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Modes of Uncertainty in HCI

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now
the essence of knowledge
Boston — Delft

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Preface

"We hope this finds you well during these difficult and uncertain times."

> The nature of writing about uncertainty is that it is an uncertain pursuit. I had no idea when I would get the perspective needed to write something external. Any sense of urgency to share material had given way to a concern with survival and a reassessment of priorities. And the material I had seemed old and tired now that a new crisis had come. Maybe it is more important that I spend my time helping people on my street rather than pontificating on uncertain futures, I wondered. If there is no business as usual, what should we make together and in what arenas?
>
> So, "normality" and "certainty" were casualties and it is salutary to be forced to think what this means in one's own life rather than just theorizing about it in a workshop, as I did at the start of lockdown, or in a book. During the pandemic and its aftermath, my world shrank and all my old usual things, like travel, eating out and theatre, disappeared from my life and a new wave of things came in. But what does it take to qualify for that familiarity, that frequency of occurrence? To be usual? When does a life lived differently tip from "rare" and "special" to normal?

> If we answer that, we commit to a new way of thinking about our lives. We accept that we can change fast and flex often. If my usual is now the tiny world of my Zoom account and a few rooms, on what scale are we judging our lives now? What has happened to our temporalities? Who am I? (Light, notes, March 2020)

Though we didn't plan it this way, this monograph was produced at a time when uncertainty seemed to be at the forefront of everyone's minds (and in the "hope you are well" salutations of our emails). The rapid succession of lockdowns, conflicting public health guidance, and frenzied attempts to understand COVID-19 that so many of us experienced during the early days of the pandemic gave way to a prolonged, grinding, succession of losses. We fervently tracked infection rates, death counts, and, more recently, vaccination numbers, knowing these data didn't begin to describe the world we were living through. The urge to grab hold of something firm during such moments is a powerful one, but, as we will argue, not the only option available to us. COVID-19 will not be the last crisis, and perhaps not even the last pandemic, of the early 21st century. Expanding our set of tools for navigating and thinking with and about uncertainty will therefore be a necessary undertaking, in our personal and scholarly lives alike.

Modes of Uncertainty in HCI

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ABSTRACT

This monograph examines how HCI conceptualizes, situates, and responds to uncertainty—particularly arguing that our ability to respond to such uncertainties is governed to a great extent by the concepts we use to enframe a single, encompassing, overburdened and slippery idea. We propose four distinct "modes of uncertainty" as a means to begin to draw together the varied strands of work in HCI that address uncertainty in its many forms. The first, and most common, mode is to treat uncertainty as something in need of taming or disciplining. The second mode is to treat uncertainty as generative, or as a resource that can assist in human practices. The third is to look to the politics that shape how we encounter uncertainties and the fourth mode attends to the lived experience of uncertainty through affective dimension.

Rather than focus on uncertainty as a discrete phenomenon in the world to be studied, we look to how research goals, methods, and theoretical frames used in HCI research influence the various ways in which we encounter it. By switching from uncertainty (noun) to modes of engaging uncertainty

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(verb), we foreground uncertainty as a relational concept. We show that it is an active and ongoing condition that designers and researchers make present in different fashions depending upon their priorities and the context in which they are working. We will show that adding modes of uncertainty to our conceptual toolbox facilitates conversation between domains as diverse as disaster risk, maternal health, cybersecurity, and community organizing and lets us draw new connections between disparate areas of research including visualization studies, critical design, feminist epistemologies, and sustainability.

1

Introduction

Uncertainty is a prevalent characteristic of contemporary life and a central challenge of HCI. As humans, researchers, and designers we encounter uncertainty in a multitude of forms and a variety of settings. Many of our field sites and critical research areas, from big data to crisis informatics and sustainable HCI, or politics, health, cybersecurity, and cross-cultural dialogue are settings characterized by high degrees of uncertainty. The growing attention to uncertainty in HCI is due, in part, to the ever increasing expansion of the field and questions and contexts to which we seek to apply HCI research and practice. But events in the world – a global pandemic, climate change, political turmoil, the increased economic upheaval faced by many professions – are also forcing us to engage more directly with questions related to uncertainty. Apace with, or perhaps in response to these changes, society is turning more than ever to data as a means to enable or mediate our understanding of these phenomena, the episteme of which is fundamentally characterized by questions of probability, margin of error, standard deviation, and p-values, each of which is fundamentally about circumscribing or managing uncertainty.

This monograph examines how HCI conceptualizes, situates, and responds to uncertainty-particularly arguing that our ability to respond to such uncertainties is governed to a great extent by the concepts we use to enframe a single, encompassing, overburdened and slippery idea. HCI in fact has had quite a bit to say on the topic over its history. Indeed, design research methods have often been portrayed as tools for coping with uncertainty in product development processes. Elsewhere in the field, colleagues have investigated effective means for visualizing uncertainty, explored the benefits of ambiguity to user appropriation, or critiqued the precarity imposed upon workers in the so-called "sharing economy." Despite the myriad and diverse appearances of uncertainty in HCI, we don't currently possess the necessary conceptual apparatus to bring these varied studies into conversation. As a result, we often end up talking past each other when we might otherwise be collaborating.

In what follows, we propose four distinct "modes of uncertainty" as a means to begin to draw together the varied strands of work in HCI that address uncertainty in its many forms. The first, and most common mode is to treat uncertainty as something in need of taming or disciplining. Here, uncertainty is often encountered as a problem. This is perhaps unsurprising given our field's close connections to computer science and engineering. Western science has traditionally formulated uncertainty as problematic, or something to be overcome through progressive advances in science and philosophy. Indeed for many scholars, an asymptotic pursuit of certainty is in fact one of the defining characteristics of Modernity (Toulmin, 1992). Despite the ways in which quantum physics has complicated the issue and increased attention to so-called "wicked problems" or "post-normal" science, the disciplining perspective continues to motivate much of HCI research on uncertainty. In contrast, a second mode is to treat uncertainty as generative, or as a resource that can assist in human practices. Here uncertainty is both inevitable and, if artfully deployed, a resource for the design of artifacts and systems. A third mode of uncertainty is to look to the politics that shape how we encounter uncertainties. Finally, the fourth mode attends to the lived experience of uncertainty through affective dimensions.

The word *mode* comes from the Latin word for "method", and for our purposes designates a particular approach, or relationship toward uncertainty.[1] Rather than focus on uncertainty as a discrete phenomenon in the world to be studied, we instead look to how research goals, methods, and theoretical frames used in HCI research influence the various ways in which we encounter it. By switching from uncertainty (noun) to modes of engaging uncertainty (verb), we foreground uncertainty as a relational concept. We show that it is an active and ongoing condition that designers and researchers make present in different fashions depending upon their priorities and the context in which they are working. We will show that adding modes of uncertainty to our conceptual toolbox facilitates conversation between domains as diverse as disaster risk, maternal health, cybersecurity and community organizing and lets us draw new connections between disparate areas of research including visualization studies, critical design, feminist epistemologies, and sustainability.

[1] Well into this project, a friend recommended the edited volume *Modes of Uncertainty* by anthropologists Samimian-Darash and Rabinow (2015). Though we found the book an interesting and important contribution, our project and thus our use of the concept of "modes" is quite different.

2

Background

This project began as the result of a series of conversations and a reading group between Robert and Laura. We were both doing research and design in settings that are rife with uncertainty – climate and disaster risk and healthcare – and searching for points of connection between the two. These discussions were simultaneously ebullient, confused, and frustrating. The HCI literature seemed to offer a myriad of different tools for thinking with and about uncertainty as part of design practice or encountered in our research sites. We read dozens of books and papers, made long lists of concepts and keywords, but struggled to draw meaningful connections between the disparate strands of work we encountered. At the same time, much (though not all, see Akama *et al.*, 2018) of the formal work on uncertainty that we found in adjacent fields like risk communication and the history of science adopted a perspective that felt strikingly narrow in comparison. This perspective, which we have termed the disciplinary mode, while undoubtedly powerful, also seemed to have limits when it came to accounting for the messiness presented by people's lives and the challenges we were uncovering through our research. We knew we needed both alternative approaches

and a means of creating some throughlines between the diverse and disconnected ways in which HCI considers uncertainty.

The disciplinary mode of uncertainty was, unsurprisingly, the first set of ideas that we had to grapple with in our work with scientists studying disaster and the public's experience of health information. The view of uncertainty as something to be tamed is central to Western science and thought. The European Enlightenment – and the age of Modernity it culminated in – were oriented toward liberating (some) humans from the vagaries of nature through rationality and progress (Merchant, 1980). To their proponents, these ideas were sources of light and safety in a dark and dangerous world. According to some arguments, it was the trauma of the religious wars of Europe in the 17th century, which killed something like 20% of the population and ravaged the continent with famine and disease, that drove philosophers like Descartes to develop a means of definitively answering questions about the world and their place in it (Toulmin, 1992). The Treaty of Westphalia that brought an end to these wars is credited with laying the groundwork for modern nation states, who soon after set about developing the field of *stat*-istics as a means of accounting for and managing large territories and growing populations in a rational manner (Porter, 1996; Scott, 2008).

Throughout the 20th century, scientists and philosophers would develop all manner of approaches to debunk or delimit Modernist aspirations to disciplining uncertainty, yet the impetus remains (Hacking and Hacking, 1990). Thus, much of the contemporary research on uncertainty still works within this frame. Sources and types of uncertainty are classified (e.g., aleatory vs. epistemic), statistical methods are created to reduce uncertainty, and strategies are developed to communicate the remainder to a sometimes dubious public (Spiegelhalter and Riesch, 2011; Wynne, 1992). Further, the increasing bureaucratization of society identified by Bauman (2000) and others, is a form of disciplining that finds an outlet in modern technologies, the financialization of risk through insurance schemes (Ewald, 2019) or the adoption of risk assessments when developing environmental safeguards (Boyd, 2012). As we elaborate in the Case Studies section, such approaches to managing

uncertainty occupy center stage in many of our research sites, for better and worse.

Our work on this project was inspired by the combination of the pervasiveness of this dominant view of uncertainty along with its limits, which were readily apparent in our field sites. Along with the explanatory power provided by the disciplinary mode of uncertainty come tremendous closures. The disciplinary mode casts whole areas of human experience as "unknown unknowns" with a sort of ontological shrug of the shoulders. The tight coupling of description to phenomena asserted by the disciplinary mode created brittle social mechanisms for coping with uncertainty, leaving troves of "wicked problems" in its wake. We saw disasters whose probabilities fall outside of thresholds determined by experts and governments go unprepared for, therefore becoming all the more devastating when they did occur. In healthcare, patients and providers were left frustrated and disempowered when measures of risk, drawn from studies of large populations, felt unsuited to inform personal, situated, choices. Yet in the margins left by this mode, we also witnessed folk methods for coping with uncertainty, designerly efforts to engage with uncertainty in new ways, and substantive, if scattered, contributions in the HCI literature to examine these activities.

Looking across the contexts in which we were working, we could see our questions about making existence possible – in place and at risk – contrasted with other, more technical, HCI concerns and ways of understanding research. And we realized that even to consider the breadth of HCI practices (and the alternative ways we might understand them) is to step beyond asking about relations with computers to asking to which scholarship traditions we owe our allegiance and from where we draw our support and styles of engagement. For we could see that these distinctions in knowledge traditions underpin our modes and reflect patterns of scholarship as well as individual research interests. These questions forced us to consider what HCI is as a discipline (or as an identified set of practitioners, practices and processes). How is this cluster of research interests and approaches understood as more than the study of *humans* and their *interactions*, which already informs many other fields – from archaeology to futures studies and from theatre to psychology?

Tied to computation, one answer is to see HCI as a set of practices in the slipstream of digital technology development. A factor that thus defines these related studies is a relationship with industry and a dependence on industrial automation for relevance. This relationship – that technical relevance is not merely affected, but largely determined, by rapidly changing factors associated with industrial development, funding and market regimes – makes the concept of HCI itself prone to uncertainty and change. An analogy might be a young child dragged around on a shopping trip by a parent, never sure which shop is next. Researchers who identify with HCI have developed a strong sense of ethics, considerable generative research into potential interfaces and interactions for particular contexts and a design capacity that is now often regarded as the separate domain of *interaction design*. Yet, as a field of inquiry, it is particularly responsive to technological movements and this fundamentally shapes what is studied over time. This makes the evolution and borders of HCI prone to uncertainty. Further, when Liu *et al.* (2014) conducted a study of themes at the dominant HCI venue for sharing work, the annual CHI conference, they found that a major part of the 20 years of work they examined could be classified as *emerging and disappearing themes*. They concluded that the whole future of the discipline was uncertain.

One way of looking for a discernible discipline, despite this flux, is to see a tradition growing out of human factors work on military aircraft and psychology's increasing interest in the computer as a model of human cognition. This places early HCI methodology within the remit of science and engineering orthodoxies. Managing uncertainty to contain it was a rarely questioned tradition in man-machine studies and ergonomics, leaving a legacy as HCI formed itself. Scott (2008) notes that the very idea of discipline is itself disciplining – a part of what has been considered civilization. The history of the discipline forming is then a move toward methods for creating discrete phenomena that can be observed, described, classified and manipulated. Sociologist Norbert Elias (1972), who theorizes on disciplining the body as a civilizing move, addressed how this works in science: "By claiming absolute autonomy for one's subject matter one tries to secure the absolute autonomy of one's profession." (p. 85). Professional recognition and funding success

hang on such achievements. Telling a good, unambiguous story has been lucrative.

Yet, HCI has always been open to new influences and, though these have sometimes stayed peripheral or created new subcultures rather than influencing the whole body of thought, the sheer volume of new approaches that has swept through the domain makes it difficult to identify a heart to it. Aware of these faultlines, HCI practitioners have long participated in reflexive work, disputed about boundaries, and proposed that the fields involved render it an inter-discipline (Blackwell, 2015), where it might be valuable to consider generality rather than specialty (Blackwell quoting Scott Kim 1990) in bringing together scientific empiricism, the pragmatism of design and other influences: "Our community has broadened intellectually from its original roots in engineering research and, later, cognitive science" (Harrison *et al.*, 2007, p. 2). Bardzell and Bardzell (2015) describe the growth of alternative paradigms and point to the flourishing of an increasing "humanities-infused HCI". Nowadays, HCI's epistemological and methodological commitments (and forms of rigor) can be caught in *contrasting* the scientific and humanistic approaches rather than fastening on one approach to characterize the state of research – the discipline thriving in the space between knowledge traditions where the tensions are part of the field's fecundity.

Another significant though less visible influence is the ACM (Association of Computing Machinery) and its Digital Library (dl.acm.org), the organization supporting the majority of conferences in the HCI field and thus responsible for publishing a majority of findings). The ACM is a US organization aimed at an international audience and representing forms of computing that go well beyond HCI concerns. Its antecedence as a computing organization and ethical body for American IT professionals and its history as a scientific forum for a wide range of computer science fields has led to a style of reporting that emphasizes scientific good practice, maintained through style guides and publishing requirements. Light (2018) comments on the powerful influence of the ACM publishing model: set up to report findings, not engage in discussion and creating a creeping conformity toward an ACM style and tone, as well as format. The ACM traditions strongly constrain

how research from all HCI approaches is reported, and this affects how research is done. Devendorf *et al.* (2019) playfully subvert the dominant "findings" paradigm with Fluxus-inspired alternative contributions. Both are motivated by a desire to open research up to a broader play of ideas and structures and give methodological uncertainty a welcome on terms where it can support growth and change.

Something of this spirit informs the decisions we made as other authors came on board this project. Linked to our observations that HCI has porous boundaries and changes as digital technology goes through yet another revolution (e.g., becoming networked, domesticated, body-centered) is a lack of surprise that there are influences from anthropology, the humanities, critical theory, cultural studies and STS offering new interpretations of computation. While these may operate as countercultures within structures established by computer science templates, over many years auto-ethnography, situated knowledges, knowing otherwise, queering, seeking frictions, overtly political and campaigning work and other subversive movements have repeatedly reintroduced uncertainty into research practices, in the image of a wide array of different knowledge systems.

As we sought new understandings of uncertainty, these histories and associations came to life. We, the authors, come from related, but distinct, areas of inquiry, both in our commitments and our questions and, therefore, our understandings of how uncertainty may be engaged with. Over time, as our work has progressed together and our thinking matured, we have found spaces where our common concerns could evolve. We hosted an online workshop amidst the pandemic (Soden *et al.*, 2020), gaining additional collaborators and important insights. We began to identify patterns in non-disciplinary approaches to studying uncertainty. An early addition was generativity, in which uncertainty was viewed as a resource rather than an obstacle (Akama *et al.*, 2018). Once we gave this mode a name, we quickly noticed how it let us put in conversation a range of different literatures, including design for ambiguity, game design, and speculative design, in ways that felt meaningful and were compelling in our field sites. The other two modes, political and affective, followed shortly thereafter. Our thinking and ideas on the topic continue to evolve, and we do not claim this to be the final set of options when

engaging with uncertainty. Instead we see this as an opening up of the conversation, a glimpse of what becomes possible when the approach we take for granted is instead cast as one possibility amongst several.

Finally, we should note that the concept of uncertainty we engage with comes from a rich Western tradition of thought that values certainty. Yet, there are worldviews that do not settle upon single truths, origins or positions and, in such instances, even "uncertainty" becomes an entirely different experience or construct. These worldviews are most often categorized in HCI as "other" or "non-Western" epistemes and yet are legitimate ways of knowing and being in the world with relevance to HCI, because digital technologies impact diverse communities, ecologies and futures (see, e.g., Akama *et al.*, 2017a,b; Bidwell, 2010; Taylor *et al.*, 2018). We nod to a handful of references throughout the monograph to contest dominant ways of framing uncertainty and in our own accounts, to acknowledge the ethical and epistemic limitations of omitting plural worldviews.

