# Data Epics

## Embarking on Literary Journeys of Home Internet of Things Data

Audrey Desjardins
School of Art + Art History + Design, University of
Washington, Seattle, Washington, United States
adesjard@uw.edu

Heidi R. Biggs
College of Information Sciences and Technology, Penn
State University, University Park, Pennsylvania, United
States
hrb5307@psu.edu

**Figure 1: The Data Epics: 4 short stories written based on home IoT data.**

## ABSTRACT

In this paper, we use fiction as a method to complicate the common-place narratives of data as intangible and objective, in the particular context of Internet of Things (IoT) in the home. We, a team of two design researchers, partnered with a fiction writer and a single IoT enthusiast, Susan, to create The Data Epics: four short stories based on Susan's monthly home IoT data logs. The Data Epics revealed new imaginaries for data, showing new world-views and lively data, but also surfaced data's entanglement in meshes and hierarchies, and concerns about control and power. Our work also examines the labor of tending to and interpreting data and a particular interest in anomalies. We conclude with discussions of how data imaginaries from fiction might be imperfect, but are uniquely generative, offering a path to get closer to IoT data by *trying things on* and *zooming in and slowing down*.

## CCS CONCEPTS

• **Human-centered computing**; • **Human computer interaction (HCI)**; • **HCI design and evaluation methods**;

## KEYWORDS

Data, IoT, Fiction, Speculative, Epics, RtD, Home

**ACM Reference Format:**
Audrey Desjardins and Heidi R. Biggs. 2021. Data Epics: Embarking on Literary Journeys of Home Internet of Things Data. In *CHI Conference on Human Factors in Computing Systems (CHI '21), May 08–13, 2021, Yokohama, Japan.* ACM, New York, NY, USA, 17 pages. https://doi.org/10.1145/3411764.3445241

# 1 INTRODUCTION

"Data is the new oil." So goes the new refrain, which has gained traction over last few years (e.g. [62]). What a shocking image: 'oil' evokes an industry with an impact difficult to ignore—what started as an oil 'rush' or a wave of entrepreneurship, grit and hustle, man vs. wilderness and crude natural resource extraction has expanded to become an engine of the global economy, global infrastructures, wars and an outpouring of new technologies and ways of being in the world. If data is the new oil, we wonder, what is at stake at the boundaries of our interactions with data, on a personal as well as societal level? On the one hand, the promise of data-driven societies suggests we can tackle large issues like understanding climate change, promoting public health, maintaining national security, etc. On the other hand, D'Ignazio and Klein state: "*This extractive system creates a profound asymmetry between who is collecting, storing, and analyzing data, and whose data are collected, stored, and analyzed*" [21:45], signaling that data infrastructures and data analysis can enact power imbalances. There is a gap between how data are portrayed in popular press and everyday interactions and the complexities, messiness and non-neutrality of how data are created and used.

Imaginaries of data seem to remain tied to ideas of data as digital, immaterial, big and objective. Information scientists define data abstractly, or technically as "*agglomerations of small, discrete signals, represented as 0s and 1s in computer memory*" [43:16]. People have come to understand data as plain and neutral, and thereby objective and, inevitably, true [21, 35], leading to trends where data are used as a path toward self-knowledge in movements like the Quantified Self [13, 66]. Furthermore, data continue to be seen as homogeneous, universal and all encompassing, following new buzzwords like 'Big Data' promoting a sense of volume, velocity and high resolution [39, 40] and a belief that data are smooth and easily manipulatable [33]. These definitions and characteristics are familiar, but data remain elusive and hard to grasp or understand for laypeople who use devices or software that use and collect their data. People outside of technical knowledge bases seem limited to this set of established ideals to conceptualize and hold mental models for what data are [4]. Hong explains, "*technologies of dataification rely so heavily on the imagined legacy of the Enlightenment, and its particular alliance to objectivity, human reason, and technological progress*" [35:16], making it hard to get a handle on how they intersect with infrastructures and inroads, real material entanglements and into our day to day lives.

In this paper, we narrow in on data collected through home Internet of Things (IoT) devices: a fast growing global market which not only represents one of the most important new forms of big data but also takes place in a particularly private space, the home. While the IoT has started to allow for new ways of 'making home' [10], one of the leading challenges currently facing IoT is the algorithmic transparency and fairness with regards to how data are collected, what is inferred and who they are shared with [14, 28, 69, 71]. In response, designers, technologists, policy makers and human-computer interaction (HCI) researchers have written manifestos [28], developed visualizations [12, 37, 50] and physicalizations of data [18, 31, 47], and created DIY IoT kits for people to gain more legibility and control on their devices and data [14, 63, 69]. In parallel with these existing strategies, we propose to use fiction as a way turn the abstract, amorphous and infinite-seeming nature of IoT data into descriptions and scenarios that are more detailed and tangible—qualities that are difficult to capture or grasp with existing approaches. While science and technology studies (STS) scholars have noted a need to see data as messy and enmeshed in our lives, it has thus far been difficult to accomplish. We use fiction as a tool to illustrate these perspectives. With the Data Epics, we offer a novel strategy for examining the ways in which home IoT data are enmeshed in our lives: using fiction, we explore new imaginaries for data and processes of interpretation. The Data Epics are a series of four chapters written by Emily,[1] a fiction writer enthusiast whom we hired, based on monthly home Internet of Things (IoT) data. The data are collected by Susan, a self-declared IoT enthusiast who lives with over 40 IoT devices, whom we had met in a previous study about IoT.

In the remainder of this paper, we present data from new angles to imagine and understand data differently, away from data as objective, true, smooth or neutral. To do so, we describe the Data Epics and examine the way the stories generated new imaginaries and worlds as well as how they exposed data as lively and part of meshes, often entangled in control and power relations. We see this as a first step towards gaining awareness, and eventually agency and control around personal home IoT data. In addition, we offer a novel process to engage home IoT data that attempts to demystify and humanize the data interpretation process. To do this, we situated the research within a tight knit collective of interlocutors and researchers. We (Audrey and Heidi, two design researchers) passed one month's worth of data from IoT enthusiast, Susan, to a fiction writer, Emily, four separate times, creating four individual chapters. Each chapter we typeset, printed, bound and disseminated back to Susan and Emily. We describe the labor and interpretation of data within our process, and how this continues to stress the ways that data are not objective or impartial but interpreted and crafted. We conclude by offering two tactics to get closer to data: trying things on and zooming in and slowing down.

As a result, with this paper, our contributions lie in (1) the unique illustration of STS and philosophy concepts of data subjectivity and messiness through the Data Epics, leading to a more vibrant and vivid view of data's qualities which were not visible in previous literature, and (2) in the particular method itself of translating home IoT data into short stories.

# 2 RELATED WORKS: INTERPRETATION, DATA, AND FICTION IN HCI

## 2.1 Interpreting Home IoT Data

At its core, this project is about the processes of encountering and interpreting home IoT data. While IoT is often thought of as a series of sensors and physical devices, much of how the system works is through the capture, processing and exchange of data [2, 49]. Within HCI and design, a growing corpus of work has been aiming at understanding how people might engage with and interpret their own home IoT data, often with the goals of saving money, building more sustainable practices by saving energy or water (e.g. [11, 37]), managing indoor climate (e.g. [50]), tracking home essentials (e.g.

---

[1]Collaborators' names used in this paper are pseudonyms to protect their anonymity.

[29]) or reflecting on family routines and memories (e.g. [34, 55]). Similarly to practices in the Quantified Self movement [26, 66], data are seen as the cornerstone for self-knowledge and people are "*encouraged to take the opportunity to view and reflect on this information and use it to optimize their lives, improve their health and wellbeing, contribute to their memories or achieve Selfknowledge*" [47:1600]. Interpretation becomes central since data on their own are rarely meaningful and need context to build a larger story—such as through visualizations, smart recommendations, automated actions, or other designed data analysis functions or representations [54, 58].

Previous works have employed visualizations of data to let home dwellers understand their homes better. For example, Castelli et al. [9] as well as Kurze et al. [42] prepared sets of visualizations to understand how home dwellers make sense of their smart home sensors, often by combining the visualizations with their own knowledge of patterns and social dynamics in their homes. The challenge is, however, that even when working with contextual clues and social understanding, HCI researchers have also shown how hard it is to get data interpretation 'right', and how much data remain ambiguous and speculative (e.g. [16, 27, 61]). For instance, Fischer et al. [27] report on the data practices of energy advisors who help home dwellers navigate and understand their home energy data. Even with professional help, home dwellers may be wrong in their interpretations: "*It is to say that such readings have the character of speculations, informed guesses at best, and these of course may be erroneous*" [27:5942]. In an inquiry into the legibility of personal home data, Tolmie et al. [61] also conclude that data are very hard to interpret outside of context. Echoed in these works [27, 42, 61] is the refrain that speculating with data inevitably leads to misinterpretations and ambiguity. As a response, Gaver et al. [30] play up ambiguity and shift the responsibility of interpretation on the user instead of the device or visualization—at the same time also moving away from expectations that data can easily be equated to truth, therefore revealing the complex, ambiguous practices to work with data. Instead of trying to get data 'right' we examine how fiction can iterate through different contexts, images, and characteristics of data as the data lives and acts in the fictional worlds created by the interpretation of those data. While many works in HCI examine data sensemaking, our work is one of few examples that engage subjective, expressive and plural data representations in relation to IoT data from the home.

## 2.2 Lively, Messy, Heterogeneous Data

Perhaps as a strategy to understand better our relations to data, and why data interpretations are so challenging, scholars in HCI, STS, philosophy and design have sought to push back and warn against the imaginaries that data are clean, smooth, and objective. In *Technologies of Speculation* [35], Hong articulates how this means pushing back against long standing narratives and promise: "*The data-driven society is being built on the familiar modern promise of better knowledge: data, raw data, handled by impartial machines, will reveal the secret correlations that govern our bodies and the social world*" [35:1].

Instead of seeing data as universal and placeless, Loukissas [43] further articulates how data are deeply attached to place, that they are situated and local. He also warns against the narratives that

data are smooth and singular, instead accentuating that they are plural (hence using a plural pronoun to talk about them), and heterogeneous. Data are also embedded in assemblages with other data, things, people and settings, as Dourish [22] explains. In these assemblages, data have agency: they push and pull and have a vitality—a liveliness—of their own, according to Lupton [47]. Lupton writes: "*Just as we might reflect on how our lively companion devices live alongside us, we might also think about our lively personal digital data assemblages cohabit with us. As we co-habit with our devices and our data, we co-evolve with them*" [47:1603]. In projects like *Dear Data* [45], data are not only presented as lively, but also personal, interpretative, and smaller than in common narratives like Big Data. Finally, in *Data Feminism*, confronting claims that data are objective or neutral, D'Ignazio and Klein [21] use contemporary feminist thought as a way to examine and describe how inequalities and power differentials at the intersection of race and gender are embedded in many data practices which stands in stark contrast to the long-lasting public imaginaries of what data are and what they promise. These new articulations of data start to complicate visions that data are part of frictionless technology within ubiquitous computing and IoT systems built on values like efficiency and smoothness [33], instead revealing the messy side of data.

