Doctoral Thesis in Human-computer Interaction

Designing with care

Self-centered research for interaction design otherwise

KAREY HELMS

Designing with care

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for Quinn

Abstract

This dissertation is about the research program *designing with care* as a pathway towards interaction design otherwise amid a world in crisis. Considering how established ways of doing interaction design will change involves recognizing the role of digital materials in social injustice and systemic inequality. These concerns are inseparable from the material complexity of interactive experiences and their more-than-human entanglements in care. Through five design experiments, I explore everyday human care as wickedly attending to some care doings and not others, and an intimate and generous questioning of oneself as human.

I offer four contributions for interaction designers and design researchers. The first contribution is *designing with care*. This research program draws upon care ethics and posthumanism to establish four axioms: everyday, wickedness, intimacy, and generosity. Within this programmatic framework, the second contribution is definitions of wickedness and generosity as ethical stances that can be taken by designers and researchers. The third contribution is the synthesis of my four methodological approaches: *auto-design*, *spatial orientations*, *leaky materials*, and *open speculations*. Each is a generative and analytical pathway towards more sustainable and just futures. The fourth contribution is five careful designs as prototypes of what interaction design otherwise might be like: *technologies of human waste*, *spying on loved ones*, *leaky breastfeeding bodies*, *scaling bodily fluids*, and *a speculative ethics*.

From my research program and contributions, I discuss disciplinary resistances to suggest three possibilities for how I argue interaction design should change: engaging with mundane yet unrecognized topics, doing design work where the consequences would be present, and reconsidering how the formats of research publications could better reflect positionality. I then reflect upon the relevancy of self-centered research in moving beyond oneself for more sustainable worlds.

Sammanfattning

Denna avhandling utvecklar forskningsprogrammet *att designa med omsorg* (*Designing with Care*) som en ansats för interaktionsdesign, i en värld som i övrigt befinner sig i kris. Med utgångspunkt i att etablerade praktiker inom interaktionsdesign kommer att behöva förändras, krävs även ett erkännande av den roll som digitala material spelar i social orättvisa och systemisk ojämlikhet. Dessa farhågor är oskiljaktiga från den materiella komplexitet i interaktiva upplevelser och deras sammanflätningar in en värld som är "mer än mänsklig". Genom fem designexperiment utforskar jag vardaglig mänsklig omsorg som lömskt prioriterar vissa former över andra, och som intimt och generöst ifrågasätter sig själv som människa.

Jag erbjuder fyra bidrag för interaktionsdesigners och designforskare. Det första bidraget är *att designa med omsorg*. Detta forskningsprogram bygger på omsorgsetik och posthumanism för att fastställa fyra axiom: vardaglighet, lömskhet, intimitet och generositet. Inom denna programmatiska ram är det andra bidraget definitioner av lömskhet och generositet som etiska ställningstaganden som kan intas av designers och forskare. Det tredje bidraget är syntesen av mina fyra metodologiska tillvägagångssätt: *autodesign*, *rumslig orientering*, *läckande material* och *öppna spekulationer*. Var och en är en generativ och analytisk väg mot en mer hållbar och rättvis framtid. Det fjärde bidraget är fem noggranna designs som prototyper på hur interaktionsdesign annars skulle kunna se ut: *teknologier för mänskligt avfall*, *att spionera på sina kära*, *läckande ammande kroppar*, *skalning av kroppsvätskor* och *en spekulativ etik*.

Från mitt forskningsprogram och mina bidrag diskuterar jag disciplinärt motstånd för att föreslå tre möjligheter för hur interaktionsdesign bör förändras: genom att engagera mig i vardagliga men okända ämnen, göra designarbete där konsekvenserna skulle vara närvarande och ompröva hur formaten för forskningspublikationer skulle kunna bättre återspegla positionalitet. Jag reflekterar sedan över relevansen av självcentrerad forskning för att gå bortom sig själv för mer hållbara världar.

Acknowledgments

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I.   Introduction

In 2004, in my second semester of architecture school I was asked to diagram using a series of lines and dots on index cards "where do I come from and where am I now". At the time, I interpreted the assignment to be about representing myself as practice for representing what I would design. Representing was achieved by diagramming, which through simplification was a pathway towards understanding how people and the environment would interact with architecture. This might include diagramming a person (as a dot) moving (as a line) through a corridor (as a card), or air (as many dots) flowing (as many lines) between facades (as many cards). The index cards would capture essential moments in time between the "from" and the "now" that could explain reasons to design, such as a need for people to relocate between rooms, and effects from design, such as air gusts.

In doing the assignment, I encountered an unease in representation as it reduced my identity to a singular dot, split my story into disjointed lines, and isolated my places of inhabitance to static cards: I was a student (dot) from East Tennessee (card) that moved northeast across the Appalachian Mountains (lines) to Central Virgina (card). Was that really it? In reflecting upon all that was unaccounted for in such a simplified representation, rather than adding more to enrich my life story, I scrapped those first cards and in a second iteration I shifted focus to my morning walk from home to school. Rather than using store-bought index cards, I first created my own by cutting newspaper, colored card stock, and translucent tracing paper that I collaged to form a series of unique squares. Through an assembling and layering of paper, each square intended to describe what I had seen, heard, or felt that morning at particular places and in particular moments. This included a noticing of other people, varied textures, and uneven paces. I then arranged the cards according to geographical orientation to spatially depict my route as a two-dimensional plan. Instead of drawing lines and dots on top of them, I punctured holes through the crafted cards and through which I loosely sewed a red thread. The dots situated my position in those particular places and moments of observation, and the lines dynamically expressed connections between my positions of observation. Upon completion, I folded the thread to stack the cards, and with my walk now in a messy pile, I realized that every time I unraveled it, it could and would be remade slightly different.

Motivation and context

In 2022, I introduce my thesis with this anecdote for two reasons. The first reason is grounded within how I now understand the assignment, which positions what I consider design to be. Rather than it being about representation, I now understand it to be about relationships: diagramming was not intended to reduce, but to understand interconnections between people and places, positions and observations, and pasts and presents. From the places I stood and stepped during my walk, I saw and felt different scenes and sensations. For example, from the top of a hill I noticed the wind and circled back for my jacket; or as I approached the front entrance of the architecture school, I saw a conversation that I did not want to participate in and so rerouted to a back door. My position during my walk on one card informed what I saw, and what I saw in turn informed the next position I occupied as implied by the red thread. In this way, lines and dots on cards were not meant to essentialize moments in time as isolated, they were instead suggestive of a constant becoming between what might be inhabited, observed, and experienced. Yet also in revisiting my walk, I noticed new things as I unmade the pile to lay out the cards, which though ordered and attached to one another, were able to shift in location as the red thread was loose and malleable. This included thinking about why I took certain paths, such as a sidewalk rather than a shortcut; or speculating about what else I might not have encountered if I would have taken the front entrance, such as an uplifting conversation with my favorite staff member.

This understanding of the assignment draws upon concepts of ontological design that emphasize that as humans intentionally and unintentionally design, ways of being and becoming human are in turn designed (Willis, 2006). As Arturo Escobar says, "[W]e are all designed by what we design as subjects. We are all designers, and we are all designed" (2018, p133). This ontological inseparability is also referred to as intra-action (Barad, 2007), which problematizes the attribution of agency to only humans as having the power to construct the world. This calls attention to the active participation of "things", such as design, in affecting human experience and situations beyond expected or anticipated encounters (Bennett, 2010). It also points to the non-neutrality of design as a situated form of action (Suchman, 1987), which includes deciding what types of futures are made in the world and what worlds are worth having a future (Fry, 2020).

The second reason I introduce my thesis with this anecdote is that through a positioning of what I consider design to be, I motivate why I think design should change, and more specifically, why I think interaction design should be *otherwise*. Design *otherwise* is another way of thinking about creating change in the world that challenges established ways of doing design (Abdulla, 2018). It recognizes "that design and its thinking is deeply complicit in many structural systems of oppression, serving to concretize, perpetuate, and disseminate power and privilege" (Mareis & Paim, 2021,

p11). For example, long-standing values in design, such as universality and objectivity, exclude a diversity of human experiences beyond white and heteropatriarchal, which often ignore many voices and abilities. In relation to contemporary trends towards nationalism, heightened inequalities, and environmental exploitation, *otherwise* is part of conversations that ask what alternative values, practices, and knowledge might be necessary and present to shift design towards more ecologically and socially just futures (Forlano et al., 2019). It includes not only designing to change the world, but also how design might change amid a world in crisis (Light et al., 2017) through "thinking and doing design in different ways than are typical" (DiSalvo, 2022, p1). As further put by Maria Göransdotter, "[i]n tackling issues of living together, sharing resources and making decisions in ways different from those that have been guided by the logics of progress, industrialism and consumerism, not only does design need to change, but the frameworks and world views governing how it is understood and practiced also need to change" (2020, p299). Rather than making more or "better" designs, I understand these calls as an urgent need to rethink what it means to be a designer when ways of being in worlds are designed, which includes alternative values and methods.

Interaction design is the design of experiences with digital materials (Löwgren, 2013). In this thesis, I consider digital materials to be interactive or computational things that most often include data and technology to be things that are composed of digital materials. Considering how interaction design might be otherwise recognizes the role of digital materials in perpetuating social injustice and systemic inequality. For example, this includes surveillance practices that exploit human behavior through the commodification of personal data (Zuboff, 2019); discriminatory algorithms that determine daily life, such as who can get a job (O'Neil, 2016); and toxic biases embedded within data as economic and cultural power in society (D'Ignazio & Klein, 2020). These concerns for interaction design are seen to deepen as the material complexity is becoming increasingly more immaterial, dynamic, and complex (Redström & Wiltse, 2018). This means that it can be difficult for designers to make sense of their impact in the world, as well as to understand the potential reach and consequences of design without the possibility to responsibly intervene. These difficulties ground explorations into not only designing for such digital materials, but with them in acknowledgment of more-than-human agencies of technological things as participants in design processes and outcomes (Giaccardi & Redström, 2020). More-than-human refers to relations between beings rather than discrete entities in recognition of humans as always entangled with nonhumans, which includes other organisms, objects, and agencies (O'Gorman & Andrea Gaynor, 2020). Nonhumans can be both technological and nontechnological, and a more-than-human consideration of digital materials is alongside conceptualizations of *living artefacts* (Karana et al., 2020), "multispecies worldings" (Westerlaken, 2020), "being

where one does and thinks" (Avila, 2017), and repertoires for designing with nonhumans (Oogjes, 2022) that problematize human-centered hierarchies. Laura Forlano describes such approaches in the context of design and technology as a blurring of "boundaries between the familiar binaries of human and nonhuman, culture and nature, and human and animal that have dominated Western thinking since at least the Enlightenment" (2017a). It is within this blurring of agencies between everyday materials and human life that I investigate interaction design otherwise.

Research program: *Designing with care*

In this thesis, I ground how the field of interaction design might be otherwise through two propositions:

> **Interaction design should wickedly attend to human everyday care**
> **Interaction design should intimately and generously question what it means to be human**

The first proposition situates everyday care as an important context for interaction design. It is grounded within the notion of "care [as] so vital to the fabric of life that it remains an ongoing matter of struggle and a terrain of constant normative appropriation" (Puig de la Bellacasa, 2017, p8). Everyday care is considered informal and unpaid doings that are often unrecognized or devalued (Toombs et al., 2018), which contributes to human inequality and oppression through the perpetuation of invisible labor (Hobart & Kneese, 2020) and gendered stereotypes (Strengers & Kennedy, 2020), as well as risks ignoring how people caring for technology affects caring for other people (Michelfelder, 2020). Everyday human care includes the maintenance for and by humans in sustaining the well-being of humans and nonhumans. For example, this includes the self and shared management of essential biological processes, such as going to the toilet; caring for loved ones in domestic settings, such as raising children alongside cooking, cleaning, and reading stories; and the labor of fixing home technologies, such as configuring digital assistants. Such situations are essential to a person's physiological well-being (Blumenthal, 2014), identity formation (Buckley, 2021), and socio-material relations (Attfield, 2020). This grounds an ill-considered intervention or unintended consequence of technology as potentially revealing, shameful, or devastating. If interaction design does not attend to everyday care, it risks not supporting the foundations that make human life possible, or possibilities of living as well as possible.

The second proposition acknowledges that in everyday survival, "some humans have been considered more human than others; [and] some have been considered less than human" (Ferrando, 2018, p439). This can be seen in a marginalization of divergent care practices that do not prescribe to able-bodied norms (Piepzna-Samarasinha, 2018)

and opposition towards more inclusive toilet facilities that challenge binary categories (Slater & Jones, 2018). Who gets to count as human has historically been defined by power relationships grounded in differences of gender, race, and ability (Åsberg & Braidotti, 2018), which has manifested in essentialist and binary modes of thinking such as human/nonhuman and nature/culture. Within posthuman theories, the human as socially and materially constructed also intimately renders it an open and mutable concept of continually shifting identities and selves that through a continued questioning can challenge a centering of particular people and particular worlds (Wolfe, 2010). In summary, "[w]hat this means is that design must bring into being the material and political conditions for the human that refuse to authorise its exceptionalism in any form" (Nocek & Fry, 2020, p3). For interaction design, this questioning is especially important in understanding human life as vulnerably embedded within a material world of more-than-human agencies, which includes the role of emerging technologies in shaping experiences and blurring of boundaries (Forlano, 2017a). If interaction design and designers do not question what it means to be human through design work, it risks ignoring a plurality of lives in technologies of everyday care.

These two propositions do not seek answers or claim to contribute solutions, but instead open for thinking *otherwise* about futures in terms of preferability and possibility (Abdulla, 2018). They form the provisional scaffolding of my research program *designing with care*, which is grounded within my worldview as a set of basic beliefs that situates conceptual exploration (Redström, 2017). These beliefs include a valuing of the everyday as an important context for care, as well as a view of care as wicked within its potential to make and unmake relations of survival by orienting towards some care doings and not towards others (Puig de la Bellacasa, 2017). These beliefs also include a view of intimacy as inherent to a questioning of what it means to be human through a socio-material engagement with the self, as well as a view of this questioning as generous within the potential for vulnerability and harm amid an opening and sharing of oneself (Diprose, 2002). The relationship between the four values and their theoretical underpinnings is summarized as follows: everyday and wickedness are situated in relation to care ethics, and intimacy and generosity are situated in relation to posthumanism. This specification of my worldview shifts from what Maria Puig de la Bellacasa (2017) calls *thinking with care* as an ontological overlap between care ethics and posthumanism, to my articulation of *designing with care* as an exploratory space to prototype what interaction design might be like within these conditions. Thus, the aims of my research program are to investigate alternative methods and values for interaction design that contribute towards more sustainable and just futures; and which I accomplish by creating examples of attending to everyday human care and intimately questioning what it means to be human, which I refer to as *careful designs*.

Thinking with care   **Designing with care**
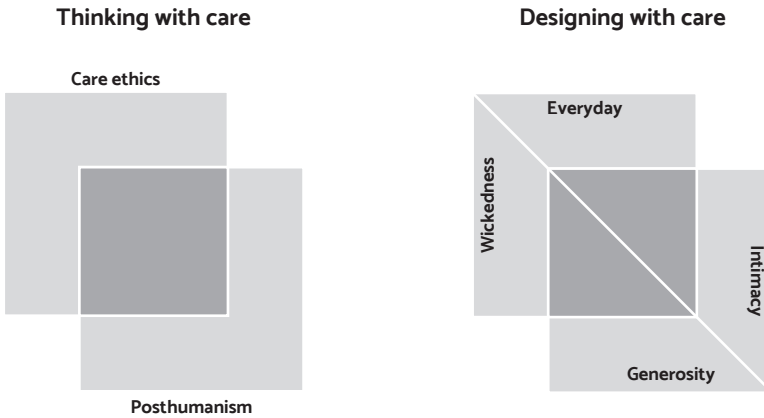
The darker color indicates an overlap between theories and my beliefs as stabilizing structures in conceptual exploration. The lighter color illustrates that not all axioms need to always be explored together or at the same time to learn new things (Redström, 2017).

Careful designs

There are five careful designs discussed in this thesis: *technologies of human waste*, *spying on loved ones*, *leaky breastfeeding bodies*, *scaling bodily fluids*, and *a speculative ethics*. First, *technologies of human waste* investigates the everyday care of bodily excretion through the design of speculative technologies that predict when and how badly a person needs to urinate. These position the associated data as intimate through the management of excretion as essential to a person's somatic health and well-being. Second, *spying on loved ones* explores tensions in caring for family members through critiques of two autobiographical design projects. It foregrounds a wickedness in designs for care as not always feeling "good" and troubles caring for design amid normative academic expectations. Third, *leaky breastfeeding bodies* challenges cultural preconceptions of humans as individual and bounded through three design explorations from my breastfeeding relationship. They are intimate in their questioning of myself within the everyday nurturing and nourishment of my child, and generous through a vulnerable sharing of myself materially with my family and socially among an academic community. Fourth, *scaling bodily fluids* imagines human survival as entangled in more-than-human collaborations through four visual and textual narratives as fables for designers to think with. It foregrounds a generosity in multispecies relations that points towards designing within unknowable possibilities. Fifth, *a speculative ethics* reflects upon social discomfort and material harm in designing and researching with my own, shared bodily fluids through "performative texts". The texts generously speculate on
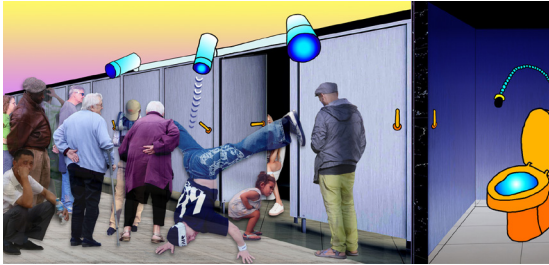
Technologies of human waste includes the design of speculative devices that predict when and how badly a person needs to urinate.
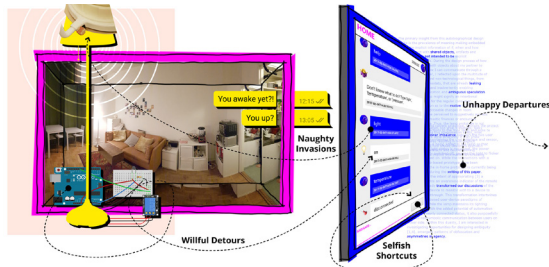
Spying on loved ones critiques two autobiographical design projects to foreground care as not always feeling "good" and proposes pathways for care that are not in-line with normative expectations.

Leaky breastfeeding bodies presents experiments with or about milk to investigate humans and nonhumans as socially and materially entangled.

Scaling bodily fluids imagines human survival as entangled in more-than-human collaborations through the creation of four visual and textual narratives.

A speculative ethics shares and reflects upon moments of discomfort and material harm within self-centered research through "performative texts".

ethical possibilities of an intimate engagement with the self. In relation to my research propositions, the careful designs do not always explore the assumptions put forth by my worldview in the same way or with the same results, but it is rather through their assembly of differences within a situated and constrained set of beliefs (Redström, 2017) that I can discuss the "success", implications, and limitations of *designing with care*.

Methodology and ethics

In creating careful designs, my research is a dialogue between theory and practice as research-through-design (RtD), an approach that considers a design process and artifacts as ways to acquire new knowledge (Frayling, 1993). I situate my process within four broader methodological approaches: *auto-design*, *spatial orientations*, *leaky materials*, and *open speculations*. First, *auto-design* is a group of methods that explicitly engage with the human self as a starting point in design and research. Second, *spatial orientations* are pragmatic and conceptual approaches that describe how human and nonhuman bodies inhabit space. Third, *leaky materials* takes into account the vitality of digital and nondigital design materials. Fourth, *open speculations* are critical and speculative design methods to materialize alternatives and invite continued engagement.

My research ethics is grounded within a desire to avoid harm through a relational emphasis on mutual care. This is referred to as relational ethics, which understands research as an ongoing and situated process in knowledge construction (Ellis, 2004; Groot et al., 2020; Phillips et al., 2021). It is based upon a feminist ethic of care that promotes a contextual mode of thinking in everyday judgments, and contrasts from procedural ethics that is based upon universal principles and moral authority (Gilligan, 1993). In my research, practicing a relational ethics involves a recognition that research situations "involve multiple moments, decisions, actions, and operations that can result in outcomes that have potential harm for people" (Markham et al., 2018). More concretely, this has included frequent and ongoing discussions with people directly included or peripherally involved in my research, such as my partner; co-speculating with him about how I, he, and our child might feel in the future about my research; active consent from myself and him, in addition to both of us giving consent for our child; as well as a use of pronouns to preserve anonymity and obscuring of visual images to protect identity.