In the next section we delve deeper into the four modes of uncertainty we have introduced here. We begin by considering the field's most apparent mode of engaging with uncertainty – disciplining. We then discuss the three further modes of uncertainty, touching upon their distinct theoretical lineages, methodological approaches, and contributions to HCI. After that, we provide a series of case studies, drawing on our own research to illustrate the ways that these modes enframe uncertainty across very different research settings. We close with further reflections on what this work offers to HCI research related to uncertainty, contextual factors that affect how one might go about working across and between modes, and opportunities for future development of the ideas presented here.

3

Four Modes of Uncertainty

In this section we offer four modes to HCI researchers working in domains or field sites where uncertainty is prevalent. We argue that these modes offer distinct lenses from which to approach uncertainty. Each asks different questions, deploys different methods, and configures uncertainty in different ways. Thus, each mode is likely to yield different sorts of contributions.

1. The disciplining mode is characterized by scoping, pinning down, measuring and predicting.

2. The political mode is characterized by asking "what counts" questions, looking at the hidden structures beneath the questions that get asked and examining the priorities implicit in the answers.

3. The generative mode is characterized by embracing uncertainty as a means to produce doubt where certainty may otherwise be assumed to serve imagination and creative thinking.

4. The affective mode is characterized by centering on the bodily experience of certainty.

In the following section, we discuss each in turn, offering a background to the mode along with characteristic examples from HCI research. We also discuss key types of contributions, as well as challenges or limitations faced by research working in each mode.

We find metaphorical similarities with modes in Western music, which offer composers a set of different configurations of scales, harmonies, and melodies which together yield different styles of music. Composers can work across different modes, trouble their boundaries, or reject them entirely in order to accomplish their goals. Similarly, we see these modes as offering different starting places for HCI researchers, acknowledging the dominant traditions of HCI but challenging them, even to the extent of questioning the epistemological basis for our ways of knowing. Depending on our habits or disciplinary backgrounds, we may be more accustomed to working within one mode or another, but our hope is to broaden the range and provide alternatives. This is not an exhaustive list and we envision future work adding further modes.

These modes may be most productively engaged at the early stages of a project, as research questions and plans are still being formulated. In these stages, the modes may suggest novel approaches or directions, help the researcher evaluate alternative framings, or draw surprising connections to other areas of HCI scholarship. We also see potential for the modes to be productive when they are used together, e.g., adding moments of generative thinking to a disciplining project or contrasting or finding synergies in the political and affective realms. In the following section, we note areas of connection between these modes as well as opportunities to use them in conjunction with one another.

3.1 Mode 1: Disciplining Uncertainty

The disciplining mode frames uncertainty as a problem, a challenge to be overcome through research design and the systematic use of replicable methods, to offer research that can be employed with confidence as the basis for action.

3.1.1 Background

We start with the disciplining mode of engaging with uncertainty in HCI. This is probably the most familiar approach for many readers. It has occupied center-stage in HCI education and contributed extensively to commercial and industrial research practices. Viewed through this lens, uncertainty is something to be overcome, managed, or mitigated in ways that ultimately contribute to the advancement of knowledge within HCI, while also giving a feeling of manageability. The disciplining of uncertainty in HCI is pervasive. It can involve managing humans, code, interfaces, interactions and/or whole products and systems, because uncertainty affects every part of the research and development process and subduing it allows the design of the research and/or the product to become what is intended. There is a direct link between the intention of design and the way that the disciplining mode is used to create efficiency and effectiveness.

Despite increased attention to so-called "wicked problems" (Rittel and Webber, 1973) or "post-normal" science (Funtowicz and Ravetz, 1994), as well as knowledge traditions where a critical perspective encourages debate, an expectation of consensus on what constitutes rigor continues to motivate the disciplining mode. A core concern is methodology, and a core methodological concern is what counts as the data to be managed and how the processes of managing data can be justified in terms of rigor, replicability and useful outcomes. Thus, data quality is a central preoccupation. There are ongoing debates on the relative merits of quantitative vs qualitative data and proposals for mixed methods (which implies employing both types of data and can benefit from using triangulation to go broader or deeper and eliminate mistakes and misinterpretations). These methodological concerns dominate the literature and discussion within the community to ensure trustworthiness and, as a result, work in this mode may not exhibit other forms of reflexivity, such as researcher positionality and responsibility for the outcomes of the research.

Looking at this mode, it is possible to see a relationship between ideas of "discipline" as an academic field and "disciplining" as a process: both run through HCI. "Disciplining" can refer to the normative work

of establishing and managing the HCI discipline as well as the processes associated with the field, attempting to create the orthodoxies of what work scholars will accept (and reject) as relevant to conferences, as legitimate in its research paradigms and as demonstrating convincing methodology. This work of maintenance has become a site of tension within the discipline, accounting for some of the resistance that may be felt to the disciplining mode by scholars with different priorities and understandings of what the research process may be. Not only are there different values in these varied influences and contrasting styles of scholarship, but adherents to the disciplining mode have, on occasion, rejected these other forms of knowledge in their pursuit of rigor. Thus, the disciplining mode is not only related to the disciplining of uncertainty that takes place within research, but it can also seek to constrain types of research and beliefs about method and relevance in the name of managing uncertainty effectively for productive outcomes. The functional aspects of this mode are pronounced and an appeal to efficiency is common, and this is sometimes extolled at the expense of contextual issues.

The disciplining mode comes from traditions where rigor involves the precision and definability of scientific practice. In HCI this approach found its pinnacle in methods such as GOMS, a process for exploring the performance of human tasks through a set of Goals, Operators, Methods for achieving the goals, and Selections rules for choosing among competing methods for goals (Card *et al.*, 1983). GOMS incorporated particular beliefs about the cognitive structures of action and was not sensitive to individual differences or growing abilities. Such approaches can be contrasted with anthropologist Lucy Suchman's (1987) work on situated action, the beginning of a long association between HCI and anthropology and a more nuanced understanding of the relationships between people and things. What Suchman demonstrated is that context and cultures matter, that intentions and actions have only the vaguest of relations and that systems are not interchangeable. While the insights from both GOMS and situated actions hail from more than 35 years ago, they set two principal directions for managing uncertainty within HCI. One is the disciplinary mode. The other opened the door to other modes

by acknowledging that complexity is irreducible and that uncertainty is not only inherent, but indeterminacy is too.

Given the unavoidability of uncertainty and the inherent subjectivity of techno-scientific practice (e.g., Latour and Woolgar, 2013), disciplining is always a compromise. There is much that is valuable to this compromising and, if growing less central, to the role that the discipling mode of uncertainty plays in HCI. There is a tradition of reporting empirical methods in enough detail to allow other researchers to judge the soundness of the research process and, thus, the findings. Methods are compared so as to optimize processes and produce research judged to be rigorous. Replicability is considered key to evaluating if method and findings are sound so that findings can be demonstrated to be robust. The RepliCHI suite of workshops and papers (e.g., Wilson *et al.*, 2011) speaks to the desire to show the scientific basis of data gathering by ensuring consistency. Appropriate sampling and sample sizes are considered for securing good research into people's patterns of belief, behavior and/or uses of technology. Eloquent critique of process is cultivated and, while this may be more dominant in this mode than critique of design outcomes, this has its own integrity related to taking responsibility for maintaining disciplinary standards.

There is a politics to the disciplining mode, but it is rarely discussed explicitly or leads to reflection on how technology is produced, the impact of design on society or the implications of seeking objectivity in research. Instead, the politics is subsumed in the performance of authoritative research that has followed due process and managed uncertainties appropriately. A downside is that outliers and other idiosyncratic data are regularly ignored as an intrinsic part of the process and detail may be ironed out. Both these processes lose access to the knowledge that anomalies and edge cases bring. And in some cases, a disciplining approach can lead to a fetishization of rigor and precision in a way that is more scientistic than scientific (Reeves, 2015). This can foreclose both productive and unproductive forms of uncertainty, but overall these practices allow focus and advance the practical knowledge which underpins many design decisions.

3.1.2 Types of Contributions

The disciplining mode takes an authoritative position, where uncertainty is eliminated as far as possible – or calculated and considered as a variable. The mode tackles uncertainty in HCI by offering structure and method to the work of analyzing and designing technology and appeals to replicability for its soundness. Work in this vein seeks to answer questions such as:

- How is uncertainty managed in data, in sampling, in the behavior of people and digital tools?
- What methods are used to manage uncertainty? How do they ensure rigor?
- Given that certainty cannot be assured, how is confidence presented? Is there a need to factor in degrees of certainty?
- What data has been excluded to eliminate uncertainty and how is this portrayed?
- What are the merits of different methodological traditions in research for managing uncertainty? How is the choice of method justified?
- How is uncertainty controlled or acknowledged in the crafting and deployment of autonomous tools and AI?

Disciplining makes the objects of research tractable and containable. This can be seen in research into human interactions, as well as in the design of computation and digital artefacts, where methods for constructing a consistent and replicable finding are highly valued.

3.1.3 Challenges

Representing Uncertainty

Disciplining uncertainty has evolved to produce a subfield concerned with representing uncertainty. This focuses on the communication of uncertainty to target users, in particular through data visualization.

Research in this vein has argued that communication of uncertainty helps inform decision-making in several domains, including hurricane risk and public transport and that visual representations of uncertainty are most effective (Bica *et al.*, 2019, Kay *et al.*, 2016). There remains interesting and important work to be done, however, to further understand when offering information about uncertainty is most useful (Greis *et al.*, 2017) as well as improve upon extant techniques to doing so. For example, Correll *et al.* (2018) experiment with novel means of including measures of uncertainty alongside the presentation of various types of data. Other work looks at attempting to better predict how audience's mental models and prior beliefs will inform their evaluation of data visualizations (Harrigan *et al.*, 2021). An increasing application for this work is in the field of sustainability research, where scientists need to demonstrate to policymakers how far their modeling is "accurate" and their confidence levels with their findings.

Deconstructing Tasks and the Challenges of Complexity

Complex systems are resistant to discipline and, more practically, some problems cannot be broken down, but only understood as emergent effects – for instance, the problem of cyberbullying does not live somewhere particular in the design of technology but is an emergent effect of networks, social media and user behavior. Disciplining succeeds by breaking down tasks to understand and manage them. While this works for even complicated tasks, complex issues such as cyberbullying, cannot be addressed by deconstructing them. An influx of thinking from the design disciplines in the 2000s has brought more tolerance for complex systems, which cannot be solved once and for all but must be treated as wicked problems that absorb and reshape intended solutions (Buchanan, 1992; Rittel and Webber, 1973). This form of uncertainty may meet with resistance, however. For instance, disciplining regimes may reject the argument that wicked problems do not have solutions, or that some problems currently framed as wicked simply require further work (see Anderson and Kolko, 2008 for one example).

Uncertainty by Design

New challenges come to disciplining from the technologies that networks, processing power and machine learning are introducing into the human-technology relationship that sits at the heart of HCI. As remoteness to ones and zeroes grows through layers of technique for coding and designing, it gets easier to assemble tools, but more mysterious as to why they do what they do. Now AI and machine learning have broken the relationship between design and the power to comprehend internal structures of action (Ananny and Crawford, 2018). Machines with deep learning can develop behaviors that were not specifically programmed in. The less one understands about why something works the way it does, the more this uncertainty can result in unexpected outcomes. The disciplining mode faces a particular challenge with these developments, despite the critical importance for lines of responsibility, liability and duties of care. What may be solved for manufacturers by end-user agreements that resituate uncertainty into the domain of the user, does not do away with the fundamental shift in what can be understood and therefore how much uncertainty accompanies particular computing initiatives, such as AI or quantum computing.

Managing Data Certainties

Meanwhile, as data increasingly come from multiple sources to be aggregated and used for decision-making, HCI needs to have a role in explaining how the certainties built on this aggregation are open to several potentially faulty assumptions. As layers of information infrastructure are stacked, assumptions become realities, with some fall-out effects (Aragon *et al.*, 2022). This phenomenon needs scrutiny as the outcome of disciplining activities in the design of research and development processes. First, the data themselves may be faulty, creating inaccurate records. Second, it may be impossible for affected individuals to prove that the data or the processing of them led to errors. Third, data have a tendency to persist and be re-aggregated, which may repeat errors and emphasize problematic aspects. It will necessarily present a view distorted by design choices. Networks make data easy to share, compare and link. The power to aggregate and manipulate across space

results in synergistic effects, which are amplified by the commercial imperative to mix different sources of data and produce consumer, lifestyle and identity profiling. The disciplining mode can begin to address unpredicted or undesirable outcomes of networking data by considering how data will be absorbed into systems that are wider than the reach of a particular project or development.

Whose Certainty?

The relationship between HCI and disciplining also appears in how tools are designed to discipline their users and avoid uncertainty in life. Nudge (Kosters and Van der Heijden, 2015) and persuasive technology (Fogg, 2003) are used to manage behavior through designed interactions that promote compliance without reference to conscious choice. For instance, nudge is used in how wayfinding devices at airports direct flow of passengers and manage uncertainties for locating destinations quickly. This may reduce anxiety (Ferro, 2014), but in practice also tends to nudge people through shopping areas for potential purchases. A concern with devices that maneuver rather than engage their owner/users is that the design presupposes that experts are right – it is a top-down model. But this factors out uncertainty completely and makes no allowance for changing advice. It has been shown that nudge cannot solve complex policy problems (Selinger and Whyte, 2012). While experts may be right in encouraging a healthier diet or daily exercise (both early areas of interest for persuasive technology), the right answer is not as certain in areas of long-term sustainability. For instance, nudge may help with recycling, but not goals to consume less, upcycle, repair or reuse, all of which save more resources and encourage more personal creativity. Light *et al.* (2017, p. 278) argue that nudge and persuasive technologies can keep people stuck in old habits that need to be superseded, reducing "generic capacity for adaptation at a time when change is accelerating" and "likely to create a culture where initiative never breaks out of familiar paradigms."

3.2 Mode 2: The Politics of Uncertainty

The political mode takes the relationship between power, values and knowledge about uncertainty as its focus: asking how uncertainty is produced, why some uncertainties receive more attention than others, and how the answers to these questions are shaped by the distribution of power in society.

3.2.1 Background

This mode examines the ways that structural factors in culture and politics influence our encounters with and understandings of uncertainty, and with what effects. In this mode, as in the previous one, uncertainty is a question of knowledge, and the technologies and socio-technical practices that give shape to that knowledge. As Scoones and Stirling (2020, p. 4) argue, "uncertainties therefore are conditions of knowledge itself – how we understand, frame and construct possible futures – and are not just hard-wired into 'objective' situations". As with other approaches to categorization and classification (Bowker and Star, 1999), approaches to formalizing uncertainty can be written into law, expressed in popular culture and the public sphere, or otherwise determine people's lives and interpersonal relations in ways that have significant consequences. Standards are often also taken for granted, fading into the epistemic infrastructure and socio-technical imaginaries (Jasanoff and Kim, 2015) of both everyday life and research in HCI. As such they can be remarkably durable, difficult at first to recognize and then to unseat.

HCI has a long, if uneven, history of examining the relationships between computing, power, and politics. As a result, we have a diverse collection of tools and concepts to draw upon when working in this mode of uncertainty. Early formulations of participatory design, for example, looked to the potential of technology in augmenting trade union efforts to accomplish workplace democracy and resist approaches to automation that simplified and deskilled labor practices (Ehn, 1988). Participatory design has since developed to offer an important means of examining and shifting power relations, both in the design process and

in the contexts in which it is applied (Beck, 2002; Huybrechts *et al.*, 2017; Pihkala and Karasti, 2018). These practices create uncertainty by questioning authority, power and what politics are influencing the design process. For example, reframing accessibility in technology involves how people with a range of abilities participate in the design and research process, to address higher-order agendas of who, what, when, why and how (Bennett *et al.*, 2019; Das *et al.*, 2020). Others including citizen science, participatory AI, and, in some situations, crowdsourcing, similarly challenge expert or otherwise dominant framings to expand alternative perspectives.

Another broad category of work in HCI, research into data standards and systems of classification has, for decades, investigated the role that such formulations play in shaping our knowledge systems, and with what effect (Bowker and Star, 1999; Lampland and Star, 2009). Standards and classifications determine the ways in which uncertainty is represented in information infrastructures (Star and Ruhleder, 1996), influencing what is given attention and how we experience uncertainty, in turn, showing how disciplining may be achieved. Research in this vein has demonstrated such infrastructures tend to privilege the biases and worldviews of the powerful, and can have significant impacts on lives of the people and social systems they purport to represent, depending on the various ways they are rendered legible (or not) to these systems (Alkhatib, 2021; Bowker and Star, 1999). Analysis of environmental models used to predict and prepare for climate change, for example, shows how competing imaginaries of place and society's relationship to nature were reflected in alternative approaches to creating data about sea-level rise, and that commonly used approaches tended to favor some imaginaries over others (Soden and Kauffman, 2019).