Our work with the Data Epics continues to build on and illustrate the considerations presented above (in 2.1 and 2.2): that data are not neutral but rather heterogenous, messy, and lively, that the work of visualization involves rhetoric, power, bias, and editorial choices, and that the process of interpretation is complicated, situated, and ambiguous. However, instead of using visualizations or manifestos, we use stories to help see data at the level of life, integrated with characters, making a different kind of sense of it altogether. In addition, our work contributes to HCI by doing some translation work from STS theoretical ideas of data as messy, plural, and heterogeneous to the more everyday artifact-oriented world of design research in the form of stories. Our contribution, hence, is not to offer new conceptualizations of data, but to place these ideas in practice and to offer granular, detailed, and visceral illustrations of these ideas about data's nature.

## 2.3 Fiction and HCI

In order to continue the project of finding new data imaginaries and understanding the labor of interpretation, in the Data Epics project we use fiction as a method to dig into data and both its psychological and material affects, adding the dimensionality and fidelity that fiction is equipped to do. Designers and HCI researchers have long acknowledged the influence of fiction in speculating and creating new worlds and future technologies, for instance via science fiction, movies and essays [23, 38, 48, 51]. Beyond inspiration, fiction is also used within design practice with well-established methods such as personas, and scenario building (e.g. [6, 32, 59]) as well as design futuring and speculation (e.g. [23, 51]). Design Fiction has emerged as a way to combine the material qualities of design with the world building characteristics of fiction [7] sometimes through diegetic prototypes, described as "things that tell stories" [5]. In recent years, HCI and design researchers have continued to develop a variety of methods to expand the scope and definition

of technologies through fictional or imaginative scenario building workshops [1, 7], counter-factual artifacts [64], design fiction probes [60], imaginary design workbooks [8], design workbooks [68] or speculative enactments [25]. As the subfield is expanding and taking multiple forms, researchers have also called for reflexive analysis of design fictions, calling for researchers to acknowledge them as situated, tied to real events and circumstances, and capable of knowledge production [17, 41, 56]. Ultimately, fiction in design has proved a powerful tool to prototype and try out new ideas before technologies are feasible, imagine alternative presents and futures, contemplate impacts of technology in imaginative ways and build rich contexts from which to conduct embodied or making-based speculation with participants and interlocutors.

Fiction is an effective way to build worlds and context, but also contributes to knowledge by taking trends or fragments from the present and synthesize them into coherent, high-fidelity 'wholes' that can take place at different scales, from different perspectives and allow readers, authors, or research participants to try on ideas. Bardzell and Bardzell discuss one way science fiction creates knowledge using cognitive speculation which is, "*characterized as speculative thinking that is grounded on the most current science (social, computer, and physical) and enhanced with imaginative extrapolation that is informed and shaped by a systematic and intellectually rigorous interpretation of comparable moments in the past*" [3]. It is a way that knowledge is synthesized, tested, and enacted in fiction [3]. Fiction in design produces knowledge through engaging the imaginary of the reader, suspending disbelief for a moment and thus allowing the reader to consider new possibilities and reframe current assumptions.

Fiction writing offers the opportunity to invent and depict other worlds, it is a medium that is both low-tech (only requires words) and high impact in creating vivid and imaginative lives for data. However, we note that a literary production also holds limitations around the linear way to read stories, and who may be able to engage with the stories, considering their format in the English language in our case.

In our Data Epics, we draw from this rich history of design and fiction to interpret data beyond symbolic representation or abstract images like visualizations. The outcomes show data as lively entities, entangled with other lively characters in the context of a variety of worlds and lives. With this removal from abstraction (graphs, zeros, ones, or the dreams of empirical truth) the Data Epics offer four tales of data that have never been told before. The Data Epics project contributes to and builds on this long history between fiction and design. While fiction in the form of design fiction or scenarios have been used to examine data, the Data Epics use stories to focus more on ontological questions (what is it like to be data) and less on teleological questions or scenarios (how might we use data).

## 3 METHOD: WORKING WITH EMILY AND SUSAN

The Data Epics project stems from a simple what if question: what if we used fiction as a way to interpret and represent home IoT data? This idea was originally conceptualized as a speculative sketch which responded to the empirical findings of our study on how home dwellers live with home IoT data [16]. To investigate this question, we worked in a team of 4 interlocutors: two design researchers (Audrey and Heidi), one participant (Susan), and one fiction writer (Emily).

We worked with participant Susan, a 70-year-old retired woman who is an avid reader and IoT enthusiast. Susan worked as a newspaper reporter before working for IBM as a speech writer, and becoming a web developer at the end of her career. We met Susan in a previous study about home IoT data, as she lives with over 40 connected IoT devices in her home and is incredibly curious about new technology. She is also open about data privacy: she loves collecting data (e.g. she has a list of all the books she has ever read, with a review) and, while well informed about data privacy, she does not worry about having her data being public online (e.g. she happily shares continuous live feeds of her indoor video cameras on the web). After working with her on past research, she told us that she enjoyed working with us and would like to stay in touch. Based on her background and our collaborative history, we thought she would be a wonderful partner for the Data Epics project.

We hired Emily, a fiction writer, for this art commission through a Facebook recruitment post on Heidi's Facebook wall. Heidi knew Emily's husband from high school in Alaska, USA, and Emily's husband actually signed her up as a way for her to continue to work creatively as a writer. Emily, a mom of two, has enjoyed writing fiction for her friends and family for over 10 years. Emily has a BA in English literature and has self published novels and novellas on Amazon.com.

Finally, we brought our own positionalities to the project as well. Heidi has a BA in English literature and a masters in Design. They are currently a PhD student in HCI. Audrey is a design researcher and professor of interaction design. Part of this close-knit research unit, we (Heidi and Audrey) were both involved in the speculation as well as the framing of the speculation that took place. As intermediaries between Susan and Emily, we were cleaning the data, visualizing the data and making books for each story. We used this closeness in our analysis of this project inspired by first-person methodological approaches [15, 24, 44, 52], approaches which take into account the position and experience of the researchers themselves into the research process.

In this work, our goal was not to 'test' the Data Epics with participants. Rather, we wanted to imagine together and reflect on what this creative inquiry could surface. We were interested in building a strong relation with Susan and Emily as a way to start flattening the playing field between researchers and research participant or commissioned artist, taking inspiration from [19, 20, 57, 65] who worked closely with weavers, a quilt master, master builders in timber framing, and a shop owner in design research projects.

### 3.1 Description of Our Approach: The Making of the Data Epics

In essence, the process of making the Data Epics happened in four major steps, which we repeated for four cycles (illustrated in Figure 2). We also ran a pilot Audrey's home to test the process with Emily before working with Susan's data. The steps went as follows:
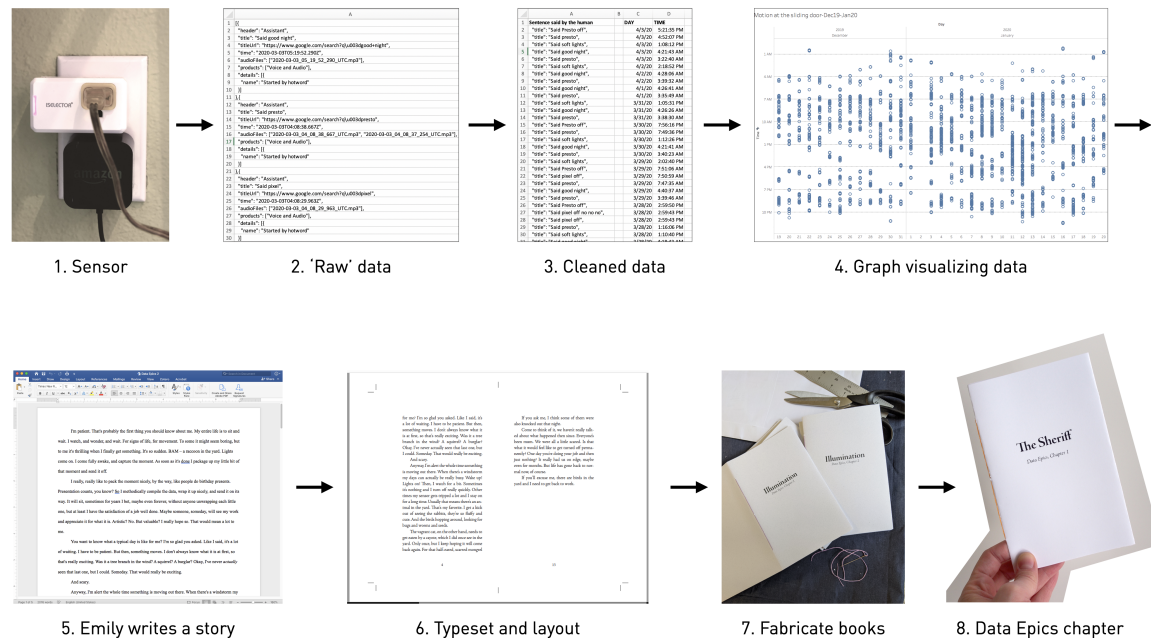
**Figure 2: Overview of the process for creating one chapter of Data Epics. Top row, left to right: Smart plug in Susan's home; Data including meta data; Cleaned data; Visualized data. Bottom row, left to right: Story written by Emily; Text typeset by Heidi; Printing and binding books; Give back to Susan.**

**(A) We collected data from Susan**. Each data epic is based on one month of Susan's data. The data came from a variety of smart plugs, smart appliances, motion sensors for her doors and back porch, and voice assistants, all devices Susan already lived with. To collect her data, we used a pre-scripted applet on the IFTTT platform to log timestamps in a Google sheet, each time a plug would be turned on or off or motion would be detected. To collect voice data, we asked Susan to download transcripts from her Google voice assistant.

**(B) We formatted Susan's data for Emily**. For each chapter, Audrey prepared the data for Emily. Audrey removed irrelevant meta data to make sure spreadsheets were readable, mostly focusing on timestamps for sensors and smart plugs, and voice transcript utterances. For chapters 2 and 4, we accompanied these spreadsheets with graphs made in Tableau (a data visualization software). We then sent the spreadsheets and graphs to Emily.

**(C) Emily wrote a short story with Susan's data**. After receiving the data, Emily took the next three weeks to write a story while we continued to collect data from Susan. We gave Emily the brief of writing stories about data's adventures beyond the home (in the spirit of an Epic), but Emily had freedom in choosing her process for writing. Emily used the data to write a story, but not necessarily in ways that tried to capture Susan and her life accurately. Each chapter is about 2000 words long.