Contributions

In this thesis, I make four contributions for interaction designers and design researchers interested in alternative ways of thinking and working within industry and academia. This includes practices that investigate the design of more sustainable worlds and question what people and environments are being cared for and how. While these

contributions are situated within human-computer interaction (HCI), they do not always explicitly involve digital materials. Yet their relevance is aimed towards designing interactive experiences differently, and points toward a shift in interaction design that highlights the relevancy of nondigital relations, agencies, and materials. The four main contributions span the first part of the thesis and the six included papers.

The first contribution is the research program *designing with care* as an exploratory space for prototyping interaction design otherwise. It draws upon care ethics and posthumanism to establish four axioms: everyday, wickedness, intimacy, and generosity. Together, these four axioms ground two propositions that can be used by designers and design researchers to generatively and analytically shape practice and exploration.

The second contribution is definitions of wickedness and generosity. My articulation of wickedness puts characterizations of difficult problems (Rittel & Webber, 1973) and unpredictable interactions (Wiltse et al., 2015) in relation to *designing with care*, whereby care is rendered as unsolvable with no inherent right or wrong outcome. This framing opens for divergent care practices as desired and is an approach for attending to a multiplicity of needs and desires. My articulation of generosity aligns with conceptions of humility (Wakkary, 2021), yet extends it in relation to a prereflective disposition that is a threat to bodily integrity (Diprose, 2002) and a material sharing with uncontrollable and unanticipated outcomes (Hird, 2007). This acknowledges that generosity does not always involve deliberate humility or choice. Both of these articulations are ethical stances that can be taken by designers and researchers.

The third contribution is the synthesis of my four methodological approaches: *auto-design*, *spatial orientations*, *leaky materials*, and *open speculations*. They each draw upon a collection of related methods that in the context of *designing with care* are generative and analytical pathways towards careful designs.

The fourth contribution is the careful designs presented in this thesis as prototypes of my research program: *technologies of human waste*, *spying on loved ones*, *leaky breastfeeding bodies*, *scaling bodily fluids*, and *a speculative ethics*. Each set of careful designs explores the axioms of my design program differently, through which they each make their own individual contributions as examples and provocations.

Positionality

How I approach my research is largely influenced by the lines and dots that inform where I come from and who I am now. The first half of my life was spent on the east coast of the United States. I received a Bachelor's of Science in Architecture from the University of Virginia in Charlottesville. I have a Master's in Fine Arts in Interaction Design from Umeå Institute of Design. Before beginning my PhD at KTH in Stockholm, I was an interaction and service designer in London for a technology

company specializing in enterprise internet of things. Each of these locations and ways of designing are significant in the making and unmaking of my politics and practices in this thesis. My upbringing and early adulthood was situated within conservative communities that stand in stark contrast with the diversity of backgrounds and experiences that I have been exposed to in Northern Europe. This tension has contributed to a questioning of logics of individualism and patriarchy, yet has also foregrounded the resources, statuses, and structures I benefit from while researching in Stockholm. This includes my privileges as a white, able-bodied, cis-gender woman in a legally recognized heteronormative relationship with subsidized child-care that generously grants me the time and support to read, think, write, and design with care.

My educational and employment backgrounds have also greatly influenced my interests and approaches. The architectural studios in my pre-professional degree were conceptually driven, and as a professor once pointed out, the designs in my graduating portfolio lacked many practical elements such as purposeful doors and windows. I see this as an early interest in exploration and critique as opposed to implementable solutions. At Umeå Institute of Design, my master's thesis critiqued society's relationship with energy through the design of speculative energy-harvesting artifacts and their entanglements with each other and a fictional family. This began explorations of written storytelling and performance as critical design methods. A short, two-year return to industry as an interaction designer provided behind-the-scenes access to the workings of everyday services that I often take for granted, such as waste collection and package delivery. This experience was formative in questioning values of efficiency and objectivity in data-driven systems, while also furthering an interest in how digital materials are entangled in supporting the daily lives of consumers and laborers.

The importance of sharing more lines and dots than those already evidenced in my papers is to ground an overview of my path in forming the worldview presented, motivate the design and research approaches I have taken, and to situate a responsibility I feel in speaking from and about my particular experiences. In relation to the design situations presented in this thesis, such as family care, public restrooms, and breastfeeding, I hope to open for more conversations regarding these topics and especially for how interaction design might change in relation to everyday oppression experienced by many people and many worlds. I do not intend to speak for or know about experiences other than my own, yet I do intend to provide readers of this thesis references that do directly engage with a plurality of humans whose lives my work might affect.

Thesis overview

This thesis as a compilation ("kappa") within which the papers are the main contribution of my PhD research and can be found in the second part of the thesis. The first part is a summary and synthesis of outcomes and contributions. It also provides a holistic overview of my research that includes a positioning among philosophical arguments and related work. It is structured as follows:

Chapter II: Thinking with care is a background and related work. I first situate my theoretical commitment to a feminist ethic of care that positions everyday human care as important for interaction design, while also grounding the significance of a wickedness in attending to it. Next, I draw upon posthumanism for a questioning of what it means to be human through an intimate and generous engagement with one's self. Lastly, I summarize how care ethics and posthumanism together support the notion of *thinking with care*, and how the highlighted axioms of the everyday, wickedness, intimacy, and generosity scaffold my articulation of *designing with care*.

Chapter III: Designing with care is my research program and methodology. I open with an introduction to the relationship between design, research, and theory before describing a programmatic approach towards making design theory and the role of design experiments. Next, I position my research methods as ways of knowing within four broader approaches. They are *auto-design*, *spatial orientations*, *leaky materials*, and *open speculations*. This includes illustrating how they inform my research program.

Chapter IV: Careful designs are five design experiments. Each is a set of explorations that prototype how interaction design might be otherwise within the conditions of my research program. They are: *technologies of human waste*, *spying on loved ones*, *leaky breastfeeding bodies*, *scaling bodily fluids*, and *a speculative ethics*. In the presentation of each, I give an overview of each experiment, report upon their individual research contributions, describe key decisions in my design process, describe how the particular methods used informed outcomes, and illustrate which axioms of the research program they investigate.

Chapter V: Discussion is a summary and reflection on my research contributions. This includes the research program *designing with care*; articulations of wickedness and generosity; four sets of methodological approaches; and five examples of interaction design otherwise as careful designs. Following a summary, I return to the notion of interaction design otherwise, whereby I discuss possibilities of engaging with mundane yet unrecognized topics, not separating where things are designed and researched, and alternative narratives of dissemination. I then reflect upon the relevancy of self-centered research for more sustainable worlds by including who or what is often excluded or absent, critiquing of oneself as an ethical obligation, and a pathways towards collaborating with many selves.

Included papers

The contributions of this thesis are based upon the following six papers.

Paper I: Do you have to pee? A Design Space for Intimate and Somatic Data

> Karey Helms. 2019. Do you have to pee? A Design Space for Intimate and Somatic Data. *ACM Conference on Designing Interactive Systems (DIS 2019)*, San Diego, California, USA. **(Best Paper Honorable Mention Award)**

In this full conference paper, I detail a design space on the leveraging of data to manage urination. It is part of the careful design *technologies of human waste* and includes three design activities: a critique of market exemplars, three conceptual design provocations that predict when and how badly a person needs to urinate, and autobiographical data-gathering and labeling of my urinary routines. From these, I contribute three considerations for interaction designers: the labeling of somatic data, the actuating of bodily experiences, and the scaling of intimate interactions. The labeling of somatic data considers the instability and uncertainty of externalizing human bodily sensations as labels, and highlights a potential conflict between what might be sensed by a system and what might be sensed by a self. The actuating of bodily experiences considers how actuation can reveal something previously unnoticed and how making this information publicly available might displace social agencies. The scaling of intimate interactions considers how such systems as shared within public spaces or services can transform power and access to basic everyday needs, and builds upon the idea of intimacy as an interactional outcome rather than a property of data. The paper also contributes my methodological process as a way to reprogram a design space, and highlights a change of positionality towards my design space by referencing my pregnancy.

Paper II: Troubling Care: Four Orientations for Wickedness in Design

> Karey Helms, Ylva Fernaeus. 2021. Troubling Care: Four Orientations for Wickedness in Design. *ACM Conference on Designing Interactive Systems (DIS 2021), Virtual Event*. **(Best Paper Honorable Mention Award)**

In this full conference paper, we draw upon queer theories to investigate caring for loved ones as not "in-line" with normative expectations of care as positive and fulfilling. Through the critique of two autobiographical design projects designed for the everyday care of our families, we describe four troubling orientations of care: *willful detours*, *selfish shortcuts*, *naughty invasions*, and *unhappy departures*. *Willful detours* highlight tensions in

affect by violating notions of "as well as possible" through inefficient and unoptimized care. *Selfish shortcuts* foreground tensions in ethics through a prioritization of one's own "good" life over loved ones. *Naughty invasions* bring attention to tensions in labor through unwelcome exposures of care doings. *Unhappy departures* emphasize tensions in affect when traces of care diverge in new directions that do not feel good. Within each, we further highlight an uneven distribution of care and the bodily ways in which humans, technologies, and spaces are oriented. From these, we argue that tensions in care may not always be designed against, but can also be desired and generative. We conclude by discussing a "wickedness" in caring for loved ones that problematizes in-home technologies as attractively naughty and potentially violent, and the four orientations as resources for interaction designers.

The conceptual initiation of the paper was shared between Fernaeus and myself. My contributions included the conceptual connections to tensions in care, methodological drawing upon queer theory, and the sharing and writing of my autobiographical design project. I led the writing of the paper within which Fernaeus contributed to all sections.

Paper III: "Vibrant Wearables": Material Encounters with the Body as a Soft System

> Vasiliki Tsaknaki, Karey Helms, Marie Louise Juul Søndergaard, and Marianela Ciolfi Felice. 2021. "Vibrant Wearables": Material Encounters with the Body as a Soft System. *Journal of Textile Design Research and Practice*.

In this full journal paper, we analyze how three projects contribute towards a conceptualization of "vibrant wearables": wearables that through their material vibrancy surface design qualities of *leakiness*, *ongoingness*, and *mutuality*. *Leakiness* is characterized by a multi-directionality of "spilling over", *ongoingness* attends to non-linear temporalities and cycles of life and death, and *mutuality* emphasizes the interdependency of vibrant encounters. These three design qualities conceptually trouble boundaries of bodies and materials and are practical resources for designers and researchers working with the body in/as a soft system. Our work offers concrete examples of how to work with material vibrancy, which is particularly relevant to new materialist discourses in textile, fashion and interaction design. We argue for the generativity of these design qualities for other designers and researchers.

Apart from sharing and writing about my felt experiences in the making of fiddling necklaces, I also contributed to the conceptual development of the paper and the writing of the introduction and contribution sections.

Paper IV: Entangled Reflections on Designing with Leaky Breastfeeding Bodies

> Karey Helms. 2021. Entangled Reflections on Designing with Leaky Breastfeeding
> Bodies. *ACM Conference on Designing Interactive Systems (DIS 2021)*, Virtual Event.
> **(Special Recognition for Diversity & Inclusion)**

This full conference paper is a pictorial format in which the visual content plays
a significant role in communicating concepts and contributions. In this pictorial,
I present three design explorations of my breastfeeding experiences: *transforming
milk into fiddling necklaces*, *knitting bras for lopsided breasts*, and *site-writing around
breastfeeding*. Through spatial and conceptual mappings of the explorations, I propose
them as alternative narratives in designing for leaky breastfeeding bodies. I also offer
two broader reflections on designing with, for, and among more-than-human bodily
materials: *generous absence* and *bodily mappings*. *Generous absence* reframes absence as
"nonexistence" or a "lack of" to an inclusion of presence in unfamiliar forms and an
openness towards the potential material consequences of design interventions. *Bodily
mappings* methodologically approaches bodies as entangled through a focus on layers
of relations for subject diversities and layers of activity for ongoing becomings. The
accompanying reading instructions to this research open for further bodily encounters
and reflections among the three explorations.

Paper V: Scaling Bodily Fluids for Utopian Fabulations

> Karey Helms, Marie Louise Juul Søndergaard, and Nadia Campo Woytuk. 2021.
> Scaling Bodily Fluids for Utopian Fabulations. *Nordic Design Research Conference
> (Nordes 2021)*, Kolding, Denmark.

In this short, exploratory conference paper, we explore human bodily fluids for more-
than-human collaborative survival through the crafting of four utopian fabulations.
Each fabulation illustrates queer scales and uses of urine, menstrual blood, and human
milk through extended or improper uses as pathways towards caring multispecies
relations within a damaged environment. In addition to the narratives, we contribute
two reflections: *imagining generous collaborations* and *crafting different measures*.
Imagining generous collaborations is an openness to unknowable possibilities in the form
of lingering questions for the imagining of more-than-human collaborations beyond
known entanglements. *Crafting different measures* points towards tensions of coinciding
scales for different ways of valuing, or "measuring", bodily fluids as usable and useful.

    The conceptual and practical work of designing the fabulations was shared
among the authors. For the final crafting of the images, I was responsible for *bodily*

fluid infrastructures and *spilled breast milk*. I initiated the collaboration in response to a journal call and I lead the writing of the paper, which included converting our process notes into the final textual narratives, and I adjusted content based on feedback from Søndergaard and Campo Woytuk.

Paper VI: A Speculative Ethics for Designing with Bodily Fluids

> Karey Helms. 2022. A Speculative Ethics for Designing with Bodily Fluids. *ACM Conference on Human Factors in Computing Systems (CHI 2022, alt.chi track)*, New Orleans, Louisiana, USA.

In this experimental, short conference paper, I perform a speculative ethics for designing with a researcher's own bodily fluids. This is through three hand-written "performative texts" that are autoethnographic accounts of moments of discomfort in designing with milk from my own breastfeeding relationship. These were created to reflect upon felt experiences of potential harm and socio-material relations of care within my breastfeeding experiences as research. They are performative through their visual and spatial compositions of written words alongside verbal readings aloud, and through a literal connection of highlighted words between the hand-written texts and the typed text of the conference paper. From these, I offer three speculative possibilities for HCI on the ethics of first-person research in designing with one's own bodily fluids: *unsafe spaces*, *situated escapes*, and *censored inclusion*. *Unsafe spaces* argues for consideration given to how the experiences of spaces inform how meaning is made in designing with bodily fluids. *Situate escapes* considers how to support the pausing, abandoning, and altering of research in recognition of uncertain temporalities of bodily fluids and their felt impact on research decisions. *Censored inclusion* encourages practices of censorship that are about a lively inclusion of engagements with past, present, and future relations. These possibilities and the approach of performative texts contribute to research for more sustainable futures by exploring the decentering of humans through an intimate engagement with the self.

Additional papers

In addition to the papers included in the thesis, I have contributed to a number of other publications during my doctoral research:

Karey Helms. 2017. Leaky Objects: Implicit Information, Unintentional Communication. *ACM Conference on Designing Interactive Systems (DIS 2017)*, Edinburgh, Scotland, UK.

Karey Helms, Ylva Fernaeus. 2018. Humor in Design Fiction to Suspend Disbelief and Belief. *ACM Nordic Conference on Human-Computer Interaction (NordiCHI 2018)*, Oslo, Norway.

Karey Helms, Barry Brown, Magnus Sahlgren, and Airi Lampinen. 2018. Design Methods to Investigate User Experiences of Artificial Intelligence. *AAAI 2018 Spring Symposium Technical Report (The Design of the User Experience for Artificial Intelligence)*, Stanford, California, USA.

Tom Jenkins, Karey Helms, Vasiliki Tsaknaki, Ludvig Elblaus, and Nicolai B. Hansen. 2018. Sociomateriality: Infrastructuring and Appropriation of Artifacts. *ACM Conference on Tangible, Embedded and Embodied Interaction (TEI 2018)*, Stockholm, Sweden.

Magnus Sahlgren, Erik Ylipää, Barry Brown, Karey Helms, Airi Lampinen, Donald McMillan, Jussi Karlgren. 2018. The Smart Data Layer. *AAAI 2018 Spring Symposium Technical Report (Artificial Intelligence for the Internet of Everything)*, Stanford, California, USA.

Pedro Ferreira, Karey Helms, Barry Brown, Airi Lampinen. 2019. From Nomadic Work to Nomadic Leisure Practice: A Study of Long-term Bike Touring. *ACM on Human-Computer Interaction 3, CSCW, Article 111 (November 2019)*, 20 pages. **(Best Paper Honorable Mention Award)**

Karey Helms, Pedro Ferreira, Barry Brown, Airi Lampinen. 2019. Away and (Dis) connection: Reconsidering the Use of Digital Technologies in Light of Long-term Outdoor Activities. *ACM on Human-Computer Interaction 3, GROUP, Article 230 (December 2019)*, 20 pages.

Karey Helms. 2020. Careful Design: Implicit Interactions with Care, Taboo, and Humor. *ACM Conference on Designing Interactive Systems (DIS 2020, Doctoral Consortium)*, Eindhoven, Netherlands.

Pedro Sanches, Noura Howell, Vasiliki Tsaknaki, Tom Jenkins, and Karey Helms. 2022. Diffraction-in-action: Designerly Explorations of Agential Realism Through Lived Data. *ACM Conference on Human Factors in Computing Systems (CHI 2022)*, New Orleans, Louisiana, USA. **(Best Paper Honorable Mention Award)**

Background & worldview

II.   Thinking with care

This chapter is the theoretical background that situates my understanding of care within larger frameworks, assumptions, and values. It contains two subsections that summarize my worldview (Redström, 2017). In the first subsection, I situate my theoretical commitment to a feminist ethic of care that recognizes its potential to transform interaction design. Within this, I ground the relationship between care and everyday survival, which accentuates human and nonhuman entanglements and technological interdependencies. From this, I then position a wickedness in care that acknowledges its unequal distribution and possibilities for welcome and unwelcome change. This includes unsettling hegemonic regimes that devalue everyday care as expected and as always fulfilling, and troubling dominant hierarchies that prevent divergent pathways of care for humans and multispecies relations. In the second subsection, I situate posthumanism as my ontological approach that in thinking with care accounts for more-than-human agencies. From this, I present related work that takes the human self as a starting point to explore more-than-human relations, which I position as intimate due to a vulnerability of the self that is centered. I then describe notions of generosity that account for an openness toward more-than-human relations and consider the potential risks of change.

A red thread that runs through the two subsections is *thinking with care*: a posthumanist perspective of care as a diverse and interdependent mesh of relational doings to sustain worlds for and by many beings (Puig de la Bellacasa, 2017). Altogether, this chapter expresses my research worldview as "a set of theories held true as a foundation for further research" (Redström, 2017). I conclude the chapter with a summary of my worldview, including its scope, boundaries, and intersections to ground a transition from *thinking with care* to *designing with care* as my research methodology.

Care ethics

Care means and does many things. This is evident in a vast lineage of research on care that includes a diversity of domains, applications, definitions, and histories. A brief sample includes research within political theory (e.g. Tronto, 1993), critical psychology (e.g. Noddings, 2003), labor policies (e.g. Boris & Parreñas, 2010), (dis)ability studies (e.g.

Piepzna-Samarasinha, 2018), animal rights (e.g. Donovan & Adams, 1996), and healthcare practices (e.g. Stuart & Holmes, 2013). There are also differing theoretical histories of care that build on, for example, Heidegger's scholarship as discussed by Babich (2018). My interest in care builds upon feminist histories and is situated within its ethico-political dimensions (Tronto, 1993), the (un)making of human and nonhuman relations (Haraway, 2016), and practices of knowledge production (Puig de la Bellacasa, 2017). Within these, my research scope encompasses informal and unpaid care doings. I understand ethics to be concerned with power and agency, whereas a moral understanding of care is concerned with rules governed by established norms (Braidotti, 2022). I draw upon a feminist ethic of care due to its focus on relationality, interdependence, reciprocity, and responsiveness over normative judgment that is based on universalized principles and abstract reasoning (Held, 2006). Thus, an ethic of care is not about "a realm of normative moral obligations but rather about thick, impure, involvement in a world where the question of how to care needs to be posed" (Puig de la Bellacasa, 2017, p6).

The origin of a feminist ethic of care is often attributed to Gilligan's foundational work *In a Different Voice* (1993), which counters gendered readings of justice and proposes an ethic of care that is based upon women's experiences of responsibility and relationships. The idea of rejecting universal principles for the particularities of each care relationship is furthered through a maternal perspective (Noddings, 2003). These two examples illustrate second wave feminist underpinnings that challenge patriarchal hierarchies and normative epistemologies, and have since transcended a focus on gender binaries, equality, and heteronormativity in favor of an intersectional perspective that accounts for race, class, ability, sexuality, and additional forms of discrimination (Crenshaw, 1989). Care as a "women's morality" reinforces structures of inequality and privilege, whereas "a care ethic that includes the values traditionally associated with women" promotes attentiveness, responsibility, compassion, and nurturance (Tronto, 1993, p3). The latter includes a recognition of difference among those without power and an acknowledgment of human interdependency in meeting others' needs within daily life. These ideas are central to Tronto and Fisher's definition of care as "everything that we do to maintain, continue, and repair our 'world' so that we can live in it as well as possible" (Tronto, 1993, p103).

