (e.g., how the biochemistry of BD makes them feel) with external reflections of their behavior and actions in social contexts (e.g., how their actions are perceived by others). Participants created persistent, material representations of their experiences through a series of visual elicitation activities that served as concrete points of reference from which personal experiences could be probed and clarified (Figure 2) [18]. This enabled more specific conversations about connections between personal data across time, magnitude of episodes, and complexities of interdependencies. Through this work, we found that cultivating opportunities to clarify and confirm representations of self is critical for supporting vulnerable individuals who, like our participants, may have experienced doubt, scorn, or distrust from society over the course of their lives. Vernacular associations and values associated with mental health, collective engagement, and representations of identity materialized in participant-generated visualizations. Current work is focused on identifying practices related to revealing and concealing personal information and creating visualization requirements from these observations.

3.3 Social semiotics

My qualitative study of the creation, use and dissemination of vernacular visualizations in a citizen science project provides an example of the application of social semiotic frameworks to the study of vernacular visualization practices [3]. Citizen science projects are informal learning experiences that provide the public with opportunities to engage in authentic science activities. Volunteers perform discrete tasks that contribute to science initiatives, typically involving collecting or analyzing large sets of data. Citizen science projects often depend on the engagement of a diverse set of stakeholders ranging from subject matter experts to members of the general public. Within citizen science, visual representations of information have been used to communicate findings to the general public, to recruit and train volunteers, and to enable volunteers to engage with science in meaningful ways. While the roles of visual information in formal science contexts have been widely explored, e.g., [45], [72], [73], visualizations and visual practices in the informal science learning vernacular of citizen science are less understood.

Social semiotic analysis focuses not only on what is represented in a given image, but also how that representation was created and what can and is done with it by specific audiences [70]. For example, imagine three images, each depicting an apple in some way: 1) a digital photograph stored on a smartphone providing a record of an apple that was recently eaten; 2) a printed reproduction of a painting of an apple seen at an art museum, taped to a cubicle wall; and 3) the shiny silver apple-shaped logo that adorns the base of a computer monitor sitting on a desk.

Social semiotic theory articulates the differences and similarities among these three images by making a distinction between: 1) the coded system that represents apple-ness regardless of context (i.e., in spite of differences, each image can be recognized as referencing the same specific type of fruit), and 2) the many ways that these three images are radically different from each other, from their material form, to their social significance, to the nuanced meanings that each references. In social semiotics,

these differences reflect conventions, assumptions, and expectations often originating with a particular social group [70].

Those with power can influence these “rules” or “boundaries” of interpretation. For example, depending on who is controlling the interpretative process, a photograph documenting a clear case of police brutality can be reframed as undeniable evidence of a dangerous criminal being arrested [71]. Marginalized groups can appropriate semiotics conventions for subversive purposes, such as when certain types of street art and graffiti are used as communication channels and vehicles of social protest among disenfranchised communities.

A participant observation study conducted with the University of Washington's Coastal Observation and Seabird Survey Team (COASST) used social semiotic analysis to explore the role that vernacular visualization practices play in data-rich collaborative and coordinated work contexts. Visual documents were collected and analyzed as products of dynamic sociotechnical activities [74].

For example, within the COASST project, the process of observing, identifying, and documenting deceased coastal birds is supported through a highly visual field guide and protocol handbook. Observations are recorded using a detailed datasheet that includes visual icons (Figure 3a and 3b). Beached birds are also documented through a series of digital photographs. Data visualizations, in both draft and final form, were collected and analyzed for this study. In addition to examining these visual artifacts, an inventory of digital and analogue tools that play a role in vernacular visual practices was compiled in order to better understand the technological infrastructure that supports data practices in this citizen science project.

The COASST study points to some of the important roles that vernacular visualization practices can play in providing support for coordinated work, communication practices, and data infrastructures. The observational and organizational structure provided by visual resources and practices in the COASST project are essential tools for facilitating the flow of information and data among stakeholder groups, performing as infrastructure to support the doing of citizen science. However, observations of visual practices deployed in the doing of citizen science raise a host of questions about the nature and value of understanding vernacular visualization practices:

- **Where do the boundaries of data visualization work lie?** Should *all* of the COASST practices discussed here be considered visualization? Is there a broader range of visual practices that should be considered when supporting coordinated work? What is at risk by considering a more holistic set of data-driven visual practices when supporting coordinated activities?
- **Are these vernacular designers doing something different from professionals or are they just not as well trained?** What is the boundary between expert and non-expert? How can the practices of vernacular designers be advanced without assuming that they need or want the same skills or training as professionals? Are there specific tools that can better support the work of these designers?
- **If a visualization does not follow prescriptive best practices established in one domain, does that mean it is useless in all contexts?** What does it mean for a visualization to work “in the wild” as opposed to in the lab? Are there vernacular literacies that need to be accounted for when thinking about visualization curricula and tools?