Then finally, **(D) Audrey and Heidi would receive a story from Emily and turn it into a book**. We wanted the stories to have a material presence, as a way to make them special and personal, something that could be held in the hands. For the design, we were inspired by the layout and typographic choices of other fiction books. We printed the books at university print shops to enhance paper quality and print accuracy. Heidi did the binding of the books by hand. After every book was made, we gave a copy to Susan and Emily.

We conducted four rounds of Data Epics, leading to 4 chapters, from October 2019 to May 2020. 4 chapters gave us the space to grow into this practice. During that period of time, we (Audrey and Heidi) served as intermediaries between Susan and Emily. We made sure to keep them anonymous to each other and to refrain from revealing information about their daily lives, their living situations or their backgrounds. This anonymity was important so that the interpretation of the data into fiction stories relied on the data themselves.

After each chapter, we conducted a short interview with Emily to ask about her process of interpretation, and with Susan to capture her reaction to the story. After Susan had read the last story, we coordinated a 60 minutes final exit interview where Susan and Emily met. In preparation, we asked everyone to choose a quote they wanted to discuss from one of the 4 chapters.

### 3.2 Analytical Approach

We conducted three parallel lines of analysis: a) literary textual analysis of the four Data Epics Stories; b) open coding on the interviews we conducted with Emily and Susan; and c) reflexive analysis of our making process (including data cleaning and book making). For each line of analysis, we conducted a first round of thematic analysis to highlight themes. We then conducted a second round of thematic analysis that included all three lines of analysis to look at how themes connected, responded to or complicated each other.

**Table 1: Overview of the 4 chapters of Data Epics**

| Title and Plot | Data used |
|---|---|
| **The Sheriff**<br>An outdoor motion detector, who jokingly refers to himself as the Sheriff because he protects the home, reflects on his life looking at the backyard, his role in the house and his relationship to other IoT devices. | 16 excel sheets: timestamps of smart plugs and motion and door sensors |
| **Illumination**<br>The story alternates between the life of a data bit holding potentially incriminating information (a light was turned on at an odd time) and Paige's investigation through her IoT data to find out if her partner is cheating. Spoiler alert: he didn't, he accidentally 'butt dialed' the lamp. | 18 excel sheets and graphs: timestamps of smart plugs and motion and door sensors |
| **New Recruit**<br>In a pseudo-apocalyptic alternate reality, Amy, a security guard, is closest to a cobbled together IoT network which monitors the perimeter fence of a small group who is trying 'to rebuild'. The story ends with a breach of the fence by a person trying to escape danger, who then becomes the new recruit. | 1 excel sheet: timestamps and transcripts from Google Assistant voice data |
| **The Inspector**<br>A woman is being 'stalked' via her data. The stalker doesn't take shape for quite some time (oscillating between a thing, a system and a man) but is obsessed with gaining access to the narrator's data. At a breaking point, the woman visits the Inspector, who asks her questions about the escalation of the stalking and takes over the case. | 14 excel sheets and graphs: timestamps of smart plugs and motion and door sensors. 1 excel sheet: timestamps and transcripts from Google Assistant voice data. 1 folder of 170 voice assistant audio recordings |

The analysis generated themes that outlined new types of imaginaries created through the Data Epics as well as considerations around interpretation, labor and anomalies in data.

## 4 OVERVIEW OF THE DATA EPICS

An epic is described by Merriam Webster dictionary as "*a long narrative poem in elevated style recounting the deeds of a legendary or historical hero*".[2] In the early days of Data Epics we imagined these data-based stories might be about the journeys data take out into the world and back again, epics not dissimilar to the way Odysseus left and returned to his home after many years in *The Odyssey*. Instead, Emily's way of writing these epics showcases data enmeshed with the fabric of everyday life at home and beyond, telling the story of data from a variety of viewpoints and characters. The Data Epics are four different and unrelated stories which probed at the meanings of data from different angles. These four stories taken together created imaginaries: new places for data to exist, giving points of contact to connect with IoT data.

Before we analyze the Data Epics project, we share the opening pages of Chapter 2: *Illumination* (see figure 3). While each story is available in the supplemental materials and we encourage you to read them, we share a long form excerpt to start to give a sense for what a Data Epic *felt* like. While not all the epics are told from the perspective of a data bit (some are from human or sensor perspectives), we felt this excerpt best represents the liveliness of data and how new worlds are made in the Data Epics. We also share an overview of each chapter in Table 1 to give ground to the detailed anecdotes and analysis we present later.

## 5 EXAMINING IMAGINARIES OF DATA

In this first section of our findings, we highlight how the Data Epics, through their imaginary castings of data, open up new trajectories for further understanding data. We argue that by giving data a place to *be* in the world through fiction, the stories offer tangible and situated ground for further reflection on data. Below, we report on new worlds for data, vibrant lives of data, meshes of data and other things, and power's particular role in the stories. This section mostly builds on the literary textual analysis we, Heidi and Audrey, conducted of the four Data Epic stories. We also interweave highlights from our interviews with Susan and Emily in which we discussed Emily's interpretation and intentions, as well as Susan's reactions.

### 5.1 New Worlds of Data: Defamiliarizing Data

Typically, in HCI and design research, data are left immaterial and often placeless, somewhere in 'the cloud', away from places home dwellers might be or access. Loukissas argues against this dangerous assumption and states that data are of somewhere and have a material presence in the world [43], grounding and making data's impacts on the world 'more real'. Using fiction, Emily was able to situate data in a variety of places, giving tangible context for data to exist in.

For example, in *Illumination*, through the eyes of a data bit we get a glimpse into a world of data. A world first begins to form when we see the data bit in relation to other data and humans. As we saw in the excerpt above (Figure 3), the chapter casts data zipping by humans so fast they appear almost frozen when "*copies zing around the room, unnoticeable to the animals that reside within*

---

[2]https://www.merriam-webster.com/dictionary/epic

it". The data bit also encounters other data, "*some could be her twins and others almost unrecognizably different*" and "*old timers*", hinting at a society of data with diverse members. We also glimpse the world's infrastructures as the bit approaches her destination: "*slowing, searching for her place in the giant structure. It calls out to her and there, there she goes*" which illustrates a kind of superstructure in the data-verse where all data congregate. This world of data—moving at a speed imperceptible to animals—with their own culture, feelings and perceptions, builds new contexts for data. This worldview begins to draw what data do, where they go, and how they exist, even if not perfectly accurate, this narrative extends beyond IoT homes to include a place where data *reside.*

In our literary textual analysis, we also found *New Recruit* to be an example of a new world. This story takes place in a world set in the aftermath of global collapse due to plague (this was the first story written during the COVID-19 pandemic): "*once upon a time she'd been a budding ecologist, barely out of school. Then the plague had swept through. People died and countries began to point fingers*

at each other. . . it devolved into chaos . . . disease and famine and war." Amy had eventually found her way to this group of "*people who were trying to rebuild*". They live in a camp which used cobbled together technologies to subsist: "*they had scrounged up as many computer parts as they could, running them on the power they were able to produce themselves from stolen solar panels and homemade wind turbines. They had old golf cart and electric car batteries for storage.*" The main character is in control of monitoring the perimeter fence through data, "*the data was the most important part. She had perimeter alarms and notifications in case something was getting to near.*" This world exposes the potential of a bricolage of found technologies to support life off the grid when infrastructures fail. The world in New Recruit not only offers a new place for data to exist, but, more importantly, does so by countering the assumptions that data come from new, shiny, perfect, innovative IoT devices.

In reaction, during her interview after reading the third chapter of Data Epics, Susan reflected on the power of the world of the story to carry back into her own home, showing connective tissues

Illumination

*Data Epics, Chapter 2*

She is born in darkness. The absence of light does not bother her, nor does it confuse her. Coming alive with the imperative of most living things, to move, she does. At speeds almost incomprehensible she rushes off as quickly as she can, determined not to be a laggard. Only knowing that she has a destination she must get to. She does not yet know what that destination is, only that she must get to it, and quickly.

Making copies of herself, she reaches in every direction, searching. Something catches hold of her but it's not her destination, so it drops her. The copy disappears, but there are an almost infinite number of them so it does not matter. If she reaches the end of her tether without connecting to her host she will simply rebroadcast herself, for as long as it takes.

Her copies zing around the room, unnoticeable to the animals that reside within it. She is everywhere and nowhere, for she still has not found her home.

She meets others similar to herself, some

3

**Figure 3: Opening pages of Illumination**

that could be her twins and others almost unrecognizably different. It is a strange world. Soon enough she becomes numb to the others passing her, focused only on her own destination. As they each are as well. So many of them, uncountable in their vastness. She is seeing only a tiny fraction of the total even within this dwelling.

She slows, knowing that she is near the end of her journey. She does not know how she knows, nor does she understand what's to happen next. She merely senses something in the dark, something large of which she is to become a small part. Slowing, searching for her place in the giant structure. It calls out to her and there, there she goes. She snuggles herself in and relaxes back. She is home.

Sometime later, a long time later, the entire structure wakes like a leviathan. Each individual such as herself begins to quiver. They're being called upon. This is why they exist, why they are so important. Seemingly at random they're called forward, each one shining for a brief mo-

4

ment. This is the first time she's been called but some of the old timers know exactly what they're doing but the whisper goes around that it's been a long, long time since any of them have been called on like this. Only a few of the very oldest bits of data have ever had the privilege. She watches them carefully, noting how still they are and for how long each one is in the spotlight. There does not seem to be any reason to it, why some are required for longer times than others.

When it's her turn she musters all of her courage. It's brighter than anything she could have imagined, hurting her and thrilling her at the same time. Her moment is endless and over almost immediately, it feels. When it's over, when it's moved on, she rests back in her place, content that she's done her work.

But then she was called for, again and again. It both surprised and pleased her to be so needed, so valuable. It is the point of her existence but still she is proud.

◆ ◆ ◆

Paige stared at her phone, frowning. She

5

**Figure 3: Opening pages of Illumination (continuing)**

between the Data Epics and her own lived reality. She was surprised to encounter her own data in the other-wordly context: "*Um, it was interesting to read because it was so much more of a, um, story. Yeah. Yeah. So, you know, you're reading along into the story and then all of a sudden it's like turning my lights off in my bedroom.*" Reflecting on how her Google Assistant command of "*good night*" (one she is intimately familiar with) appeared in the story and reached out through the story and felt as though the lights in her room should turn off as well.

As mentioned above, Emily's interpretation of Susan's data created new worlds and world views *within* and *alongside* IoT homes, and even seemed to travel from a post-apocalyptic world back into Susan's home to turn off the lights. The stories offer new backdrops to ground data by offering them a place to go, bringing our imaginations along with. These explorations also enabled data to take on a lively quality, which we discuss in the following section.

## 5.2 Lively Data: Data as Active in the World

While data are sometimes assumed to be collected as 'raw', malleable material, almost devoid of agency, Lupton instead argues that data are lively: "*[data] are about life itself (details about humans and other living species); they are constantly generated and regenerated as well as purposed and repurposed as they enter into the digital knowledge economy*" [46:2]. The Data Epics present data taking a life of their own, a life where they come into existence, travel around, are duplicated, exchanged, and might be deleted.