Puig de la Bellacasa (2017) revisits this definition to articulate three embedded dimensions of care: the labor behind "maintenance", the ethics and politics of a pursuit for a "good" life, and the affective disposition of "as well as possible". She explains that care does not exist if all three dimensions are not present, yet these dimensions expose tensions as they are not always equally distributed within a thick web of giving and receiving. Puig de la Bellacasa posits that "[w]orlds seen through care accentuate a sense of interdependency and involvement" (2017, p17): a relational way of thinking that

challenges who, or what, is included in "our" world and questions how care is posed through these dimensions. It is from this understanding of care as a relational doing that Puig de la Bellacasa grounds the notion of *thinking with care*, which also recognizes its potential as transformative and troubling. While care is concomitant to the life and livelihood of many beings, giving care can be unrewarding and receiving care can be disruptive. For example, this might include exerting emotional labor in the caring for a loved one that does not feel reciprocal, or offering to help someone complete a task that infantilizes their abilities. Such frictions acknowledge a heterogeneous ontology whereby "to or not to care about/for something/somebody, inevitably does and undoes relation" (Puig de la Bellacasa, 2017, p70). This relational entanglement extends to thinking and knowing, processes that "require care and affect how we care" (Puig de la Bellacasa, 2017, p69), a premise grounded upon the situatedness of knowledge whereby the worlds we think and know with are bound to a multiplicity of relations (Haraway, 1988).

This brief introduction to care ethics situates my theoretical understanding and motivates a focus on everyday human care that should be wickedly attended to. The everyday recognizes informal "doings" that are necessary for the survival of humans and nonhumans within what a person chooses to care or not care about and for. In further positioning the importance of everyday human care, I situate related work on the everyday in design and knowledge production, and highlight human interdependencies and technological entanglements. "Wickedly attending to" aims to account for tensions in the three dimensions of care, and their potential to transform caring relations. I ground wickedness in relation to the concept of a wicked problem (Rittel & Webber, 1973), as well as notions of troubling, unsettling, and (un)making in design.

Everyday human care

In describing a shift from Latour's *matters of concern* to *matters of care*, Puig de la Bellacasa highlights that "'to care' contains a notion of doing that concern lacks" (2017, p42). This grounds "everything we do" as the mundane and material practices that sustaining living, such as the meeting of instrumental needs and basic wellbeing. In this way, the everyday is understood as what a person practically cares about in relation to survival. This includes meeting nutritional needs, feeling secure and safe, cultivating social connections, and managing bodily excretion for oneself and other people; as well as taking care of nonhumans, as for example, plants, animals, the environment, or technology.

Yet, "[c]are is so vital to the fabric of life that it remains an ongoing matter of struggle and a terrain of constant normative appropriation" (Puig de la Bellacasa, 2017, p8). This can be seen in the prioritization of some lives over other lives in discriminatory healthcare services or extractivist practices of the environment. In response to structural

inequalities and everyday uncertainties, care is also mobilized "as a critical survival strategy" within a long lineage of fighting for human rights and against precarious futures (Hobart & Kneese, 2020). As political warfare (Lorde, 1988; Ahmed, 2014), it challenges neoliberal individualism that positions the self as one's own responsibility, and instead recognizes the self as embedded within complex relations and forces that impact the intimate and mundane details of everyday life (Hobart & Kneese, 2020). It is important to note that within this emphasis on interdependency that counters Western and industrialized aversions to "dependency", (dis)ability scholars highlight these notions as not discrete or mutually incompatible (Kröger, 2009; Piepzna-Samarasinha, 2018).

In relation to design, "the work of design makers, producers, and assemblers can be ordinary and everyday - part of routine mundane lives - and it is this capacity that makes design so potent" (Buckley, 2021, p46). This grounding of the everyday as an important context rests upon a recognition of design's role in the becomings of worlds that are safe, sacred, and livable (Escobar, 2018). In particular, the home has been highlighted as where people are made and undone and not isolated from broader socio-political infrastructures (Pink et al., 2017), and the significance of the home can be seen in a body of interaction design and HCI research (e.g. Strengers & Kennedy, 2020; Oogjes et al., 2018; Reddy, 2020; Taylor et al., 2007). Yet "everyday care", such as interpersonal or social care that might take place at home between people, is often neglected in interaction design research due to its informal and unstructured nature (Toombs et al., 2018). Care has been most often seen in regards to formal healthcare (e.g. Mishra et al., 2016), but there is a diverse body of work beyond formalized practices into bridging medical and domestic settings (e.g. Jenkins et al., 2019), notions of repair and maintenance (e.g. Jackson et al., 2012; Maestri & Wakkary, 2011; Mattern, 2019), and knowledge production (Balaam et al., 2019; Howard & Irani, 2019; Light & Akama, 2014; Toombs et al., 2017).

More nascent bodies of interaction design research engage in everyday human care through three novel approaches. The first is caring for a person's own everyday wellbeing though noticing intimate body parts or bodily materials (Balaam et al., 2020). This work foregrounds marginalized people or experiences that are often absent or considered taboo in design. This includes looking at the vagina (Almeida et al., 2016), attending to ovulation (Homewood et al., 2019), touching menstrual blood (Campo Woytuk et al., 2020), and revisiting the politics of self-care (Tomasello & Almeida, 2020). The second is attending to everyday human care as oriented towards nonhumans. This work highlights entanglements between people and things that either directly or indirectly support human lives. Examples include "caring for things that care for us" (Wiltse, 2020), such as through the training of home assistants (Michelfelder, 2020) or the maintaining of an insulin pump that keeps a person alive (Forlano, 2017b). "Thingcare" is also used to refer to the everyday care for nontechnological things by home dwellers (Key et al.,

2021). The third extends the second to multispecies relations, and in particular to the often overlooked processes that contribute to both human and nonhuman flourishing. This includes exploring ways of sensitizing humans to the loss of pollinators (Jönsson et al., 2021), extending human menstrual health to planetary well-being (Campo Woytuk & Søndergaard, 2022), and more broadly expanding participatory design to include more-than-human entities (Akama et al., 2020).

My focus on everyday human care encompasses the three design approaches highlighted above. I often orients towards informal domestic or intimate settings centered around the self as a starting point. This includes the places that people spend a significant amount of time, where instrumental needs are met, and the relationships that contribute to them being met. More specifically, this includes the home, the bathroom (public and private), and familial relationships. Thus, the everyday can be understood as a commitment towards survival and flourishing in contexts that are meant to be sacred and safe. The everyday is not a homogenous concept (Bennett, 2005) and has been critically theorized as indistinct from Western consumer society (Gardiner, 2000; Lefebvre, 1991). In this thesis, I recognize that everyday human care is informed by political structures, yet my focus is on material doings and felt experiences. I also recognize that it is not isolated to particular contexts due to the traveling of people and materials across contexts. This positioning further extends to my practices of knowledge construction as an everyday practice of care "as something we can do as thinkers and knowledge creators, fostering also more awareness about what we care for and about how this contributes to mattering the world" (Puig de la Bellacasa, 2017, p41).

Wickedly attending to

Puig de la Bellacasa (2017) asserts that relations involve care and care involves relations. This relational positioning acknowledges human agencies as entangled within heterogeneous worlds of diverse selves, bodies, and environments that compose ways of being. Yet while interdependency might be inherent to care, it does not mean that all relations are caring. In articulating three dimensions of care — work/labor, affect/affective, and ethics/politics — Puig de la Bellacasa describes how all three dimensions must be present for care to exist, but that they are not always equally distributed. She describes how affectively caring about without doing the labor to care for is closer to moral intention, such as wishing the best for people in crisis but not doing anything to help. Furthermore, an unequal distribution of dimensions might include illegally sharing prescription drugs (i.e. a tension in ethics) or emotional ambivalence in paid care work (i.e. a tension in affect). This aligns with the assertation that care does not always feel good to give or receive, nor should be equated as always positive or innocent (Murphy, 2015). In calling for a politics of "unsettling" care, Murphy presents some

troubling ways in which North American feminist health activism positioned as care has inadvertently supported hegemonic regimes of racism, classism, and colonialism. She argues for "the continued necessity of critique and historical accountability and hence the negative affects that come with it, as constitutive and crucial to the work of crafting a politics of technoscience that engages care" (Murphy, 2015).

Care can make and unmake relations, both intentionally and unintentionally, and neither the making or unmaking are ever purely right, wrong, "untouched by trouble [...] or a definitive critique" (Puig de la Bellacasa, 2017, p11). Rather, engaging with care is about acknowledging that sometimes choosing not to care for something, or caring less, can be beneficial for the livelihood of some and equally disruptive for others. Aptly put: "[c]are is a selective mode of attention: it circumscribes and cherishes some things, lives, or phenomena as its objects. In the process, it excludes others" (Martin et al., 2015). This includes directing knowledge production activities towards some concerns over others, to prioritizing a person's own mental health over giving more time and energy to workplace demands. Selective knowledge production might be grounded in a genuine desire to not harm others amid limited time and resources, yet contributes towards a knowledge gap on particular populations. Prioritizing one's health might be grounded in a genuine desire to challenge oppressive conditions, which in referencing Virginia Woolf's (1996) quiet revolt through fostering indifference, Puig de la Bellacasa underscores as "the disruptive power of choosing not to care about what we are enjoined to" (2017, p5). This relational emphasis between care's dimensions and directions foregrounds a wickedness amid its possibilities for welcome and unwelcome change by orienting towards some care doings and not others.

Wickedness is often heard in reference to wicked problems as infinitely messy and complex design situations that are impossible to solve (Rittel & Webber, 1973), and more recently in relation to interactions with technology that are always unfinished due to a continuous unfolding of experiences (Wiltse et al., 2015). This framing has been particularly relevant in relation to global concerns such as climate change, poverty, and pollution. It has prompted new approaches towards more desirable futures, such as Transition Design (Irwin, 2018), which takes responsibility for the futures that design materializes and recognizes its ability to prompt change "within the domain of 'wicked problems' because it involves a kind of designing that 'stays with' a problem" (Tonkinwise, 2015). As pointed out through the proposal of "wicked solutions" as solutions that remain problematic (Light et al., 2020), these aims are akin to *staying with the trouble* (Haraway, 2016) that understands "trouble" as a way of living with tensions inherent to a relational ontology rather than seeking reconciliation or ways out.

There are examples of design research that deliberately engage with a wickedness of care not as problems to be solved, but instead to explore unstable relations and

unequal tensions as generative pathways for design. In discussing how to unsettle planetary extinction, Light (2022) highlights harmful relations between people, technology, and the environment that cannot be avoided and should not be sustained, but rather subverted through purposeful care of relations that support other pathways forward. This recognition of entanglements between climate care and human care can be seen as wicked through a deliberate engagement with friction in igniting planetary change. Jönsson et al. (2019) reflect upon their roles as educators in a summer school that prompted an acknowledgment of tensions in *teaching with care*. This included the emergence of some students not feeling cared for, and the authors' open questioning of pedagogy as about avoiding frictions or proactively preparing design students for them. Similar tensions are encountered in design students' concerns amid building a design repertoire through an engagement with taboo humor and how it might impact their future professional reputations (Helms & Fernaeus, 2018).

My articulation of wickedness draws from designerly notions of unsolvable and unstable situations that are inseparable from an entangled world of human and nonhuman relations. In drawing upon a relational ontology of care, I understand the three dimensions and their inherent tensions as wicked in that they are not to be solved or resolved, but rather troubled and even deliberately desired as ways to instigate change. This might involve seeking a particular tension that is counter to societal expectations and structures that otherwise promotes normative and limited ways of being in the world as humans and with nonhumans. In this way, wickedly attending to everyday human care can be seen as attractively naughty in aiming for divergent care practices and in attending to a multiplicity of needs and desires amid a diverse world that makes human life possible.

Posthumanism

Posthumanism aims to deconstruct the notion of the human and highlight agencies of nonhumans. It questions "familiar binaries of human and nonhuman, culture and nature, and human and animal that have dominated Western thinking since at least the Enlightenment" (Forlano, 2017a). As a relational ontology (Barad, 2007; Haraway, 1991), it understands such concepts as entangled and always becoming rather than discrete and stable. In describing the etymology of the word "human", Haraway draws attention to its origins of meaning as "earthling" or "earthly being" that acknowledge material and symbiotic ways of being in the world (O'Connor, 2021). The positing of "we have never been human" is in contrast to modern notions of human exceptionalism and bounded individualism that describe the human in relation to others only to make itself (Haraway, 2003). In challenging modern notions, the posthuman is a hybrid figure composed of multiple agencies that are environmental and technological. Thus, posthumanism

does not grant humans ontological superiority (Wolfe, 2010), and argues that human exceptionalism and its exclusionary standpoint towards progress has and continues to contribute to ecological crisis (Light et al., 2017). For example, this includes destruction of ecosystems for capital gain and exploitation of animals in agricultural industries.

Within the deconstruction of the human, posthuman feminism also acknowledges the superiority that some humans are granted over other humans. Humanism has historically upheld "an implicit and partial definition of the human, while claiming to provide a universal and neutral representation of all humans" (Braidotti, 2022, p10). This definition has often been based upon Leondardo da Vinci's sketch of the Vitruvian body as a European white man with distinct and perfect proportions, which has excluded and created violence towards people considered to have negative differences with this ideal (Braidotti, 2022). An intersectional lens that includes gender, race, class, sexual orientation, and ability has demonstrated "that the human is not one but many, and it shall thus be accounted in plural ways," (Ferrando, 2018, p439). From this perspective, questioning what it means to be human involves acknowledging a plurality of human lives and ways of being in the world. This position is increasingly seen in relation to the field of technology, within which social injustices and discriminatory practices are augmented and proliferated (O'Neil, 2016). For example, this includes analog and digital photography's nonrecognition of darker skin, as well as racist algorithms that dictate access to healthcare and financial services (Benjamin, 2019).

In response to the upholding of the human as a universal, rational, and autonomous subject, feminist thinking calls for attending to "the partial, situated, and socially-constructed self" and critical race studies call for a further decolonization of categories and hierarchies that classify some people as "others" (Forlano, 2017a). In affirmative recognition of differences of location and power, Braidotti aptly confronts planetary concerns for the environment and an inclusive wellbeing of difference as "we-are-(all)-in-this-together-but-we-are-not-one-and-the-same" (Braidotti, 2019, p118). This is furthered as posthuman feminism (Braidotti, 2022), which explicitly draws upon lineages of feminist theory to think with complex multiplicities and differences of humans and nonhumans. Braidotti describes this approach as a relational but differential ethics that celebrates the worth of humans, assesses humanism in regards to those who have been excluded, and "embraces the non- and the in-human entities as constitutive components of human subjectivities" (2022, p67). Importantly, this lineage of thought differs from transhumanism and object-oriented ontologies. Transhumanism promotes human enhancement in extension from Enlightenment ideals that can be seen to preserve or augment the primacy of some humans over others (Ferrando, 2018). Object-oriented ontologies emphasizes a flat ontology whereby everything (e.g. person, plant, object, or atom) is granted the same status of existence, but does not explicitly

engage with how existence is valued differently.

This selective overview of posthumanism from a feminist history further grounds my ontological approach in thinking with care as a relational and embodied commitment. I understand posthumanism to dually be about the deconstruction and reconstruction of the human — not an erasing of the human — in regards to a more-than-human world of shared responsibilities and consequences. "More-than-human" foregrounds relations over entities and humans not just as people, but as always entangled with other organisms and beings (O'Gorman & Gaynor, 2020). In particular, I draw upon posthuman feminism and its alignment with ecofeminism and new materialism (Braidotti, 2022). Ecofeminism is a political movement that investigates connections between ecological and feminist issues (Sturgeon, 1997). New materialism is a series of movements that rethink subjectivity through an emphasis on non- or more-than-human processes, forces, and agencies (Connolly, 2013). In the following, I situate my perspective within these to motivate the human self as a starting point in questioning what it means to be human, which I position as an intimacy with the self; and to account for an openness towards corporeal ways of being human beyond the bounded individual, which I position as a generosity of always becoming.

Intimacy with the self

In distinguishing an ecofeminist and new materialist perspective within posthumanism, Stacy Alaimo (2014) asserts the human "subject as already part of the substances, systems, and becomings of the world". This means that people are not distinct or separate objects, as for example in object-oriented ontology, but rather always becoming through intra-acting agencies that entangle the material self with environmental, technological, political, and cultural systems (Alaimo, 2010). This trans-corporeality accounts for bodily processes and ways of being that are a matter of survival. That is, the human self is not universal or stable, but instead materially embodied with a multiplicity of abilities, orientations, and desires (Braidotti, 2022). This is further grounded in the assertion that "there is no 'I' separate from the intra-active becoming of the world" (Barad, 2007, p394). Thus, questioning what it means to be a human calls for considering oneself as one of many humans and more-than-human amid an entanglement of bodies, ecosystems, and technologies. Noticing is a way of attending to histories of being human with nonhumans that involves slowing down and observing entangled ways of life (Tsing, 2017). This is similar to a cultivation of paying attention with the aim of inducing "an attentiveness to things and their affects" (Bennett, 2010, pXIV). Among other scholars, Bennett recognizes that such cultivation is reliant upon a centering of oneself as a human. This seemingly contradictory approach within broader aims to decenter the human is grounded in a feminist recognition of the self as always

situated, even if always becoming, and acknowledges one's position and location as not the same as considering oneself in isolation or superior.

In interaction design, there is a growing body of work that deliberately centers the self to apprehend the role of environmental and technological agencies in blurring dominant binaries and shaping human experiences. This includes designing for collaborative survival (Liu et al., 2018), in which the first author Jen Liu designed tools specific to her own body to explore connection and kinship with nonhuman species. This was to cultivate an intimate experience in wearing the tools and to discover interactional nuance in human-fungi relationships. Heidi Biggs sought intimacy with birds for the broader aim of understanding her new local ecology (Biggs et al., 2021). From this, the authors attend to a dissolution of human/nonhuman boundaries that contributes to a reorganization of humanist hierarchies. While Light et al. (2017) do not explicitly promote a centering of the self, and even highlight a need to resist self-centeredness, they do advocate for paying attention as an individual and as a human to more-than-human entities as a pathway towards being more responsible.

Although the above examples are primarily situated in a post-anthropocentric agenda that is concerned for the environment, another set of examples deliberately centers the self in response to increasing entanglements between technologies and humans (Frauenberger, 2020), and are particular towards a blurring of bodily boundaries. Homewood et al. (2020) offer insights on how human bodies are somatically and culturally always becoming with everyday self-tracking technology. They draw upon corporeal feminism (Grosz, 1994) to emphasize the relationships between people and objects that contribute to how humans experience being in the world and form a sense of self. Tsaknaki (2021) describes experiences of wearing inflatable Breathing Wings, which prompt affective engagements with the wearable as a perceived "other" and a blurring of boundaries between herself and technology. Forlano (2017c) analyzes her own lived experiences, focusing on the use of an insulin pump and glucose monitor to manage Type 1 diabetes. She describes herself as ontologically becoming "a disabled cyborg body" and also situates her "becoming" as an epistemic site. In reflecting upon her privileges within structural inequalities and the temporalities, materialities, and sociocultural norms inseparable from her becoming, Forlano also unpacks the word intimate to characterize a felt closeness of bodily relationships and vulnerabilities in attending to the self as entangled. She later describes such intimacies with technology as dehumanizing within the burdens and collapse of mutual care for her devices that are meant to care for her life (Forlano, 2017c).

My view of intimacy builds upon a recognition of the self as materially entangled in the environment, with technology, and among other humans. From this perspective, intimacy is a dual closeness or familiarness with oneself as well as with someone and

something else. Intimately questioning what it means to be human means reckoning with how a person understands their self and corresponding relations as deeply entangled in more-than-human worlds, which might also be uncomfortably revealing, humbling, or not in-line with previous self-conceptions. Resulting experiences of vulnerability originate from a centering of oneself that then reaches beyond in acknowledgment of:

> *"Care is a human trouble, but this does not make of care a human-only matter. Affirming the absurdity of disentangling human and nonhuman relations of care and the ethicalities involved requires decentering human agencies, as well as remaining close to the predicaments and inheritances of situated human doings"* (Puig de la Bellacasa, 2017, p2).

This commitment to intimately questioning what it means to be human is a commitment to relationality and rethinking of assumptions from one's own situatedness and socio-material embodiment. If one does not question what it means to be human in everyday life, there is a risk of ignoring differences among people and how people exist as more-than-human.