Research in the political mode of uncertainty draws on methods from the humanities and critical social sciences (Bardzell and Bardzell, 2015; Harrison *et al.*, 2011). The links between power and knowledge are widely explored in these fields, because of continued concerns about what these are assumed to be. In addition to the participatory methods described above, this may also include ethnography (Dourish, 2014) and historical research (Soden and Palen, 2018; Soden *et al.*, 2021a) as well as critical and speculative design techniques (Wong and Khovanskaya, 2018) trace

politics and power and their effects on knowledge systems. Entrenched assumptions in AI systems call for "studying up" (to show, for instance, how algorithms influence social justice processes) (Barabas *et al.*, 2020). In addition, "value sensitive design" offers multiple practical techniques for surfacing hidden values embedded in technology design, including those held by stakeholders (Friedman and Hendry, 2019).

Research in feminist and social justice oriented HCI has sharpened our attention to how the design of technologies can reflect and entrench discrimination and oppression along various axes of power. Scholarship from fields beyond, such as critical race theory (Ogbonnaya-Ogburu *et al.*, 2020), queer theory (Light, 2011), critical disability studies (Forlano, 2017a), and post/de-coloniality (Irani *et al.*, 2010) is reorientating HCI research toward understanding multiple, intersectional precarities that are being experienced by many. These draw attention to why some communities face more harmful forms of uncertainties, and bring ontological focus on multivariate experiences of uncertainty that are both shaped by, and work to entrench wider patterns of inequity and marginalization in the societies in question.

3.2.2 Types of Contributions

The political mode of uncertainty is a critical and reflexive position, in that it helps to evaluate the consequences of particular constellations of knowledge, standards, assumptions about uncertainty that can often be assumed in the disciplining mode. This can reveal the relationship between particular categories, such as data and technology design choices, or structures like inequality, precarity and histories that create particular experiences. Ultimately, this mode can help achieve what Scoones and Stirling (2020, p. 21) call "an open and accountable relationship to uncertainty."

The political mode of uncertainty in HCI offers a bundle of theoretical perspectives and methodologies aimed at uncovering the role that cultural and political power play in defining whose common or commonsense views on uncertainty is in focus. Work in this vein seeks to answer questions such as:

- Which uncertainties are given attention? In contrast, what certainties are assumed?
- What categories and standards are used to enframe uncertainty? With what effect?
- When uncertainties involve harms, threats, and risk, how are they variously experienced and portrayed? Who and what is at stake?
- What can we learn about the political and cultural context of our research sites by examining how uncertainty is conceptualized and addressed?
- What are the positionalities of those researching and participating? Whose accounts are given, and whose are omitted?

As we will see with generative mode, this shows that things might be otherwise: current politics and technologies are not inevitable. It is therefore broadly critical in orientation. In some cases this mode can and does present alternative designs (Irani and Silberman, 2013; Vlachokyriakos *et al.*, 2018).

3.2.3 Challenges

Interactions Between Society and Technology

One challenge for work in this mode is demonstrating causal directions between societal perceptions of uncertainty and the data and technologies used to represent them. In other words, do we think (and enforce) certain things about a topic because that's what our data tells us? Or did we design our data in a certain way because it tracks with wider scientific and cultural perspectives on a topic? Such interactions are often mutually constitutive and thus untangling the complex interactions can be difficult. This can also make it challenging to determine how and where to best intervene.

Interdisciplinarity

A key challenge of the political mode is the intensely interdisciplinary scholarship of much of the work in this space. This mode often requires

that researchers draw on bodies of scholarship far afield from what is taught in introductory HCI courses, including work in the humanities such as critical studies of gender, class, race, history, and political economy. Arguably, more effort is needed to develop and articulate a more expansive vision for HCI research. However, we caution that expansion can be turbulent and destabilizing, especially when this requires fundamental questioning of deeply held ideas. It is not that easy to "let go" of "expertise" or knowledge and experiences acquired through hard work. A political lens can help sharpen the ethics of boundary crossing and mixing while being open to complexity. However, it is not always clear that what many universities and departments consider "core HCI" at present adequately prepares future designers and researchers to address these questions. This forces us to confront challenges raised earlier, relating to the boundaries of HCI research, and how these have been negotiated over time.

More-than-Western Viewpoints

Another concern with much of the political rhetoric around HCI is that while it challenges the way that designs and values are uncritically manifested in mainstream technology, it rarely goes further to question the onto-epistemological basis on which even this critical scholarship in HCI is built. The centrality of Western thinking is increasingly challenged, such as in critiques of the outputs of Modernity (Irani *et al.*, 2010; Sengers, 2010), in Technology for "Development" (Bidwell and Browning, 2010; Brereton *et al.*, 2014; Winschiers-Theophilus *et al.*, 2015) decolonizing design (Escobar, 2018; Schultz *et al.*, 2018), more-than-human (Akama *et al.*, 2020; Liu *et al.*, 2019) and Indigenous cosmopolitics (Christen, 2001; Cushman, 2013; Schultz, 2018). Such scholarship welcomes pluriversal worldviews as onto-epistemes for understanding and being in human-human-other relations. These are merely the sharp end of a tendency to overlook work in languages other than English and its written form, and politics other than that which is legible in the Global North-West.

Access/Positionality

Uncertainty tends to be observed and studied from a position of confidence and privilege by those who can "afford" to be uncertain or those who are willing to take on risk (Akama *et al.*, 2018). This requires further heightening of ethics and careful, reflexive, collaborative research, especially when working with participants with varied, intersectional disadvantages As a community, HCI has significant work to do in accessibility, diversity, inclusivity and equity, not to take these as given or assume their importance but to examine each and more, openly with participants.

3.3 Mode 3: Uncertainty as Generative

The third mode we propose assists researchers to approach uncertainty as an opportunity for new forms of generativity and creativity through reflexive reorientations of their work or imagining alternative possibilities.

3.3.1 Background

Approaching uncertainty with a generative lens has several lineages in HCI. One approach focuses on temporal dimensions of uncertainty, often conceptualizing the future as uncertain, creating a generative space in the present to imagine multiple and alternate types of futures. Facing an uncertain future, generating many possible futures can help people in the present try to understand, prepare for, or gain insight into how to engage with these. Possible and uncertain futures are attempted to be knowable and manageable in the present through practices such as scenarios.

HCI scenario practices draw on concepts from futures studies (Go and Carroll, 2004) (sometimes implicitly), which posits that the future is inherently uncertain, and scenarios can help people contend with multiple possible futures (Pargman, 2017). Nathan (2008, p. 2) justify scenarios' usefulness by arguing that "to engage in systemic thinking in the face of complexity and uncertainty designers need [...] generative tools that enable them to consider and enumerate possible futures." It

is thought that designers, institutions and businesses can better plan for the future by preparing for potential risks in the present. Creating and exploring potential futures acknowledges the uncertainty in being unable to anticipate and explore every possible outcome, including a way to contemplate and mitigate potential harms.

Related HCI research that focuses on the uncertainty of the future recognizes that visions of the future are socially constructed in the present, such as Dourish and Bell's (2011) work discussing how the near or "proximate" future of ubiquitous computing is continually socially maintained and updated. Additional HCI research focuses on the shared visions of the future that groups and institutions create and work toward (Lustig, 2019; Wong and Jackson, 2015). This research makes an analytical move that recognizes that these visions of the future can be contested, re-defined, and re-worked. This creates a space to utilize generative approaches to reconsider what many futures might be like, and for whom (including more-than-humans).

Design futuring methods provide a way to imagine what futures might be like, by depicting and imagining possibilities in order to produce knowledge through reflection, debate, and contestation (rather than solving an immediate problem) (Kozubaev, 2020). These include methods and practices such as speculative design, critical design, adversarial design, and design fiction. Design futuring methods seek to provoke or dwell upon uncertainty by generating and exploring multiple possibilities, in order to critique, question, or propose alternate sociotechnical configurations of many worlds. By positing the future as uncertain, these configurations are then opened up as inspirations for design, or social or political action. While often future-oriented, the worlds imagined through design futuring methods can be used to view the present or past as uncertain using the same critical lens. This allows researchers to explore alternative or counterfactual presents (Auger, 2013; Hillgren *et al.*, 2020), or provide alternative perspectives on historical practices (Jungnickel, 2015; Rosner, 2018; Tanenbaum *et al.*, 2012). Altogether, these practices can help challenge the linear stability of the past, present, or future that characterize particular worldviews.

A second lineage of approaches uses generativity to create uncertainty about the structures and categories that researchers use to make

sense of many worlds in order to suggest other ways of knowing and being. Rather than seeing systems as stable and certain, moments of breakdown or disruption provide the opportunity to surface or change the politics of systems, as described by scholars studying infrastructures (Houston *et al.*, 2016; Star and Ruhleder, 1996). Designers can utilize methods that explicitly create new moments of disruption or breakdown to surface, unravel, and contest the politics of sociotechnical systems (Wong, 2020). Rather than try to hide messiness through "seamless" or invisible design, "seamful" design recognizes that technologies present uncertainties in how they may breakdown in messy and complex ways (Chalmers *et al.*, 2003; Inman and Ribes, 2019). Seamful approaches see these frictions and breakdowns as new opportunities for thinking about relationships and interactions between humans and technologies. Similarly, Gaver *et al.* (2003) posit that ambiguity can be seen as a potential resource for designing systems rather than something to be disciplined. Thinking of uncertainty generatively can help researchers relate and lean into uncertainties and help others to do so, often through enabling people's participation by invoking curiosity, reflexivity, learning and catalyzing transformation (Akama *et al.*, 2018).

Other practices use design to intentionally create uncertainty in order to challenge what "counts" as HCI research, playing with the field's boundaries and norms. These practices often fall under the umbrella of "research through design" (Frayling, 1993; Gaver, 2012). Some practices invert dominant metaphors to pay attention to what is considered at the margins rather than the center of the field, such as critical technical practice (Agre, 1997; Dourish *et al.*, 2004) and reflective design (Sengers *et al.*, 2005). Critical design offers a way to consider and embrace alternative norms than what may be at the center of HCI, for example, challenging the idea that design necessarily "solves" problems (Bardzell and Bardzell, 2013; Blythe *et al.*, 2016; Dunne and Raby, 2001; Morozov, 2014). Practices of purposely creating new uncertainties for researchers to experience, such as utilizing artistic "disruptive improvisations" (Andersen *et al.*, 2018) or "amusements" (Devendorf *et al.*, 2019) can help researchers and designers explore new experiences while also exploring and challenging HCI norms, such as asking what counts as a "contribution" to the field. Together, these

practices use generative methods to intentionally destabilize or produce uncertainty in what otherwise feels certain as a mode of inquiry or way of knowing in HCI.

A third lineage couples generativity with reflexivity (Bardzell and Bardzell, 2011; Light, 2011) to attend to relationalities and positionalities more carefully when enacting change. The emphasis on self-awareness, internal transformation and learning, at least from the outside, might not be as "obvious" to be noted as creative, but even subtler shifts in perspectives, which reflexivity enables, can be quite radical in adjusting courses of action. Co-designing and participatory design are always contingent upon the dynamics of collaborative and community work, requiring researchers and practitioners to be adaptive, responsive and reflexive in unpredictable circumstances (Akama and Light, 2018). The willingness to lean in, to embrace turbulence and work with disruptions (Akama *et al.*, 2018), to enable off-plan forays and negotiate expectations demands critical, ethical and creative commitments.

Research focusing on appropriation and reappropriation of technology acknowledges that there is inherent uncertainty in the deployment and adoption of technology, as people will interpret and use them in ways that designers or researchers did not expect. Rather than viewing these unexpected uses negatively or pathologically, it can be an opportunity to see alternative relationships, values, and ways of being in the world. Studying practices of appropriation and unexpected use can help researchers gain insight into cultural processes (Lindtner *et al.*, 2012); and technologies can be intentionally designed to support more open-ended engagement and appropriation (Sengers *et al.*, 2008).

3.3.2 Types of Contributions

Generative approaches re-purpose uncertainty as a resource toward different ends.

Creating conditions for something different or new. Generating scenarios that show different outcomes or visions of an uncertain future can help coalesce resources, work, expectations, or sentiment toward enacting

particular futures over others. Generativity can also help researchers explore uncertain problem spaces, such as identifying new potential risks or harms related to emerging technologies. Researchers might ask questions such as:

- What possible alternative socio-technical configurations of the world can we imagine?
- What is the problem space of an emerging or uncertain domain?
- What are the possible courses of action in an uncertain domain?
- What social values do researchers (and other stakeholders) want to center in the worlds we work toward?

Creating new uncertainties to destabilize what seems "certain". Designers, researchers, and practitioners can also intentionally introduce new forms of uncertainty into situations. This might be done to create new experiences, as a way of destabilizing and calling into question practices and organizations of knowledge, power, and expertise. This might also be done to critically analyze a phenomenon, or present new alternatives. Questions that researchers might ask here include:

- How do we make what seems inevitable seem less certain? (Making both seemingly certain dystopian and utopian futures seem less certain)
- What can we learn by introducing uncertainty into these situations?
- What can we learn by inverting relationships of power and making the dominant seem less certain?
- How do we trouble certainty and singularity in design claims in order to make space for multiplicity and conflict in outcomes?

Sitting with existing uncertainties in a new way. Researchers can consider viewing existing uncertainties in a new light, as a resource for design rather than as a problem to be solved. The mere act of noticing differently and embracing uncertainty can be active and generative in

its own right, suggesting new possibilities for how people might relate to technologies and systems of knowledge. This could open up spaces to ask new normative or ethical questions about how people *should* exist and behave. This embrace of uncertainty may help orient us toward greater uncertainties we may face in the future (for example, uncertainties caused by climate change). This reorientation toward uncertainty may also serve as a form of building capacity for resilience, especially for fields or practices that are currently premised on certainty and prediction. Questions that researchers might ask here include:

- How can uncertainty be used as a resource for design?
- How might we notice uncertainties that are not intentionally caused by researchers and designers in new ways?
- How can we relate to or co-exist with uncertainties?

3.3.3 Challenges

Several challenges exist when using the generative mode:

Who gets to participate in generating perspectives, and on whose terms?

Researchers have advocated more diverse participation and perspectives to be represented in speculative and futuring practices, drawing on traditions such as participatory design, co-design, Afrofuturism, and feminist utopianism (Bardzell, 2018; de Martins and de Oliveira, 2016; Gatehouse, 2020; Light, 2021; Winchester, 2018). Yet inclusion requires more than just broadening the number and types of people who are involved, but rather necessitates reflecting on how current practices and structures also serve to exclude. For instance, the time and place of a design workshop can serve to include or exclude certain populations (Rosner *et al.*, 2016), or academic authorship norms may prevent co-designers from receiving the same amount of credit for a project as an academic author (Light, 2018).

How do we make spaces for multiplicity?

Generative approaches to uncertainty suggest multiple orientations and relationships that people may have with uncertainty–such as thinking about multiple forms of futures, or viewing and experiencing the same uncertainty in different ways, or recognizing different and multiple forms of uncertainty. Creating zones for a critical technical practice within a field can help recognize and legitimate multiplicity (Agre, 1997; Dourish *et al.*, 2004). Yet there can be challenges in enacting this work within existing research disciplines or communities, as researchers may need to choose when to uphold and when to challenge dominant community norms in order to remain legible to the field (Khovanskaya *et al.*, 2015).

How do we trace and communicate generativity and uncertainty?

What materials, practices, and media are used to engage and "trace" uncertainty? (Akama *et al.*, 2018) What are the implications of using different materialities and forms of media? Uncertainty might be explored through forms including writing, video, audio, photography, drawing, mathematical model making, data collecting or interacting with other people. How might different materials encourage different types of relationships that people have with uncertainty? Likewise, how are these engagements presented to other audiences? While text-based academic papers present one form of communicating the outcomes of uncertainty (and knowledge gained), other formats such as pictorials, design fictions, interactive exhibits, zines, workshops, and so forth may serve to convey uncertainty in new ways and emphasize aspects such as the aesthetics or the effects of uncertainty (e.g., Temple Works, 2015).

How do we communicate our goals and politics of generativity?

Researchers, designers, and practitioners may have a variety of goals or politics when working in the generative mode. For instance, someone may have a pragmatic desire to use generativity to help make decisions in the present amidst uncertainty; someone else may wish to introduce a more critical set of politics by creating disruptions and new forms of uncertainty; others may shift their goals as they move between different

groups and communities. How can researchers and designers be reflexive about their goals and politics while using and communicating about the generative mode? Without a clear understanding of a project's political commitments, it is possible for generative and speculative work to be reappropriated by systems that it is trying to critique or position itself in contrast to? (Wong and Khovanskaya, 2018)

3.4 Mode 4: Uncertainty as Affect

This fourth lens, the affective, focuses on humans' lived and felt-experiences of uncertainty. To use "affect" in this way is to align it within post-anthropocentric theory, as it describes the capacity for any given body to act upon another (Bennett, 2010). Uncertainty, here, can be seen as a potential or force formed at the intersection of speculation, memory, and human corporeal experience. This is best captured in the colloquial use of the English word "feel"—we come to *feel* uncertainty as much as think *about* uncertainty, as though it is a kind of premonition, a ghost or something unsettling. But what is this feeling? How do we come to "feel" a statistic force, or field of possibility? And how have such feelings given rise to modern technologies that engage uncertainty? This lens allows researchers to focus attention on how we investigate and render the felt-experiences of uncertainty, and the responses we devise to address (and often placate, sanitize or rationalize) the body.