Figure 3a and 3b. Example pages from COASST field guide, including species page. Image credit: COASST.

These are questions that I am continuing to explore in current work. Ongoing research investigating vernacular data practices is showing that attending to non-expert design practices (in this case, referring to the practices of those not trained in information visualization or graphic design) can have a positive impact on technology development by introducing new, pragmatically driven approaches to supporting coordinated work and communication among diverse communities of practice.

By focusing on non-expert visualization designers, this research surfaces opportunities for empowering individuals to engage with data on their own terms. Findings from this study, focused on one community of practice, provide empirical and methodological support for future comparative studies of vernacular visualization design practices. The cumulative results of this work will contextualize limitations of existing public-facing data tools and infrastructure and enhance requirements for new tools, while at the same time shedding light on new forms of data, visual, and technical literacies.

4 CONCLUSION

Greater understanding of vernacular visualization design practices can have a positive impact on technology development by

generating (1) more responsive user-centered approaches to visualization development and evaluation, (2) better insights into methods for empowering users to engage with data in meaningful ways, (3) more diversified technology design communities of practice, and (4) a broader spectrum of frameworks for understanding the role that data-driven visual representations play in communication, coordination, and collaboration. In turn, improved public-facing systems for creating visual representations of information will have an enormous impact across a range of contexts.

The methodologies that are briefly described here can inspire and support changes to the ways we think about defining requirements for the design of visual encoding systems that will be used within vernacular contexts. This work also plays an important role in increasing our understanding of emerging data practices and literacies across a range of contexts. By engaging with non-expert visualization designers, this work surfaces opportunities for empowering individuals to engage with data on their own terms. The cumulative results of this approach can also contextualize limitations of existing public-facing visualization tools and infrastructure and enhance requirements for new tools. Exploring vernacular visualization practices can shed light on new forms of visual and technical literacies, highlighting a range of situated communicative practices associated with the creation and use of visualizations.

REFERENCES

- [1] J. Heer, F. van Ham, S. Carpendale, C. Weaver, and P. Isenberg, "Creation and collaboration: Engaging new audiences for information visualization," in *Information Visualization: Human-Centered Issues and Perspectives*, A. Kerren, J. T. Stasko, J.-D. Fekete, and C. North, Eds. Berlin Heidelberg: Springer, 2008, pp. 92–133.
- [2] A. Kerren, J. T. Stasko, J.-D. Fekete, and C. North, Eds., *Information Visualization: Human-Centered Issues and Perspectives*. Berlin, Germany: Springer, 2008.
- [3] J. Snyder, "Vernacular Visualization Practices in a Citizen Science Project," in *Proceedings of the 2017 ACM Conference on Computer Supported Cooperative Work and Social Computing*, 2017, pp. 2097–2111.
- [4] J. Snyder, E. L. Murnane, C. Lustig, and S. Volda, "Visually Encoding the Lived Experience of Bipolar Disorder," *Proc SIGCHI*, forthcoming.
- [5] M. Dörk, P. Feng, C. Collins, and S. Carpendale, "Critical InfoVis: exploring the politics of visualization," *CHI13 Ext. Abstr.*, pp. 2189–2198, 2013.
- [6] A. Kerren, J. T. Stasko, J.-D. Fekete, and C. North, "Workshop Report: Information Visualization–Human-Centered Issues in Visual Representation, Interaction, and Evaluation," *Inf. Vis.*, vol. 6, no. 3, pp. 189–196, Sep. 2007.
- [7] T. Munzner, *Visualization Analysis and Design*. CRC Press, 2014.
- [8] S. K. Card, J. D. Mackinlay, and B. Shneiderman, *Readings in Information Visualization: Using Vision to Think*. San Francisco, CA: Morgan Kaufmann, 1999.
- [9] C. Ware, *Information visualization: perception for design*. Elsevier, 2012.
- [10] T. Isenberg, P. Isenberg, J. Chen, M. Sedlmair, and T. Moller, "A systematic review on the practice of evaluating visualization," *IEEE Trans. Vis. Comput. Graph.*, vol. 19, no. 12, pp. 2818–2827, 2013.