Generosity of becoming

Generosity is often understood as giving more than expected or necessary, which might include a person showing kindness to an animal or offering something physical, such as food, to another person in need. Generosity has been further described as virtuously giving something as a gift, albeit within a continuous expectation of giving and receiving (Mauss, 1990). Yet as positioned by Rosalyn Diprose (2002), the assumption of morality and the notion of a gift exchange are within problematic histories of power and human inequality. In line with other feminist philosophers, Diprose criticizes generosity as moral excellence and draws attention to the circulation and devaluing of "gifts" from disempowered and marginalized social groups. For example, within the politics of reproduction this can be seen in the subject-formation and subjection of people who experience maternity (Hausman, 2004). Their gifts are often systemically "forgotten" in comparison to, for example, property owners and wage earners. In "remind[ing] us that every life is dependent upon a whole range of openings to other lives" (Hird, 2007), an intercorporeal model of generosity is proposed as an openness to the other that precedes and exceeds the formation of the subject and social contractual relations: "generosity is not the expenditure of one's possession but the dispossession of oneself, the being-given to others that undercuts any self-contained ego" (Diprose, 2002, p4). This model is situated among critiques of individualism and emphasizes an interdependency that is without deliberation.

Corporeal generosity is furthered as a literal giving and receiving of matter, and more specifically through the accounting for the material processes of pregnancy, child birth, and breastfeeding (Hird, 2007). This includes nutrients, DNA, viruses, and other matter gifted through the placenta and milk. Based upon these examples, corporeal gifting is "the radical opening up to unknowable events [with] the potential threat of harm through unanticipated possibilities" that often remain unrecognized, such as a premature birth and fetal immunity (Hird, 2007). This is important because it acknowledges material agencies in becoming human as unstable, unknowable, and immeasurable. Furthermore, within this uncertainty and indeterminacy, "there is as much possibility of threatening the integrity of bodies as there is of opening up new possibilities" (Hird, 2007). This can be seen in line with critiques of human exceptionalism, in which "becoming is always becoming with" a diversity of bodies that includes humans and nonhumans (Haraway, 2008, p244); yet also considers the potential risks in a generosity of becoming that disrupt and alter notions of the bounded individual.

Generosity in design is proposed as a step towards humility in considering human survival as dependent upon and in relation to nonhuman survival (Wakkary, 2021). Wakkary posits generosity as a form of horizontality, that is, a positioning of oneself as a human designer alongside other humans and nonhumans. This is in contrast with a vertical, privileged positioning of humans that does not account for relational ways of being. In this way, generosity is risky because of the potential humility and vulnerability in embracing horizontality (Wakkary, 2021). Horizontality is investigated through Oogjes first-person accounts of learning how to weave, from which nonhuman presence and participation are revealed (Oogjes & Wakkary, 2022). Similarly, vulnerability is advocated for as an ethical stance in design, which involves risk through socially opening oneself and relinquishing part of one's autonomy (Popova et al., 2022).

By contrast, Wilde (2021) explores vulnerability in relation to the human body as itself materially unbounded and a site of more-than-human inquiry. In focusing on human feces and the gut microbiome through participatory workshops and autoethnography, Wilde transcends looking outward at socio-cultural humility and looking radically inward at the more-than-human bacterial relations that contribute to human existence and experience. Nielsen and Almeida (2021) similarly design with the immune system as a site of symbiosis and mutualistic care between humans and more-than-human entities. These approaches align with conceptions of livingness (Karana et al., 2020) and the unpredictable outcomes of living materials in design (Camere & Karana, 2018) that consider risks of contamination and vulnerability in thinking about death and uncertainty. Unintended outcomes and unknowable possibilities are also seen in relation to what might be considered nonliving, yet still agentic, design materials such as data

technologies (Giaccardi & Redström, 2020).

    My articulation of generosity is grounded in an open dispossession and material sharing of oneself that is a threat to bodily integrity. While this is similar to Wakkary's description of humility and Popova et al.'s description of vulnerability, my articulation differs in that it understands generosity as not always deliberate or socially experienced, but also pre-reflective in the material making and unmaking of a human self as personally, interpersonally, and communally entangled. This positioning is important in acknowledging histories of devalued bodily gifting that contribute to social injustice (Diprose, 2002) and rigid hierarchies of classifying "others" (Shildrick, 2019). It is also important in understanding that what counts as a human self "is not only the embodied and embedded realities of bound individuals, but also the specific properties, propensities and inclinations of matter itself: genes, cells, codes, algorithms, stocked in databanks that can be stored, sold and exchanged" (Braidotti, 2022, p59). This resists reductionism in an openness to otherness and an ongoing questioning of what makes "one" (Puig de la Bellacasa, 2017) that might be beyond control and certainty as a person or as a designer. Thus, generously questioning what it means to be human accounts for more-than-human entities, living and nonliving, as inseparable from what it means to be a self and recognizes the potential for unanticipated outcomes amid thinking with entanglement.

From *thinking with care* to *designing with care*

This chapter began by situating my theoretical commitment to *thinking with care* that is grounded in a feminist ethic of care and posthumanism. I identified four aspects that situate my worldview: *everyday, wickedness*, *intimacy*, and *generosity*. I conclude this chapter by describing the relationships between the four qualities. This includes what is not included, and how the axioms specifically relate back to design otherwise. This grounds a transition from *thinking with care* to *designing with care* as my research approach.

    Within care ethics I highlight (1) the everyday as a design context and (2) a wickedness in caring relations. The *everyday* calls for attending to survival and flourishing within contexts where care is often taken for granted or accepted in normative forms. While everyone's everyday is different, this does not consider situations beyond mundane, informal, and often repetitive experiences amid a diversity of human care. For example, it includes managing bodily excretion, maintaining devices at home, nurturing familial and multispecies relationships, and forms of knowledge production. It does not include paid healthcare practices or professionally supporting technological breakdowns. A *wickedness* recognizes care as troubling through its unequal distribution that opens for possibilities to make and unmake caring relations.

Wickedly attending to everyday human care does not consider care pure, without friction, or always fulfilling. It recognizes that being careful also involves choosing to care less or not at all about something else. It includes acknowledging entangled relations, living with tensions, and generatively engaging with frictions. It does not include considering unequal distributions of care as possible to solve or without an ongoing unfolding of tensions.

Within posthumanism I highlight (3) an intimacy of human experience and (4) generosity within more-than-human relations. *Intimacy* calls for attending to experiences of vulnerability amid intentionally centering the self to reckon with human and nonhuman entanglements. For example, it includes paying attention to how oneself is situated, acknowledging differences with perceived "others", and exploring experiences of closeness with technology that might be unfamiliar or uncomfortable. It does not include considering a human as a stable, complete self or distinct from other humans and nonhumans. *Generosity* recognizes a material gifting that further contributes to experiences of vulnerability and a blurring of bodily boundaries. It differs from intimately questioning what it means to be human in that it includes considering the socio-material exchanges and risks within a pre-reflective gifting of one's self. This means that one does not always choose or have a choice to give or receive something that impacts their being in the world. It does not include risk amid a human-to-human offering of presents, the transfer of economic resources, or the sharing of possessions out of intentional kindness or for monetary gain.

The overlap between everyday and intimacy focuses on experiences of vulnerability in everyday contexts. This deliberately aims to center the everyday care of humans as a mode of inquiry into human and nonhuman experiences of survival. If interaction design does not attend to everyday human care, it will continue to contribute to ecological disaster and species extinction through ignoring what is needed for people, things, and environments to flourish. If interaction design does not intimately question what it means to be human, it risks not acknowledging how humans are responsible and accountable for the wellbeing of themselves and others, which could otherwise foster more collaborative relationships towards the survival of many. The overlap between wickedness and generosity foregrounds the social and material relations of care to open for a diversity of experiences and a multiplicity of agencies. If interaction design does not wickedly attend to everyday human care, it will continue to support a centering of (particular) humans and (particular) worlds, and miss opportunities for technology to support marginalized everydays and not support discriminatory practices. If interaction design does not generously question what it means to be human, it risks not acknowledging more-than-human material entanglements that environmentally and technologically blur bodily boundaries. Recognizing these is essential in undoing

Thinking with care　　　　　　　Designing with care

Care ethics

Posthumanism

Everyday

Wickedness

Intimacy

Generosity
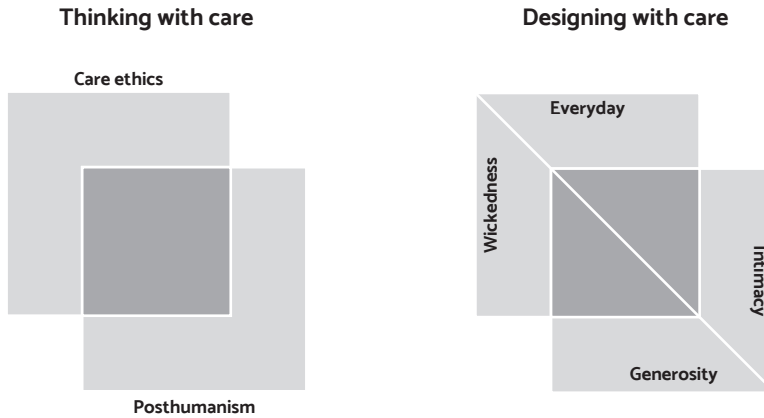
oppressive dichotomies such as self/other, human/nonhuman, and nature/culture that contribute to the centering of some everydays over other everydays.

The four aspects I have highlighted, along with their intersections, do not describe or portray all that thinking with care might entail or accomplish. Instead, they are a limited scope in the form of four axioms to intentionally explore what interaction design might be like otherwise within their boundaries. As concepts, the four axioms are selectively grounded in feminist histories from my Western position. It is precisely this scoping of boundaries and intersections that grounds a transition from *thinking with care* to *designing with care*. It deliberately and provocatively makes clear the assumptions, constraints, and limitations from which I design: what contexts, experiences, and relations I intend to explore. It does not intend to resolve design's problematic legacies that are historically grounded in an "all-pervasive anthropocentrism and exclusionary assumptions" (Mareis & Paim, 2021, p11). Instead, it prototypes an alternative that is "invested in speculative thinking of what could be but grounded in the mundane possible, in a hands-on doing connected with neglected everydayness" (Puig de la Bellacasa, 2017, p111). It is similar to *design-with* (Wakkary, 2021) through value alignments of togetherness and cohabitation; a recognition of design as accountable for shaping technology and living together with nonhumans; and a call for designers to question their response-ability in affecting others. It differs from *design-with* through its emphasis on care as not only a value, but also a wicked doing; its specificity of the socio-material risks of generosity that I argue extend beyond intentional humility; and an inclusion of what might be considered "living" materials that problematize some more-than-humans relations as *more* more-than-human than others.

III. Designing with care

This chapter describes my research methodology and a programmatic approach towards making design theory. I open with an introduction to the relationship between design, research, and theory that considers artifacts and knowledge production as political. This includes definitions of interaction design and research-through-design, as well as situating why and how they might be different, or *otherwise*. I then define my programmatic research approach and the relationship between design experiments. Next, I position my methods within four broader approaches. The first, *auto-design*, is a group of methods that explicitly engage with the human self as a starting point in research. The second, *spatial orientations*, are pragmatic and conceptual approaches that describe how human and nonhuman bodies inhabit space. The third, *leaky materials*, takes into account the vitality of technological and nontechnological design materials. The fourth, *open speculations*, are critical and speculative design methods to materialize alternatives and invite ongoing engagement. Lastly, I situate the four approaches diagrammatically in relation to my research program *designing with care*.

Design, research, theory

The relationship between design, research, and theory is described as unstable and transitional (Redström, 2017). This is grounded in a recognition of design as a change-making practice (Simon, 1996), which is oriented by a concern for creating *what might be* rather that making statements about *what is* (Zimmerman et al., 2007). In this way, design can also be seen to always be redesigning itself as it continuously changes the world within which it is defined. This instability distinguishes design from science as a generative rather than a falsifiable discipline in which "there is always an implicit *sometimes* in statements about how to design successfully" (Gaver, 2012). This contrast between design and science (Cross, 1982; Cross, 2001) is significant in relation to how HCI promotes, evaluates, and values knowledge produced through design. Like design, research produced through design is also always in flux, which in the field of interaction design can be seen as a response to ongoing transformations of digital materials and a revisiting of disciplinary structures and their embedded values.

    Interaction design is a relatively new field and often attributed as being coined by

Bill Moggridge in 1984 as the design of interactions with digital technology (Löwgren, 2013). Although commonly considered a sub-field of HCI, it "recognizes itself as a 'design discipline' in that its ultimate objective is to create new and change existing interactive systems for the better" (Fallman, 2008). This emphasizes an orientation away from instrumental "use" to expressions of "presence" (Hallnäs & Redström, 2002), and towards the ethical and aesthetic judgments of a designer in creating interactive experiences that are appropriate to a situation (Löwgren & Stolterman, 2004). The designerly making of judgments is a "reflective conversation with the situation" whereby through creative experiments, such as sketching, a practitioner generates new understandings of a problem space and experiential possibilities (Schön, 1983). Despite a dominant focus on experiences as integral to defining interaction design, the form of the computational object is also important, which includes cultivating an understanding between "complexity of the surface and the complexity of the inner workings of an object" (Mazé & Redström, 2005). While significant in differentiating the discipline from HCI, these orientations towards meanings of use (e.g. Redström, 2008), aesthetic qualities (e.g. Hallnäs, 2011; Löwgren, 2009), and computational materials (e.g. Jung et al., 2017; Vallgårda & Redström, 2007) are not static and can be seen to be evolving amid continued developments of digital materials that challenge what has traditionally been considered the "C" in HCI.

A proliferation of data-driven technologies in everyday situations, unexpected places, and across a multitude of artifacts and services challenges with what, how, and when humans interact with digital materials. The "C" as a computer and container of digital materials is no longer bound to a static or discrete device. While it has long been envisioned as ubiquitously distributed (Weiser, 1991), its runtime assembly and distribution of computational processes challenges how designers have previously coped with the complexity of interactive technology and calls for ways of engaging with uncertainty and decentralized interactions (Giaccardi & Redström, 2020). The notion of *faceless interaction* takes an in depth look at what an interactive interface might become as it "disappears", and grounds conceptual shifts of individual objects and an ecological perspective of ambient interactions (Janlert & Stolterman, 2017). This complexity is similarly articulated in the notion of *fluid assemblages*: "assemblages because they are made out of a diverse range of material and immaterial resources both contained within the object as it appears in front of us as well as located elsewhere in the network; fluid because their precise forms are assembled in runtime and thus change continuously" (Redström & Wiltse, 2015). These acknowledge a socio-material complexity and immanent messiness beyond individual devices and classic interaction turn-taking between a human and a computer.

Considering how technology is changing also includes the aesthetics of digital materials: how it feels to interact with technology and how the qualities of technology contribute to how an experience unfolds for a person (Giaccardi & Karana, 2015). The

qualities include values embedded from a designer that manifest in material properties and processes (Mareis & Paim, 2021). For example, a digital thermostat designed with the value of inclusion might implement visual and audio temperature readings for greater accessibility, while also giving owners access to edit and customize the source code.

Historically, HCI has been built upon values of convenience, efficiency, and reliability (Weiser, 1991) for non-idiosyncratic human needs and desires that are grounded within patriarchal, colonialist, and anthropocentric conceptions of modernity and progress (Fry & Nocek, 2020). This is often translated into the complexity of computational technology being deliberately made invisible, whereby it is increasingly unclear what is sensing and being sensed, whom this information is serving, and when and how a designer or user might intervene (Zuboff, 2019). The implicit embedding of values in data-driven systems maintains oppressive structures, such as through the implementation of gender binaries and racial stereotypes (D'Ignazio & Klein, 2020). This promotes the absence of representation, as for example in the neglecting of Black women's maternal mortality rates (Lister et al., 2019), and the presence of over representation, as for example in discriminatory policing practices (O'Neil, 2016).

Critiques of ideology, power, and authority amid new affordances of digital materials are situated within the long-standing recognition of technological artifacts having politics (Winner, 1980). DiSalvo (2012) articulates a difference between "design for politics" and "political design". Design for politics is improving governance mechanisms, such as laws or information access, whereas political design is an "ongoing contest between forces or ideals" (DiSalvo, 2012, p8). This is significant in acknowledgment of design as future-making and thus deeply political in affecting social justice, political agency, educational knowledge, and experiential access to play and pleasure (Yelavich & Adams, 2014). As further emphasized by Willis (2006), the making of worlds is not one-directional by design, yet rather a reciprocal mode by which "we are designed by our designing and by that which we have designed". This troubles notions of biological determinacy and social causation within what it means to be human through highlighting an ontological inseparability between the design of technology and design of humankind (Fry, 2012). It further emphasizes an urgent rethinking of values, processes, and ways of knowing amid planetary concerns for species extinction, marginalized voices, and political crises (Forlano et al., 2019; Fry & Nocek, 2020). This includes decolonizing legacies of design pedagogies and institutions that have shaped contemporary structures of oppression, such as through differential admission of women that persist in forms of discrimination (Mazé, 2019); and rethinking "abstract, context-less" conceptions of time that align with Western notions of industrial capitalism, which for example manifests in designing for obsolescence that contributes to climate change through discarded materials and toxic waste (Willis, 2020, p77).

There are many responses within interaction design to this dual changing of technology and revisiting of long-standing values, and in particular the questioning of individualism, objectivity, and universalism. Tangible interaction design proposes shifts from information centric to action centric perspectives, from studying system properties to qualities of user activity, from supporting individual use to sharable use, and from considering objective to subjective interpretations of experience (Fernaeus et al., 2008). Data is argued as always designed within multilayered activities of conceptual, collection, and aggregation processes that foreground its non-neutrality (Feinberg, 2017). This resistance to treating data as objective is furthered by exploring how data is entangled within the everyday lives of designers, which suggests possibilities to cultivate expanded meanings of digital materials as messy and ambiguous (Sanches et al., 2022). *Designing with the body* is a response to the rise of ubiquitous technology, which calls for a qualitative shift in interaction design through an intimate correspondence between human actions and interactive reactions (Höök, 2018). Referred to as *soma design*, this approach challenges mind-body dualisms in HCI for a richer repertoire of aesthetic expressions through technology (Eriksson et al., 2020) and for the counteracting of privilege through a bodily cultivation of pluralism and participation (Höök et al., 2019).

There are also responses that do not explicitly address how designing with digital materials might be different, and instead acknowledge the danger of maintaining harmful logics and normative views in interaction design processes and theoretical commitments. For example, Rosner (2018) deconstructs the logics of design thinking and argues for alliances over individualism, recuperations over objectivism, interferences over universalism, and extensions over solutionism. Spiel (2021) draws attention to how artifacts in HCI implicitly uphold difference as deviant and to be fixed through unmarked bodily norms and marked non-normative bodies. *Critical race theory* is adapted for HCI to theoretically ground grappling with racism, while also highlighting the importance of attuning to race across all design activities (Ogbonnaya-Ogburu, Smith, & To et al., 2020). Also across topics and processes in HCI, strategies of unmaking aim to disassemble values, beliefs, and knowledge in favor of more sustainable materials, practices, and epistemologies (Sabie et al., 2022).

Many of the above responses overlap design practice and knowledge produced through design. Although based upon design practice, designing as research differs from designing as practice through the intention of designs as outcomes and its reflective engagement with theory. Fallman (2003) distinguishes between *design-oriented research* and *research-oriented design* in which the former emphasizes a deliberate knowledge contribution through design as problem-setting and the latter focuses on the production of artifacts through problem-solving. This distinction highlights different perspectives of design that need to be accounted for in understanding and evaluating

what design "is" in HCI and interaction design research, and how it can make valid and substantial knowledge contributions. While instances of specific designs are characterized as ultimate particulars (Stolterman, 2008), which are research contributions themselves, design-oriented research also affords the creation of intermediate-level knowledge that is more abstracted than instances and more specific than generalized theories (Höök & Löwgren, 2012). The example of *strong concepts* illustrates this liminal state of knowledge, and importantly, how it can be assessed for novelty, rigor, and relevance in relation to interaction design within HCI as an academic discipline (Höök & Löwgren, 2012). Other forms of intermediary knowledge through design include annotated portfolios, methods, criticism, experiential qualities, and guidelines. In addition, Redström (2017) proposes the making of definitions as design theory that is a knowledge contribution in supporting what becomes through design over time.

In alignment with a feminist perspective of knowledge production (Haraway, 1988), research-through-design recognizes and calls for the importance of identifying researchers' positionalities to ground and situate knowledge production through design and dissemination processes (Bardzell & Bardzell, 2011; Søndergaard & Hansen, 2017). Not only do design artifacts and digital materials have politics, the designers and researchers themselves are also embedded within disciplinary structures and accountable for power relations. It further highlights the importance of what theories researchers engage with in making theories of design, who a researcher chooses to cite in substantiating claims (Ahmed, 2017), and how research ethics are understood and enacted.