*Illumination* starts with the birth of data, inspired by one data point in Susan's lamp smart plug data which did not follow her typical patterns. In the excerpt of the opening of *Illumination* we presented above (figure 3), we read vivid descriptions of what it is like to exist as data, with an emphasis on speed, movement, infinity and immateriality. Beyond these descriptions, in our literary textual analysis, we also read what it feels like for data to be called upon, or to be looked at, where they live, and how one data 'self' is broadcast
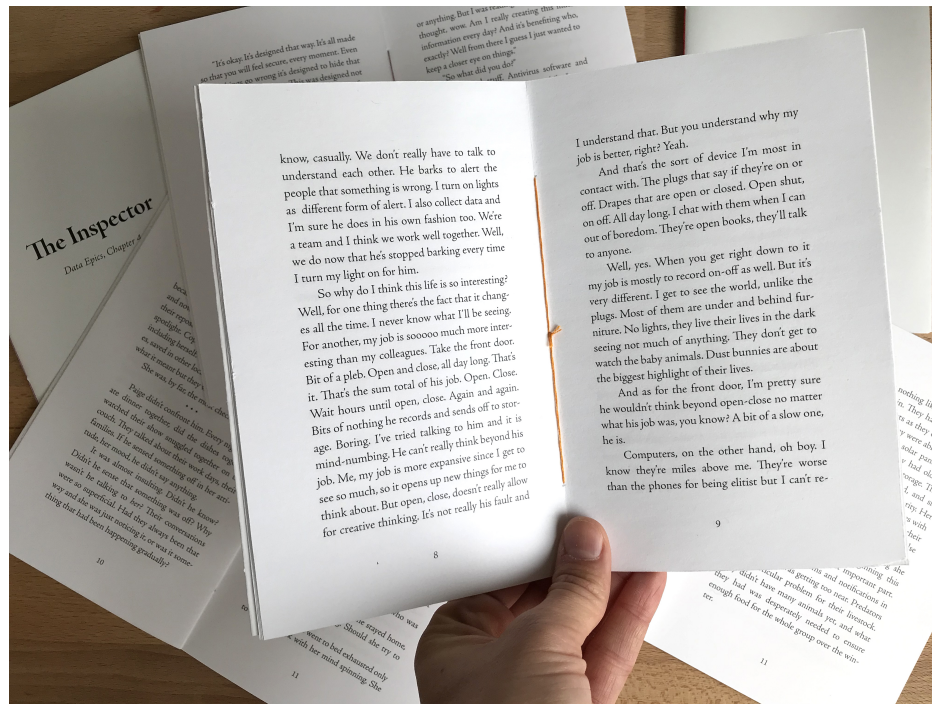
**Figure 4: Inside spread of the Data Epics**

as a multitude of data bits looking for a home. During an interview about this chapter, Emily commented the perspective of data was difficult to imagine: "*So I sort of glommed on to just being one bit, because trying to write the perspective of all of the data seemed really daunting. Like, I don't even know how you'd begin to write from hundreds or thousands of perspectives.*" In the plot of Illumination, Emily artfully crafts a narrative where single bit of data may exist as an infinity of copies, but again, she admits how challenging it was to translate from the reality of how data work, to intelligible fiction writing.

Our literary textual analysis also allowed us to see how data can sometimes take a more passive liveliness in the world: data were not always doing something, but often times they were waiting. For example, in *The Sheriff*, the motion sensor protagonist (who refers to himself as a sheriff at one point) reports on his ambivalence regarding his satisfaction in capturing and carefully packaging data and the possibility that data might never be 'used': "*It will sit, sometimes for years I bet, maybe even forever, without anyone unwrapping each little one, but at least I have the satisfaction of a job well done.*" This sentiment is echoed in Susan's relationship to her data. In the exit interview, we asked her if her relation to her data had changed as a result of this project. She responded: "*Yeah y'all keep asking me what I think why I collect all the data. And what I expect the data to do [. . .] I never have had any good answer. And I still don't. But I do like the idea that it's all accessible.*" In this archival existence of data, Susan finds comfort, even if she still can't fully articulate why data has this importance in her life.

Data also took on an ambiguous and awkward liveliness through stories which had data and IoT devices 'try-on' genders. In our literary textual analysis of Illumination, we observed that the main data-bit character is referred to using female pronouns without real explanation and no other data bit is referred to as a gendered being. However, it does bring her to life in a feminine way and puts her into a relationship with the other main character who is a female. Gender is also given to the motion sensor in *The Sheriff*. The motion sensor 'sheriff' refers to his colleague, the front door, as a 'he' but then reflects, "*I say 'he' but, of course, he's no more a he or she than I am. But it's awkward to speak of a colleague as "it". I'm sure you understand.*" Emily used gender as a tool to build characters but the awkward or ambiguous gender systems for data exposes a kind of data-gender-performativity—Emily is trying out gender on data without clear-cut results.

Finally, just like with any life, if data can be born, they can also disappear, or die. For instance, in *Illumination* we read, "*The data was there and then she wasn't. All her copies were erased, her companions, the whole structure itself was gone.*" The chapter ends with "*Just gone, her existence winked out*". This theme also surfaced in The Sheriff, although with a more humorous spin about 'the cloud', when the protagonist/narrator (the motion sensor) wonders: "*When it rains, is that data that's been deleted?*" These events are dramatized in the Data Epics, but their liveliness and evocativeness bring back on the table current debates within HCI around the right to forget [70] and policies that aim to constrain how long companies might have the right to keep home IoT data (or any personal data, as a matter of fact).

We found that these lively accounts of data gave visceral imaginaries of data having their own lives, through the details and context of the lifeworlds. For HCI and design researchers and home

dwellers alike, this close view of data may start to bring attention to the active role they play when they are created, the ongoing potential they have while they wait and the possibilities of keeping or deleting them. We claim, however, that showing data as lively does not necessarily mean making them characters, but instead showing them in relation to others, within habitats and their own self-hoods, which we explore in the following section.

## 5.3 Meshes: Data Interwoven with Other Things and Beings

The Data Epics further position data amongst many other things: structures, animals, humans, sensors, etc. All these things often served tactical purposes in Emily's mind: she needed a setting, and characters to build stories. Yet, these meshes help further reveal what critical data studies scholars call data assemblages: "*A data assemblage consists of more than the data system/infrastructure itself, such as a big data system, an open data repository, or a data archive, to include all of the technological, political, social and economic apparatuses that frames their nature, operation and work*" [40].

By showing data in relation to others, their existence becomes more complex, more social and more political (as we will see in the following section about power). For instance, in our literary textual analysis of *The Sheriff*, we notice how the motion sensor sees itself in relation to the family dog "*He and I are pretty similar actually. We both work on guarding the property. [..] He barks to alert the people that something is wrong. I turn on lights as a different form of alert. I also collect data and I'm sure he does in his own fashion too.*" The motion sensor 'sheriff' sees itself as part of a 'little fiefdom', a concept that rang true for Susan, as she stated in her interview about this chapter: "*There's so many electronics in this house that I do think that when I'm asleep, they all get together and decide [things] so I don't really worry about it. I just hope they have my best interests at heart, so I try not to talk trash about them either*".

Data were also positioned in relation to humans, at times, to activate the stories. When talking about the structure of *Illumination*, which alternates between data view and human view, Emily recounts: "*So I knew I was going to have to intersperse it with some other story and, and also sort of make the, make the data itself interesting because the data doesn't necessarily know what it is or know what makes it in particular fascinating for us.*"

For Susan, this connection between data, devices and humans translated to reflections about her own behavior at home, she explains in her interview about that chapter: "*Every time I opened the door, I'm like what am I doing to the story now. And particularly if I open this door, well actually either one. Yeah. And opened it by mistake. So close it again. Real fast. No, no, I'll screw it up.*" While she recounted this with humor, this shows how a project like the Data Epics can help materialize one's relationship to data capture in the home, as one element within a much larger dynamic assemblage of people, things, sensors and other data.

## 5.4 Power: Data Anxieties and Control

"*Data feminism is about power—about who has it and who doesn't*", claim D'Ignazio and Klein [21]. With worlds created and meshes of actors, the Data Epics also, perhaps inevitably, showcase how data are embedded within power dynamics. One of the major anxieties surrounding data is that of privacy (as exemplified in works such as [53]), or the question of who is controlling one's data and what power does it afford them. We were fascinated by the power figures—and the inherent hierarchies they were part of—that emerged in our stories, particularly in *The Sheriff* and *The Inspector*.

For example, through our literary textual analysis of *The Sheriff*, the motion sensor sees himself within a hierarchy we, as design researchers, hadn't considered: the hierarchy of devices to each other. If the computers are "*the aristocracy of our little fiefdom*" because they coordinate the IoT devices and "*give us our orders*" he reflects, "*I guess that would make me like the sheriff? Helping to ensure law and order. Yeah, I like that. I'm the sheriff in these parts, haha.*" The sensor, here, embedded in the hierarchy, becomes a figure of power in that he is helping to enforce a kind of ordered operation out of his hands. In the exit interview, Susan remarked that for her, these hierarchies felt right, "*how true all of they were, I mean that everything that has a personality has the correct personality*". Seeing the front door sensor referred to as "*bit of a pleb*" and the smartphones cast as "snobs" helped confirm Susan's mental model for how her IoT works at home.

Our literary textual analysis also revealed other examples of power figures, including the Inspector who is presented as a paternalistic power figure, taking control of an unruly and overwhelming situation (in *The Inspector*), and Amy who gains power to protect through her use of data when she is "*in charge of monitoring the perimeter so that nothing like the incident would happen ever again*" (in *New Recruit*). These power figures illustrate a desire to know what data are for, who they give power to and how we might protect ourselves both *from* them and *with* them. Are we empowered by our data? Or is it empowering some vast *other* like a corporation or the government? In the Data Epics, Emily's writing explores several different power relations held in data such as how data can know us completely: "*.. he got to know all of it. Every detail of her life.*" (excerpt from *The Inspector*), but can also be used against us, resulting in betrayal, "*It's not you. This was designed not to trigger your instincts . . . I trusted it. I trusted it all. . . And your sense of betrayal is perfectly valid*" (excerpt from *The Inspector*).

However, in response to reading *The Inspector*, Susan was not impressed. She stated, in her interview, that the plot was a cliché about how, "*the more data you collect the more dangerous it is. And there's nothing good that can come out of any of it, except for danger.*" As someone who collects and shares a lot of personal data, she is constantly chastised, which she finds insulting, she explains: "*I'm intelligent enough to know how to manage [my data]*" and that people think because she doesn't protect her data more, "*[she] will be just forever, tragically, a victim. [..] I'm not a victim.*" So, while many have anxieties about data, interestingly, the data this story is based on is from someone who is adamantly open about her data, loves data, assumes the risks of sharing her data openly and wants more of it!