To engage the affective lens of uncertainty, we must first acknowledge that uncertainty can produce bodily and emotional responses. For many, uncertainty produces feelings of fear or vulnerability, which many people see as negative experiences and, thus, targets for a technology to alleviate. The affective lens asks us to refrain from judging the quality of this experience as good or bad and to investigate and/or render it in new forms. Using an affective lens within HCI specifically allows technology to play many roles, such as: a subject for reflection (how is technological adoption shaped by discomfort in uncertain situations); or a medium through which one can express or tell of their experience (say, a design probe for logging emotional experience of an unknown future). Furthermore, affect can be a facet of experience to consider alongside the interpretation and representation of "objective" data. As D'Ignazio

and Klein write in their explanation for including emotion in data visualization, "the embrace of multiple perspectives and positionalities helps to rebalance the hierarchy of reason over emotion" (D'Ignazio and Klein, 2020, p. 84). Holistically, the affective lens foregrounds felt and emotional elements of experience and implicitly asserts that such experiences are worthy of representation and deeper consideration. It tempers the habit we often see in Design and HCI to jump to solutions by asking, first, if a solution is possible, desirable, or simply offers a distraction or illusion of control. By taking up an affective lens to uncertainty, researchers may develop nuanced understandings of the emotional landscapes within which technologies are shaped and deployed.

3.4.1 Background

The history of HCI reveals many ways to investigate affect. The disciplinary diversity of this field has led to different treatments and considerations of what "counts" as affective experiences. These various practices tend to separate mind, body, and the social in various degrees of fidelity and enroll distinct methodologies toward their inquiry. Below we distinguish three threads in the treatment of emotion that characterize work in HCI. These threads are not comprehensive and in their rough categorization we acknowledge that obscure approaches that blend multiple perspectives.

Affect as Categorical Data

The first treatment of affect, largely common in cognitivist traditions, is to treat it as a series of emotional categories that a person can identify with (or a computational system can infer from facial expressions or biodata) at any given time. This data can be used as input to a technological system, can classify broad trends in emotional experience, or can be used to evaluate the effectiveness of a system in terms of the emotional experiences it produces. While it offers strength in its ability to classify, organize and make arguments about aggregate populations, the categories lack nuance in capturing highly personalized experiences

of emotion or the existence of multiple, even conflicting, emotions in a given situation.

Affect as Interaction

Researchers aligned with the humanities and some social science traditions diverge from the cognitivist perspective by shifting the unit of analysis from the individual to the collective. Boehner *et al.* use the term "affect-as-interaction" to acknowledge the interpersonal dimensions of affect (Boehner *et al.*, 2007) and the situational and embodied qualities of experience that are left out of studies of individual minds. Researchers working in this thread tend to take an ethnographic orientation by immersing themselves in the lived environments of users, groups of users or particular interactional settings and render affective experience through written narratives of the events that took place.

Affect as Embodied Physical Experience

Others focus on affect from the perspective of bodily, or felt, experience. This unites affect as a phenomenon that is co-constructed in the body and the mind. The central role of the body as locus of experience has been visible within programs of whole-body interaction (e.g., Fernaeus *et al.*, 2012), gaming (e.g., Mueller *et al.*, 2018), and soma design (e.g., Höök, 2018) and tend to focus on studies (either autobiographical or with a small set of participants) in which emotions and physical experiences are both induced and described. These outcomes may exist as written narratives of felt experience and also become embodied in technological objects that participate within the somatic experience (such as Lindström *et al.*'s (2006) *Affective Diary*). Rather than attempting to categorize or make sense of collective emotion, such work acknowledges that elements of experience cannot always be articulated as language and seeks broader, more inclusive methods of participating within affective experiences.

3.4.2 Types of Contributions

Considered alongside the disciplinary, generative, and political lenses, the affective lens of uncertainty attempts to bring discussions of feeling, of both designers and users, into the calculus of design. The affective lens thus aligns with Puig de la Bellacasa's (2017, p. 81) interpretation of "thinking with" uncertainty in that it "creates new patterns out of previous multiplicities, intervening by adding layers of meaning rather than merely deconstructing or conforming to readymade categories". This definition renders both affect and uncertainty as "multiple"– entities that are enacted in various forms while held together by the same names (Mol, 2003, p. 152). The affective lens, thus, attempts to make this landscape visible and participate within it in particular ways and in its foci and outcomes, creates the following (non-exhaustive) list of contributions:

Renderings of Uncertain Experiences

One form of contribution the affective mode offers is renderings of deeply personal experiences of affective experience. We call them renderings, rather than descriptions, to highlight that these can take more forms than simply written accounts or descriptions and can instead be embodied in sculptures, paintings, sonic experiences or alternative design objects such Design Memoirs (Devendorf *et al.*, 2020a). These renderings, like ethnographic accounts, contribute to HCI in their ability to alert or sensitize a broader research community to a particular concern or constituency. They help us reflect on our patterns of design by articulating a deeper sense of how and why a situation led to a given desire for a technology. Uncertainty figures into these studies in that they often focus on reactions to uncertain events or situations. Thus, such contributions can emerge from questions like:

- How might people describe the physical/emotional experience of working from home?
- What is the emotional experience of self-tracking during a major life transition?

– What affective experiences contributed to the use of an IoT home surveillance system?

Reflective Designs

Beyond narrative objects and descriptions, investigating uncertain situations and experiences through an affective lens can lead to design objects that intervene and/or provoke a person to engage in reflective activities about their affective experiences. Such devices offer a particular somatic exercise, activity or response that encourages someone to reflect on their affective experiences of uncertainty. These could be engaged within a design study, in the form of probes or co-speculations, or may be an outcome of a design activity. These might emerge from questions like:

– How might a design object provoke deeper reflection on one's response to news about the climate crisis?

– How might users live with a smart home device that responds "I don't know" when it does not have a verifiable answer to a question?

Calls for Attention to Understudied Domains of Inquiry

The focus on physical experience can also foreground domains of inquiry that have received less attention in HCI. Specifically, attending to the felt might allow us to interrogate aspects of experience that defy simple rationalization. Subjects like transcendence, desire, carnal urges, or rage can become the focus of inquiry because the affective lens does not need to categorize them so much as draw out their dimensions and relationships to uncertain phenomena. We might also ask about how spiritual practices shape technological adoption? By taking root in embodied and situated perspective, "thinking with" uncertainty through an affective lens allows us to investigate how uncertainty manifests within different bodies, different spaces, and people holding different worldviews.

3.4.3 Challenges

Reflective or Self-Indulgent?

One of the challenges that emerges with the felt, especially when approached from an autobiographical perspective, is knowing when to stop—which aspects of personal experience are meaningful to contributions in HCI and which are better kept to ourselves? As we consider how to navigate this challenge, we wander into politically charged discussions within HCI. The first considers the longstanding influence of political/patriarchal practices in determining what we believe "matters" or is "new" for HCI (Devendorf *et al.*, 2019). The second considers the role of art and craft practices within HCI as an affective recollection of our own, or of a subject, will never stand up to traditional notions of scientific rigor. They are viewed as rooted in subjectivity, bias, and positionality and, as Gaver (2012) argues of design research, their fertility lives in the imaginations and emotions they may provoke. Just as a book, movie, or memoir can move and prompt perspective-altering insights, affective or autobiographical research can focus on an HCI audience, digging specifically into details and experiences that fundamentally shape the design and implementation of interactive systems. As work in this domain diversifies, debate will likely ensue.

Research Ethics

Probing the felt experience autobiographically or with a group requires careful navigation of research ethics because it is likely to surface emotional responses, painful experiences, and trauma. This may especially be the case in contexts where research subjects care deeply about the contexts in which the research is taking place (Howard and Irani, 2019). Recent scholarship has highlighted the emotional labor of design research for both designers and participants (Balaam *et al.*, 2019; Hirsch, 2020). Hirsch specifically argues for "trauma-informed" research and consent practices while Howard and Irani suggest that guidance can be found in bioethics and Feminist Science and Technology Studies (STS) Literatures. A point of consensus among all this work is the agreement

that existing university ethics protocols do not fully account for the power dynamics and unexpected outcomes in reflective design research.

4

Case Studies

In this section, we draw on our own research in quite distinct areas – disaster risk, cybersecurity, healthcare, and community organizing – in order to explore how the different modes of uncertainty we have introduced so far illuminate different aspects of each case, raising different questions and making different contributions as a result.

4.1 Modes of Uncertainty in Flood Risk Modeling

By Robert Soden

4.1.1 Introduction

Over a four-day period in September of 2013, a year's worth of rain fell on Boulder County and the surrounding region. This was called a 1,000-year rainfall event and it flooded every major drainage along the Front Range, killing a number of people and causing hundreds of millions of dollars in damages. The flood upended the lives and livelihoods of entire towns in the mountainous area, taking years to recover. Some who lost their homes were never able to return. As is the case in every disaster, the effects of the 2013 Colorado floods were

distributed unevenly across different households and communities in the region, but its exact impacts were unpredictable and, to some, quite surprising. In the popular imagination, disasters are defined by their extreme uncertainty. By examining the impacts of risk modeling on public perceptions of uncertainty related to disaster in the run-up to the Boulder floods, this case study engages with both the promise and limits of the disciplining mode, and demonstrates the importance of alternatives.

The Latin roots of the word disaster literally mean "bad star", signifying the extent to which the causes of these "acts of god" were for so long believed to be beyond the reach of humanity. Attempts to tame such vagaries of nature through reason and systematic observation were central parts of the Enlightenment project. In the wake of the devastating Lisbon earthquake of 1755, Rousseau, contra both to those who chalked the event up to God's revenge on an immoral society and to others who saw it as evidence of a capricious universe, argued that the vulnerability to the earthquake was the result of everyday decisions about where and how to build our cities and how to organize society (Dynes, 2000). These arguments were novel at the time but they helped, along with developments in physical sciences that led to increased understanding of why earthquakes happen, to introduce a sense of agency over subsequent decades and centuries into societal relationships to disaster that had been previously lacking in European discourse. In this emerging view, disasters were caused by interactions between dangers in the environment, and societally determined vulnerabilities to these dangers. Disasters were thus, within limits, both foreseeable and preventable.

Flood risk modeling is an interdisciplinary technical effort to estimate the likelihood and potential impacts of flooding for a given place and time. Drawing on engineering expertise and scientific study of hydrology and related fields, flood modelers use complex statistical software to bring together data describing phenomena such as rainfall, elevation, soils, vegetation, and elements of the built environment into a common frame where their interactions may be analyzed. The models are meant to inform risk management efforts such as emergency preparedness, land-use planning, or flood mitigation projects. One of the largest consumers

of flood models in the United States is the NFIP, or National Flood Insurance Program. Enacted by the federal government in the late 1960s as a means of mitigating the increasing financial impacts of flooding, the program requires that owners of properties found through the use of standardized flood models to be within the 100-year floodplain purchase flood insurance. Though the 100-year flood maps were designed primarily to support the NFIP program, they play a major role in shaping the popular imagination of flood danger across the country, influencing real estate markets, local planning, and individual decision-making about flood preparedness.

To better understand the influence of the 100-year floodplain models on the public's experience of risk, colleagues at the University of Colorado and I (Robert) conducted a research project in the wake of the 2013 floods (Soden *et al.*, 2017). To examine expert perspectives, I took an internship at an engineering firm that was contracted by the US Federal Emergency Management Agency to update the 100-year floodplain maps for the state. While there, I assisted in various tasks related to data preparation and map production, looked over the shoulder of experienced engineers as they went about their work, and interviewed many of the firm's employees about their perspectives on the process and its outcomes. In addition, our research team interviewed members of the public about their experiences during the flood and the role of the flood maps in shaping their understanding of risk. The perspectives we explored through this research help illustrate how each of the modes of uncertainty leads to very different conceptions of flood risk.

4.1.2 Disciplining Flood Risk

At present, the dominant mode of dealing with uncertainty in flooding has been attempts to discipline it through science and engineering expertise. This perspective guides the work of scientists and technologists in the field, and its driving assumption is that, with better sensors, higher-resolution data, and more powerful algorithms, experts can create more accurate and precise estimates of potential flood impacts. Sophisticated approaches to data visualization and risk communication are developed to help the public navigate any remaining uncertainty. And

on some level, these assumptions are reasonable. Over the past several decades, advances in the field have given experts greater understanding of flood risk. However, our research in Boulder revealed that current data standards for conveying uncertainty, unless addressed, will limit the ability of such advances to support meaningful public understanding of risk. The 100-year flood standard, by presenting flood risk in a binary fashion (one is either in the floodplain or out of it), represents a problematic form of closure in scientific and public understanding of flood hazard.

As a result of the binary way that the flood maps circumscribe risk, many residents of Boulder county who lived outside of the floodplain were unprepared for the possibility that their homes could experience flooding during the storm. In interviews, few told us that they had purchased insurance or taken other protective measures. Furthermore, the regulatory and insurance implications for property mapped inside the flood hazard zone, as well as the impact on real estate values, have turned flood mapping into an intensely politicized process, where homeowners with the resources to engage can tie up map updates in public comment processes that stretch on for months or years. At present, some 60 percent of NFIP flood maps are thought to be out of date (Office of Inspector General, 2017), due in part to such debates. One flood expert, describing the situation, said "the idea of a floodplain boundary came about during a period when we had a much coarser understanding of how floods worked. Now we have better information, better data, better models, yet we still use this outdated approach. You're either in the floodplain or out of it."

Though we can imagine alternative data standards that would convey more complex understandings of flood risk, some level of uncertainty will always remain. For example, during the flooding, everything from debris and small landslides in the canyons above Boulder to residential landscaping to attempts by residents to build makeshift defenses channeled the floodwater in unpredictable directions. Furthermore, the impacts of climate change on flood risk in a given location will be quite particular to that area, and thus difficult to project at scale. Continued research is underway on these topics, and improvements in the science and technology of flood mapping will certainly be important. However,

these challenges remind us of the warnings of Duhem and Quine that scientific claims about the world around us will always be, to some extent, underdetermined by our finite capacities as humans. Therefore, we looked to other modes of uncertainty for addressing this situation.

4.1.3 Uncertainty as Opportunity

Another mode of addressing uncertainty that is gaining traction in some circles is to treat it as something generative, or productive, rather than a problem to be isolated, reduced, and managed. For Akama *et al.* (2018), uncertainty is a "technology" that can be usefully disruptive in overly determined contexts, allowing creativity and speculative practice to flourish in the cracks. Similarly, Gaver *et al.* (2003) write that ambiguity, an allied concept, supports "deep appropriation" of ideas and technologies: "By impelling people to interpret situations for themselves, it encourages them to start grappling conceptually with systems and their contexts, and thus to establish deeper and more personal relations with the meanings offered by those systems (p. 233)." In this mode, uncertainty is not located in technologies of representation (e.g., maps, models, databases) but rather emerges in particular settings and during particular moments that can be leveraged by designers toward their particular ends. We can thus seek to stage encounters that allow the possibility for uncertainty to emerge in useful ways.

As part of our exploration of the 100-year floodplain standard in Boulder, we undertook two very simple exercises in the design of flood risk information that would encourage participants to engage more deeply with uncertainty. In the first, we used games to support collective questioning and discovery of flood risk. Participants, working together in small teams, were given various types of flood information and then deliberated over various flood protection measures, coming to new insights and understanding through their debates and discussions. This approach contrasts what we observed to be most Boulder residents' experience of flood data, if any, which from our interviews revealed an individual experience of using government produced maps to determine whether one's residence was inside the flood hazard zone or not. The second experiment used what is called frictional design (Korn and

Voida, 2015) to complicate flood maps by adding other kinds of risk information, most notably the extents of past flood events. Here, simply showing residents that previous flooding had affected areas outside of the flood hazard zone generated deeper engagement in the form of questions about how the maps are produced and what exactly they are meant to convey.

In these examples, uncertainty became an invitation for the public to look more closely and promised rewards in the form of more in-depth understanding of the complex and collective aspects of flood danger. Rather than a problem to be solved, approaching uncertainty in this mode positions it as a resource that can be drawn upon, where appropriate, to support communication, education, or public participation in risk management. By staging encounters with uncertainty as an opportunity to provoke speculation, curiosity, or deep engagement, our field can help cope with, and even benefit from, uncertainty in situations where it is impossible or undesirable to fully eliminate it. This is a clear departure from the approach to many contemporary flood management schemes, which, operating through a disciplinary mode, have been described as taking a command-and-control relationship to nature (McPhee, 2011). Instead, developing a facility for managing ambiguity and uncertainty becomes an important strategy for developing societal resilience to disaster.

4.1.4 The Politics of Flooding

To engage with the political mode of uncertainty, we asked about the ways in which uncertainty, as an object of knowledge, is systematically produced, or a result of particular historical constellations of ideology and power. In this mode, uncertainty in flood mapping is neither seen as a problem to be addressed or a resource to be leveraged, but instead the target of questions such as:

- How do the answers to some questions about flood risk and impacts become seen as uncertain and in need of greater evidence?
- How is it that other potential uncertainties are not found problematic?

- How do political interests, such as those of the fossil fuel industry, deploy uncertainty strategically in order to influence policy around issues like climate change or regulations on real estate development?
- How does scientific and technical expertise privilege the study of some forms of risk and vulnerability over others?