This non-exhaustive summary positions my understanding of interaction design and how knowledge is produced through design. Importantly, it highlights the changing nature of interaction design that emphasizes a focus on the embedded values and fluid form of digital materials, and the traditional processes and historic ideologies that have contributed to why interaction design is the way it is and not otherwise. This includes the prioritization of particular humans, humans in general, and singular yet universal notions of the user as an individual, subject, and consumer. It also calls attention to the importance of situated knowledge production and the work of disciplinary structures in valuing contributions from research-through-design. It foregrounds the power and privilege of interaction design and designers in ontologically shaping the material and political conditions for being human. In the following, I expand upon the relationship between design, research, and theory by first introducing a programmatic approach towards interaction design otherwise and then describing design experiments as instantiated possibilities of my approach.

Research program and propositions

Redström describes a design research program as "[a]n alternative approach to theory development in the context of design research driven by practice, by experimentation and making" (2017, p2). In drawing upon broader notions of a program, he further articulates the defining of a research core composed of basic assumptions and theories that remains stable as long as it continues to generate new ideas, definitions, and theories. In this way, the core axioms "are about the intent and structure behind something about to unfold" (Redström, 2017, p85). He positions this as important in differentiating between a product, project, program, practice, and paradigm along a spectrum of what a design is to what designing is. This spectrum of design is not to be interpreted as a thing to an activity, but instead the space between a particular outcome and the broader effort of reaching such outcomes. A product is an instantiation of what a design is, a project describes the immediate context of a design, a practice describes different types of organized efforts and structures, and a paradigm is the most general articulation of designing as an endeavor (Redström, 2017). While all of these terms might be fluid in everyday language, "they are all *definitions made through design*" that address different aspects and tensions between the particular and the general, and are useful in positioning a program as an approach to theory development and knowledge construction (Redström, 2017, p45).

A programmatic approach can be seen as in opposition to research questions, within which a particular type of answer is always implied. A design research program is speculative in searching for alternatives and not knowing what those alternatives might be like. This points to how theory produced by research through design tends to be "provisional, contingent, and aspirational" (Gaver, 2012). In my research, I have foregrounded experiments over problem-solution dichotomies to make sense of and reflectively engage with the complexities of technology and everyday life. Yet these approaches do not have to stand in opposition, and there are research questions in some of the included papers that help guide and construct my research trajectories. Thus, the formulation of a research program did not just emerge from a first articulation of what are considered the final propositions, but at times was guided by clear questions. Furthermore, although I am experimenting and speculating about alternatives for interaction design, the design space of my research is not random. I bring my experiences and politics into the design work as views regarding what already appears to be problematic with interaction design and in particular contexts. These situated and deliberate critiques are evidenced in the semantics of my two research propositions:

> **Interaction design should wickedly attend to human everyday care**
> **Interaction design should intimately and generously question what it means to be human**

My use of *should* instead of *could* takes a prescriptive stance from which to prototype alternatives of how interaction design ought to be. This is speculative in opening for possibilities that fit within the particular boundaries of my research program, and thus can be evaluated on how successful such a prescription is through its outcomes. It is not speculative in opening for anything to be possible outcomes, as a more lenient and unbounded *could* would do in implying that interaction design could also *not* do what I suggest. Nor is it meant to occlude or defuture possibilities (Fry, 2020). Rather the *should* opens for exploring the preferability of a different and particular starting point for defining what interaction design is: "of making a more diverse set of possible nows more *present*" (Redström, 2017, p130). This articulation of my propositions is defined by the four axioms presented in Chapter II. It grounds the conceptual precision of an intentional unfolding and acknowledges my designerly process in searching for alternatives of how interaction design could be otherwise.

Design experiments

A designed artifact as an experiment reveals the issues a designer thinks are important through choices made in addressing those issues (Gaver, 2012). In this way, the design space is not random and the research program does not just emerge from the articulation of propositions, but is a conversation between designing particulars and thinking about how they relate to one another. While some of the experiments might have been grounded in research questions, the motivation has been speculative in searching for alternatives, yet not knowing what those alternatives might be like (Redström, 2017). These experiments then scope and challenge the boundaries of a research program in an ongoing dialogue built upon assumptions and exploration. Schön highlights the conducting of experiments in design as integral to the generative understanding of possible outcomes and changes in a situation that might occur (1983). Similarly, prototypes as filters and manifestations of design ideas play an important role in exploring a design space and reflecting upon rationales and alternatives (Lim et al., 2008). In this thesis, I refer to my experiments as *careful designs*, which are collections of experiments in a diversity of finish and form. They are explicitly situated in relation to my research program *designing with care*. For example, this includes knitted bras as wearable artifacts, abandoned material investigations with milk, refined visual collages, and open-ended textual narratives. Although I am predominately using the term experiment here, many of these can also be considered products as instantiations of what a design is; and within particular collections, they can also be considered projects through their contextualization as a set.
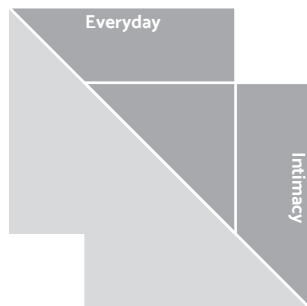
An often remarked upon difference between academic research and commercial work is in regards to the former frequently having unfinished prototypes (Redström, 2017).

Redström explains this difference as grounded within research prototypes as examples rather than "ends in themselves". Regardless of their resolution or whether their details fulfill intended functions, they are still designs through their expression of difference. This is important in noting my decision to not call my research *careful experiments* and instead to call them *careful designs*. I do not consider their experimental nature that is grounded in speculative exploration, unresolved functionality, or finish abandonment to discount them as designs or definitions of designing. Instead, my naming reflects the aforementioned relationship between notions of an experiment that I draw upon, as well as my aim through the articulation of a research program to investigate possibilities of otherwise. Furthermore, calling them careful designs positions my work away from notions of scientific experiments that follow research question and answer dichotomies within a predefined process, and allows for a more fluid and inclusive inquiry of their differences in finish and form that might remain unresolved and unstable.

There are five sets of careful designs presented in this thesis: *technologies of human waste*, *spying on loved ones*, *leaky breastfeeding bodies*, *scaling bodily fluids*, and *a speculative ethics*. *Technologies of human waste* investigates the everyday care of excretion through the design of speculative technologies that predict when and how badly a person needs to urinate. *Spying on loved ones* explores tensions in the everyday care of family members at home through critiques of two autobiographical design projects. *Leaky breastfeeding bodies* challenges my cultural preconceptions as an individual and bounded human through three design exploration within my breastfeeding relationship. *Scaling bodily fluids* imagines everyday care of human survival as entangled in more-than-human collaborations through the creation of four visual and textual narratives as fables for designers to think with for the present. *A speculative ethics* reflections upon social discomfort and material harm in relation to designing and researching with my own, shared bodily fluids through "performative texts".

As a set, these careful designs position what basic beliefs among the four axioms are explored. In their initial presentation, all four axioms are given equal weight in diagrammatic size to illustrate difference across the experiments in speculating about key assumptions. This illustrates the ongoing forming of my research program prior to the articulation of propositions, which demonstrates the provisional and experimental forming of my research program. Thus, rather than saying "this is typical of *designing with care*", the careful designs can be read as this is typical of "this relationship between axioms of *designing with care*". Furthermore, it is through my understanding of the differences (and similarities) between careful designs that I am able to avoid repetition and structure the contours that condition my experiments. How and when they explore the worldview of my research program is not always equal relative to each programmatic axiom. That is, the axioms are not binary in their presence or absence.

Technologies of human waste

Everyday

Intimacy

Spying on loved ones

Everyday

Wickedness

Leaky breastfeeding bodies

Everyday

Intimacy

Generosity

Scaling bodily fluids

Everyday

Generosity
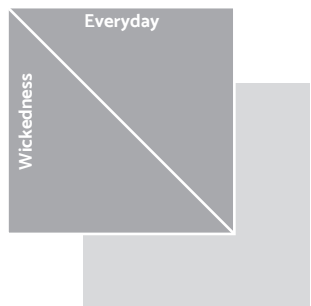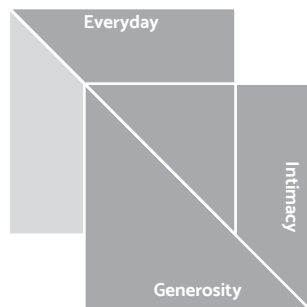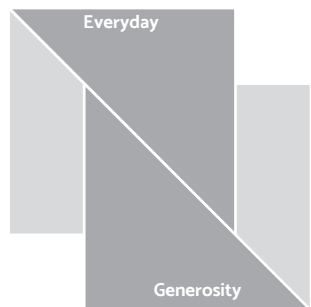
The careful designs are arranged left to right, top to bottom in the approximate order that they were prototyped.

A speculative ethics was ongoing during the initial forming of the research program. In drawing upon all axoims, it can be seen as in direct dialogue with both propositions and all four axioms.

A speculative ethics

Everyday

Wickedness

Intimacy

Generosity
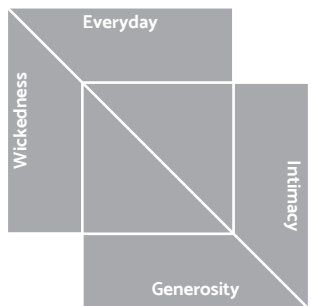
Nor is their understanding of each axiom conceptually uniform and the articulation of axioms are at times expanded upon through experimentation.

Ways of knowing

In the unfolding of my research program, I have used a variety of methods as designerly ways of knowing (Cross, 1982) when carrying out my design experiments. In the following, I present these methods and how and why they were used. I also offer diagrammatic illustrations of them in the context of *designing with care*. The synthesis of them is key in articulating how interaction design might be otherwise as both the axioms and ways of working and knowing go hand in hand in proposing alternatives, or as posited by Haraway, "It matters what matters we use to think other matters with" (2016, p12). This is important in shifting from what a design is to what designing is in describing the processes and methods of creating experiments, which also allows for the further unpacking of resources, context, and shortcomings presented in Chapter IV.

Auto-design

Auto- is a linguistic combining form used to indicate a self in relation to a compound word, such as autonomous or autograph. In interaction design, auto- is seen in reference to autobiographical design (e.g. Desjardins & Ball, 2018), autoethnography (Ellis et al., 2010), and autoethnographic design (e.g. Biggs et al., 2021). These all reference the self, yet contain differences. Autobiographical design is defined as the design and self-usage of a system, and emphasizes genuine usage to validate a subjective stance amid potentially conflicting personal and professional research agendas (Neustaedter & Sengers, 2012). As both the maker and user of a system, it enables access to nuance and intimacy to aid in analysis; yet, as highlighted in the proposal of design memoirs, autobiographical design can also foreground complex emotional narratives for shared contemplation (Devendorf et al., 2020). By contrast, autoethnography does not place emphasis on design, yet through description and analysis of one's own behavior, it similarly draws upon dual perspectives of a researcher "as both the informant 'insider' and the analyst 'outsider'" (Cunningham & Jones, 2005). In an autoethnographic detailing of living with an insulin pump and glucose monitor, Forlano states, "It's easy to critique technological systems. But it's much harder to live intimately with them" (2020). This emphasizes the importance of the dual perspective in the broader technical, social, and legal entanglements that are revealed through deeply felt participation (Forlano, 2020). The term autoethnographic design combines rigorous practices of noticing with designerly aspects of making in which the "genuine need" foregrounded in autobiographic design is in relation to a deliberate research agenda rather than use. This can be seen in reflective audio and

visual explorations of personal birdwatching experiences (Biggs et al., 2021).

Auto-methods in interaction design research are also sometimes referred to as first-person perspective. This framing is prevalent in somatic and embodied design in which an emphasis on the self foregrounds a training of aesthetic sensibilities and subjectivity in critical reflection (Höök, 2010). Grounded in the notion of the lived body (Merleau-Ponty, 2002), soma design combines movement-based activities with first-person reflections to cultivate a designer's appreciation for their experiential and cultural body as it politically participates in the world (Höök et al., 2018). This can be seen in focusing as a method to engage with bodily knowing in interaction design (Núñez-Pacheco & Loke, 2022). Similarly, drawing on pragmatist aesthetics, practices of embodied design ideation use strategies of estrangement to challenge automated perceptions of a self in relation to technology that might be taken for granted (Wilde et al., 2017). This often involves "bringing" the human body into situations that purposefully feel strange to detect relational arrangements that might be otherwise tacit or unnoticed (Bell et al., 2005).

In the context of my research, I refer to this collection of approaches as *auto-design* in reference to drawing upon a variety of these approaches, but with a stronger emphasis on the self as an open and mutable concept in relation to and through design activities. This means that auto- methods in turn can transform, or blur, boundaries between oneself, design, and other humans and nonhumans. This preference towards auto- also draws upon approaches not present in interaction design, and in particular the practice of autotheory. Fournier describes autotheory as a "self-conscious way of engaging with theory — as a discourse, frame, or mode of thinking and practice — alongside lived experience and subjective embodiment" (2021, p7). I further align autotheory with histories of performance that are deeply significant and often therapeutic for oneself in intimately engaging with personal experiences, and in inviting audiences through storytelling to experience an experience (e.g. Alexander, 2000; Ensler, 2000). In summary, *auto-design* includes recognizing and grappling with my own experiences, differences, relations, and theoretical commitments to notice, understand, and discover new meanings of everyday entanglements.

Spatial orientations

The notion of "making space" often refers to crafting an environment or conversation that opens for plurality of voices to be contributed and heard. This opening can be understood as conceptual or literal, and is often in relation to design as activism that aims to counter the oppression of marginalized experiences (e.g. Søndergaard, 2020). Light's queering as a method is similarly interested in allowing "new truths, perspectives and engagements to emerge through a refusal to accept definition" (2011), which can problematize political structures through critique and mischief. Light's positioning

of queering as a "space-making exercise" draws upon the Greek root of the word that means to treat oblique or go in an adverse direction. This approach can be taken towards designing against a toxic status quo within technology, or towards disrupting design as a toxic status quo (Canlı, 2017). Queering as a method spatially aligns with Sara Ahmed's (2006) concept of orientations as starting points for apprehending a shared inhabitance between people, objects, and spaces that shape "who" or "what" attention is directed towards. In this way, orientations are about the physical proximity of humans and nonhumans, and also "involve directions toward objects that affect what we do, and how we inhabit space" (Ahmed, 2006, p28).

In interaction design, there are a variety of methods that do not explicitly draw upon queer theories or notions of troubling, but do share conceptual notions of space and orientation. Body maps, also sometimes referred to as body sheets, are a visual tool for documenting human felt experiences, often in relation to how a human body moves through space (Loke et al, 2012). They can be seen in the design process of shape-changing technology that is meant to orient attention to and conversations around subtle bodily changes during menstruation (Søndergaard et al., 2020). Peeters at al. (2020) break conventional approaches to audience engagement of written research by inviting readers to physically engage with the pages of a publication. Although not described as a method, this approach rethinks how a reader bodily and spatially engages with research dissemination, which in turn orients attention to particular aspects of the research and how research more broadly is communicated. Critique as a method from the humanities is used to reflexively recognize and engage with positionality in relation to objects of interaction design (Bardzell et al., 2015). This acknowledges situatedness and power within design, and how bias might be oriented by and from particular bodies with intersectional privileges (Buckley, 2021).

In drawing from these approaches, I refer to the range of related methods used in my research as *spatial orientations*. This is to emphasize dual pragmatic and conceptual interests in how human and nonhuman bodies are oriented in space, and the social, material, and situated relations of bodies that inform critique, troubling, and mischief. This framing is selective and orients away from conceptualizing my methods as "queering" in recognition of my situated perspective of what is "normative" (Wiegman & Wilson, 2015); and also in a drawing upon architectural methods that engage with notions of space, such as site-writing and mapping otherwise. Jane Rendell (2010) describes site-writing as a critical and ethical spatial practice that explores the situatedness of the author in relation to the site of writing and particular objects of study. Nishat Awan (2017) proposes "mapping otherwise" to capture the messy realities of socio-material relations that are often left out in methods of mapping as neat and precise representations. In summary, *spatial orientations* are a collection of methods in relation

to the positioning of a designer that includes recognizing and investigating situatedness.

Leaky materials

There is a long history of exploring the materials of interaction design and how to work with those that are invisible or intangible in everyday lives. This includes considering the expressions of materials that might be hidden, such as electricity or cell reception, and the spatial manifestations of temporal forms, such as processes that are either off or on (Redström, 2005). Accounting for temporality highlights the potential of designing with immaterial processes, such as computational bits, and long-term behavioral transformations over time and beyond proximate use (Mazé, 2007). More recent approaches conceptualize digital and nondigital materials as lively and/ or living in recognition of more-than-human agencies, such as material speculations of artificial intelligence (Nicenboim et al., 2020) and data from domestic objects as positional-less, ephemeral, and undefined (Desjardins et al., 2020). In addition, there is a growing body of work in HCI on designing with biological or bio-based materials. This includes devices for appreciating human bodily fluids (Campo Woytuk et al., 2020; Homewood et al., 2019), biodegradable artifacts made from food waste (Bell et al., 2022) and menstrual blood (Campo Woytuk & Søndergaard, 2022), and interactive interfaces made from marine organisms (Groutars & Risseeuw et al., 2022). These latter examples expand material repertoires beyond the digital through diverse approaches from which the biological material is both a subject (e.g. being touched) and an object (e.g. an interface). These examples are also defined through human and nonhuman relationships, that is, they are more-than-human in recognition of entanglements between people and materials.

Within interaction design, "leaky" is used to describe a variety of nonhuman systems and objects. Notions of data leakage (Shklovski et al., 2014) and digital leakage (Pierce, 2019) draw upon leakage as a metaphor in privacy discourse to discuss creepiness as the sensation of an embodied or personal boundary violation. The notion of "leaky objects" refers to the unintentional revealing of implicit information about people from shared digital devices, which enables meaning-making through ambiguous speculation and expressive communication (Helms, 2017). This conceptualization reimagines the technical notion "leaky abstraction" from the perspective of a user experience designer (Helms et al., 2018). In human-centered AI (HAI) research, leaky abstraction is defined as ad hoc representations of technical details to aid in collaborative software development, which positions leaky as "incomplete and constantly changing design knowledge" (Subramonyam et al., 2022). Another body of work situates leaky in relation to feminist investigations of human bodily boundaries (Shildrick, 1997). This includes how a leaking of bodily fluids, such as menstrual bleeding, represents a lack of control within socio-cultural norms and in relation to lived experiences with self-tracking technologies

(Homewood et al., 2020). It is also explored in drawing with watercolor as fluid speculations, which imagine entanglements between human and nonhuman materials, such as bodily fluids from people and animals, to reflect upon the fluidity of artifact boundaries, designerly knowledge, and material choices (Yurman, 2022).

My use of *leaky materials* draws upon both digital and nondigital investigations through their shared emphasis on entanglements that disorder perceptions of individual human control, autonomy, and boundaries. This emphasizes the more-than-human qualities of materials as vibrant and fluid. Vibrant means that they are temporally affecting and expressively agentic (Bennet, 2010); and fluid speaks to how materials and bodies continuously change and travel (Redström & Wiltse, 2018), which blurs boundaries between people, technology, and environments. Although this puts less emphasis on whether materials are considered human or nonhuman, and more emphasis on the particular qualities, it does not discount differences between nonhuman digital materials and human bodily fluids. Rather, it opens for reckoning with more-than-human relational entanglements that highlight how leaky is conceptually and practically manifested in interaction design through materials. This investigates the relevance of nondigital materials, such as milk, for interaction design and HCI; and foregrounds material particularities through situated explorations across experiments. In summary, *leaky materials* conceptually and practically grapples with what can be shaped by interaction design methods through an emphasis on a mingling, disordering, and transforming of bodily boundaries.

Open speculations

Speculation can be considered inherent to design as a change-making practice that materializes alternatives. In relation to the imagining of futures, it is often referred to as speculative design in which new worlds are brought forth through the questioning of existing practices, values, norms, and power relations (Kozubaev et al., 2020). Speculative design can be positioned under the umbrella of critical design, within which it is argued that all design is deconstructing to construct anew through critique, with more extreme variations aimed to deliberately provoke responses rather than solve problems in relation to challenging a status quo (Dunne & Raby, 2013). While critique can also be considered inherent to design, it is not necessarily a negative practice. Rather, it can also be a reasoned and sensitive search for value to ground design (Bardzell & Bardzell, 2015). Thus how critique is positioned and manifested ambivalently varies in the shaping of realities (Mareis et al., 2022). Design fiction is a future-oriented method that makes use of narrative to contextualize seemingly everyday objects in a fictional world to suggest future implications of technology (Bleecker, 2009), such as in relation to energy consumption (Helms & Fernaeus, 2018) or menstrual-tracking technologies (Søndergaard &

Hansen, 2016). Related methods include speculative enactments that invite participatory reflections on consequential scenarios (Elsden et al., 2017), experimental and provocative designs to prompt discussions (Yurman, 2017), and playful food imaginaries through experimental workshops (Wilde & Dolejšov et al., 2021).