This dynamic expresses anxieties around data, not only the need to control and understand their use, but the control and power hiding in its use already, asking the question: who is responsible or who can even be responsible for how data are used now and into the future? Part of understanding how data are used, and a continuation of overturning ideas of data as objective and smooth is to examine the labor and many decisions that go into data interpretation.

# 6 LAYERS OF INTERPRETATION

In section 5, we saw how the stories themselves began to portray data in new ways: living a lively life alongside humans, borrowing and re-arranging narrative tropes or configurations to make sense of themselves, helping to imagine differently and complicating narratives of data as perfect, neutral and homogeneous. In this second section of our findings, we turn to the second goal of this paper: examining processes of interpretation close-up, to challenge the seemingly impenetrable opacity of data infrastructures and the objectivity of their presentation. This section is informed by the reflexive analysis of our making process (from data cleaning to book making) as well as our interviews with Susan and Emily, and briefly builds off of our literary textual analysis as well. For design and HCI, this part of our inquiry has implications for how home IoT data processing may be presented and how data visualizations might be understood—suggesting the need for data literacy and criticality.

## 6.1 Examining the Labor Of Interpretation

Throughout our reflexive analysis of our process of making the Data Epics, matters of labor, craft and skills around data were revealed. These matters occurred both in the stories themselves, through how the data were represented, but also in our own process of collecting, formatting and sharing data as well as in the fabrication of the books themselves.

*6.1.1 Human labor in data processes.* By choosing to employ ourselves in the process of data interpretation (instead of computers and algorithms), our processes for manipulating data were inherently slow, small and handmade. Each step was marked by small adjustments, the making of new techniques, or problem solving to remove errors from our process. For instance, when working with voice data, Susan had to change her habits of using Alexa as a voice assistant to instead use Google Assistant (at the time, Alexa data was not downloadable). To do so, after attempting remote trouble shooting, Audrey went to meet Susan at her house where they worked together for about 90 minutes to successfully download the data. Working with voice data also required Audrey to learn new formulas and sorting strategies in Excel to clean the voice assistant data from Google Assistant. In another example, Audrey had to navigate a bespoke process for creating graphs to visually represent the smart plugs data to give Emily. Audrey, who does not have a data science or computer science background, used a mix of Excel and Tableau to generate the graphs, but not without trials and tribulations. In contrast to the assumption that data are easily manipulated, small complexities and mistakes within the data and data structure yielded inconsistencies in the graphs themselves (e.g. days missing on the x axis, or irregular steps in the hours of the day on the y axis). Knowing how to clean the data in Excel and how to import and manage the axes in Tableau required practice, and slow tedious work to create graphs that 'looked' right, or at least right enough to inspire Emily. Our reflexive analysis also highlighted how craftsmanship was clearly present in Heidi's work with the type setting, typography and layout of the booklets themselves, another form of data interpretation—once data are in the form of stories, they are yet again transformed from

Emily's text document to a material book. As stories developed Heidi had to adjust typography, for example, in *Illumination*, they designed a visual cue of three centered dots to separate voices/world views as the narrative switched from a data bit to a person.

As seen above, data do not simply 'appear' and become ready to be used, nor are they visualized or materialized easily. When we shared some of these examples with Susan during the exit interview, they resonated with some of her own experiences with her data, "*incompatible data is my nemesis right now. So yeah, when I think of all the data about me that I have collected in all of its various forms. It's just a stumbling block to getting a complete picture*". Susan understood what we had just encountered: the friction between the assumption that data are seamless, immediate and malleable, and the reality where data are the result of a tedious and precise craft *that requires creative problem solving skills.*

*6.1.2 Data labor beyond humans.* While it became clear that data interpretation required some forms of human labor, reinforcing what previous studies have found [21, 27, 43, 61], our literary textual analysis of the Data Epics also positioned 'labor' outside the realm of humans. For instance, sensors themselves are seen as hard and dedicated workers. In *The Sheriff*, the motion sensor reflects: "*I really, really like to pack the moment nicely, by the way, like people do birthday presents. Presentation counts, you know?*" Comparing data packages to birthday presents elevates the emotional investment the sensor has towards the data collected and sent. Continuing on, it discusses the value of the work: "*Maybe someone, someday, will see my work and appreciate it for what it is. Artistic? No. But valuable? I really hope so. That would mean a lot to me*" Regardless of data's immediate use, the sensor tirelessly collects and packages data, as if there was an internal motivation to do this work with precision, even perfection.

Resources and energy also become part of the labor and cost that make it possible for data to exist, as our literary analysis showed. For instance, in the post-apocalyptic world of *New Recruit*, Amy, the main character, is aware of the demands of keeping large files and large amounts of data archives: "*They didn't have enough server space or power to keep the video streams so she had to look through the text of what had happened during the night*". In a world where resources are limited, the high fidelity of video data is traded off for light-weight text logs. And, simultaneously, a reduction in external resources like storage space and energy translates to Amy needing to put in more of her own labor to work with the data traces. These passages show how data costs something, and how manifesting data is intermingled with material resources and human labor.

Instead of data being smooth and ubiquitous, we uncovered how data are cumbersome unless fixed within established infrastructures. Implications for HCI and design are two sides of a coin: one is that data are difficult and expensive in time and money to process without good infrastructure, therefore, the best infrastructures might, over time, have the most access and power over data processes, and two, that data might need to be designed for more flexible infrastructures where working with data is more transparent and flexible, allowing for more access.
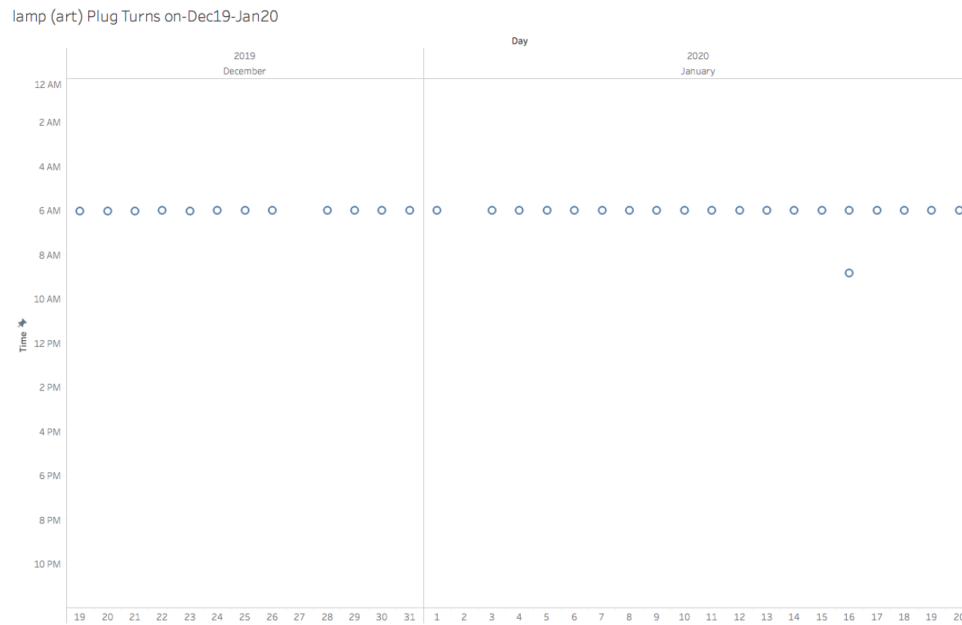
**Figure 5: Smart plug data for Susan's lamp. Notice the few anomalies (days missing and two points on January 16th).**

## 6.2 Interpretation Strategies: Anomalies, Patterns and Misunderstandings

Throughout the project, at each step of interpretation, patterns and anomalies emerged. Emily used these anomalies to build narrative and formulate storylines around data.

When Emily discussed her writing process during our interviews, she often mentioned her curiosity being piqued by a seemingly out-of-place data point or curious pattern. For example, *in Illumination*, she mentioned seeing lights go off and on regularly, but one case of a light coming on in the middle of the day (see Figure 5): "*it goes on at a certain time, it goes off at a certain time, but there are like two anomalies and I don't know why. And so I was trying to figure out how to use them.*" However, sometimes, in the case of the motion sensor, patterns were hard to find (see Figure 6). In analyzing data for *The Sheriff*, Emily explains that she decided the motion sensor was outside because the data seemed quite random. She tried to see patterns in the data that correlated to times of day, but it was all over the map, sometimes there was a batch of four movements triggered in four minutes. This made her wonder what could trigger such a random pattern and imagined it was probably an animal in the yard.

Anomalies and patterns find their way into the stories as character behaviors, motivations and experiences. Capturing the anomalies gave Emily points of tension to build life events in the stories, and even to speculate on what could cause exceptions. For example, in *The Sheriff*, the motion sensor protagonist tells the story of a

power outage in a snowstorm, "*It kept snowing and snowing, and branches fell. . . Then everything went dark and I suddenly fell asleep. On the job!*" illustrating how anomalies might feel from the sensor perspective, but more importantly directly illustrating how data can be unreliable, and imperfect.

Patterns and anomalies also became infused with command language like 'good morning' and 'good night' in the case of voice data. In *New Recruit*, Emily wove a story around a series of voice commands. She explained the challenge of using voice commands, stating, "*I was trying . . . to figure out how I would use her voice commands in a story . . . you know, like the 'good morning' command would start things up and, uh, that seemed pretty easy, but then it was, yeah, it was just trying to build an actual story around that.*" However, during her interview about this chapter, Susan mentioned that Emily picked up on a mistake she made in her commands, writing, "Pixel off" instead of Susan's usual command, "Presto off". The fact that the voice command could have many meanings allowed Emily to imagine a story around anomalies without even noticing them—while Susan, fully aware of their context, immediately noticed the mix-up.