Flood risk is distributed unevenly, and in ways that track with other forms of inequity. A corollary to the oft-stated argument that "there is no such thing as a natural disaster" is that vulnerabilities to these events are the products of social, cultural, and political processes (Wisner *et al.*). Thus while there are many uncertainties surrounding disaster risk, it is in some ways quite predictable that marginalized communities will suffer a disproportionate share of their impacts, and struggle the most to recover in the aftermath. And in fact, a recent report by the United States Federal Emergency Management Agency (FEMA) has highlighted racial disparities in how the agency manages disaster preparedness and response, arguing that "through the entire disaster cycle, communities that have been underserved stay underserved and thereby suffer needlessly and unjustly." (Scientific American, 2021). What is less recognized, however, is how current approaches to modeling and understanding disaster risk contribute to this situation. One example is how common practices of cost-benefit analysis which use property values as a measure of the "benefit" of protection lead to wealthier areas receiving disproportionate investments in flood mitigation schemes. is much more work to do to unpack how current approaches intersect with other axes of inequity.

To examine this further we might also look to an emerging body of work on agnotology (Proctor and Schiebinger, 2008). Agnotology explores the social and political construction of ignorance in ways that are similar to this mode of thinking about uncertainty. We may be able to draw upon this area of work to support and clarify our own thinking. In the case of flooding, this political mode might lead us to ask why we focus more on some uncertainties, like how much rain will fall and where will it go over a given time period, while giving less attention (and research funding) to questions around the structural factors that yield

certain kinds of vulnerabilities to flooding, or limit some groups' ability to recover in the aftermath. This perspective might lead us to focus on the uncertainty of different issues, for example, by asking questions about the probability of residents' ability to return to their homes following a major disaster, as one study related to earthquakes in San Francisco recently did. It might also mean moving even further away from "solving" uncertainty from a technical perspective and toward a fuller critique of how uncertainty appears in our sites of research and practice, with what effects, and at the expense of whose interests.

4.1.5 Affect: Living with Risk

The Gilbert White Memorial stands just next to Boulder Creek, in the middle of the city's small downtown. Standing 18 feet tall, and roughly obelisk in shape, it bears several horizontal steel bands that mark the water heights, at that location, of past flood disasters as well as estimated heights for 100 and 500 year flood events. White, known to the field as the father of floodplain management in the United States, lived and worked in Boulder for many years (Tobin, 2006). By placing this memorial in a highly trafficked part of town, White's colleagues and former students not only paid tribute to his life and legacy, but also sought to confront viewers and passers-by with the everyday reality of living with flood danger. The interplay of past disasters with possible events in the future, as indicated by flood height markers, creates a slight feeling of foreboding in attendant viewers, even as placards to the side that describe White's work highlight the potential for science and planning to improve public safety.

In contrast, the 100 year floodplain maps produced by the National Flood Insurance Program evoke an altogether different sort of affect. Bearing all the adornments of modern cartography – including legend, graticule, and scale-bar – they offer clean lines to delineate zones of risk from those of safety. They project the confidence and cool rationality of the discipline of engineering that produces them. They inspire trust. Indeed, the field of disaster risk communication generally cautions against messaging that evoke fear or outrage in the public (Gray and Ropeik, 2002). While fear-based messaging can sometimes be effective

to motivate protective behavior, such as evacuation, in the short term, researchers warn that it may also lead members of the public to discredit the source or that repeated exposure to such messages may desensitize them over time (Morss *et al.*, 2018). The pretension to affect-lessness that characterizes so much of Western epistemology (Murphy, 2006) is thus present in disaster research as well.

But of course, disasters *are* scary to those who experience them. They also cause sadness, excitement, outrage, even jubilation in their passing. They are tremendously affective phenomena. The 2013 Boulder floods left not only destroyed buildings, bridges, and roads in their wake, but severe psycho-social impacts such as post-traumatic stress disorder and depression among survivors (Dursun *et al.*, 2016). Decades of disaster research has found that other indicators of mental health struggle, including rates of suicide and domestic violence, spike after disaster. However, very little of the machinery of the United States disaster mitigation or recovery infrastructure accounts for this, in part because data about these impacts is not collected in a systematic fashion (Barrios, 2017).

4.1.6 Conclusion

Throughout the course of human history, flooding has consistently been one of the most common and damaging forms of disaster. Despite meaningful advances in recent years in the science of flood risk, efforts to fully discipline the uncertainty that surrounds them will always fall short. Our research into the maps and models that shaped public and expert understanding of flooding shows that alternative modes of engaging with this uncertainty can be fruitful. Here, the generative mode compelled members of the public to delve deeper into the science of flooding and bring to bear some of their own understanding of local context on their evaluation of flood maps. The political mode encouraged us to focus on distributional inequities of flood risk and ask why some residents were exposed to greater risk burdens than others. The affective mode helps us think through some of the emotional and psycho-social aspects that relate to coping with disaster uncertainty. Each of these modes raise important questions and avenues of future work for HCI and

crisis informatics researchers. As the role of data and ICTs in disaster management continues to increase, such research will be vital for helping both experts and the public engage carefully with the uncertainties of disaster risk.

4.2 Approaching Uncertainty From the Perspective of a Caregiver

By Laura Devendorf

This case study centers on how uncertainty is engaged within practices of caregiving. This topic of caregiving has become a focus of mine since taking on the role of "parent" to two young children, as well as facing more expectations of care as a cis-women teacher and advisor. However, I do not wish to limit this discussion to the specific, and gendered, notions of care that are often associated with nursing, teaching, gardening, or other common conceptions. This is because care, more broadly, pervades all aspects of social relationships including the relationships we form with and as designers. In their survey of experiences with caregivers engaging diabetes technologies, Kaziunas *et al.* (2017) write that "care is (and has always been) many things simultaneously: a human struggle between control and freedom; of seeking peace of mind and giving into anxiety; and of empowerment and taking on the burden of another". We hear resonant ideas emerging in narratives of emotional labor (Balaam *et al.*, 2019), care for subjects (e.g., Toombs *et al.*, 2018), or care for non-human organisms (e.g., Dew and Rosner, 2018). For Puig de la Bellacasa (2012, p. 70), care is a necessary part of living and "is therefore concomitant to the continuation of life for many living beings in more than human entanglements—not forced upon them by a moral order, and not necessarily a rewarding obligation". Drawing on Puig de la Bellacasa, and framing this notion of care within design, Light and Akama (2014) locate care in the practices of creating space for people to come together to re-examine relationships, re-make their environments, re-imagine familiar places and to reflect, learn and debate about making futures. It follows that designing with care is to structure ways to support sustainable and flourishing relations in ecologies of beings and materials.

By bringing care and uncertainty together, I want to foreground care work as an uncertain endeavor, specifically when it is experienced as a desire to protect and an inability to assess or know if one's efforts are making a positive impact. This emerges in parenting as well as the way we care for our environments, communities, or users and forces us to confront the limits of our knowledge, ability, or perception. In the following sections, I present a survey from my own reflective experience as well as previous work in HCI that acknowledges the variety of ways we can work within and against limits.

4.2.1 Disciplining: Calculating, Futures, Faith

One outcome of a disciplining approach to the uncertainties of caregiving is to use technology to offer a sense of control over the unknown through perceived ability to make better predictions. I have attempted to gain this control and ability through the use of baby-tracking apps. These apps codify long existing practices of logging infant activities like nursing times and durations, the mother's diet, the timing and nature of their bowel movements, and the child's mood. The goal is to form correlations between such observations in order to make adjustments that improve the child's mood or overall health (perhaps by detecting possible foods that the mother consumes that irritate the child). This is disciplining in its attempt to render uncertainties as data to reflect upon and assess. It can be valuable when the data reveals clear links that suggest improved behaviors (e.g., identifying a food allergy), but, from my own experience, tracking made me feel utterly powerless. For me, patterns did not reveal themselves but the idea that data gave me power became a kind of distracting obsession.

When approached from the perspective of disciplining, uncertainty is tamed through calculation: what kinds of actions would constitute care and what actions would protect myself and others from harm. For example: What steps do I need to take to ensure that my child is safe, happy and healthy? What protections should I consider in order to create space for my research subjects to report discomfort? What measures should I adopt to care for myself and my career in taking on certain sources of funding and projects? These questions are

common among "disruptive life transitions" such as the transition to a new parent, where one is encountering uncertainty in navigating a new role or responsibility (Barclay *et al.*, 1997; Britton *et al.*, 2019) but elements of such questioning extend into situations characterized by caregiving uncertainty more broadly. When a question is asked in terms of calculation, the answer often comes in the form of calculating upon the bits of information available. In this frame, these bits are rendered as data, medical advice, societal expectations, legal findings, often formulated from instances of care-gone-wrong. Yet, in the realm of parenting, this advice is muddled with societal expectations of women, profit motivations, conflict from updated studies, and popular mythologies, such as the relation of midwifery with witchcraft (Handley-Cousins, 2020; LaPlante, 2017). With the current trend of "data-driven parenting" (Oster, 2019), parents are invited to make sense of their personal data in order to navigate solutions that make their daily lives more livable, or, in my case, offered an illusion that their life could be more livable if they identified the correct data.

Disciplining uncertainty with calculation also produces a side-effect of introducing heuristics to care and, in those heuristics, can introduce particular biases or enact expectations of care. In providing support or care for others, mothers or otherwise, researchers are making judgments of which heuristics are worth including in calculations and which behaviors to encourage. While some of these heuristics may align with the recommendations by organizations such as the World Health Organization (e.g., Balaam *et al.*, 2015; Wardle *et al.*, 2018), others may stem from aspects of their personal faith, culture, or society expectations of what mothers (or caregivers) ought to be performing.

A final side-effect of a disciplining approach can be the introduction of a split between the subject providing care and the subject receiving care. These splits emerge between the designer (who is providing care in some way) and the user (receiver of designer's care) as well as the caregiver and care-receiver relationship. A cut can be formed along the line of a perceived difference that divides one group into caregivers and the other to people or things to be cared for. In some cases, there are differences in age or ability that figure into how we calculate this difference. In others, we may have socio-economic privilege and aim to

reach out and "do good" for a group of people who we see as having less privilege or access. While it may be argued at any given time who is caring for whom, the categories themselves set up care as a kind of transaction between different categories of subjects.

4.2.2 Generative: Good Relations, the Present, Multiplicity

Approaching uncertainty faced by caregivers through a generative lens frames the unknown as a resource. Technologies, then, can offer ways of relating to or engaging in uncertainty that allow us to find other experiences of value that emerge precisely from our lack of control. This can include an attention to the present, a sense of humility, or a form of camaraderie and empathy with those undergoing similar experiences. With this shift toward acceptance, or what Akama *et al.* (2018) describe as "surrender" to uncertainty, come other ways of engaging and designing with the uncertain situation. Specifically, ways that avoid divisions of power and ability (e.g., caregiver, cared-for) by treating all roles as navigating an inherently unknown and uncertain landscape. The basis is a likeness (we both need to deal with uncertainty) as opposed to a difference (I can protect you from uncertainty). I find inspiration for such approaches within feminist and Indigenous onto-epistemologies that focus less on a hierarchical organization (e.g., the caregiver and the cared for), recognizing the ongoing existence of multiple roles (e.g., that everyone is at once a caregiver and care receiver).

Kim Tallbear, Canadian Research Chair on Indigenous Peoples, Technoscience, and Environment, writes:

> In rejecting the binaries of *life versus not life* and *humans versus nature*, as well as other more graduated Eurocentric hierarchies of life, I foreground an everyday Dakota understanding of existence that focuses on "being in good relation." . . .Thinking in terms of being in relation, I propose an explicitly spatial narrative of *caretaking relations*—both human and other-than-human—as an alternative to the temporally progressive settler-colonial *American Dreaming* that is ever co-constituted with deadly hierarchies of life. A relational web as spatial metaphor requires us to pay attention to

> our relations and obligations here and now (TallBear, 2019, p. 25).

In this view, the researcher may choose to decenter considerations of the uncertain future and cultivate an opening toward what is possible in the more immediate present. For instance, instead of asking, "what steps do I need to take to ensure that my child is safe, happy and healthy." we might ask "what is my role within an assembly of forces shaping the wellbeing of my child, other beings, and the world in which they participate." This is a relational view of care, as Puig de la Bellacasa (2017, p. 70) writes, where "interdependency is not a contract, nor a moral ideal—it is a condition." To care is not a higher calling or a way to "give back" so much as a cultivation of the conditions necessary for humans and non-humans to flourish. A related invitation of the generative mode offers researchers the opportunity to widen the foci of research in terms of subjects to consider—including health of the parents, the home, the community, and/or the ecosystem when attempting to intervene in these care relations. The future takes form as a field of possibilities, and the generative researcher uses their actions to "sow" this field, so to speak, in order to cultivate potentials for care in the here and now.

A generative approach to uncertainty can manifest as an art of recognizing where we sit in relation to the uncertainty and how we might keep our balance in the moment. A calculation will happen, a desire for control may still exist, a decision will be made, but we surrender to the idea that the decision may not ultimately be determined by the goals and wishes of those variables that are "in" the equation. Held in a balance with the disciplining mode, the generative mode can bring humility and reflection where researchers might otherwise turn to faith in science, data, or technological progress.

4.2.3 Political: Questioning Categories, Assumptions, and Habits

A political orientation to matters of caregiving can be a useful way of assessing and understanding the hierarchies of power that materialize in caregiving practices, particularly those imposed by heuristics and optimizations in the disciplining mode. For example, the power dynamics

inherent in being determined a caregiver vs. care-receiver begs for a reflection that prioritizes what and whom to give attention to. Conflicts between personal cultivations of belief and largely medicalized narratives of care practice speak of similar politics that reveals hidden values, related to the politics of power, values and knowledge that frame uncertainty.

The political lens can help us disentangle and reflect upon our own judgments and biases in emotionally charged situations, of which caregiving figures prominently. For instance, in present-day debates about vaccination, there is a strong tendency to demonize or assert the stupidity of those who resist (or do not resist) the medical narratives arguing for vaccination. And while we may hold our own beliefs and stance in the debate to be true, taking a moment to engage deeply in the narratives of those we disagree with can be useful in revealing histories and experiences that offer such positions validity. For example, in her book examining vaccination narratives through their roots in class difference, monster stories, and present day narratives of purity, Biss (2015) explores how the narratives of the medical systems are tarnished by their histories of exploiting black populations or vilifying practices of midwifery. Bringing these histories and narratives into frame, through design research, ethnography or archival research, can shed light on the politics in what is presumed in various approaches and understandings of care, and therefore, questions how claims become known.

Similarly, the political lens can help researchers ask how some populations become the subjects of care. This emerges in cases where research populations traditionally seen as those that need care speak back to designers to present a different narrative of their abilities. For instance, Bennett *et al.* (2019) study "biographical prototypes" as "counter-storytelling" objects to render the everyday acts of design by disabled populations as equally valid modes of prototyping to consider within HCI. In "Weaving by Touch," Das *et al.* (2020) describe how visually-impaired weavers reveal different and nuanced understandings of material craft practice that challenge those developed by sighted crafters. In asking what it means to provide care, this work suggests that the assumption of someone needing care can patronizingly structure

the design relationship from its inception. This speaks to the politics of whom, what and why of change.

Work under the banner of ICTD has also found itself at a position of conflicting belief systems in what it means to care for a population. For instance, in "Designing within a Patriarchal Society," Sultana *et al.* (2018) describe the struggles faced in enacting westernized ideals of care and empowerment in contexts that do not share such values. Rather than designing for what the designers believe to be right, they describe, instead, how they found better care for subjects to be achieved when designing within the systems they personally opposed. In a later study, Sultana and Ahmed (2019) advocate for looking at social systems and faith systems that contrast dominant orientations of HCI, such as witchcraft, in order to "combat ideological hegemony" within HCI. This work demonstrates the deeply coupled nature of uncertainty, care, and faith, and how perspectives outside of those we consider to be logical or correct are particularly useful for foregrounding the belief systems we tend not to engage.

4.2.4 Affective: Feeling and Irrationality

Approaching the uncertainty of caregiving through the affective lens turns our attention to the embodied experiences of those performing or receiving care.

While we see attention to affect often manifest within design research is in the deployment of probes or activities in "needs finding" phases of research, it can also serve as the research outcome in itself. For instance, my own struggles as a parent became the grounds for an exploration with other designers/parents that focused on our relationships to technology in caregiving. Framed as "design memoirs," myself, Kristina Andersen and Aisling Kelliher approached design as a way to illustrate our experiences (Devendorf *et al.*, 2020a,b). The project resulted in a series of artifacts that at once represented alternative approaches to care for mothers, as well as a series of alternative heuristics for assessing caregiving technologies. Ultimately, it attempts to sensitize the design community to the complex demands and expectations of mothers. It also strove to show that somatic experience in many ways presents itself as irrational. For example, that one can feel multiple conflicting emotions

simultaneously and that those emotions (fear and pride) are linked. Starting from the felt, then, helps attend to the messiness and irrational dimensions of human nature that become hidden when categories and heuristics are applied.

As a strategy for understanding the felt, it can be helpful to start from the body in the form of attending to the somatic dimensions of everyday life, to the various ways in which bodily experience and cognitive processes take shape (e.g., Forlano, 2017b). As posthumanism tells us, we are, indeed, more than a mind in a box, but a situated evolving being emergent from a deep connection of embodied experience and cognitive process (Hayles, 1999). Thus, uncertainty is felt physically as much as emotionally. The felt is a space where we needn't form a singular narrative, where emotions come and go, and where memory distorts and reshapes how and what we feel. It accounts for the way in which things, like risk assessment, are never purely logical. For instance, the objects that pose the most harm to children are cars and beds, yet, we tend to spend our time fearing more rare instances of harm. Mothers, in particular and speaking from my own experience, find themselves rationalizing many counterintuitive behaviors in order to find comfort or peace, in order to deal with our own emotional states as well as the horror we fear of harm to our children.