Amid a diversity of speculative methods, who gets to speculate and what corresponding futures are imagined is critically questioned (e.g. Forlano, 2021). Martins (2014) proposes "feminist speculative design" as an intersectional perspective on privilege and oppression in response to speculative practices that comply with, rather than challenge, the status quo through an apolitical stance that promotes normative futures. This perspective is extended to situated and embodied encounters with speculative objects by drawing attention to "taking care of the possible" as an ethico-political commitment to curation (Pennington, 2018). Feminist utopianism is proposed to ground futures embedded with democratic ideals and voice marginalized perspectives (Bardzell, 2018). Utopian visions as optimistic stories are seen in speculations of sexuality and aging (Schulte et al., 2021). A body of work situated in critical race studies highlights systemic forms of racial oppression in design that reify inclusion as a thin promise. This includes calling for HCI to make explicit processes of racialization (Tran O'Leary et al., 2019) and drawing upon Afrofuturism (Bray & Harrington, 2021; Harrington et al., 2022).

My articulation of *open speculations* as a way of knowing through the materialization of alternatives, positions "open" as an ongoing opening up and questioning of futuring. This understands speculating as not just about projecting forward in time, but also about revisiting pasts and reimagining presents to continuously critique modes and values amid imagining change. In this way, it draws upon practices of fabulating that tell stories of alternative histories to open for different possible futures (Rosner, 2018), other-worldly fables that might be radically different presents to think with and hope for (Haraway, 2016), and "big enough stories" for surprising connections (Lindström & Ståhl, 2019). "Open" further suggests design speculations as always unfinished in recognition of ongoing participation in making new and unmaking old connections through collaborations with designers and audiences that might be synchronous or asynchronous. Practically, this includes visual collages, speculative artifacts, and playful texts that invite engagement through deliberate frictions, unanswerable questions, ambiguous narratives, and performative words. In summary, *open speculations* materialize possibilities of otherwise, yet strive for an ongoing engagement and reinterpretation of the otherwise put forth.

Summary of methodological approaches

The four ways of knowing are diagrammatically and textually described in relation to how they affect my research program *designing with care*.
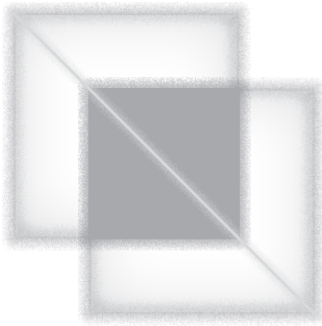
Auto-design

Auto-design as a group of methods explicitly engages with the human self as a starting point in research, with an emphasis on the self as an open and mutable concept in relation to and through design activities. This means that auto- methods transform, or blur, boundaries between oneself, design, and other humans and nonhumans.

The diagram has a centered core that recognizes the situatedness of a self, yet the boundaries of the axioms are blurred in recognition of a self as socially and materially constructed. This illustration conveys how a centering of oneself challenges the boundaries of the research program, such as what everyday care includes, and how the challenging of boundaries might lead to knowledge beyond knowing about oneself.

Leaky materials
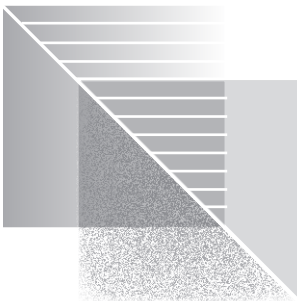
Leaky materials takes into account the vitality of digital and nondigital design materials, such as data and bodily fluids. It puts emphasis on design materials as more-than-human and fluid in how they travel, flow, and disorders species boundaries and individual autonomy. This means that design materials cannot be contained.

The diagram use different textures to suggest how different materials have different meanings and different agencies in shaping ways of doing design. The textures do not intend to one-to-one map to the axioms, but instead aim to show that for example, working with data in relation to generosity might lead to a different outcome than working with bodily fluids. Yet, materials are not isolated, and also overlap and collaborate in knowledge production.

Spatial orientations

Spatial orientations are pragmatic and conceptual approaches that describe how human and nonhuman bodies inhabit space. It draws attention to the corresponding social, material, and physical relations of bodies that inform critique, troubling, and mischief. This means that spatial orientations explore the physical and political positions of people and things, and the messy realities of these relationships.

The diagram skews the research program by movements such as tilting, turning, twisting. In doing so, through misalignment it troubles accepted definitions of the axioms to make space for other interpretations. Though misalignment, it also questions the positioning of the axioms in relation to one another, and invites ongoing making and unmaking of relationships between values, bodies, and space.

Open speculations

Open speculations are critical and speculative design methods to materialize alternatives and invite ongoing engagement. This understands speculating as not just about a linear future, but also reimagining presents and pasts. Open points to them being incomplete and unfinished in recognition of ongoing participation and collaboration that invites new engagements and continuous critique.

The diagram breaks open the boundaries of the research program to welcome other interpretations, voices, and designs that might challenge or build upon what is put forth as otherwise. Its dispersal of openings aims for many pathways of connection, and the lines recognize that alignment across all axioms might be impossible and not necessarily preferable for all. Yet, it maintains a shared center that hopefully seeks a diversity of perspectives coming together for many alternatives.

IV. Careful designs

This chapter is an overview of my design experiments, which are examples of careful designs. As a speculative inquiry of interaction design otherwise through a diversity of finish and form, I refer to them as careful designs rather than careful experiments to position my work away from scientific processes that often follow research question and answer dichotomies (Redström, 2017). By examples, I am not saying that they are exemplars of how to design with care or posthumanism, and they are not intended to be "solutions" for a world in crisis. But rather they are situated designs within my worldview as what Redström refers to as: "the scaffold we needed to make sense of a vast range of possibilities open for us: for navigating the potentiality of what could become, not the actuality of what became" (2017, p66). In this way, they are examples of what *designing with care* might look like through the various ways that they draw upon everyday survival and more-than-human relations, but not always at the same time or in the same ways. Some projects extend this beyond the textual and visual content of the paper(s) included in this thesis to the composition of the paper itself (e.g. Papers IV and VI) and other forms of dissemination (e.g. video made for Paper II).

For each of the five careful designs, I first give a short introduction and then summarize the knowledge outcomes contributed as presented in associated paper(s). I next expand upon key decision points in my design process for that particular experiment. These decisions contextualize broader issues of concern with the world and interaction design as identified in previous chapters. Within the design decisions, I also highlight the relevancy of particular ways of knowing from my research methods. Lastly, I position the careful design in relation to my research program *designing with care* and how it relates to the four axioms and two propositions, which includes revisiting the diagrams to show an uneven distribution of the axioms.

Technologies of human waste

Technologies of human waste investigates the leveraging of intimate and somatic data in the management of bodily excretion. This is through the design of speculative technology that predicts when and how badly a person needs to urinate. It is relevant to interaction design by engaging with data that is collected and analyzed for predictive systems. For example, this includes wearables that track personal biometrics, which might be used to predict health risks or spending habits. I detail the design space of *technologies of human waste* in Paper I, which includes a critique of market exemplars, three conceptual provocations, and autobiographical data-tracking of urinary routines. In the following, I first consider the types of knowledge outcomes contributed. I then reflect upon the motivation of the topic within my broader research context, important conceptual decisions in considering data as an entangled material, and the significance of my changed positionality in understanding the provocations. Lastly, I relate design decisions to the four methodological ways of knowing described in Chapter III and describe how this design experiment relates to the four axioms of *designing with care*.

Knowledge outcomes

The knowledge outcomes of this careful design are detailed in Paper I and include (1) my process of building a design space for intimate and somatic data, (2) three provocations as images and scenarios, (3) three considerations on the externalization of internal sensations through data-driven technology, (4) and my process of reframing my design space. The first and fourth outcomes are methodological in providing an example of how to conceptually construction a design space for urination and how a designer might reprogram (Binder et al., 2011) a design space in an ongoing discovering of relations. A design space is understood as a representation of possible outcomes that aim a person's attention during a design process (Westerlund, 2005). In the first outcome, a critique of market exemplars is also intermediary knowledge because it is more abstract than a particular design but not as general as theory. The three provocations of the second outcome are *truth and dial*, *clip and snip*, and *survey and shoot*. Each is an ultimate particular in the form of an image and scenario that are specific examples of speculative devices that predict when and how badly a person needs to urinate (i.e. "pee-ometers"). The names of each provocation deliberately highlight frictions between human and nonhuman agencies amid socio-cultural norms. The images are explanatory in visually describing how the three provocations work and might be problematic, yet also aesthetically playful as exaggerations rather than solutions to prompt discussion. The third outcome is considerations for the labeling of somatic data, the actuating of bodily experiences, and the scaling of intimate interactions. These are intermediary knowledge that through the generalizing of my reflections and insights, provide descriptive guidance for designers working with intimate and somatic data.

Clip and snip is garment clip that raises the hem of the garment based on the wearer's urge, and if the urge is not handled in an appropriate time frame, the clip has an emergency razor to trim off the garment.
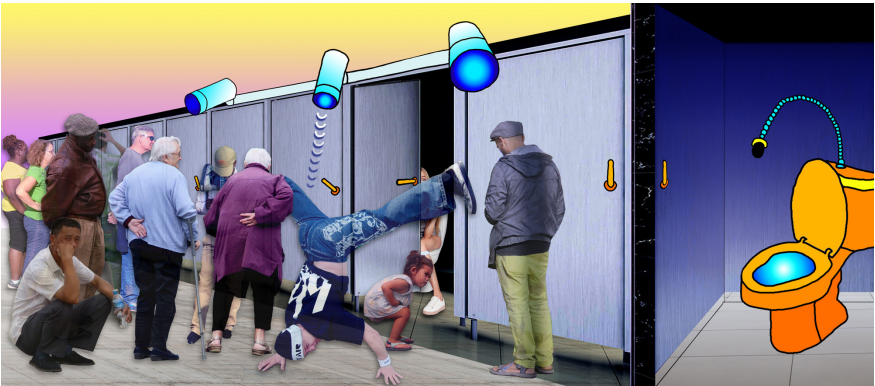
Survey and shoot is a camera network that forms representations of urinary urges of people in a public space, and grants facility access to the greatest urge through the shooting of an air haptic or "poof".
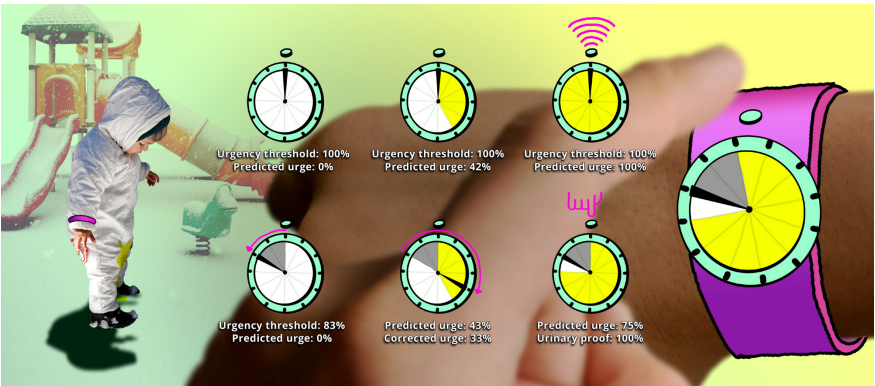
Truth and dial is a watch worn by a guardian to manage the urinary urge of a child, and uses an audio alarm to coerce the guardian to respond urgently to an urge amid possible social shame.

Design decision: Workbooks of speculative abstracts

This careful design emerged during the creation of workbooks of speculative abstracts (Helms et al., 2018). The workbooks were situated in a project called Smart Implicit Interaction that funded my research, and which was comprised of a multidisciplinary team of interaction design researchers, social scientists, and machine learning scientists. I understood my role as an interaction design researcher to be about unpacking the notion of implicit interaction and contributing design exemplars for a variety of situations. My starting point for "smart" was understanding how to conceptually and practically design with data for decision-making systems, such as those that incorporate machine learning. I led the creation of multiple design workbooks (Gaver, 2011) to collaboratively gather and unpack definitions of implicit interaction with the team, and to explore design directions for data in a variety of contexts (e.g. outdoors, city, and body). One of the workbooks was a booklet of cards that contained abstracts written by myself and team members of future papers.

One of the abstracts proposed the idea of a "pee-ometer" as a speculative device that "predicts when a user has to pee based on body movements" (Helms et al., 2018). The first idea for this brief emerged in a group discussion on interesting machine learning applications. It was immediately met with mixed opinions and hesitation. I was cautioned against urination as a design context and how my use of humor in previous work (Helms & Fernaeus, 2018) might be perceived as offensive. Even though managing urination is often considered taboo, I did not aim to challenge the taboo, but rather to make use of it in probing responses to machine learning in such a situation. For example, the names "technologies of human waste" and "pee-ometers" are meant to be provocative. The use of "waste" points toward urination as taboo in being disgusting and often absent from design and everyday conversation. "Pee-ometer" points toward it as taboo in aligning the name with another mundane activity - step-counting pedometers - and also accentuates societal conceptions of optimization.

My motivation was further grounded from multiple perspectives. I was interested in bringing the technical idea of "training" from machine learning into a design space that already has cultural associations of training, that is, potty-training. There were clear tensions in how training a system might call attention to a bodily process that is expected to be intuitive and discreet for adults, and how the use of such a system might challenge autonomy for a bodily process that a person is expected to manage individually in early childhood. I speculated that there was a relationship between how the personal training of a machine learning algorithm might in turn affect a person's intimate bodily perceptions. In addition, I suspected that an uncomfortable challenging of human autonomy might be related to a valuing of the management of bodily excretion as individual within normative associations of it as private and taboo
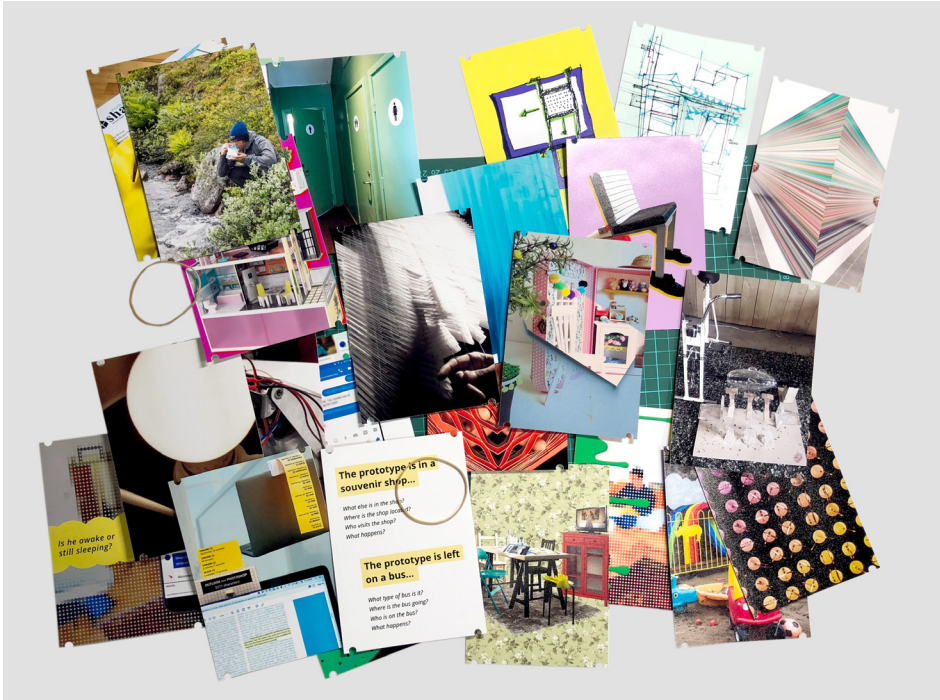
Workbook of speculative abstracts with initial careful design description. I assembled the abstracts as a deck of cards, for which I added a corresponding image for each. The intention behind the abstracts as cards was that they could be shuffled with images and abstracts mixed and matched as a way to deconstruct and reconstruct our project design space.

Technologies of Human Waste

The broad topic of my research is Smart Implicit Interaction, defined by an interdisciplinary project composed of Artificial Intelligence, Social Sciences, and Interaction Design academic disciplines. While the overarching project is interested in a more meaningful choreography between implicit and explicit interactions with technology through Machine Learning, my design research activities are more specifically investigating agency, care, and gender within everyday infrastructures and practices. I am actively investigating these themes through several concurrent design projects.

One such project is the design and prototyping of a 'pee-ometer,' or a wearable device that predicts when a child has to pee based on fine bodily movements during potty-training. On one hand, through this project I am bringing the technical concept of training from Interactive Machine Learning into a design space for critique and investigation of Machine Learning as a design material. On the other hand, I am interested in technologies of human waste, from privacy, shame, and deletion to gender, identity, and aesthetic bodily experiences. Within the universality of human waste, the pee-ometer aims to explore the construction and imposition of particular domestic practices, social norms, and physical infrastructures.

(in modern Western society); and within a tension between it being a universal human bodily function, yet also extremely particular and idiosyncratic in everyday life. Thus, it raised questions of how to design for something that is ubiquitous but with great harms if generalized as universal, and how individualized a design could and should be.
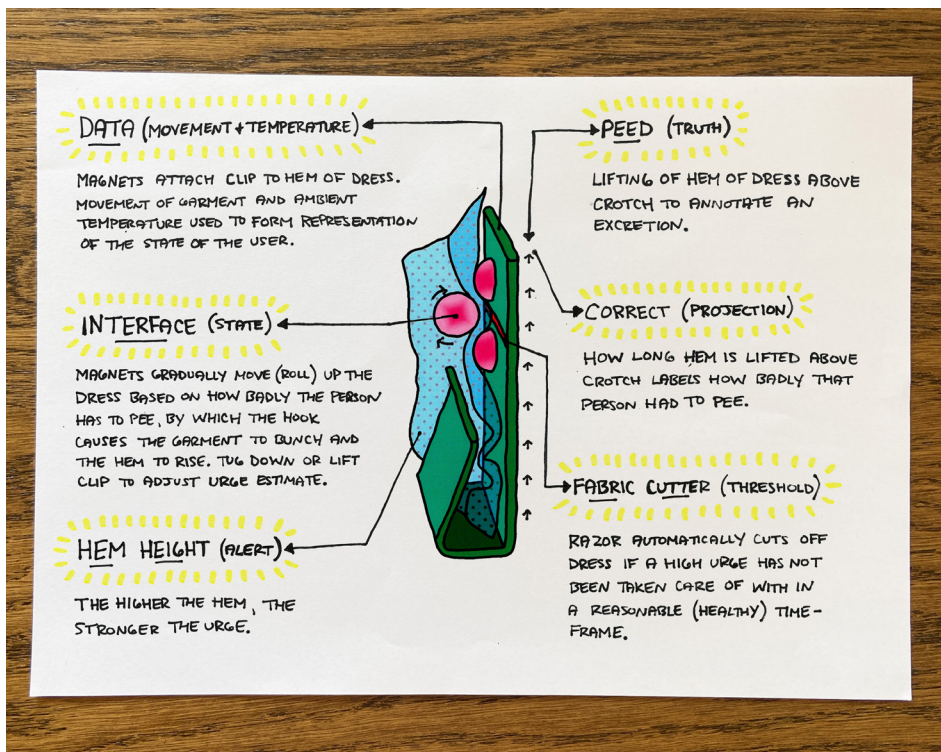
Design decision: Annotated concept sketches

As described in Paper I, following a critique of market exemplars I designed three pee-ometers as provocations. In working with three themes from the critique, each provocation explored a different situation: on-body (i.e. *clip and snip*), familial relationships (i.e. *truth and dial*), and public spaces (i.e. *survey and shoot*). This aimed to think through the particulars of varying situations across the same human bodily function. This did not attempt to cover all possible everydays in the management of urination, but to extend the designing with intimate and somatic data to a variety of situations that might prompt differing possibilities and concerns. In the first activity, I created a visual mood board to synthesize the chosen theme. In the next, I sketched a fictional product and annotated interactions with data. Lastly, I described a scenario as if it were a real product going to market.