- [11] C. Plaisant, "The challenge of information visualization evaluation.," *Proc. Work. Conf. Adv. Vis. Interfaces*, pp. 109–116, 2004.
- [12] F. B. Viégas and M. Wattenberg, "Tag clouds and the case for vernacular visualization," *interactions*, vol. 15, no. 4, pp. 49–52, 2008.
- [13] H. Glassie, *Vernacular architecture*. Indiana University Press, 2000.
- [14] T. Hubka, "Just folks designing: Vernacular designers and the generation of form," *J. Archit. Educ.*, vol. 32, no. 3, pp. 27–29, 1979.
- [15] Z. Pousman, J. T. Stasko, and M. Mateas, "Casual information visualization: Depictions of data in everyday life," *Vis. Comput. Graph. IEEE Trans. On*, vol. 13, no. 6, pp. 1145–1152, 2007.
- [16] E. P. S. Baumer and J. Snyder, "Interpretive Impacts of Text Visualization: Mitigating Political Framing Effects," *ACM Trans. Comput. Hum. Interact. TOCHI*, under review.
- [17] M. Hearst and D. Rosner, "Tag clouds: Data analysis tool or social signaller?," *Proc HICSS*, pp. 160–169, 2008.
- [18] J. Snyder, "Visual Representation of Information as Communicative practice," *J. Am. Soc. Inf. Sci. Technol. JASIST*, vol. 65, no. 11, pp. 2233–2247, 2014.
- [19] J. Snyder, "Drawing Practices in Image-Enabled Collaboration," *Proc. ACM Conf. Comput.-Support. Coop. Work CSCW 2013*, p. San Antonio, TX, February 23 – 27, 2013.
- [20] M. Matthews, E. Murnane, and J. Snyder, "Quantifying the Changeable Self: The Role of Self-Tracking in Coming to Terms With and Managing Bipolar Disorder," *Human-Computer Interact.*, vol. 32, no. 5–6, pp. 413–446, Feb. 2017.
- [21] M. Matthews *et al.*, "The double-edged sword: A mixed methods study of the interplay between bipolar disorder and technology use," *Comput. Hum. Behav.*, vol. 75, pp. 288–300, Oct. 2017.
- [22] J. Snyder, "Participatory Design to Support Serious Mental Illness," Group Health Foundation: Lessons Learned from Community Engagement, White paper, 2018.
- [23] E. L. Murnane, T. G. Walker, B. Tench, S. Volda, and J. Snyder, "Personal Informatics in Interpersonal Contexts: Towards the Design of Technology That Supports the Social Ecologies of Long-Term Mental Health Management," *Proc ACM Hum-Comput Interact*, vol. 2, no. CSCW, pp. 127:1–127:27, Nov. 2018.
- [24] H. H. Clark, *Using Language*. New York: Cambridge University Press, 1996.
- [25] A. Rapoport, "A framework for studying vernacular design," *J. Archit. Plan. Res.*, vol. 16, no. 1, pp. 52–64, 1999.
- [26] D. Stairs, "Okuwangaala: The Persistent Vitality of the Vernacular," *Des. Issues*, vol. 18, no. 3, pp. 70–88, 2002.
- [27] T. P. Moran, "Everyday adaptive design," *Proc DIS*, pp. 15–16, 2002.
- [28] E. von Hippel, *Democratizing Innovation*. Cambridge, MA: MIT Press, 2005.
- [29] E. Shove, *The design of everyday life*. New York: Berg, 2007.
- [30] R. Wakkary and L. Maestri, "The resourcefulness of everyday design," *Proc Creat. Cognition*, pp. 163–172, 2007.
- [31] S. Bardzell, D. Rosner, and J. Bardzell, "Crafting quality in design: integrity, creativity, and public sensibility," *Proc DIS*, pp. 11–20, 2012.