An attention to the felt becomes a sensitizing experience that aims to expand how a designer considers its users. Where disciplining modes aim for a prediction, considering the felt acknowledges all the conflicting stories that are sidelined in order to focus on the singular narrative. It considers the sites at which multiple conflicting aims must be negotiated and the wider milieu in which decisions will be made.

4.3 Uncertainty in the Design of Cybersecurity Toolkits

By Richmond Wong

4.3.1 Introduction

Cybersecurity is a multifaceted socio-technical concept. While often assumed to be in the domain of data, computer code, and mathematical guarantees, cybersecurity can also be thought about as a contested,

political, and social concept as well. This case study shows how the different modes of uncertainty can help highlight and surface different concepts of security presented in cybersecurity toolkits. It draws on a research project conducted with collaborators James Pierce, Sarah Fox, and Nick Merrill analyzing 41 cybersecurity toolkits–collections of materials intended to help users achieve security online (Pierce *et al.*, 2018). We conducted our analysis in part to understand how these toolkits conceptualized and enacted "security" as a social value worth promoting and protecting.

Our analytical perspective views security as a series of processes and practices that produce conditions or states ranging along a spectrum from being more secure to more insecure, rather than an objective and binary static state of being secure or insecure. Systems, designs, and sociopolitical conditions make something in/secure; people and conditions are not in/secure on their own. Security is thus a value that is enacted through active and ongoing processes (Houston *et al.*, 2016). As described by Nissenbaum, there are multiple conceptions of security – such as the technical goals of confidentiality, integrity, and availability, or the ways in which national security interests construct collective ideas of being secure, insecure, or under threat (Nissenbaum, 2005). Cybersecurity toolkits are a set of artifacts that help define and frame who or what is in/secure, and what types of actions are needed to work toward achieving states of security. This analysis can help HCI researchers and practitioners think about the multiple concepts and definitions of security, and to help think about security as a sociotechnical concept (Coles-Kemp and Hansen, 2017).

Uncertainty is an almost definitional component of security. Security is sometimes defined as a response to particular threats or potential attacks, but still there remains uncertainty in whether the "correct" threats or attacks have been identified, uncertainty in whether and when an attack might occur, and uncertainty in whether the actions taken to prepare for them will be successful. For some, just the act of being digitally connected or being "online" might itself bring new uncertainties, to which the response of security may be appealing. Potential harms that might occur to subjects, groups, and institutions include digital harms (e.g., compromised data), physical injury, economic loss, psychological

and emotional harm, and reputational harm (Agrafiotis *et al.*, 2018). Furthermore, security risks may be known and felt in different ways, as perceptions of risk and what actually poses a risk (as far as they can be known) may differ.

In his case study we explore how the different modes of uncertainty offered in this monograph can help surface different conceptions of security, or help highlight different dimensions of security, creating opportunities for considering security during design.

4.3.2 Disciplining: Securing Against Uncertainty

Many security measures aim to discipline uncertainty, attempting to manage and govern possible, uncertain futures (Amoore, 2013). The frame of security indicates something under threat that needs to be protected. The subject(s) under threat can vary – perhaps being something smaller and discrete such as a computer system, a network, or a database. At other times, security might conceptualize life itself as being under threat, such as through the uncertainty biological threats of unexpected pandemics (Lakoff, 2008; Samimian-Darash, 2013), or construction of uncertainty surrounding terrorist threats to national security (Nissenbaum, 2005). While the magnitude of uncertainty and potential harm varies across these examples, uncertainty (and the risks associated with it) can become a part of everyday life (Beck, 2006). While this uncertainty cannot be eliminated, disciplining it carries the hope that security harms will be less likely to occur, and if they do occur subjects will be better prepared to recover. Given this framing and the potential for social, digital, personal, physical, emotional, or financial harm, it makes sense that much of security work is oriented toward trying to discipline uncertainty as a strategy for living with it.

In our exploration of toolkits, we found a range of dimensions along which the toolkits differed. When considering how the toolkits attempted to discipline uncertainty, three dimensions emerged, offering different considerations for design. First, measures to discipline uncertainty might enroll different actors and stakeholders. Toolkits articulated a range of technical and social measures, placing the responsibility for security in different stakeholders. Sometimes trying to achieve security involves

technical measures that attempt to reduce the likelihood of attacks: backing up one's computer, updating software on digital devices, or using strong passwords. Other times it is about training humans to embody discipline in their actions: looking out for phishing attacks, looking for https symbols, or having heightened awareness of their actions online. Some toolkits view individuals as needing to perform and enact security measures, while others view security as more of a group responsibility.

Second, the disciplining mode surfaced a dimension regarding the degree to which security is achievable. Sometimes toolkits depict the disciplining of potential security risks as ongoing: social and technical security practices have to be learned and continually enacted over time in order to continue managing and reducing uncertainty. At other times, disciplining security risks is seen as achievable: some toolkits suggest that if a user follows a particular set of defined actions or uses a specific set of tools, they will then reach a secure state.

Third, the disciplining mode surfaced a temporal dimension of security, considering when disciplining might take place. Some toolkits focus on taking preventative measures to try to reduce potential security threats (thus reducing uncertainty). Others discuss how to mitigate risks to situations that users may have already encountered (such as how to find and remove personal information that already exists in publicly-accessible databases). And another set of toolkits attempt to mitigate harms in response to lapses in security that have already occurred, such as a "crisis hotline" for security that one might contact after a security breach.

When a researcher or practitioner frames a problem as one of security, it often brings in notions of threat, harm, and vulnerability as well as uncertainty. Disciplining uncertainty, to reduce or manage it, becomes an attractive mode through which to approach these issues, given the range and magnitude of potential harms that individuals and communities might face. While disciplining may be the prevalent approach to viewing uncertainty as it relates to security, our analysis of toolkits also found that many suggested that there are uncertainties that cannot be fully disciplined and that some uncertainties will always remain, one explicitly

saying "there is no perfect option for security."[1] These juxtapositions occurred across multiple toolkits, which provided checklists and how-to guides meant to work toward aspirational states where uncertainty would be eliminated, while acknowledging that those states are not fully attainable.

4.3.3 Generative: New Security Threats and New Worlds for Security

Using the generative mode suggests other ways of interacting with security. Analyzing how cybersecurity toolkits make use of the generative mode surfaced two different goals of some of the toolkits: (1) Helping to make the unknown visible and legible to disciplining; (2) interrogating the assumptions we make when conceptualizing security and how it might be accomplished.

First, some toolkits provided generative activities to help people imagine new threats that may have previously been unknown or unrecognized. These toolkits still conceptualize security as a set of risks that need to be mitigated and disciplined; however, the nature of the threats and risks themselves are uncertain. Generative activities can help explore and define these uncertain threats and risks. Some toolkits, like Tactical Tech's Holistic Security guide,[2] provide activities to help users reflect on, imagine, and generate: the types of potential threats and uncertainties that they may face, what might present the most stress, what resources they may have at their disposal, and what new practices or approaches they may need to consider adopting. This generative approach helps identify new uncertainties that can then be approached with an appropriate (disciplining) strategy to try to address potential new threats or harms. These practices, while generative, serve the ultimate goal of disciplining uncertainty to provide greater security. Generativity allows for the identification of new threats, before unseen, that can now be appropriately mitigated or prepared for.

There were also more artful and provocative projects related to security that we cataloged but did not analyze for our initial research

[1] https://ssd.eff.org/en/module/your-security-plan.
[2] https://holistic-security.tacticaltech.org/.

paper (Pierce *et al.*, 2018). In re-visiting these artful projects, some can be interpreted as creating new types of uncertainties by positing other ways that people might address or live with (in)security. Several projects focus on creating obfuscation for users in the face of surveillance and insecurity. The CCD-Me-Not-Umbrella[3] by Mark Shepard uses infrared lights in an umbrella to disrupt object tracking algorithms in cameras in physical spaces; Howe, Zer-Aviv, and Nissenbaum's AdNauseam browser plugin[4] automatically clicks on online ads to obfuscate users' browsing data in digital spaces. These tools artfully create new uncertainties in the data by adding noise, making it difficult for institutions that want to make use of the camera or advertising data. These projects resist existing systems of power and use uncertainty as a tactic to suggest new forms of safety and security for users. Furthermore, these projects help imagine an alternate and more secure world for users, where people can move about in physical and digital spaces without fear of being surveilled.

Similarly, some toolkits may generatively embrace the uncertainties of security to posit alternate ways of conceptualizing uncertainty. Security toolkits created by anarchist zine distributor Sprout Distro[5] focus on direct action and organizing as practices of security toward social change. The Holistic Security toolkit reimagines security as not just an individual property, but also as a communal one that requires solidarity, and an emotional wellness property that requires attention and care. Rather than seeing security's uncertainties as something to be immediately measured, reduced, and disciplined, this set of approaches views the uncertainties posed by security as an opportunity to re-imagine social orders, and who and what should be deemed important enough to secure.

4.3.4 Affective: Securing Affect

The affective mode highlights the experience of insecurity, and its associated uncertainties. During the writing of this section, within a 24

[3] http://survival.sentientcity.net/umbrella.html.
[4] https://adnauseam.io/.
[5] https://www.sproutdistro.com/catalog/zines/security/.

hour period, I received a notification from my academic institution about a large data breach, and a (likely unrelated) notification from my bank that my credit card had likely been compromised. Both notifications included information about next steps to take. My bank even provided a PDF "Identity Theft Protection Toolkit." It is worth noting however, that all the suggested actions placed responsibility for action on the person whose data has been compromised (rather than on the institution or perpetrator) – such as contacting credit bureaus, updating credit card numbers with service providers, enrolling in identity theft monitoring services, and so on. While taking these actions may help a person try to reduce or discipline the new uncertainties they face, I found that none of the information fully addressed my own experience of the sudden onset of these uncertainties: confusion over how these security breaches occurred; frustration at having to do work to reduce the potential for harm due to others' actions; anxieties about potential financial harms I might face in the future; and overwhelmed at all the next steps I had to take in a relatively short period of time.

For people in other positionalities, such as activists, journalists, or victims of racial and gender based violence, the experience of digital uncertainties can be ongoing. They may be more likely than others to face targeted security threats and harms. For others, the action of going online or interacting in digital space brings new feelings of uncertainty, confusion, distrust, or fear due to the lack of certain social and bodily markers that might engender trust, as well as the hidden or obfuscated nature of data collection via cookies and other technical measures. As digital data collection increasingly occurs in physical spaces through a range of sensing technologies, the lack of cues about how data collection, data flows, and data processing relate to social boundaries introduces new feelings of uncertainty into everyday life (Coles-Kemp and Hansen, 2017).

Using the affective mode in our toolkit analysis surfaced different metaphors for addressing security, which each indicated different conceptions about the affective experience of security and insecurity. One metaphor is the "emergency hotline," which highlights the affective experience of a person in an uncertain security situation at the moment

they experience harm. For example, the "Resisting Doxing and Protecting Privacy" toolkit is made by the "Oh Shit! What Now?" collective, an activist group.[6] Access Now's Digital Security Helpline works like an emergency hotline that can provide help if you are under attack.[7] These toolkits focus on helping people take actions once their security is breached, and consider multiple ways of support for the person who has lost security. An emergency hotline metaphor also emphasizes that responsibility for providing security falls on responders and helpers, rather than placing all the responsibility for action on the person experiencing security harms. Other metaphors, like "self-defense" or "holistic security" may emphasize capacity-building actions prior to a security breach that includes ways to build one's mental and social support. These toolkits acknowledge the affective experience of uncertainty even before any discrete attack occurs.

4.3.5 Political: Whose Uncertainties, Whose Security?

In analyzing cybersecurity toolkits, one of our main goals was to understand the ways in which the social value of "security" was contested or enacted. In other words, we were interested in the political dimensions of security. Our exploration tried to surface how security could be embedded in different relationships and situations. One example that resonated with us was the variation in what was considered a security "threat" and what was considered as helpful to providing security in different situations. One toolkit was created by the U.S. Department of Homeland Security,[8] providing tips for users to protect themselves from "cybercrime," implicitly positioning the U.S. government as assisting in providing security. However, for toolkits aimed at certain (often vulnerable) communities, the government (particularly policing forces) is framed as the potential threat, and other technical or community measures are seen as necessary to provide security. These reflections led us to the concept of "differential vulnerabilities," the recognition that

[6] https://www.ohshitwhatnow.org/2017/06/26/resisting-doxing-protecting-privacy-resources-vulnerable/.

[7] https://www.accessnow.org/help/.

[8] https://www.stopthinkconnect.org/tips-advice/general-tips-and-advice.

security is relational and that different individuals and populations have varying forms of security threats and protections, rather than thinking about security as a set of objective generalizable goals (Pierce *et al.*, 2018).

An explicit focus on the politics of uncertainty can lead to new types of research questions regarding cybersecurity. Even though most toolkits we analyzed took disciplining approaches to uncertainty, we found that *how that discipline takes shape* in a specific project or context can vary greatly. Taking a political lens to the uncertainties posed by security allows researchers and practitioners to think more carefully about whose uncertainties and which uncertainties are addressed in our conceptions of security (and conversely, who or what is left out). When considering the politics of uncertainty in security, researchers might aim to ask the following questions:

What uncertainties does this conception of "security" address? Does the affective fear or emotional violence of being harassed on social media count as a security risk, compared to having one's data stolen? Different toolkits highlight different uncertainties as central to security – some may focus on the data security components of confidentiality, integrity, and anonymity. Others may bring in affective uncertainties, such as the fears and emotional violence of online harassment. In some contexts, uncertainties stemming from misinformation, social inclusion and safety, and physical safety may be included as part of security, while at other times these may be excluded. When an uncertainty is counted as being a part of security, another set of questions is raised: to what extent can these uncertainties be fully mitigated (and disciplined), and to what extent do people have to find ways to live with them?

Whose security uncertainties matter? Some toolkits discuss a general, idealized "user," while others look at specific groups or populations, such as those at risk due to gender-based violence, activism work, political beliefs, and so forth. In each of these, the answer to "whose security is being protected?" may be different. There is an associated question about who gets to make claims and generate research about whose security and uncertainties matter. To what extent do these communities themselves have a voice in defining and shaping what their concerns and uncertainties are, compared to a researcher mediating or extracting

those concerns? The ability for different voices to play a role in defining and shaping whose uncertainties matter may differ based on community or who the research audience is.

There is an associated question of threat – who or what brings uncertainty to people's security. Sometimes there is a generic, idealized "hacker." But uncertainty may be caused due to multiple motivations from different stakeholders (Denning *et al.*, 2013) – and the nature of the security threat can be shaped by researchers and institutions. For instance, state institutions tend to shape the definitions of what constitutes "national security" threats, while a firm's chief security officer and IT trainings may shape the definitions of what constitutes an organizational security threat.

4.3.6 Conclusion

This case study shows that looking at uncertainty in relation to security through the different modes helps show the elasticity around the boundaries of the concept of security. This helps a researcher look at security as a multi-dimensional concept that can be defined in different ways with different implications for who and what gets included as being in need of security. This is in line with how others have taken critical perspectives on social values such as "privacy" or "fairness" (Mulligan *et al.*, 2016, 2019; Shilton *et al.*, 2014). Furthermore, this builds on scholarship that studies the discourses, infrastructures, and systems of power that render certain things as uncertain security "risks" or "threats," creating the need for (often technical) countermeasures, and showing how risks, threats, and countermeasures are not distributed evenly (Suchman *et al.*, 2017).

Beyond being useful analytical modes, these modes can help suggest different types of research and design approaches to cybersecurity in HCI. The disciplining mode reflects the disciplining dimensions of security we found in our analysis of cybersecurity toolkits: disciplining uncertainty in cybersecurity means taking ongoing actions to both identify and reduce risks. When using the generative mode, HCI researchers can create design interventions for security to create a space where people can generate and imagine new potential threats. This shares some

similarities with practices of "threat modeling" in security practice, but often tries to help practitioners expand what they consider a security threat. The affective mode provides a new dimension for researchers and designers to consider in security. In contrast to concepts of security that only focus on technical harms, considering affective experiences opens up issues like online harassment to be considered as security threats, where one's emotional and affective state is disrupted or attacked, leading to uncertainty of control or well-being. The political mode asks researchers and designers to be more reflective when using the term "security" in their work, asking questions such as "what uncertainties does this conception of security address", "Whose uncertainties are we securing," or "What work is needed to address security uncertainties." Being more specific and intentional about how one is conceptualizing security can help lead to more specific design and research outcomes that engage or address that concept of security.

4.4 Uncertainties of Designing with and for a Community Online

By Yoko Akama and Ann Light

4.4.1 Introduction

Service Design Melbourne (SDM), one of the largest and most active networks in service design in Australia,[9] has garnered 3,500 members since its inception in 2010. It is a non-commercial, volunteer-run network that regularly hosts a range of co-located gatherings. One of the authors, Yoko, co-founded the network with another colleague at RMIT University, and the leadership has transitioned annually to new custodians, nominated by the volunteering committee. The extreme disruptions of the pandemic are the background to this section, giving us the chance to explore how continuous "infrastructuring" (Karasti, 2014; Star and Ruhleder, 1996; Star and Bowker, 2002) by a group of designers during 2020 navigated ways to design with and for a community-of-interest

[9]This is the Western name by which it is commonly known, but this is the unceded lands of Aboriginal and Torres Strait Islander peoples. Woi Wurrung and Boon Wurrung groups of the eastern Kulin Nations are the Traditional Custodians of a city by the bay of Naarm, now called "Melbourne".

called *Design and Ethics* (D&E), a wing of SDM. In following the four modes of uncertainty, this case study describes how the D&E group shifted their activities from physical events to online as a response to the uncertainties of the pandemic.