Through the annotating of interactions with data, my aim was to isolate moments of interaction between a person(s) and a pee-ometer. I did this by describing how I understood data prediction and training, and how those system interactions might be experienced by a person. For example, for the provocation *clip and snip*, this included the following annotations: data (movement and temperature), interface (state), hem height (alert), peed (truth), correct (projection), and fabric cutter (threshold). The specification of the data helped me think through how a person's behavior and environment might make this concept possible. The interface corresponded to how I perceived the meeting between the person wearing the clip and the state of the system in predicting a urinary urge. This was articulated through the magnetic balls that move up or down in response to predictions and a person tugging at the clip as system training. The hem height is an alert for the person wearing the clip or for another person who might be helping. This indication of the predicted urge is in relation to the urgency of which it should be handled as defined in the system. Lifting the garment above the crotch is considered an absolute marker of truth: the person has peed. This is a way that the system could be trained. Another form of training is through the correcting of a projection, which is interpreted by the system from the length of time that the hem is lifted above the crotch. This length of time is significant from the assumption that it is in direct relation to the amount of urine being excreted. The fabric cutter that clips off the bottom of the garment was critical in considering how to design a friction between the person and the system. It is a consequence imposed by the system if a person does not handle the urge

within an appropriate (i.e. "healthy") time-frame, which explicitly probes an interplay between human and nonhuman agencies.

The importance of the annotations is that I was trying to think through how labeling, training, predicting, and actuating might be felt and experienced by people. They sought tensions between the system as universal and it as particular for a person and situated within societal values and infrastructures. The annotations explored data as information about an urge that is difficult to quantify and entangled with socio-material practices that further complicate how data represents and transforms notions of reality (Sanches et al., 2022). This includes the presence of other people and toileting infrastructures, as well as how a person might negotiate with technology to establish or prove the "truth" of an experience and the potential biological, technological, and social consequences of a negotiation.

The annotated concept sketches are a synthesis of scenarios with a focus on discrete interactions among people and with data, and translate my understanding of technical concepts into pragmatic design details.

## Design decision: Reflection on changing positionality

In addition to the design of the pee-ometers, I also tracked and labeled my urinary routines for six months. As described in Paper I, this approached urination as "lived" (Merleau-Ponty, 2002) and was to defamiliarize myself with an everyday practice that I often do not notice as a white, able-bodied cis-woman in Sweden and the United States, where the tracking took place. This included how it would feel to track data that I culturally consider personal and private, and to notice what might have been previously obscured to me about associated spaces, artifacts, and people. The tracking and labeling felt consequential because the process of noticing took place in the contexts where the consequences of the pee-ometers would be experienced.

Paper I gives an overview of the technical set-up and three stages of the autobiographic tracking and labeling. The pee-ometers' predictions were intended to be based on body movements. That is, I wondered if a digital model of my urinary urges could be built from mapping activity data to autobiographic tracking of urinary urges. This was important for the technical set-up of my tracking, and in particular the including of date and timestamp that could be matched with activity data. I did not previously describe the potential role of the activity tracker because I never attempted to access, look at, or integrate such data into a prototype. The non-system-generated data in the tracking of urges became very laborious to collect and make sense of, and reframed more preconceptions than I had anticipated. This included more closely attuning to the social and material context, such as liquid intake, proximity of a facility, and cultural norms of health. It also drew attention towards a significant change in my life that changed the positionality from which I had designed the pee-ometers: pregnancy. This was important because I did not expect my life situation to defamiliarize myself with something that I had designed: knowing I was trying to conceive prompted reflections on what *clip and snip* might reveal about an urge beyond the presence of an urge (e.g. "heath" or lifestyle status), and becoming pregnant changed my perception of *truth and dial* as provocatively speculative to unprovocatively useful.

This highlights the dynamism of a designer as a self in an ongoing reflective reframing of a design space. My changing positionality was informed by relations with the data as a material that I was shaping and that was shaping me through my noticing. This includes drawing attention to positions that I was not previously considering as significant within my design intentions and from where I could critically revisit what I am designing differently. I found this humbling because it enriched my understanding of a subjective standpoint as not declarative, static, or absolute but rather as ongoing and embedded within a multiplicity of social and material relations that are also continuously shifting.

1	TIMESTAMP	DAY	TYPE	STATUS	NOTES
715	8/18/2018 15:10:45	Sun	message	Need	to pee 60%, on long walk listening to interviews but home now in view and urge emerges
716	8/18/2018 15:11:31	Sun	message	Need	80% fast increase
717	8/18/2018 15:12:53	Sun	message	Going	90% at home
718	8/18/2018 17:25:46	Sun	message	Drinking	a glass of ice water back at home
719	8/18/2018 17:35:25	Sun	message	Drinking	cup of hot chocolate
720	8/18/2018 17:55:54	Sun	message	Note	must be dehydrated because still don't have to pee
721	8/18/2018 22:19:42	Sun	message	Drank	two glasses of water this evening and a big hot chocolate
722	8/18/2018 22:19:56	Sun	message	Going	pee before bed, 70%
723	8/19/2018 7:22:06	Mon	message	Went	an hour and a half ago 95%, was dreaming about it
724	8/19/2018 8:14:50	Mon	message	Drinking	cup of coffee and glass of water
725	8/19/2018 9:17:43	Mon	message	Going	30% mainly because i was thinking about an excuse for a break to get up from my computer
726	8/19/2018 9:55:15	Mon	message	Going	20% before leaving home for pool
727	8/19/2018 9:55:23	Mon	message	Drinking	glass of water before leaving
728	8/19/2018 10:44:17	Mon	message	Drinking	from big water bottle while walking, maybe equivalent of glass
729	8/19/2018 11:34:17	Mon	message	Drinking	a glass of water and cup of hot chocolate (cooling first)
730	8/19/2018 12:30:09	Mon	message	Went	60% at home
731	8/19/2018 13:23:58	Mon	message	Drinking	glass of water
732	8/19/2018 13:30:23	Mon	message	Going	40% pre-nap pee
733	8/19/2018 14:25:37	Mon	message	Going	post-nap pee 50%
734	8/19/2018 14:25:38	Mon	message	Drinking	glass of water
735	8/19/2018 15:09:43	Mon	message	Drinking	hot chocolate
736	8/19/2018 15:40:25	Mon	message	Went	50%, i think i go a lot when working from home out of needing a break
737	8/19/2018 15:40:30	Mon	message	Drinking	a glass of ice water
738	8/19/2018 19:35:49	Mon	message	Drank	a beer in the past hour, 3.5% if that makes a pee difference
739	8/19/2018 19:36:01	Mon	message	Drinking	a big glass of lime water with dinner
740	8/19/2018 21:01:52	Mon	message	Went	5 minutes ago, 80% but dehydrated
741	8/19/2018 21:02:01	Mon	message	Drinking	another glass of lime water
742	8/19/2018 21:02:24	Mon	message	Note	have been charging fitbit for the past 2 hours, need to note gap in data
743	8/19/2018 21:58:49	Mon	message	Going	10% before bd
744	8/19/2018 21:59:01	Mon	message	Drinking	glass of water before bed
745	8/20/2018 6:03:46	Tue	message	Went	an hour ago 90%, then back to bed
746	8/20/2018 7:12:49	Tue	message	Went	about 30 min ago, 20%
747	8/20/2018 7:13:07	Tue	message	Drank	a cup of coffee and a glass of water in the past hour

Autobiographic tracking of my urinary routines was accomplished through the messaging of habits and urges to a custom bot in the Telegram chat application. In combination with a Google Apps Script, each message was forwarded to a spreadsheet and sorted into five columns. Images were also separately forwarded to a private slideshow with captions stored as speaker notes.
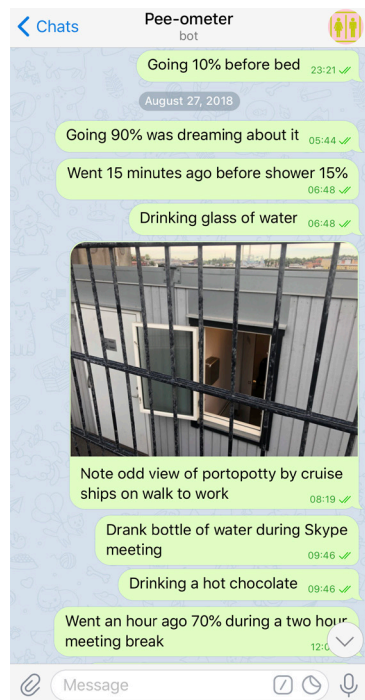
Ways of knowing

In considering key design decisions, the workbook of abstracts is an example of *open speculations*. It invited a variety of voices through the collaboration between team members. This was important in formulating the pee-ometer concept and in opening for interpretations of everyday contexts to explore implications of predictive technology. This is furthered in the interplay between visualizing the pee-ometers and detailing each scenario as if they was real, which invited a multiplicity of interpretations grounded in the concept of predicting urinary urges. My use of *open speculations* focuses on the axioms of everyday and intimacy, and in particular, probes experiences of closeness that might be uncomfortable between people and predictive technology.

The annotated concept sketches are an example of designing with data as a *leaky material*. They highlight data as relational and frictional in disordering human autonomy. In my process, this more-than-human emphasis is significant in highlighting care as wicked and in foregrounding moments of vulnerability. The annotations focus on the practical manifestations of data as leaky through articulating how unquantifiable sensations might be visually or tangibly expressed, how personal urges might be socially exposed, how discrete interactions between a person and technology might inform a broader system. Together, these details explore the fluidity of data between people and technology, which blurs boundaries among humans and with nonhumans. This use of *leaky materials* focuses on the axioms of wickedness and intimacy. In addition, the annotated concept sketches in conversation with the visual and textual scenarios draws upon *spatial orientations* to position people and interactions with leaky materials in physical space. This can be seen in the audio alarm in *truth and dial* or the air poof in *survey and shoot*, which highlight a messiness in human-technology relations.

The self-tracking of urinary urges and my reflection on a changing positionality are examples of *auto-design*. The data collection centered myself as open and mutable, and from which I could notice urinary habits. This was important as I have not experienced discrimination within digital or built infrastructures for managing bodily excretion, and have not experienced an unmet need of care or access. This can be seen as similar to an unmaking of a human self by paying closer attention to how I materially exist through my everyday maintenance, which blurred boundaries between myself, other people, data, and the spaces we traverse and inhabit. In contrast, my reflection on a changing positionality further grounded the core from which I situate myself in designing. This was through the noticing of new positions and attending to how my pregnancy reframed my design space for intimate and somatic data in Paper I, and also informed my design space with bodily fluids in Paper V. My use of *auto-design* focuses on the axioms of intimacy and generosity in attending to vulnerabilities of sharing oneself, and wickedness in unmaking and making relations with oneself.

Initial positioning

Revised positioning
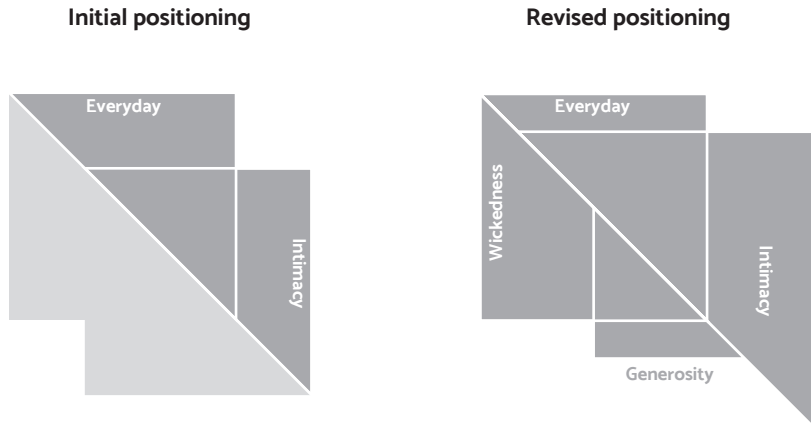
Research program

Relative to the axioms of my research program, I initially positioned *technologies of human waste* as only exploring everyday human care and intimacy with the self. It is grounded in the everyday through its focus on bodily excretion as a necessary and universal metabolic process of humans, which must be cared for by individual people and broader society through public infrastructures. It is grounded in posthuman intimacy through its focus on how not caring for bodily excretion, or only caring for normative or universalizing ideals, can be harmful to a self by not accounting for bodily differences and cultural idiosyncrasies. Each of the provocations highlights a vulnerability of the self through the deliberate designing of frictions, such as the social exposure of an urge in *clip and snip*. They further the vulnerabilities in reckoning with human and nonhuman entanglements through the annotations of predictive technology that points toward data as agentic. Furthermore, in building upon research that highlights intimacy as an interactional outcome (Kwon et al., 2018), I point towards data as intra-active in being designed and in designing human experiences.

Subsequent to a revisiting of key design decisions, everyday and intimacy remain the most prominent, and wickedness and generosity are evident to a lesser extant. Everyday remains stable in size as the overarching concept and three provocations are grounded in a mundane process and different situation. It does not increase in size in acknowledgment of the situations as limited in scope and put forth from my perspective of what is everyday. Intimacy expands in recognition of the various interactional possibilities between a human and the pee-ometers, as seen in the annotations, that might be uncomfortable due to a closeness with technology or a difference between people. Wickedness is present in the provocations as a playful exaggeration of potential outcomes and trade-offs between how to care for urination. For example, in *truth*

and dial this is the audio alarm meant to embarrass caretakers; in *clip and snip* this is the cutting off the garment hem if a person does not respond in an appropriate urge in time; and in *survey and shoot* this is shooting of an air "poof" and speculative "pee dances" to convince a camera that one has to pee. These elements do not intend to make fun of people's everyday anxieties, but are an acknowledgment of being embarrassed and shamed by technology in a ongoing negotiation of care's tensions. Wickedness is also present in my reframing of relations between my positionality and the provocations. Generosity is the least present and evidenced through my autobiographic data-tracking and changing positionality. This is an example of an open dispossession that is not pre-reflective yet still significant in questioning my certainty as a designer and the stability of my design intentions. Generosity remains smaller than the other three axioms for this reason and because I do not consider the unanticipated outcome of my changing positionality as significantly risky to myself as autonomous.

Critique of market examplars, single-page moodboards to synthesize themes into possible concepts, and annotated sketches of each concept.

DESIGN OPPORTUNITIES FOR BODILY EXCRETION

INTIMATE AND SOMATIC DATA AS A DESIGN MATERIAL

Row 1 — Potty Watch

TIME / WATCH — FRICTION BETWEEN AUTOMATIC AND BODILY WAYS OF KNOWING

POTTY WATCH — The Toilet Training Timer That Makes Potty Fun & ... Lets Your Little One Know When It's Time to Go! TRY ME! Push Timer

DATA — DATA IS EITHER ABSOLUTE AND TOO LATE, OR SOMEWHAT ARBITRARY AND HIGHLY UNIVERSAL (TIMER OF SENSOR)

TOUCHPOINTS — ...FACES, INTERACTION, SENSORS, SERVICES + LIFE CYCLES, WHAT IS SUCCESS?

INVASIVE + INTIMATE — AGENCY: WHO IS IN CONTROL... CYBORG: MECHANISM IN HUMANS

WEARABLE DEVICE — ALWAYS "ON" INTERFACE THAT ISN'T TRACKING BUT PERSISTENTLY WARNING

LAYERED INFORMATION — WHAT IT TELLS ME ABOUT MYSELF VS WHAT IT TELLS OTHERS ABOUT ME (ALARM)

LAYERED INFORMATION — FRICTION BETWEEN PROGRESSION AND CORRECTION (AGENCY) (LOUDNESS)

"Mom, I haven't wet the bed."

DATA (AGNOSTIC) — UNKNOWN (!) HETEROGENEOUS DATA STREAMS PROVIDING A REPRESENTATION OF THE STATE OF THE USER.

INTERFACE (STATE) — DYNAMICALLY UPDATING ESTIMATE OF HOW BADLY ONE MIGHT HAVE TO PEE.

AUDIO (ALERT) — SPEAKER PLAYS AUDIO ALERT WHEN PEE PROJECTION REACHES ALARM THRESHOLD, AUDIO PLAYS UNTIL PEED BUTTON IS PUSHED.

PEED (TRUTH) — PUSH BUTTON TO ANNOTATE THAT ONE IS PEEING OR HAS PEED.

ALARM (THRESHOLD) — MOVE DIAL AROUND WATCH FACE TO SET AN ALARM TO BE NOTIFIED THAT ONE SHOULD PEE.

CORRECT (PROJECTION) — TURN OUTSIDE DIAL TO ADJUST ESTIMATE OF HOW BADLY ONE MIGHT HAVE TO PEE.

Row 2 — Dress / Wearable

INTIMATE INTERFACES — WRAP, TANGLE, TRAP, ENCLOSE... PRICK, PRESSURE, AND HAPTICS

AGENCY + DATA — BUDDY OR POLICE? INVISIBLE AGENTS IN CONTROL... WHO/WHAT KNOWS MORE?

IxD TOUCHPOINTS — MECHANICAL BITS CLOSE TO GENITAL BITS: COLD OR COMFORTABLE?

...EXPERIENCES — ...EDICALIZED, ...TRICATE, DELICATE, ...RAPY, EFFORTFUL
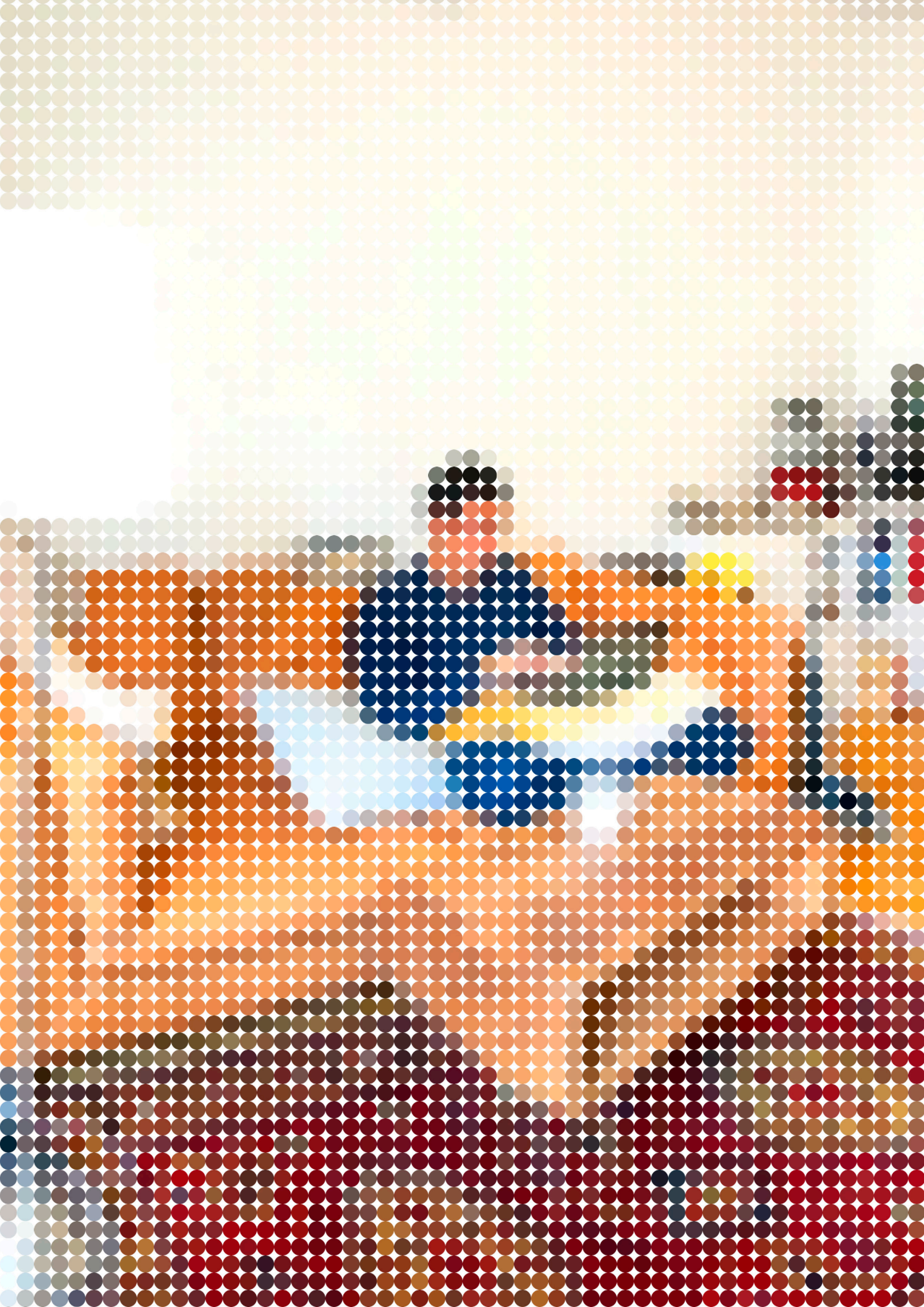
WEARABLE DEVICE — HOW IT IS WORN AND TAKEN OFF IS GENDERED

...ITY VS CLEAN — WHAT ARE THE ...IBLE AND INVISIBLE ...ODILY SENSATIONS ...D ASSOCIATION?