- [32] C. Torrey, E. F. Churchill, and D. W. McDonald, "Learning how: the search for craft knowledge on the internet," *Proc SIGCHI*, pp. 1371–1380, 2009.
- [33] J. Zimmerman, "Designing for the self: making products that help people become the person they desire to be," *Proc SIGCHI*, pp. 395–404, 2009.
- [34] D. Rosner and M. Ames, "Designing for repair?: infrastructures and materialities of breakdown," *Proc CSCW*, pp. 319–331, 2014.
- [35] E. Björqvinnsson, P. Ehn, and P. A. Hillgren, "Participatory design and democratizing innovation," *Proc Particip. Des.*, pp. 41–50, 2010.
- [36] J. G. Tanenbaum, A. M. Williams, A. Desjardins, and K. Tanenbaum, "Democratizing technology: pleasure, utility and expressiveness in DIY and maker practice," *Proc SIGCHI*, pp. 2603–2612, 2013.
- [37] S. Kuznetsov and E. Paulos, "Rise of the expert amateur: DIY projects, communities, and cultures," *Proc Nord.*, pp. 295–304, 2010.
- [38] S. Lindtner, G. D. Hertz, and P. Dourish, "Emerging sites of HCI innovation: hackerspaces, hardware startups & incubators," *Proc CHI*, pp. 439–448, 2014.
- [39] M. Ratto, M. Boler, and R. Deibert, *DIY citizenship: Critical making and social media*. Cambridge, MA: MIT Press, 2014.
- [40] A. Williams, A. Gibb, and D. Weekly, "Research with a hacker ethos: what DIY means for tangible interaction research," *interactions*, vol. 19, no. 2, pp. 14–19, 2012.
- [41] L. Suchman, "Representations of work: Making work visible," *Commun. ACM*, vol. 38, no. 9, pp. 33–35, 1995.
- [42] C. North, "Toward measuring visualization insight," *Comput. Graph. Appl.*, vol. 26, no. 3, pp. 6–9, 2006.
- [43] C. Danis, F. B. Viegas, M. Wattenberg, and J. Kriss, "Your Place or Mine? Visualization as a Community Component," *CHI 2008 Proc.*, pp. 275–283, 2008.
- [44] R. V. Burri and J. Dumit, "Social Studies of Scientific Imaging and Visualization," in *The handbook of science and technology studies*, E. J. Hackett, O. Amsterdamska, M. Lynch, and J. Wajcman, Eds. Cambridge, MA: MIT Press, 2008.
- [45] M. Lynch, "The externalized retina: Selection and mathematization in the visual documentation of objects in the life sciences," *Hum. Stud.*, vol. 11, pp. 201–234, 1988.
- [46] L. Pauwels, Ed., *Visual cultures of science: Rethining representational practices in knowledge building and science communication*. Hanover, NH: Dartmouth College Press, 2006.
- [47] K. Shilton, "Values Levers Building Ethics into Design," *Sci. Technol. Hum. Values*, vol. 38, no. 3, pp. 374–397, 2013.
- [48] B. Friedman, P. H. Kahn Jr, and A. Borning, "Value sensitive design and information systems," in *The Handbook of Information and Computer Ethics*, K. E. Himma and H. T. Tavani, Eds. Hoboken, NJ: Wiley, 2008, pp. 69–102.
- [49] K. R. Fleischmann and W. A. Wallace, "A covenant with transparency: Opening the black box of models," *Commun. ACM*, vol. 48, no. 5, pp. 93–97, 2005.
- [50] M. J. Bietz, E. P. Baumer, and C. P. Lee, "Synergizing in cyberinfrastructure development," *Comput. Support. Coop. Work CSCW*, vol. 19, no. 3–4, pp. 245–2, 2010.