Our discussion of pattern finding and looking for anomalies would not be complete without also discussing what data were left out. Susan lives with multiple cameras at home (pointing inside and outside). However, in the four chapters of Data Epics, we chose to not engage with the video data they produce. First, this type of data comes with additional challenges in terms of gathering, managing, and viewing data because of its time-based nature and size
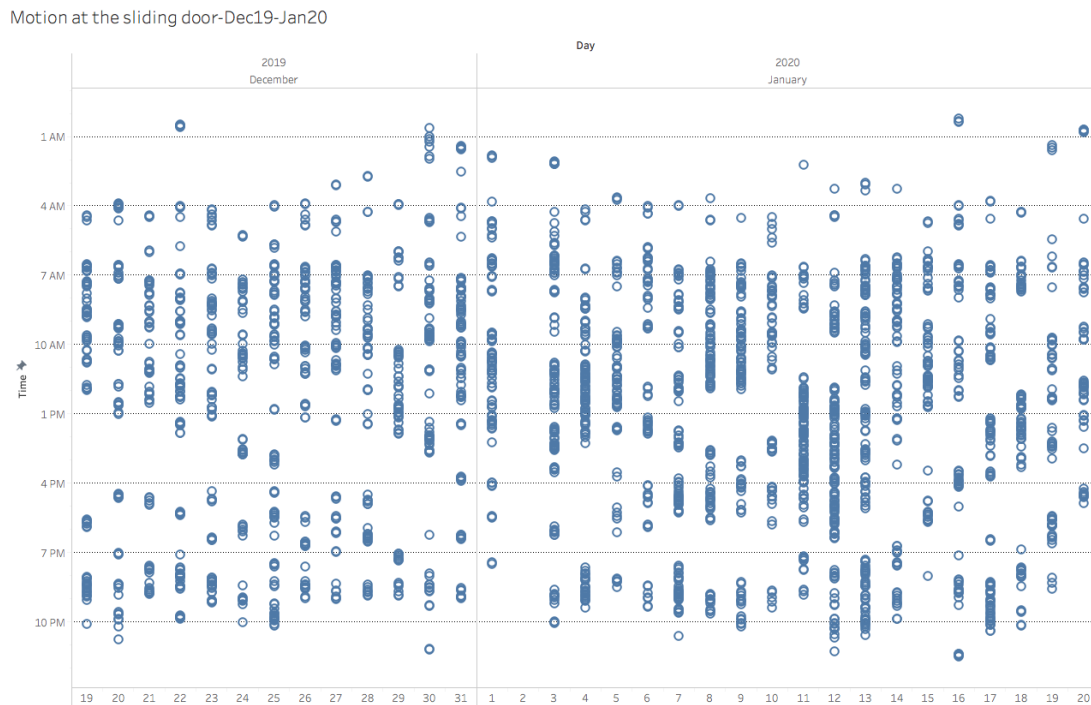
Motion at the sliding door-Dec19-Jan20



Figure 6: Motion sensor data from Susan's sliding door.

of archive it creates. Secondly, video data also had the potential to dramatically change the relation between Susan and Emily, eroding Susan's anonymity. This opens an interesting tension: while home camera video data are also part of IoT home data, they offer different challenges in interpretation. We might explore this data in future work.

Depending on goals of HCI researchers, it is important to note that different types of data use different patterning and problem-solving skills for users to understand. Using numeric, threshold data from motion sensors or plugs, Elizabeth found more spatial and temporal anomalies, but the case of voice data, anomalies went undetected as she simply incorporated all commands into the story. Data interpretation is situated not only in a place or situation, but in the data type.

## 7 DISCUSSION: GETTING CLOSER

The Data Epics project's aim was to investigate what kinds of stories could or would be told if they were based in someone's home IoT data in ways that ran counter to established ways of seeing data as objective, immaterial or unsituated. But we were also concerned with how these new imaginaries and understandings of data might give home dwellers a greater sense of agency with their data, wondering if home dwellers might be able to find new ways to engage with and interpret their own home data through fiction stories. While, Susan did not necessarily find profound meaning in her lamp's smart plug, nor did she uncover the deep patterns of her back door motion sensor, we argue that her engagement with the Data Epics helped her find new ways to *read data*. After reading the first chapter, while she found the story entertaining, she

expressed confusion and questioned her expectations about how her data was translated: "*I'm not sure I get any connection between my particular data and the story. My not having squirrels or dogs or an overhang, feels like my own literal expectations are set incorrectly. So maybe it's just about the general orbit of non-random-ish data, but if that's the case, what part do my spreadsheets play?*" But with time, Susan started to appreciate how her data became part of the stories. She learned that the epics could never be a perfect mirror of her own existence at home, but that some slivers of her life would reappear, transformed yet recognizable, throughout the stories. For example, she recognized the hierarchy in her devices at home, and she saw the voice commands she uses at home in a completely different context (a post-apocalyptic world). In a sense, she also learned how to *be with data* differently at home, in an embodied way. She imagined how her own opening and closing of the door transformed data. During the exit interview, it was clearer that through this new way of reading data and being with data Susan now saw the relationship between her data and the Data Epics in a new light: "*I was surprised that any of it matched [. . .] I was kind of more surprised at how closely it resembled so much of me. That was what was more surprising to me than the differences*".

The Data Epics are not a tool for precise interpretation of unique IoT events. However, they were successful at getting Susan (as well as Emily, Audrey and Heidi) closer to home IoT data in ways that STS theorists and other HCI researchers have argued are important: getting close to data as situated, lively and materially enmeshed in our lives and homes. Getting closer, we argue, is perhaps an important step in building intimacy, knowledge and trust with data,

something crucial and necessary before finding ways to gain agency and control of one's data.

We conclude this paper by offering two tactics for 'getting closer' to home IoT data: using multiple parallel tracks to *try things on*, and playing with fidelity and scale by *zooming in and slowing down*.

## 7.1 Tactic: Trying it On

In *Technologies of Speculation* [35], Hong exposes the difficulties to break away from rehearsed narratives around data: that data are objective, clean, and true. When writing, Emily echoed these difficulties, remarking: "*it's really hard with data to feel like you're being original because so much has been written about the dangers of big data. And, you know, [. . .] like Black Mirror has how many episodes about different perspectives on data and yeah, there's like Sci Fi novels. So really kind of hard.*" Popular culture as well as long standing traditions around truth and ways of knowing are strongly anchored in our perceptions of data.

In response, we see the Data Epics as curious explorations or tentative imaginings. They are ways to *try things on*, and see how they feel. Examples like data trying on different genders, or how Emily trying different personalities on sensors, illustrate how these stories, characters, and personalities didn't need to be perfect, accurate or real—instead, they were meant to try out new things. To move away from established narratives about data, we argue that we need a variety of openings in many directions to produce a plurality of ways to envision data, something we did with fiction in the Data Epics. Since we can't talk to data or ask them to join into design research, by writing stories with data, we are able to suspend disbelief and imagine not just the outputs of data (how will they be used) but the qualities and characteristics of data (how are data in the world) allowing us to instead look at tacit feelings and intuitions about data, issues that are concerns, and generate new imaginaries.

Through each chapter, we saw nuances and details that tested new ideas of what it might be like to be data or close to data. The Data Epics are existential or ontological exploration (What are data? How do they live? What are their lifeworlds?) which operate in the high-fidelity modality of fiction. Fiction writing required the data to fit into a world and a story and operate on a timeline, while engaging with other beings and lives. This fidelity helped move away from teleological frameworks often applied to data (How can I use data? How will data benefit me?). In that context, a series of various imaginaries, even if they each came from one home, with one home dweller, seems to hold a generative power to continue building new conceptualizations for what data are.

Fiction has the power to 'try on' things, as a way to reach to things we can't know otherwise. With the Data Epics, we tried on things, within one house, based on Susan's data, through Emily's eyes. In terms of future work, what might we learn if experimented with Data Epics in a variety of homes, or a diversity of participants? What might be uncovered if we imagined what data from urban informatics or wearables might be like through fiction? What types of imaginaries would be produced if we worked with many writers, each building off of data but also their own creative ways of interpreting data?

## 7.2 Tactic: Zooming in and Slowing Down

The project also aimed at putting our team front and center in the process of interpreting and representing data, instead of algorithms or faceless corporations. We chose to work in a very small team: 2 design researchers, one fiction writer and one home dweller (data producer and collector, and reader). We started this project with the intention of acknowledging the human touch in any data process [21] by pushing that presence to the extreme. By ourselves being the ones who choose to use IFTTT and Google spreadsheets, who clean data and make graphs, who write whole stories from data, who design and fabricate books and who ultimately read the Data Epics, we gained first-hand experience of data's interpretive transformations. As a result, we notice how much data manipulation had to happen, even in a seemingly very simple idea: a fiction writer will write a story every month based on one's home IoT data. In our process, we also see how the materials we used (the spreadsheets of timestamps, the graphs, the words in the stories, the books), served as traces for the multitude of decisions we made when transforming data. These layered transformations are all interpretive in nature: every time we changed material and form, we continued to interpret data. And while these transformations often remain invisible and inaccessible in IoT, keeping data abstract and unattainable, our process got us much closer to data and allowed us to imagine data differently. This became visible and noticeable to us only because we had slowed down (by virtue of being humans and not algorithms) and zoomed into the processes of data translations.

Zooming in and slowing down was also part of our methodological commitments for doing this research. We worked closely with our interlocutors in a small team, and acknowledged our own authorial roles in the work, similarly to autobiographical design and other first person research approaches in HCI [15, 44, 52]. This allowed us to develop a relationship with Emily and Susan that felt not only exciting and productive for us as researchers, but that also benefited Emily and Susan. Emily had mentioned that she wanted to find time in her busy life to write more fiction. The Data Epics gave her a topic, deadlines, a goal, and an audience to practice her art. Susan, whom we had worked with previously on a different project, kept telling us that she didn't want our collaboration to end, that she enjoyed seeing what we 'were coming up with'. At the end of the study, Susan even remarked that her view on her data hadn't really changed, other than she felt closer to it and just wanted more of it. Our encounters with her confirmed and enhanced her love for data—an outcome we didn't anticipate since part of our research agenda was to critique everyday views of data. We also felt our close relationship built mutual trust, for example, Susan felt safe expressing displeasure with *The Inspector*.

As we reflect on our relation with Emily and Susan, we also acknowledge how our intention to work with people who had time, flexibility and interest to support a generative co-imagining had consequences on who we worked with (white women of a certain socio-economic background). While our group worked well together, it is not a given that other groups would lead to similar results. Nevertheless, our approach illustrates well how what is produced in research is not only what researchers produce, but also what comes of the practices of our interlocutors. Or as Howard and Irani put it: "*They [participants] also have their own projects –*

*projects in which researchers may be an instrument*" [36:1]. Working closely with a single participant over time allows for care to emerge and to soften the extractive emphasis on discovery and invention so often present in research processes. As a result, the tactic of zooming in and slowing down the interpretation of data in the Data Epics were not only present in the material translations that marked our process, but also within each of us, interlocutors, who were interpreting the data through our own goals and positionalities. We encourage HCI and design researchers to also see themselves as potential instruments to see, feel, and grasp data processes at a human scale, as a tactic to get closer, and ultimately better understand data, and how to design with and around them.

## 8 CONCLUSION

In this paper, we presented the Data Epics a series of four fiction short stories written by Emily, a fiction writer, using data from Susan, an IoT enthusiast's home data. Through creating and presenting the Data Epics, we show how fiction can be used as a generative strategy to diversify imaginaries of data and create many ways of seeing data, in particular as lively, part of new worlds and entwined in meshes and power structures. Our work also reports on data interpretation from 'up close', highlighting it as a process that is situated, messy and requiring human labor. Ultimately, we argue that in order to gain better agency and understanding of home IoT data, we might need strategies to grow closer to data, through tactics like trying on lots of ideas of data, and zooming in and slowing down, not only to the process of data interpretation, but our research process as a whole.