SDM has built a community that enables members to call on each other for support, learning, inspiration, collaboration, employment and resource-sharing on human-centered design. A sense of community, belonging and purpose is evident in a SDM post made during its 10th anniversary celebration: "The immense sense of community and friendship . . . is so rare to find. I hope during these trying times that we can continue to do this; to look out for, check in and support each other" (RD). The Design and Ethics (D&E), a subgroup of SDM, emerged to foster a safe, intimate and informal physical gathering to enable conversations on tricky ethical issues, in response to the growing profession that was deploying methods and approaches too unproblematically under the "human-centered" mantra (Agid and Akama, 2018). D&E grew in presence within the SDM community, where it currently has 400+ members. It is one of the most active channels on *Slack*, where questions, resources and events are posted and often responded to thoughtfully with a discussion.

The transitions to working remotely online touch on mature discussions in HCI on how computer mediated communication could be designed for and the new uncertainties introduced in work and social collaborations mediated by digital tools (e.g., Herring *et al.*, 2013; Kelly, 2019). From the early argument that "on the internet, no one knows you are a dog"[10] to the discourses that showed people bring their identity politics with them into virtual spaces (Wright and Webb, 2011), there has been a lively discussion of what online discourses enable and constrain. Shifting to online reflected the global, rapid transition in day-to-day business to avert the risk of infection. Yet using video conferencing facilities reintroduced questions about "reduced social cues" (e.g., Thurlow *et al.*, 2004, p. 40) where people shrank into small rectangles, devoid of space for less formal encounters, unable to make eye contact

[10]See https://en.wikipedia.org/wiki/On_the_Internet,_nobody_knows_you%27re_a_dog.

or tacitly signal their desire to interject or otherwise manage exchanges. Meetings were disciplined to stay quiet, careful, on-topic or and disrupted by poor wifi, pets, and families intruding in the background. While some people were excluded by the move to online, others were empowered. For the D&E group, continuing online followed the extreme learning curves of the COVID-19 "new normal".

The account next details D&E's transitions, noting how uncertainty accompanied choices made and catalyzed the designers' care, sensitivity and reflexivity to create mechanisms to engage more safely with divergent and contested issues, and at the same time, unsettling their own presumptions of certainty.[11] As with other cases, we start with the disciplining mode to acknowledge its prominence for mitigating risks, while the latter sections expand affective, generative and lastly the political mode, noting that none of these modes are completely distinct.

4.4.2 Disciplining Uncertainties of the Pandemic

Disciplining uncertainties related to governance, compliance and power to reduce risk, harm, and vulnerability are echoed elsewhere in this book. Disciplining the uncertainties of the pandemic was commonplace by various government agencies to enforce policies to "flatten the curve" of infection, modeled on epidemiologists' data predictions (Black *et al.*, 2020). Disciplining strategies also included social distancing, mask-wearing and mandating lockdowns and house-bound isolation, but other patterns of disciplining could be seen by the public, seeking out their own measures like stockpiling toilet paper and hand sanitizers. These home-grown approaches included scrabbling around for new tools for remote working, strategies to home-school, finding new ways to exercise and socially connect with family, friends indoors. Reflecting this broader community-generated initiatives, the Design and Ethics (D&E) members shared similar approaches to mitigating risk through self-imposed boundaries, including things to prioritize, refraining from non-essential outings, fixing bikes to avoid relying on the public transport and doing meditation.

[11] Where direct quotes from participants in the D&E group are used, we include the initials of the speaker.

In these early months of the pandemic, the design and technology fields were quick to respond with concrete approaches and outcomes for protection. These can be seen in technologies wielded for contact tracing to control and manage the spread of COVID-19 and in new materials and manufacturing for personal protective equipment (PPE). The design media celebrated these visible, tangible and expertise-led responses to the pandemic. The breakneck agility at which designers were asked to react created other uncertainties in shifting their professional practices. Service Design Melbourne (SDM) community, for some, became a "go to" place to help work things out and voice the downside of this speed: "It feels like the pandemic and our responses to that have restricted the space to grow this practice" commented one of the D&E regulars (RB) in a thread that got to the heart of questions. How could practice flourish online and what could D&E do to support meaningful work at this time? The kinds of negotiations shared revolved around working out how user-research and co-designing should shift from physical, co-located interactions. Interviewing, travelling, fieldwork, observations and more, suddenly became an ethically questionable intrusion into people's lives as well as raising safety concerns for all involved.

Asymmetries and inequalities, if they were not obvious to designers before, were starkly revealed in various ways. These range from reliable access to internet and digital devices; having a spare, private room to attend an online meeting, to affordances of time and energy because of increased duties for childcare or cuts in household incomes. Discussion of designers' privilege, including critiques of the transactional ways research has often been undertaken (Costanza-Chock, 2020), will come later (under the politics section), so for now, we note how this confusion and negotiation may indicate the profession's lack of awareness of such asymmetries before. This is voiced by one D&E organizer:

> The risk is that the people who were always easy to leave out become easier to leave out. How do we make sure that folks are "staying with the trouble" even when that's hard? . . . the pandemic raises especially knotty questions, well, shit, we weren't doing accessible stuff before this. This is an opportunity to reset it. (RL)

4.4.3 Affectively Feeling a Way Through

Uncertainty is felt by the practitioner who is experiencing related or varied happenings alongside others – they are not standing outside the phenomena but already entangled within and implicated in these sites (Akama *et al.*, 2018; Suchman, 2002). As we shall hear, a multitude of competing emotions and experiences were affecting D&E organizers and members as they navigated turbulent uncertainties of the pandemic.

D&E members were observed sharing their experiences in the precarity of employment, loss of professional identity and grief from letting go of habituated practices of designing, such as facilitation, participating in workshops and attending gatherings. Mental health and domestic violence were on the increase and stresses and fractures across societies were daily witnessed and experienced (Gulati and Kelly, 2020; Usher *et al.*, 2020). These affective dimensions echo other multivariate bundles of emotions described in the other sections like fear, harm, threat, confusion and discomfort for self, families and communities that can often be a major trigger to disciplining uncertainty. Similarly, reflections from the D&E organizers show parallel acts of precaution and managing.

> Fear of losing a job, losing a loved one, in COVID-19, these are right there. You're going to assume that anyone in our group is possibly going through such uncertainty or loss. However, that fear of not knowing is always true. We're just pretending that we know what the future holds. I pretended to have knowledge and security . . . delude myself for thinking I have control that allows me to function. In COVID-19, none of us can hold on to that delusion of control. . . . When working with community . . . you're always wanting to account for precarity. The COVID moment brought that reality for us to examine how we come together, how often we check in, how we care and the thoughtfulness with which we engage the group and community. . . . It makes me reflect why we think that's necessary only in this heightened time. It's always how we should be approaching (KM).

A whole stack of overwhelming pressures was also being experienced by the D&E organizers: "I was so saturated that I lost direction, had no choice but to respond to the situation from deep within, how you're doing and how people were feeling. . . . The idea that you can do things for people was an impossible hill to climb for me" (RL). The D&E organizers remark how they felt torn by multiple sets of obligations to support the larger community, to guide the volunteers in their roles, and to be mindful of how much capacity they had to cope through these times. While willing to continue gatherings online, they were also feeling the strain:

> I'm really keen to get back into organizing and hosting as well, but I'm also struggling a bit with the realities of the situation and the transition. . . . If anyone is keen to get started now as a distraction from the world, please don't let my needing to go to ground get in the way (RL).

SDM and D&E are sustained through volunteer labor; issues such as burn-outs, finding the right "fit" and recruitment and retention (as observed elsewhere in community work e.g., Scherer *et al.*, 2016), are always present. RL's call to pause activities can be seen as offering a nourishing respite given the stresses that permeated across all sectors of the society. During the most disruptive months in Melbourne, from March to May 2020, no D&E events were organized, but the private catch-ups among the group served another purpose: "Good to participate in an existential recalibration together. We haven't landed on something concrete, but done good thinking on what it is and why we are here." (RL)

After deciding to put the events on hold, D&E custodians KM and RL continued to meet frequently to listen and share their personal observations about the group and broader community. Making this time and being available to one another are strategies in emotional self-care. Taking time out to "check in" with oneself can sustain one's own well-being and facilitate positive social interactions, enhance relationships and cultivate empathy and compassion (Restubog *et al.*, 2020). As we hear from KM: "Having that space to debrief with RL pretty consistently meant that, at least for me, I was able to show up for the group. . . .

It was more about what's happening with the group, rather than who was going to do what, next."

Their care and attentiveness percolated into the bigger D&E Zoom meetings, which started with an extensive "checking in" where the purpose was to be present, listening or responding to each other's remarks, rather than following an agenda. This contrasted with previous meetings, which defaulted to keep tasks and conversations focused. "We felt our way though it . . . to be settled in ourselves coming into D&E" (RL). Working from home and in isolation undoubtedly reduced contact with various relational spheres, so social support was important: "My need for smaller and higher-intensity relationships jumped up enormously, and that's what's made sticking around D&E worthwhile" (RL).

These reflections indicate that in uncertainty – where there are no roadmaps – the only action is to feel a way through. But rather than adopting the traits of creative agility and innovative pivoting celebrated in design (e.g., Avle *et al.*, 2017), in contrast the rudders we see here at work are to care, trust and be sensitively present for one another. This attests to the remarkable generosity and custodianship of D&E organizers, as well as their resourcefulness in having physical, spiritual and mental strength to keep investing in the group, community and purpose. These observations reflect examples elsewhere, for instance in the UK where neighbors, volunteers and the community sector self-organized food, medication deliveries, dog walking and wellbeing checks (Rippon *et al.*, 2020) and in Cape Town, South Africa, where care for the elderly, local advocacy and information dissemination were led by communities through variety of social media platforms (Odendaal, 2021).

While listening to concerns on SDM Slack, the D&E organizers were also working through what D&E's role ought to be, beyond organizing broader community events. For KM, this reaffirmed the need to feel part of a nourishing community, to have dialogue with people who are caring, compassionate and stimulating and willing to answer any questions: "It's nice to know that we're excited as a group to take on those knotty issues, and that's enough to sustain us right now. We're united in the willingness to be vulnerable and inarticulate, and a willingness

to stay with the trouble". Time, labor and emotional investment in constant dialogue was necessary to build stronger foundations of trust and collegiality, and to feel they were able to continue engaging and facilitating D&E gatherings. Echoing Devendorf's account, above, we see care in the everyday forms of labor (Puig de la Bellacasa, 2012) underlying their approach.

We can also hear in their reflection an existential recalibration at work that required them to pause and patiently work through their personal and professional roles in the group, as well as a re-thinking the purpose of D&E. In this, we witness an active form of listening to their own feelings and to one another's by inviting such sharing as a necessary part of connecting and working together, reflecting the broader workplace practices being adopted during the pandemic (Restubog *et al.*, 2020). The radical shifts in practice undertaken by D&E were in many ways generative, requiring iteration and experimentation for alternative possibilities. This generativity enabled the organizers to work with and through the uncertainties of the pandemic to explore mutually rewarding engagements.

4.4.4 Generative: Approaches to Doing Differently

Generative dimensions of design and technology celebrate creativity, innovation, problem-solving and envisioning alternatives. These attributes are valuable in engaging with uncertainty, considering it as a resource. In this section, we highlight other qualities, like learning, reflecting, adapting and transforming, all of which are the underpinning practices of responding generatively to uncertainty and which we saw plentifully.

D&E was already becoming a community of learning. It was not cohering around typically commercially valuable knowledge, but rather aimed to build ethical awareness, language and place for rehearsing in small groups, so people felt confident to take these conversations back to their workplaces. The organizers aimed to maintain this purpose during the pandemic, not by putting labor into organizing more events and different workshops, but by digging deeper into the ethics of how one *is*, in relation to others.

As we heard already for RL, D&E was always a space away from work to step into as oneself, instead of performing one's job or role: "D&E feels different, in that it invites people to relate differently, not 'sell' themselves" (RL). This relational aspect has both affective and generative dimensions, associated with emergent forms of learning and transforming: "What is that relational learning of being in relationship with people who are changing the way you think about how you show up and be ourselves" (KM). The emphasis on "oneself" and "how you show up" were frequently mentioned in D&E organizers' meetings, turning attention to how one's existence could be different online, because the same digital platforms felt like a wearisome extension of work.

Witnessing the features of D&E posts (ranging from calling out worrying "empathy" trends in professional settings to how users as people were being represented or omitted in service design) made RL ask: "Is there something in taking time to keep coming back to this group and using it as a space to talk about difficult questions?". The organizers considered how the group could continue to be as active in its transition to Slack so it could remain a safe, fruitful space for "rehearsing" discussion related to ethics in ideas, languages or practices that might not be readily accommodated in certain workplaces:

> It is here that we can bounce ideas around and rehearse for other spaces. A moment to talk about unformed thoughts. These questions circulate in other spheres and these things come up. This has always been a group for us to bring concerns that matter to us personally. These conversations or this space is always personally motivated. (YA)

Leveraging existing community discussions on Slack generated further initiatives. While the group worked through seeding, supporting and engaging with such activities, other ideas were floated to document and share these rich conversations more broadly:

> Reviewing our notes makes me interested in the idea of publishing a *Medium* piece based on these discussions. The way we worked through that process, or where we started and where we ended up in the conversation. It is something

> I love to have documented. I am interested in exploring how to make evident the process here of how we are processing ethical questions in a dialogical format. . . . How do we "use" this group to work through those knotty issues, or create capacity, be supportive, in order to see and address those knotty issues? And also being open to how that can be translated or shared beyond this group? How can centering/connection here might connect with people outside? (KM)

In these accounts, the generative reorientations evidence ways to marry purpose and action differently, so that the labor of running physical events can be replaced by care for fostering ways to relate and maintain a community in a different format with different barriers to access and engagement. The ethical practices that were born during these reflective months lead both to a generative recalibration to align D&E organizers' motivations, passions and purposes so that their contributions might find further value within the community and a number of more political considerations, which are now turned to since some issues became more urgent to address in witnessing how uncertainty disproportionately impacts some people more than others.

4.4.5 Politics of Disproportionate Uncertainty

Uncertainties of the pandemic impacted societies that already had symptoms of systemic inequities and violence. Global news reported increasing numbers of the dying, infected, excluded or ignored; those who were already stateless, unprotected, under-resourced and living with extreme poverty, instability, poor sanitation and overcrowded shelters were hit hardest (de Moraes, 2020; Sen, 2020; Ullah *et al.*, 2021). This revealed again how uncertainties are political and disproportionate, exposing intersectional disadvantages in age, class, race, ethnicity, gender and geopolitical borders. What happened during the pandemic is that people with the privilege of greater security, for whom uncertainty was perceived as someone else's problem, found these illusions shattered and an end to the constancy of comfort and choices. The form of national, state and municipal control that pertained to the majority of SDM

members (being in Australia) contributed to this abrupt realization. To confront such symptoms and the violent systems, structures and practices in which Design/ers are implicated, is one reason among many that D&E organizers are motivated to be part of this group, e.g., RL – "design is the area I have the most agency around reducing violence", or YA who laments, "service design's ethical muscle is so, so weak."

D&E events and Slack discussions have raised critical questions as to how to understand and grapple with the ethics and politics of Design. These discussions have included gender, disabilities, decolonizing, anti-racism, social equity and myriad complex ethical issues. Raising these gave a chance to learn together and create encouragement, support, guidance, for and with one another. For example, as the pandemic was revealing social injustices so starkly and horrified by the police murder of George Floyd, D&E organized its first online event in June 2020, "Can we (and designers) imagine a world without police".[12] This took a discursive format with Shana Agid, an embedded designer-researcher, activist and organizer in Critical Resistance, a US-based grassroots organization seeking to end reliance on the interconnected systems of prisons, policing, surveillance, and other mechanisms for control and confinement. The event folded in Shana's (Agid, 2014) critique of design's role in "improving" unjust systems with more "humane" and "community-engaged" approaches, which merely normalize incarceration and perpetuate systems of policing. The need for design to deconstruct oppressive systems and propose alternative paradigms for care, safety and support for communities felt more urgent than ever before and the event became one of the largest events of 2020 and the whole D&E series.

The event's discussion centered on Design's complicity in systemic structures of violence. It captures the political mode of exploring uncertainty in more than just content. The Eventbrite invitation was multi-authored by recombining fragments of posts on D&E Slack around this incident, to acknowledge that this event was one part of an ongoing, rich and contested dialogue among this community. Given its political and

[12]Recording of this event can be viewed at https://vimeo.com/428664857/957b8a4093.

volatile context, the D&E organizers were sensitive to the need to create a safe space online where conversations could travel in unexpected directions. These forms of care and labor, shown as attention to facilitation and reflection throughout the transition to online engagement continued into their political organizing. The welcoming of clumsy questions and awkward discussions that are often impossible to share in professional settings allowed for a more honest dialogue about designer roles and the political nature of all creative activity. If we look with the political lens at the uncertainties the pandemic created, we can see here a community that was trying to make the best of the situation by becoming more reflective on these very issues.