- [51] S. L. Star and K. Ruhleder, "Steps toward an ecology of infrastructure: Design and access for large information spaces," *Inf. Syst. Res.*, vol. 7, no. 1, pp. 111–134, 1996.
- [52] M. Flanagan, D. C. Howe, and H. Nissenbaum, "Values at play: Design tradeoffs in socially-oriented game design," *Proc SIGCHI*, pp. 751–760, 2005.
- [53] J. A. Koepfler and K. R. Fleischmann, "Studying the values of hard-to-reach populations: content analysis of tweets by the 21st century homeless," *Proc IConference*, pp. 48–55, 2012.
- [54] J. P. Woelfer, A. Iverson, D. G. Hendry, B. Friedman, and B. T. Gill, "Improving the safety of homeless young people with mobile phones: Values, form and function," *Proc SIGCHI*, pp. 1707–1716, 2011.
- [55] K. R. Fleischmann, "Information and Human Values," *Synth. Lect. Inf. Concepts Retr. Serv.*, vol. 5, no. 5, pp. 1–99, 2013.
- [56] H. Nissenbaum, "How computer systems embody values," *Computer*, vol. 34, no. 3, pp. 120–119, 2001.
- [57] J. Snyder, K. Shilton, and S. Anderson, "Observing the Materiality of Values in Information Systems Research," *Proc HICSS*, 2016.
- [58] J. Snyder and K. Shilton, "Spanning the Boundaries of Data Visualization Work: An Exploration of Functional Affordances and Disciplinary Values," in *iConference 2019: Information in Contemporary Society*, 2019, pp. 63–75.
- [59] P. Isenberg, A. Tang, and S. Carpendale, "An exploratory study of visual information analysis," *Proc. SIGCHI Conf. Hum. Factors Comput. Syst.*, pp. 1217–1226, 2008.
- [60] M. Brehmer, S. Carpendale, B. Lee, and M. Tory, "Pre-design empiricism for information visualization: Scenarios, methods, and challenges," *Proc. 5th Workshop Time Errors Nov. Eval. Methods Vis. BELIV*, pp. 147–151, 2014.
- [61] J. S. Yi, Y. A. Kang, J. T. Stasko, and J. A. Jacko, "Toward a deeper understanding of the role of interaction in information visualization," *IEEE Trans. Vis. Comput. Graph.*, vol. 13, no. 6, pp. 1224–1231, 2007.
- [62] A. Endert, P. Fiaux, and C. North, "Semantic interaction for visual textanalytics," *Proc SIGCHI*, pp. 473–482, 2012.
- [63] Y. A. Kang and J. T. Stasko, "Examining the use of a visual analytics system for sensemaking tasks: Case studies with domain experts," *IEEE Trans. Vis. Comput. Graph.*, vol. 18, no. 12, pp. 2869–2878, 2012.
- [64] J. Hullman and N. Diakopoulos, "Visualization rhetoric: Framing effects in narrative visualization," *IEEE Trans. Vis. Comput. Graph.*, vol. 17, no. 12, pp. 2231–2240, 2011.
- [65] E. Segel and J. Heer, "Narrative visualization: Telling stories with data," *IEEE Trans. Vis. Comput. Graph.*, vol. 16, no. 6, pp. 1139–1148, 2010.
- [66] J. Snyder *et al.*, "Making Things Visible: Opportunities and Tensions in Visual Approaches for Design Research and Practice," *Hum. Comput. Interact. Spec. Issue Des. Think. Ed Jack Carroll Scott Klemmer*, vol. 29, no. 5–6, pp. 451–486, 2014.
- [67] J. Snyder, "Activities & artifacts: the dual nature of image-making in communicative practice," *Proc. 2012 IConference*, p. Toronto, ON, 10–17, 2012.
- [68] M. Rohde, P. Brödner, G. Stevens, M. Betz, and V. Wulf, "Grounded Design – a praxeological IS research perspective," *J. Inf. Technol.*, vol. 32, no. 2, pp. 163–179, Jun. 2017.
- [69] C. D'Ignazio and L. F. Klein, "Feminist Data Visualization," *Workshop Vis. Digit. Humanit. VIS4DH Baltim. IEEE*, p. 5.
- [70] T. van Leeuwen and C. Jewitt, *Handbook of Visual Analysis*. London, UK: Sage Publications, 2001.
- [71] C. Goodwin, "Professional Vision," *Am. Anthropol.*, vol. 96, no. 3, pp. 606–633, 1994.
- [72] K. Knorr-Cetina and K. Amann, "Image Dissection in Natural Scientific Inquiry," *Sci. Technol. Hum. Values*, vol. 15, no. 3, p. 259, 1990.
- [73] M. Lynch and S. Woolgar, *Representation in Scientific Practice*. Cambridge, MA: MIT Press, 1990.
- [74] C. Østerlund, "Documents in Place: Demarcating Places for Collaboration in Healthcare," *Comput. Support. Coop. Work CSCW*, vol. 17, pp. 195–225, 2008.