We see the Data Epics as the start of a journey into more nuanced, messy, lively and situated ways of seeing data. While we thought the Data Epics would be about data leaving and returning home, and about the mystical things that might happen elsewhere, we now see they are part of a larger (epic) research agenda to make data come alive and understand how they are entangled in the lives of people living with domestic IoT. The mysterious and elusive qualities of data are perhaps our best allies at the moment, as they allow for imagination to continue to flow towards new ways of connecting with data.

## ACKNOWLEDGMENTS

## REFERENCES

[1] Kristina Andersen. 2013. Making Magic Machines. In *10th European Academy of Design Conference - Crafting the Future, Gothenburg, Sweden*, 1–11. DOI: https://doi.org/10.2307/j.ctvg8p3md.12.

[2] Luigi Atzori, Antonio Iera, and Giacomo Morabito. 2010. The Internet of Things: A survey. *Computer Networks* 54, 15 (October 2010), 2787–2805. DOI: https://doi.org/10.1016/j.comnet.2010.05.010.

[3] Jeffrey Bardzell and Shaowen Bardzell. 2014. "a great and troubling beauty": Cognitive speculation and ubiquitous computing. *Personal and Ubiquitous Computing* 18, 4 (2014), 779–794. DOI: https://doi.org/10.1007/s00779-013-0677-8.

[4] Genevieve Bell and Paul Dourish. 2007. Yesterday's Tomorrows: Notes on Ubiquitous Computing's Dominant Vision. *Personal Ubiquitous Comput.* 11, 2 (January 2007), 133–143. DOI: https://doi.org/10.1007/s00779-006-0071-x.

[5] Julian Bleecker. 2009. Design Fiction: A Short Essay on Design, Science, Fact and Fiction. *Near Future Laboratory* March (2009), 49. DOI: https://doi.org/10.1145/1516016.1516021.

[6] Åsa Blomquist and Mattias Arvola. 2002. Personas in action: Ethnography in an interaction design team. *ACM International Conference Proceeding Series* 31, (2002), 197–200. DOI: https://doi.org/10.1145/572020.572044.

[7] Mark Blythe, Kristina Andersen, Rachel Clarke, and Peter Wright. 2016. Anti-solutionist strategies: Seriously silly design fiction. In *Proceedings of the 2016 CHI Conference (CHI '16)*, 4968–4978. DOI: https://doi.org/10.1145/2858036.2858482.

[8] Mark Blythe, Enrique Encinas, Jofish Kaye, Miriam Lueck Avery, Rob McCabe, and Kristina Andersen. 2018. Imaginary Design Workbooks. *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems - CHI '18* (2018), 1–12. DOI: https://doi.org/10.1145/3173574.3173807.

[9] Nico Castelli, Corinna Ogonowski, Timo Jakobi, Martin Stein, Gunnar Stevens, and Volker Wulf. 2017. What Happened in my Home? An End-User Development Approach for Smart Home Data Visualization. In *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems* (CHI '17), Association for Computing Machinery, New York, NY, USA, 853–866. DOI: https://doi.org/10.1145/3025453.3025485.

[10] David Chatting, Gerard Wilkinson, Kevin Marshall, Audrey Desjardins, David Green, David Kirk, and Andy Boucher. 2017. Making Home: Asserting Agency in the Age of IoT. In *Proceedings of the 2017 CHI Conference Extended Abstracts on Human Factors in Computing Systems* (CHI EA '17), ACM, New York, NY, USA, 526–533. DOI: https://doi.org/10.1145/3027063.3027081.

[11] Marshini Chetty, David Tran, and Rebecca E. Grinter. 2008. Getting to Green: Understanding Resource Consumption in the Home. In *Proceedings of the 10th International Conference on Ubiquitous Computing* (UbiComp '08), ACM, New York, NY, USA, 242–251. DOI: https://doi.org/10.1145/1409635.1409668.

[12] Andy Crabtree, Tom Lodge, James Colley, Chris Greenhalgh, Kevin Glover, Hamed Haddadi, Yousef Amar, Richard Mortier, Qi Li, John Moore, Liang Wang, Poonam Yadav, Jianxin Zhao, Anthony Brown, Lachlan Urquhart, and Derek McAuley. 2018. Building accountability into the Internet of Things: the IoT Databox model. *J Reliable Intell Environ* 4, 1 (April 2018), 39–55. DOI: https://doi.org/10.1007/s40860-018-0054-5.

[13] Kate Crawford, Jessa Lingel, and Tero Karppi. 2015. Our metrics, ourselves: A hundred years of self-tracking from the weight scale to the wrist wearable device. *European Journal of Cultural Studies* 18, 4–5 (August 2015), 479–496. DOI: https://doi.org/10.1177/1367549415584857.

[14] Dries De Roeck, Karin Slegers, Johan Criel, Marc Godon, Laurence Claeys, Katriina Kilpi, and An Jacobs. 2012. I Would DiYSE for It!: A Manifesto for Do-it-yourself Internet-of-things Creation. In *Proceedings of the 7th Nordic Conference on Human-Computer Interaction: Making Sense Through Design* (NordiCHI '12), ACM, New York, NY, USA, 170–179. DOI: https://doi.org/10.1145/2399016.2399044.

[15] Audrey Desjardins and Aubree Ball. 2018. Revealing Tensions in Autobiographical Design in HCI. In *Proceedings of the 2018 Designing Interactive Systems Conference* (DIS '18), ACM, New York, NY, USA, 753–764. DOI: https://doi.org/10.1145/3196709.3196781.

[16] Audrey Desjardins, Heidi R. Biggs, Cayla Key, and Jeremy E. Viny. 2020. IoT Data in the Home: Observing Entanglements and Drawing New Encounters. In *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems* (CHI '20), Association for Computing Machinery, Honolulu, HI, USA, 1–13. DOI: https://doi.org/10.1145/3313831.3376342.

[17] Audrey Desjardins, Cayla Key, Heidi Biggs, and Kelsey Ashenbeck. 2019. Bespoke Booklets: A Method for Situated Co-Speculation. In *Proceedings of the 2019 on Designing Interactive Systems Conference (DIS '19)*, ACM, 697–709.

[18] Audrey Desjardins and Timea Tihanyi. 2019. ListeningCups: A Case of Data Tactility and Data Stories. In *Proceedings of the 2019 on Designing Interactive Systems Conference* (DIS '19), ACM, New York, NY, USA, 147–160. DOI: https://doi.org/10.1145/3322276.3323694.

[19] Laura Devendorf, Katya Arquilla, Sandra Wirtanen, Allison Anderson, and Steven Frost. 2020. Craftspeople as Technical Collaborators: Lessons Learned through an Experimental Weaving Residency. In *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems* (CHI '20), Association for Computing Machinery, New York, NY, USA, 1–13. DOI: https://doi.org/10.1145/3313831.3376820.

[20] Kristin N. Dew and Daniela K. Rosner. 2018. Lessons from the Woodshop: Cultivating Design with Living Materials. In *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems* (CHI '18), Association for Computing Machinery, New York, NY, USA, 1–12. DOI: https://doi.org/10.1145/3173574.3174159.

[21] Catherine D'Ignazio and Lauren F. Klein. 2020. *Data Feminism*. MIT Press.

[22] Paul Dourish. 2017. *The Stuff of Bits: An Essay on the Materialities of Information*. MIT Press.

[23] Anthony Dunne and Fiona Raby. 2013. *Speculative Everything: Design, Fiction, and Social Dreaming*. MIT Press, Cambridge, Massachusetts.

[24] Carolyn Ellis, Tony E. Adams, and Arthur P. Bochner. 2010. Autoethnography: An Overview. *Forum Qualitative Sozialforschung / Forum: Qualitative Social Research* 12, 1 (November 2010). Retrieved October 31, 2014 from http://www.qualitative-research.net/index.php/fqs/article/view/1589.

[25] Chris Elsden, David Chatting, Abigail C. Durrant, Andrew Garbett, Bettina Nissen, John Vines, and David S. Kirk. 2017. On Speculative Enactments. *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems (CHI '17)* (2017), 5386–5399. DOI: https://doi.org/10.1145/3025453.3025503.

[26] Daniel A. Epstein, An Ping, James Fogarty, and Sean A. Munson. 2015. A Lived Informatics Model of Personal Informatics. In *Proceedings of the 2015 ACM International Joint Conference on Pervasive and Ubiquitous Computing* (UbiComp '15), ACM, New York, NY, USA, 731–742. DOI: https://doi.org/10.1145/2750858.2804250.

[27] Joel E. Fischer, Andy Crabtree, Tom Rodden, James A. Colley, Enrico Costanza, Michael O. Jewell, and Sarvapali D. Ramchurn. 2016. "Just whack it on until it gets hot": Working with IoT Data in the Home. In *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems* (CHI '16), Association for Computing Machinery, New York, NY, USA, 5933–5944. DOI: https://doi.org/10.1145/2858036.2858518.

[28] Ester Fritsch, Irina Shklovski, and Rachel Douglas-Jones. 2018. Calling for a Revolution: An Analysis of IoT Manifestos. In *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems* (CHI '18), ACM, New York, NY, USA, 302:1–302:13. DOI: https://doi.org/10.1145/3173574.3173876.

[29] Carolina Fuentes, Martin Porcheron, Joel E. Fischer, Enrico Costanza, Obaid Malilk, and Sarvapali D. Ramchurn. 2019. Tracking the Consumption of Home Essentials. In *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems* (CHI '19), Association for Computing Machinery, New York, NY, USA, 1–13. DOI: https://doi.org/10.1145/3290605.3300869.

[30] William Gaver, Phoebe Sengers, Tobie Kerridge, Joseph Kaye, and John Bowers. 2007. Enhancing Ubiquitous Computing with User Interpretation: Field Testing the Home Health Horoscope. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (CHI '07), ACM, New York, NY, USA, 537–546. DOI: https://doi.org/10.1145/1240624.1240711.

[31] William W. Gaver, John Bowers, Kirsten Boehner, Andy Boucher, David W.T. Cameron, Mark Hauenstein, Nadine Jarvis, and Sarah Pennington. 2013. Indoor weather stations: investigating a ludic approach to environmental HCI through batch prototyping. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (CHI '13), ACM, New York, NY, USA, 3451–3460. DOI: https://doi.org/10.1145/2470654.2466474.

[32] Kentaro Go, John Carroll, and Virginia Tech. 2004. Scenario-based task analysis. *The Handbook of Task Analysis for Human-computer Interaction* (January 2004).

[33] Byung-Chul Han. 2018. *Saving beauty* (English edition. ed.). Polity Press, Cambridge, UK; Malden, MA.