4.4.6 Conclusion

While the four modes are organized into distinct sections by the monograph authors, they are, as we have described, intertwined. This case study shows that, during the pandemic, when fear, confusion and vulnerabilities were heightened, affective dimensions are constant accompaniment for communities who learnt how to be disciplined in their own ways, transitioning their everyday practices to live with the uncertainties. These transitions demonstrate generative ways in which people learned new ways to work, relate and live within constraints. As designer-researchers, compelled to respond and work in these contingent, turbulent and precarious conditions, we also saw ethical and reflexive accounts that closely attended to the organizers' own and others' positionalities. Designing with and for communities necessitates questions of how, why, when, who and what matters, which are always political. This case study reveals, then, that the conceptual clarity we aim to offer through the four modes can inadvertently flatten the complex and messy contexts in which we encounter uncertainty. This is something to guard against, with perhaps the generative, affective and political modes offering a means to heighten reflexive consciousness of the researcher.

5

Further Considerations

In surveying the many approaches to uncertainty within HCI identifying the four modes presented here, we have aimed to distill the various treatments into pathways with which to engage uncertainty. In doing this, we offer room for our readers to locate the particular uncertainties they might be engaging in a project, and to orientate to each mode to see what insights might emerge. Thus, we see this monograph offering a conceptual toolkit for HCI researchers. Rather than asserting the applicability of any given mode to a given context, we have aimed to show that uncertainty underlies our research constantly and the politics of each mode heightens the choices researchers make about which uncertainties they engage with and how. In our writing, we have shown that one case can be engaged through many modes, and that each mode can be activated through many cases. These choices, like all methodological choices, will shape the research, leading our reader to ask how, then, should they take up the concepts presented here. To further assist in the development of and engagement with the four modes, we organize this section into two primary concerns: identifying key contextual factors that may shape which modes one employs opportunities for further development of the modes.

Engaging Multiple Modes

In the case studies, the four modes of uncertainty stretch our thinking across four contexts in which uncertainty might be considered: disaster, security, caring and the pandemic. Naturally, some of these contexts are more easily described in one mode or another. However, in showing how all contexts may be described through all four modes, we suggest there is merit in thinking with more than one mode for the analysis it produces. As authors, we had particular orientations when we began the work of accounting for these lenses, but as they were teased out for use in the studies, we understood more about both our areas of interest and the way that uncertainty could be considered within them. The framings are not exhaustive, as we have already noted, yet spinning our orientation through these four turns has enabled us to see new relations.

The idea of engaging multiple modes became most interesting when we contrasted the political, generative and affective modes with the disciplining mode. As discussed, the disciplining mode is an established and familiar mode for engaging uncertainty in the public imagination as well as particular subcommunities of HCI. Indeed, an obsession with "problem-solving" has been argued as a form of decoupling design problems from structures, historicities and matrices of domination (Costanza-Chock, 2020). Admittedly, we approached the project in the beginning looking for other ways of engaging uncertainty that *rejected* disciplining, but through writing and discussing, we found that all modes must be held in a balance. Thus, we found ourselves developing a more tempered respect for the disciplining mode. We see the other modes—political, generative, and affective—as a way to anchor the disciplining or add moments of friction and reflection to processes.

A second reflection on the four modes stems from our experience trying to categorize or otherwise highlight similarities or areas of overlap between them (see Figure 5.1). We often found ourselves debating whether the four modes were distinct or had inherent connections. In particular, we saw tendencies in our writing to contrast disciplining with generative, and political with affective. The affective mode tended toward stronger synergies with the generative. Our difficulties in identifying exactly what these relationships were, or to clearly demonstrate

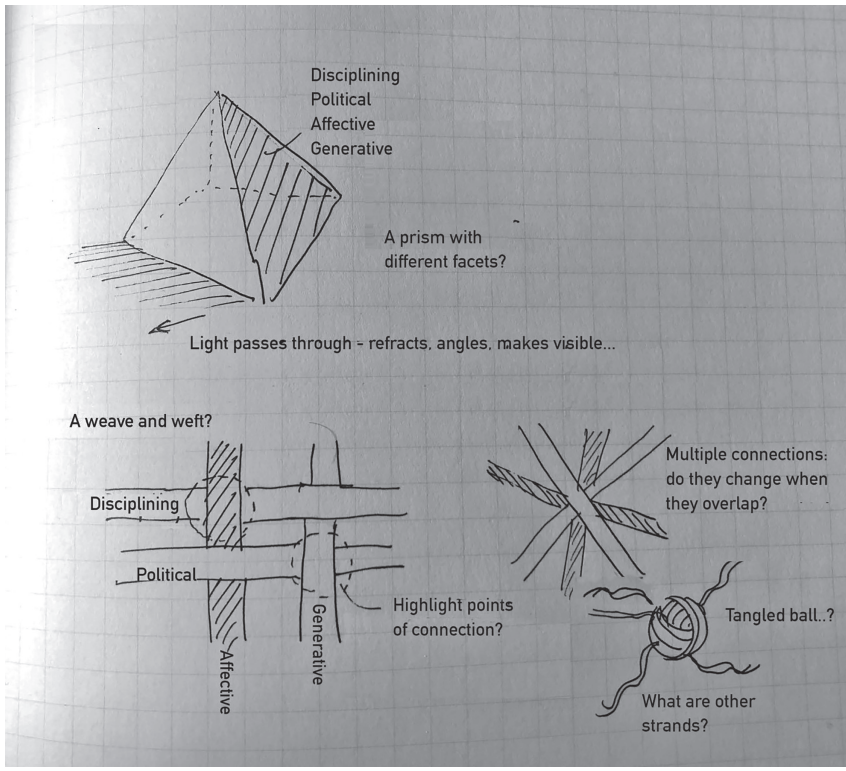

Figure 5.1: Draft sketch of the relationality of different modes used to think through the monograph.

the value in doing so, led us to conclude that our thinking was more fertile when we considered the modes as four alternative approaches through which to encounter uncertainty. This also allowed us to shift between modes more freely, and forced us to add contours to the modes that allowed them to operate largely independently.

Temporality and Uncertainty are Intertwined

Our encounters with uncertainty are bound up with various temporalities. Sometimes uncertainty is located in the present and entangled with current experiences, such as caregiving and navigating during the pandemic. At other moments, pressing uncertainties are located in the

future, entangled with the potential myriad outcomes of events like floods or security breaches. These degrees of difference may vary along political contours as well; while some people are positioned where they can conceptualize uncertainty as further away in the future, others are experiencing uncertainty as an intimate part of everyday life. Our case studies focused on uncertainties in the present and future rather than in the past – perhaps reflecting a bias of HCI research more broadly (see Soden *et al.*, 2019, 2021b) – but some researchers do use methods to engage with uncertainties placed in the past, such as contending with incomplete historical records or revisiting past practices by making them seem less certain than they might otherwise appear (Jungnickel, 2015; Shorey and Rosner, 2019). This suggests an opportunity to challenge the temporal categories that may have felt certain to the modes we have provided here.

For instance, when we place uncertainty as being further in the future, it becomes more vital to consider what aspects of future, speculative, worlds we hold constant (thus presuming a type of certainty), and what aspects we vary (thus presuming a type of uncertainty). Social and technical aspects of speculative futures are often anticipated to change in radical and indeterminate ways, while environmental, political, and economic systems are often depicted as more stable and less unpredictable (Soden *et al.*, 2021a). This may be, in part, due to blind spots and the dominant interests of HCI research. Nevertheless, careful consideration of what we change or hold stable suggests different types of political commitments to the worlds we see as possible or want to work toward. This again reminds how uncertainties are political and disproportionate, exposing intersectional disadvantages in age, class, race, ethnicity, gender and geopolitical borders. Such structures are continuously reaffirmed because "under white supremacist capitalist heteropatriarchy and settler colonialism, scoping also often is used as an excuse to ignore, bracket, or sideline questions of structural, historical, institutional, and/or systemic inequality" (Costanza-Chock, 2020, p. 122). Making the "certain" uncertain can erupt and magnify the fissures created by centuries of unjust practices.

Furthermore, we might interrogate what conceptions of time we use to think about uncertainty. HCI researchers have described orientations

of temporality akin to chronos or kairos. For chronos, Mazmanian *et al.* (2015) discusses circumscribed logics of time (seen as chunkable, single-purpose, linear, and ownable) and as kairos with a porous logics of time (seen as spectral, a mosaic, rhythmic, and implicated in social relations). Others, like Odom (2014), posit "slowness" as an alternative way of engaging with temporality. While the futures cone is a common metaphor toward thinking about uncertainties in the future, Kozubaev (2020) note how this representation promotes a linear conception of time with a Western and English-speaking bias. Building on this critique, Howell (2021) provide alternative metaphors for thinking about temporality in design futuring that challenge notions of linear technology progress, eschew binaries between present and future, and highlight relationalities and assemblages. A more linear view of time might see uncertainty as occurring as a result of discrete events over time, for instance, a breach in security or a design intervention creates a new uncertainty. Playing with this linearity is speculative work that asks how design might have created or responded to forks in the past, making the reality of the present less certain (e.g., Light, 2021; Pargman, 2017). Alternate conceptions of time, including non-Western logics, philosophies and worldviews, consider plural cycles or rhythms, highlighting alternate and peripheral ways for researchers to engage uncertainty (see Akama, 2015; Refiti *et al.*, 2021; Rose, 2012).

Engagements with Uncertainty Shift While Experiencing Uncertainty

One of the idiosyncrasies of writing this monograph during the global pandemic was the way it foregrounded the disjunctures between thinking about uncertainty and living with it. As authors, we found ourselves reflecting quite often on the unsettling experience of tacking back and forth from describing uncertainty to being in states of uncertainty ourselves. Much of our writing here adopts a critical scholarly distance in order to witness, and in some sense discipline, the various forms that uncertainty takes in HCI. This stands in contrast to the events of 2020–2021 and our individual experiences of them. We're still digesting

this contrast, but want to raise two points that have struck us forcibly in this context.

First, there is a politics to who is privileged enough to be able to adopt a reflective stance toward uncertainty, and who is forced to grapple with uncertainty and precarity as part of their daily life. It is not a coincidence that, in emergency after emergency, some communities are expected to be "resilient" while others expect to be protected. The impacts of COVID-19, as with all disasters, were both shaped by, and revelatory of, the deep inequities produced by global capitalism. Indeed, at the time of this writing, there is mounting evidence that the world's wealthy elite have profited wildly during the pandemic. Such inequities are present in academia as well, where gender and other disparities in paper submission have spiraled (Ahn *et al.*, 2021). Such examples lend evidence to Chaudhary's (2020) provocative thesis about climate change, another crisis whose impacts and uncertainties are unevenly distributed, that "we're not all in this together".

Second, as the modes we have introduced here suggest, the character of uncertainty that emerges in our research settings is significantly shaped by the worldviews that orientate us to it. Each of the modes we have introduced has different theoretical backgrounds, utilizes different research methods, and yields different sorts of contributions. Together, these arguments accumulate into a relational view of uncertainty in HCI. Even the choice whether to understand our assembly of insights as an aggregation or a juxtaposition says something about the kind of research we are pursuing and our sense of uncertainty's properties. Feminist peers haves already identified this orientation, like Star and Ruhleder's (1996, p. 112) relational formulation of asking "when is an infrastructure." That is to say, infrastructure only becomes such, "in relation to organized practices." Perhaps, as with infrastructure, uncertainty is then better understood analytically as an emergent, rather than fixed, characteristic of a reality to which we are external observers. This again is the politics of positionality for some to recognize that we can't separate ourselves from our experience; it shapes our work, our perspectives, and the kinds of uncertainties we find in our work. At a philosophical extreme, we might see all knowledge as indeterminate and made by the nature of our inquiries (Barad, 2007).

Developing New Modes

As tools for reflexivity, the four modes featured in this monograph can act as reminders as well as counter-balances that could catch our disciplinary habits kicking in when examining uncertainty in our research. Additionally, if the modes are to multiply and adapt, they can also begin to include a more diverse set of perspectives than those provided by the authors. Thus, we believe modes must remain porous so it continues to be open to other features that "leak" out as a "misfit" under the four modes.

These reflections return us to concerns we raised in the introduction about the limitations of the dominant Western epistemology from which uncertainty in HCI is drawn, having been framed by a science that attempted to stand outside this stream of being. As noted, other onto-epistemes have matured in civilizations where "uncertainty" is framed and engaged with quite differently. Even a mention of these alternatives helps us recognize the politics of omission, so often a feature of Global North accounting. For instance, other worldviews that consider uncertainty differently include Zen Buddhism and Indigenous onto-epistemes where human-nature or mind-body have never been separated in hierarchical constructs. Zen Buddhism attends to practices of self-awareness which orientates a practitioner to be ready, present and open to engage with uncertainties of worlds. A famous teaching by the late Zen master, Thich Nhat Hanh (1991), invites us to "wash the dishes to wash the dishes", instead of washing to have clean dishes, to curb goal-driven mindsets that aim to predict, analyze or control uncertainty. Such practices of being present to uncertainties can "awaken and attune to the pulsation of broader ecologies" and into the "immediacy of the ever changing moment" (Akama *et al.*, 2017b, p. 354) that may enable design and HCI to consider radically different human-technology-world becomings. Design and technology is already integrated with relational and entangled worldviews that can teach HCI about designing with more-than-humans in the Anthropocene (Akama *et al.*, 2020; Bachler, 2020).

Another example: the continent now known as Australia has co-evolved with fire over 75,000 years through an Aboriginal practice called

"fire-stick farming" that cleared leaf litter, burnt grasslands and created rich grazing for wallaby and kangaroo (Pascoe, 2016). This contrasts significantly with how settler-migrant societies in Australia see fire as a threat, suppressing its use and creating "fuel build-up". For worldviews that separate human from nature, cordoning off "untouched" bushlands like national parks to "preserve" them has further magnified disaster (Steffensen, 2020). Over the centuries, bushfires have escalated into intensely hot crown fires that leap and explode in a destructive path, as witnessed during *Black Summer* 2019–2020. Instead of prohibiting and fearing fire, Wurrundjeri Elder, Uncle Dave Wandin (2021, para 13) teaches cultural burning to "heal Country" because "you know that fire is not something that you need to be afraid of – it's a useful tool, if you understand it".

At various points we toyed with the idea of a fifth mode in the form of inaction, waiting, or otherwise *not designing*. However this idea arrived so late in our co-authoring that we did not feel able to engage it fully. We mention this here because modes have a tendency to suggest action, doing, and engaging. This means we could also consider an "anti-mode" that suggests inaction, pausing, or other forms of nonengagement (Akama and Light, 2018). This "anti-mode" radically counters the implicit assumptions of research as an act of doing and the limits of our ability to articulate exactly what we did not do, or the places we were inactive within our case studies. Pausing is a particular feature that emerged in the community organizing case study when the Design and Ethics group re-orientated to continue designing with and for this community during the 2020 pandemic.

Modes like pausing, stopping, waiting are common qualities observed during the lockdown where things literally stood still – people, cars, flights, machinery and goods – that allowed scientists to record a significant drop in seismic noise (Lecocq *et al.*, 2020) and marine biologists to listen to cetaceans, like whales, dolphins and orcas that were silenced or drowned out before by underwater noise pollution (Thomson and Barclay, 2020). This "leaky" mode is mentioned here, to catch disciplinary biases in Design and HCI that tends to favor outward, visible, active and intentional modes of engagement (as seen in disciplining and

generative). It is concerning when pausing is framed as a binary opposite as "passive" or "inactive" (Akama, 2019) when arguably it is akin to practices of waiting as a form of graceful patience that features in many faiths, virtues and teachings (Akama and Light, 2018; Schnitker, 2012) that have grappled with various uncertainties of many worlds. The same politics of omission by western epistemes and disciplinary scripts have also been discussed by other scholars in design anthropology where notions of "surrender" as way to let go of habitual distancing commonly seen in research and to embrace errors, accidents, serendipity and indeterminate slippages as features of uncertainty (Akama *et al.*, 2018).

6

Conclusion

The four modes we proposed in this monograph have been insightful for us in revealing both contrasting and inter-linked features of uncertainty (see Table 6.1). In concluding, we want to leave the readers with a paradox: research into uncertainty highlights the obvious fact that all cannot be known, but also, to know is to render some uncertainties as the opposite. This relatively banal truism has been there from the start, and our co-exploration of the modes have not yielded any further enlightenment. Therein lies an incomprehensible, perpetual cycle, which again compels researchers to try and grasp at uncertainty while being cognizant that it cannot be fully "attained". As discussed, even the modes we offer are partial occlusions we create by subscribing to them, so expanding more modes or lenses will likely reveal further enigmas that have not yet been explored. Ultimately, we are optimistic that this monograph might enrich HCI's understanding of uncertainty in ways that attend to the politics of its work and are generative in outcomes. Even as we imagine these modes offering expansive approaches for designers and researchers working on questions of uncertainty, we also see the possibility of identifying linkages between research sites that were previously disconnected. We hope we have offered some resources for navigating the turbulence of the moment and those that are yet to come.

Table 6.1: Multiple modes of uncertainty

	Disciplining	**Political**	**Generative**	**Affective**
Central Foci	Felt, emotional, somatic	Sources, dilemmas, risks	Possibility, ambiguity, stories	Power, boundaries, categories, agendas
Actions	Autobiography, guided experience	Calculate, communicate	Play, fiction, engagement	Survey, analyze
In order to	Render uncertainty	Reduce uncertainty	Include uncertainty	Identify (omissions, partiality of) uncertainty
Towards	Acceptance	Avoidance	Possibility	Restraint
Requires	Closeness, Openness, care	Boundaries, categories	Structure, surrender	Partiality
Creates	Evocations, Narrative, artifact	Best practices, recommendations, distinctions	Propositions	Voices, perspectives

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