[34] Yasamin Heshmat, Carman Neustaedter, and Brendan DeBrincat. 2017. The Autobiographical Design and Long Term Usage of an Always-On Video Recording System for the Home. In *Proceedings of the 2017 Conference on Designing Interactive Systems* (DIS '17), ACM, New York, NY, USA, 675–687. DOI: https://doi.org/10.1145/3064663.3064759.

[35] Sun-ha Hong. 2020. Technologies of Speculation: The Limits of Knowledge in a Data-Driven Society. NYU Press.

[36] Dorothy Howard and Lilly Irani. 2019. Ways of Knowing When Research Subjects Care. In *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems* (CHI '19), Association for Computing Machinery, New York, NY, USA, 1–16. DOI: https://doi.org/10.1145/3290605.3300327.

[37] Karin Kappel and Thomas Grechenig. 2009. "Show-me": Water Consumption at a Glance to Promote Water Conservation in the Shower. In *Proceedings of the 4th International Conference on Persuasive Technology* (Persuasive '09), ACM, New York, NY, USA, 26:1–26:6. DOI: https://doi.org/10.1145/1541948.1541984.

[38] David Kirby. 2010. The future is now: Diegetic prototypes and the role of popular films in generating real-world technological development. *Social Studies of Science* 40, 1 (2010), 41–70. DOI: https://doi.org/10.1177/0306312709338325.

[39] Rob Kitchin. 2014. Big Data, new epistemologies and paradigm shifts. *Big Data & Society* 1, 1 (April 2014), 2053951714528481. DOI: https://doi.org/10.1177/2053951714528481.

[40] Rob Kitchin and Tracey Lauriault. 2014. *Towards Critical Data Studies: Charting and Unpacking Data Assemblages and Their Work*. Social Science Research Network, Rochester, NY. Retrieved September 6, 2019 from https://papers.ssrn.com/abstract=2474112.

[41] Sandjar Kozubaev, Chris Elsden, Noura Howell, Marie Louise Juul Søndergaard, Nick Merrill, Britta Schulte, and Richmond Y. Wong. 2020. Expanding Modes of Reflection in Design Futuring. (2020), 1–15. DOI: https://doi.org/10.1145/3313831.3376526.

[42] Albrecht Kurze, Andreas Bischof, Sören Totzauer, Michael Storz, Maximilian Eibl, Margot Brereton, and Arne Berger. 2020. Guess the Data: Data Work to Understand How People Make Sense of and Use Simple Sensor Data from Homes. In *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems* (CHI '20), Association for Computing Machinery, Honolulu, HI, USA, 1–12. DOI: https://doi.org/10.1145/3313831.3376273.

[43] Yanni Alexander Loukissas. 2019. *All Data Are Local: Thinking Critically in a Data-Driven Society*. The MIT Press, Cambridge, Massachusetts.

[44] Andrés Lucero, Audrey Desjardins, Carman Neustaedter, Kristina Höök, Marc Hassenzahl, and Marta E. Cecchinato. 2019. A Sample of One: First-Person Research Methods in HCI. In *Companion Publication of the 2019 on Designing Interactive Systems Conference 2019 Companion* (DIS '19 Companion), ACM, New

[45] Giorgia Lupi and Stefanie Posavec. 2016. *Dear Data*. Princeton Architectural Press, New York.

[46] Deborah Lupton. 2016. Digital companion species and eating data: Implications for theorising digital data–human assemblages. *Big Data & Society* 3, 1 (June 2016), 2053951715619947. DOI: https://doi.org/10.1177/2053951715619947.

[47] Deborah Lupton. 2017. Feeling your data: Touch and making sense of personal digital data. *New Media & Society* 19, 10 (October 2017), 1599–1614. DOI: https://doi.org/10.1177/1461444817717515.

[48] Aaron Marcus. 2013. The history of the future: Sci-Fi Movies and HCI. *Interactions* 20, 4 (2013), 64–67. DOI: https://doi.org/10.1017/S0040557404000250.

[49] Daniele Miorandi, Sabrina Sicari, Francesco De Pellegrini, and Imrich Chlamtac. 2012. Internet of things: Vision, applications and research challenges. *Ad Hoc Networks* 10, 7 (September 2012), 1497–1516. DOI: https://doi.org/10.1016/j.adhoc.2012.02.016.

[50] Jimmy Moore, Pascal Goffin, Miriah Meyer, Philip Lundrigan, Neal Patwari, Katherine Sward, and Jason Wiese. 2018. Managing In-home Environments Through Sensing, Annotating, and Visualizing Air Quality Data. *Proc. ACM Interact. Mob. Wearable Ubiquitous Technol.* 2, 3 (September 2018), 128:1–128:28. DOI: https://doi.org/10.1145/3264938.

[51] Omar Mubin, Mark Billinghurst, Mohammad Obaid, Philipp Jordan, Patricia Alves-Oliveria, Thommy Eriksson, Wolmet Barendregt, Daniel Sjolle, Morten Fjeld, and Simeon Simoff. 2016. Towards an Agenda for Sci-Fi Inspired HCI Research. *Proceedings of the 13th International Conference on Advances in Computer Entertainment Technology - ACE2016* (2016), 1–6. DOI: https://doi.org/10.1145/3001773.3001786.

[52] Carman Neustaedter and Phoebe Sengers. 2012. Autobiographical Design in HCI Research: Designing and Learning Through Use-it-yourself. In *Proceedings of the Designing Interactive Systems Conference* (DIS '12), ACM, New York, NY, USA, 514–523. DOI: https://doi.org/10.1145/2317956.2318034.

[53] James Pierce and Carl DiSalvo. 2018. Addressing Network Anxieties with Alternative Design Metaphors. In *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems* (CHI '18), Association for Computing Machinery, New York, NY, USA, 1–13. DOI: https://doi.org/10.1145/3173574.3174123.

[54] María Teresa Rodríguez, Sérgio Nunes, and Tiago Devezas. 2015. Telling Stories with Data Visualization. In *Proceedings of the 2015 Workshop on Narrative & Hypertext* (NHT '15), ACM, New York, NY, USA, 7–11. DOI: https://doi.org/10.1145/2804565.2804567.

[55] Mario Romero, Zachary Pousman, and Michael Mateas. 2008. Alien Presence in the Home: The Design of Tableau Machine. *Personal Ubiquitous Comput.* 12, 5 (June 2008), 373–382. DOI: https://doi.org/10.1007/s00779-007-0190-z.

[56] Daniela K. Rosner. 2018. *Critical Fabulations: Reworking the Methods and Margins of Design*. MIT Press.

[57] Daniela K. Rosner, Samantha Shorey, Brock R. Craft, and Helen Remick. 2018. Making Core Memory: Design Inquiry into Gendered Legacies of Engineering and Craftwork. In *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems* (CHI '18), ACM, New York, NY, USA, 531:1–531:13. DOI: https://doi.org/10.1145/3173574.3174105.

[58] E. Segel and J. Heer. 2010. Narrative Visualization: Telling Stories with Data. *IEEE Transactions on Visualization and Computer Graphics* 16, 6 (November 2010), 1139–1148. DOI: https://doi.org/10.1109/TVCG.2010.179.

[59] Bruce Sterling. 2009. Design Fiction. *Interactions* 16, 3 (2009), 20. DOI: https://doi.org/10.1145/1516016.1516021.

[60] Bruce M. Tharp and Stephanie Tharp. 2018. *Discursive design: critical, speculative, and alternative things*. The MIT Press, Cambridge, Massachusetts.

[61] Peter Tolmie, Andy Crabtree, Tom Rodden, James Colley, and Ewa Luger. 2016. "This has to be the cats": Personal Data Legibility in Networked Sensing Systems. In *Proceedings of the 19th ACM Conference on Computer-Supported Cooperative Work & Social Computing* (CSCW '16), Association for Computing Machinery, New York, NY, USA, 491–502. DOI: https://doi.org/10.1145/2818048.2819992.

[62] Joris Toonders. 2014. Data Is the New Oil of the Digital Economy. *Wired*. Retrieved September 13, 2020 from https://www.wired.com/insights/2014/07/data-new-oil-digital-economy/.

[63] Blase Ur, Melwyn Pak Yong Ho, Stephen Brawner, Jiyun Lee, Sarah Mennicken, Noah Picard, Diane Schulze, and Michael L. Littman. 2016. Trigger-Action Programming in the Wild: An Analysis of 200,000 IFTTT Recipes. In *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems* (CHI '16), ACM, New York, NY, USA, 3227–3231. DOI: https://doi.org/10.1145/2858036.2858556.

[64] Ron Wakkary, William Odom, Sabrina Hauser, Garnet Hertz, and Henry Lin. 2015. Material Speculation: Actual Artifacts for Critical Inquiry. *Aarhus Series on Human Centered Computing* 1, 1 (2015), 12. DOI: https://doi.org/10.7146/aahcc.v1i1.21299.

[65] Jayne Wallace, Jon Rogers, Michael Shorter, Pete Thomas, Martin Skelly, and Richard Cook. 2018. The SelfReflector: Design, IoT and the High Street. In *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems* (CHI '18), ACM, New York, NY, USA, 423:1–423:12. DOI: https://doi.org/10.1145/3173574.3173997.

[66] Gary Wolf. 2009. Know Thyself: Tracking Every Facet of Life, from Sleep to Mood to Pain, 24/7/365. *Wired*. Retrieved August 20, 2019 from https://www.wired.com/2009/06/lbnp-knowthyself/.

[67] Richmond Y. Wong, Vera Khovanskaya, Sarah E. Fox, Nick Merrill, and Phoebe Sengers. 2020. Infrastructural Speculations: Tactics for Designing and Interrogating Lifeworlds. In Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems (CHI '20), Association for Computing Machinery, New York, NY, USA, 1–15. DOI: https://doi.org/10.1145/3313831.3376515.

[68] Richmond Y. Wong, Ellen Van Wyk, and James Pierce. 2017. Real-Fictional Entanglements: Using Science Fiction and Design Fiction to Interrogate Sensing Technologies. In Proceedings of the 2017 Conference on Designing Interactive Systems (DIS '17), ACM, New York, NY, USA, 567–579. DOI: https:

//doi.org/10.1145/3064663.3064682.

[69] Jong-bum Woo and Youn-kyung Lim. 2015. User Experience in Do-it-yourself-style Smart Homes. In Proceedings of the 2015 ACM International Joint Conference on Pervasive and Ubiquitous Computing (UbiComp '15), ACM, New York, NY, USA, 779–790. DOI: https://doi.org/10.1145/2750858.2806063

[70] 2020 Right to erasure. Retrieved September 16, 2020 from https://ico.org.uk/for-organisations/guide-to-data-protection/guide-to-the-general-data-protection-regulation-gdpr/individual-rights/right-to-erasure.

[71] Green Paper: Fostering the Advancement of the Internet of Things | National Telecommunications and Information Administration. Retrieved July 29, 2019 from https://www.ntia.doc.gov/other-publication/2017/green-paper-fostering-advancement-internet-things.