"Give us the goods, and leave the engineering to us"

DNA bebe

DATA (MOVEMENT + TEMPERATURE) — MAGNETS ATTACH CLIP TO HEM OF DRESS. MOVEMENT OF GARMENT AND AMBIENT TEMPERATURE USED TO FORM REPRESENTATION OF THE STATE OF THE USER.

INTERFACE (STATE) — MAGNETS GRADUALLY MOVE (ROLL) UP THE DRESS BASED ON HOW BADLY THE PERSON HAS TO PEE, BY WHICH THE HOOK CAUSES THE GARMENT TO BUNCH AND THE HEM TO RISE. TUG DOWN OR LIFT CLIP TO ADJUST URGE ESTIMATE.

HEM HEIGHT (ALERT) — THE HIGHER THE HEM, THE STRONGER THE URGE.

PEED (TRUTH) — LIFTING OF HEM OF DRESS ABOVE CROTCH TO ANNOTATE AN EXCEPTION.

CORRECT (PROJECTION) — HOW LONG HEM IS LIFTED ABOVE CROTCH LABELS HOW BADLY THAT PERSON HAD TO PEE.

FABRIC CUTTER (THRESHOLD) — RAZOR AUTOMATICALLY CUTS OFF DRESS IF A HIGH URGE HAS NOT BEEN TAKEN CARE OF WITH IN A REASONABLE (HEALTHY) TIME-FRAME.

Row 3 — Public Toilets / Surveillance

DATA / SURVEILLANCE — PUBLIC TOILETS AS "LEAKY OBJECTS", WHAT MIGHT THEY EXPOSE?

ACCESS + CONTROL — LIMITATIONS AND INFRASTRUCTURES THAT GOVERN WHERE, HOW, WHEN, AND WHO

PUBLIC VS PRIVATE — PERFORMING A PRIVATE ACT IN A PUBLIC SPACE - IMPACTS BOTH ACT ITSELF AND HOW ONE TREATS/TAKES CARE OF THAT SPACE

AUTOMATION — TECH LEARNS BEHAVIORS AND ADAPTS SPACES, CAN MASK PROBLEMS OR CONCERN

DATA + SOCIAL — HOW BADLY ONE HAS TO PEE (AND HISTORY) DETERMINES QUEUE + ACCESS

REGULARITY — FRICTION BETWEEN PREDICTABILITY AND SPONTANEITY OF OURSELF AND AMONG OTHERS

ADAPTATION — IMPLICIT TRAINING OF WHAT OR WHOM? NEW SOCIAL ADAPTATION?

FEAR + SAFETY — WORKING SPACES, SOCIAL NORMS, WHO ELSE HAS BEEN HERE? (HYGIENE)

DATA (COMPUTER VISION) — SURVEILLANCE CAMERAS COLLECT IMAGES TO FORM REPRESENTATION OF THE STATE OF THE USER.

INTERFACE (STATE) — DIRECTIONALITY AND IMPLIED FIELD OF VISION OF CAMERAS INDICATES DATA COLLECTION SPACES, WHILE A LIGHTER BLUE LENS PROVIDES FEEDBACK OF PERSON IN FOCUS.

AIR HAPTICS (ALERT) — CAMERAS "SHOOT" AIR AT PERSON THAT HAS TO PEE THE MOST, IMPLICITLY NUDGING THEM TO A SECRET, YET AVAILABLE FACILITY.

NETWORK (THRESHOLD) — ACCESS TO HIDDEN FACILITIES IS BASED UPON WHO HAS TO PEE THE MOST IN CONJUNCTION WITH AVAILABILITY.

PEED (TRUTH) — FLUSH TOILET TO ANNOTATE AN EXCRETION.

CORRECT (PROJECTION) — TOILET BOWL CALCULATES HOW MUCH URINE HAS BEEN EXCRETED (VIA SOUND AND VOLUME) TO LABEL HOW BADLY THAT PERSON HAD TO PEE.

Spying on loved ones

Spying on loved ones explores tensions in care through a critique of two autobiographical design probes. This careful design was in collaboration with Ylva Fernaeus. It can be seen as relevant to interaction design as situated within a proliferation of technology in the home. For example, this includes the (mis)use of digital technologies to care for loved ones, such as surveillance cameras or baby monitors, and their normative position of what constitutes "good" care. One of the design probes was created by me and investigated how I could remotely monitor and speculate about my partner's wellbeing at home through a custom chatbot and deployment of sensors. The other design probe was created by Fernaeus and was a system to notice if one of her children entered another room, and to remotely initiate an audio distraction that would divert them from an unsafe situation. In Paper II, we detail the motivation and setup of each, and then draw upon queer theories (Ahmed, 2006; Butler, 2006) to investigate ways of caring as not "in-line" with normative expectations. In the following, I first describe the knowledge outcomes. I then detail how I negotiated power imbalances in my prototype, the importance of approaching care as spatial in critiquing ourselves, and why we performed a talk show for the presentation of Paper II. Lastly, I position key design decisions within my four ways of knowing and I revisit it in relation to the axioms of my research program.

Knowledge outcomes

As described in Paper II, the knowledge outcomes from this careful design include (1) a prototype as an artifact, (2) a first-person narrative of my experience in making the prototype, (3) collages with diagrams of our reflective analysis, and (4) four orientations as resources to spatially navigate tensions of care. The four orientations are: *willful detours*, *naughty invasions*, *selfish shortcuts*, and *unhappy departures*. The first two contributions are instances of design knowledge as they are specific examples, or ultimate particulars, in the form of an artifact and descriptive account. The third contribution is a visual critique that draws upon care and queer theories to abstract the fourth contribution - the four orientations - from the particular instances. The four orientations and the critiques as collages with diagrams are intermediary design knowledge grounded in interaction criticism (Bardzell et al., 2010). The naming of the four orientations is in reference to a possible non-normative association of care (i.e. willful, naughty, selfish, and unhappy) and a possible spatial orientation (i.e. detours, invasions, shortcuts, and departures). The combined naming contributes to their abstracted positioning from design instances. They are intended to be generative and analytical resources for interaction designers in considering tensions of care for the conceptual development or an evaluation of an interactive experience. The visual critique is less abstracted than the four orientations, and is useful through its explanatory power in

relating the four orientations and care as spatial to the design instances. The visual critique can also be appropriated as an evaluative approach. The fifth contribution is the video presentation of Paper II in the form of a talk show. It is intermediary design knowledge as a form of criticism in which Fernaeus and I communicate our insights and values relative to our autobiographical designs. This is done through an alternative form of research dissemination, which can also be seen as a specific example.

Design decision: Adding the light flicker

My PhD research began with an autobiographical design probe that investigated how my partner and I communicate through shared domestic objects when one is at home and the other is not (Helms, 2017). I created a custom informational infrastructure through the deployment of simple sensors around the home, and from which I was able to monitor my partner's usage of particular objects and speculate about his wellbeing. One of the sensors was a photocell attached to a lamp. As described in Paper II, I added a light flicker in recognition of a power imbalance. Whenever I would check the status of the light, the light would flicker to expose my checking on him. My desire to remedy the power imbalance recognized technology as not neutral, and how the non-neutrality was situated within my relationship. It drew attention to the everyday ways that people check-in on loved ones as a form of care, yet also how care could be abused or misconstrued. I saw an opportunity for data to travel and transform from a status I could access to a flicker he could see as spatial evidence of that data. The evidence of my care was also grounded in my cultural desire to be, and be seen as, a supportive partner.

In implementing the light flicker, I realized that it would only be seen by him if the light was already on and would not be seen if the light was off. I considered trying to also switch it on if the light was off, as there was a possibility of him being home with the light off and not seeing the flicker. I decided to not pursue this route because if he really wanted to know every time that I was checking the light's status, he could go into the chat log and look. I prioritized it only flickering if on, which countered technology as attention-seeking, always on, and "truthful". Instead, it allowed for continued speculation and the possibility for him to be "away" (Helms et al., 2019). That is, as recounted in Paper II, it was originally designed so that I could speculate about his well-being, and this decision expanded the speculation to include not knowing if he will know that I am checking on him. This furthered the countering of technology as absolute and maintained variability in our relationship through my intent for ambiguity. The implementation of the light flicker also created an opportunity for him to turn off the light, and also turn off my spatial presence as a possible unwelcome invasion. This was my approach to balance ongoing speculation within felt power relations, which troubles neat presentations of technological realities.

Design decision: Collaging spatial relations

As presented in Paper II, Fernaeus and I critiqued our design probes to unpack how care for our family members had been perceived by external audiences as "wrong" or unethical. For example, as described in an interview about my probe (Desjardins & Ball, 2018), my design intentions had been questioned despite an insistence that my partner was a part of the process. Our critique was also grounded in how both probes aimed to overcome challenges posed by physical distances and boundaries. In my situation, this was my partner at home and me at an office. In Fernaeus' situation, this was one of her children going into the kitchen while she attended to another child in the living room. This prompted us to consider nonhuman bodily inhabitants and spatial circumstances that oriented the giving and receiving of our care. We found inspiration in queer phenomenology's "orientations" as spatial directions towards objects that affect what people do (Ahmed, 2006), or as in our situations, how people come into contact with care.

The making of digital collages helped us remember and visualize spatial arrangements, which drew upon written autobiographical accounts about our probes. The materials used in the collages included a revisiting of process documentation, such
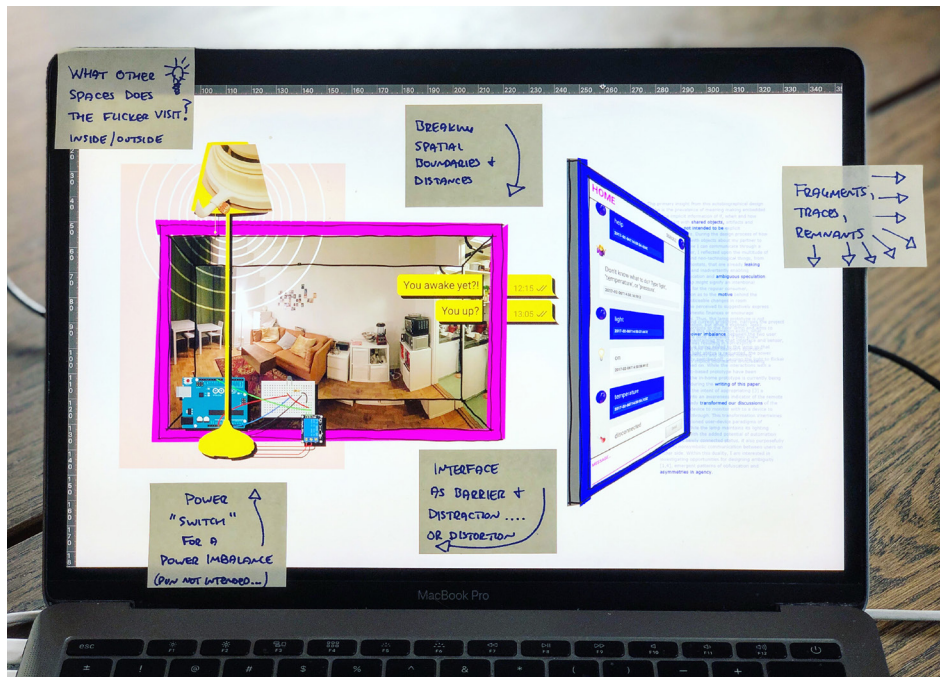

Annotations on a digital collage that aided in making sense of how our care was oriented in relation to physical locations, boundaries, and bodies. This collage is of my design probe and is constructed from photographs of my apartment and a sensor, a screenshot of the chat application, and text taken from an earlier publication.

as notes in sketchbooks; photos, such as of the spaces inhabited by the probes and taken by Fernaeus' probe; screenshots, such as from interfaces; and professional depictions of the projects, such as from internal presentations and external publications. The reviewing and assembling of these materials foregrounded how our care was directed and received across physical space, and also highlighted interconnections with digital space. For example, this included relationships between digital interfaces (e.g. chat and video), data (e.g. chat content, audio alerts, and research dissemination), and physical places and objects (e.g. homes, sensors, and actuators). This part of the process opened for a making, unmaking, and remaking of caring relationships. The making made present other people that our care was not intended for, but were either aware of it or implicated by it. The unmaking isolated discrete design decisions for further reflection, such as the light flicker. The remaking constructed new vantage points from which to conceptually consider relations between people, objects, and spaces; which practically contributed to the naming of the four orientations. It highlighted digitally and physically mediated arrangements and conceptually foregrounded what was in-line and not in-line with our cultural understandings of care and expectations a wife and mother.

This process brought a spatial perspective to care from which we noticed non-normative, or absent, forms of care that counter stereotypes of it as always positive and fulfilling, and from which we noticed the often excluded physical objects and digital relations that orient human bodies in care. This perspective considered our care as entangled with our places of inhabitance and interactions with technology. It also positioned an autotheoretical frame of analysis to critique our designs and identities as mutable and open to interpretation. Yet, as recognized in Paper II, our desire to trouble caring for loved ones is grounded within our cultural preconceptions of what is normative and some of the orientations also reinforce heteronormative roles and values. This aligns with critiques of technology trying to counter stereotypes or bias that end up still perpetuating stereotypes (Benjamin, 2019).

Design decision: Performing a talk show

Paper II was required a have 10 minute pre-recorded video presentation due to a virtual conference format. In discussing our approach, Fernaeus and I first decided that we both should be present in it to represent our caring for our loved ones. We also decided to further accentuate our gendered positions in relation to our domestic care. That is, in Paper II, we refer to myself as Wife and Fernaeus as Mother to accentuate the stereotypes of these identities in gendered expectations and productions of domestic care (Strengers & Kennedy, 2020). This sparked discussions on frustrations with how positionality, and in particular in publication dissemination (myself included), is often presented upfront as an obligatory list. While I consider such lists necessary and
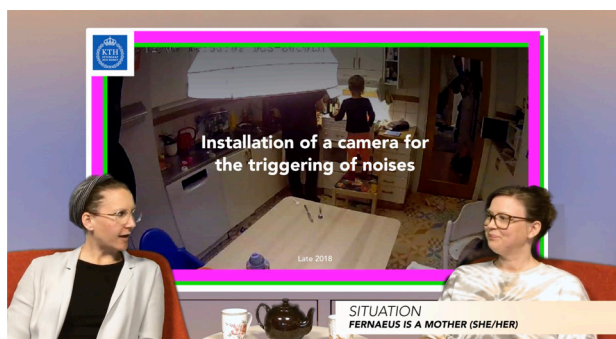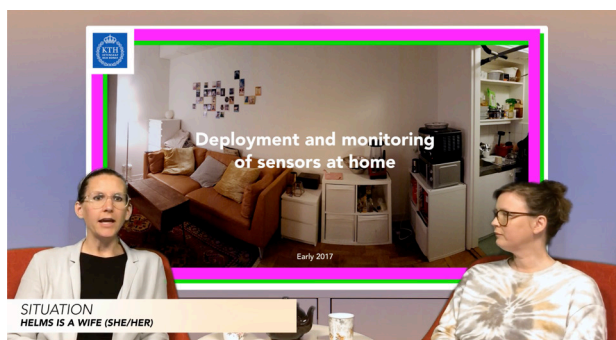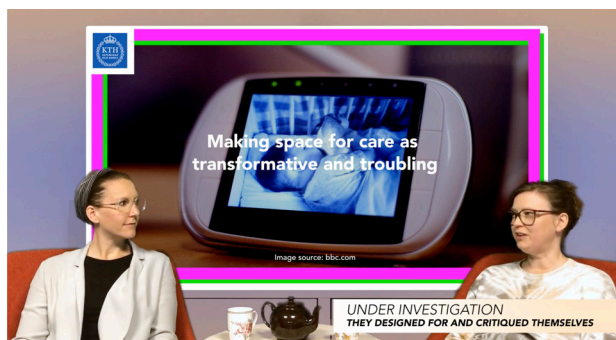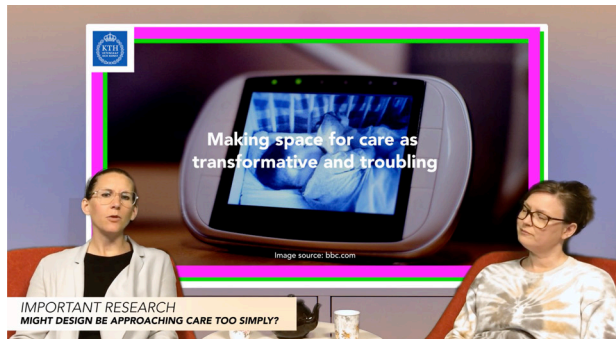
Video stills from 10 minute pre-recorded presentation. Full video is available at https://youtu.be/NYwdT4IlG7M

important in situating the perspective of the work, they often feel reductive and static as mandatory information. Thus, we aimed to explore how positionality could be presented differently in a presentation about a paper on positionality.

These aims coalesced in a talk show format whereby we put ourselves front and center "physically". This reversed research as often being central to a presentation with an author(s) in a small box on top of a slideshow, to making our presence the foreground and the research the background. A talk show setup established a stage whereby we said that we critiqued our autobiographical probes, and also performed the critique to create an evocative situation. The performance recognized an audience, and the talk show format recognized the audience as active participants in constructing their own critique. This signaled the critique of ourselves as designers and researchers as dynamic and open, which was important in accentuating ourselves as mutable and our privileges as response-able (Haraway, 2016) within an accountability for our research.

In realizing the details of the performance, we drew upon talk show aesthetics. This included chyrons, which are the text-based captions superimposed at the bottom of the screen and on top of a live recording to provide an audience with important details that might have been previously mentioned and might aid understanding an on-screen interaction. We designed these to appear at key moments to situate ourselves and to highlight tensions in our paper. The tensions encompassed our positioning of care in HCI design research (e.g. "Important research: might design be approaching care too simply?"), the validity of our research method (e.g. "Under investigation: they designed for and critiqued themselves"), a challenging of stereotypes as a wife and mother (e.g. "Situation: Helms is a wife (she/her)"), and the design intents of our probes (e.g. "Unresolved: did Helms spy on her husband?"). The chyrons added a layer of critique with ourselves as the subjects. This orientation furthered ourselves as collaboratively centered in a troubling of domestic and research norms, and from which we also invited an audience into a performative space.

Ways of knowing

Adding the light flicker is an example of *leaky materials*. The flicker as evidence of my care traveled from a where I accessed information to where my partner could access information about my access. Data from the sensor and data about data from the sensor are entangled across physical spaces. The light flicker visually illustrates how digital materials travel and change meanings in collaboration with varying people, temporalities, and situations. This also illustrates a traveling of digital materials as not always linear or stable, as for example in the hindering of the flicker if the light is not already on. Flow and retrieval of data were altered by other digital and physical factors, such as the status of a switch, and my partner's direction of attention. It also an example

of *open speculations*. This is through my intent to avoid the flicker as attention-seeking and always on, and to instead welcome uncertainty in how my care is received (or not). These uses of *leaky materials* and *open speculations* focus on the axioms of everyday and wickedness in acknowledgment of mundane situations and dynamic relations of care.

Collaging spatial relations is an example of *spatial orientations*. It drew attention to the social, digital, and physical entities that oriented our care and our critique of our care, and afforded explorations of physical and political relations. It opened for a troubling of ourselves, yet also reinforced some positions as fixed. For example, this includes our heteronormative relationships and identities as cis-women that ground a remaking, rather than unmaking, of some stereotypes. This use of *spatial orientations* focuses on the axioms of wickedness and intimacy through its exploration of how our selves are situated and the uncomfortable reckoning with tensions in our care. It also focuses on generosity through the gifting of our personal stories and artifacts that is risky through an opening of ourselves to further external critique.

Performing a talk show is an example of *auto-design*. The setup of a stage centered the human self as a starting point in our research. The chyrons and speaking to an audience recognized the self as socially constructed and open to ongoing critique. This blurred boundaries between ourselves and other people, which considered collaborative possibilities for knowledge production. This use of *auto-design* focuses on all axioms. Intimacy and generosity are explored through a novel form of dissemination that is vulnerable in its making and risky in its uncertain outcomes. Wickedness and everyday are also highlighted from our choosing to care less about following standard presentation practices and more about creatively spotlighting tensions in care.

Research program

I initially positioned *spying on loved ones* as exploring everyday human care and wickedly attending to caring relations. Everyday is present through how the two design probes informally check-in on loved ones, especially when physically separated. Such forms of care contribute towards a sense of belonging, well-being, and safety that can be seen as important for everyday flourishing. Also, this form of care is increasingly common in technological devices, such as baby monitors and digital features that allow access to "seen" and "online" statuses. Yet, as discussed in Paper II, there is a potential harm in assuming that checking-in or being checked-in on is always positive and fulfilling. These concerns ground the axiom of wickedness. It is further grounded in the everyday through its focus on research dissemination that is often situated within community recommendations and guidelines. Experimenting with the format of the video presentation considers how design research might be cared for as an everyday practice of knowledge production.
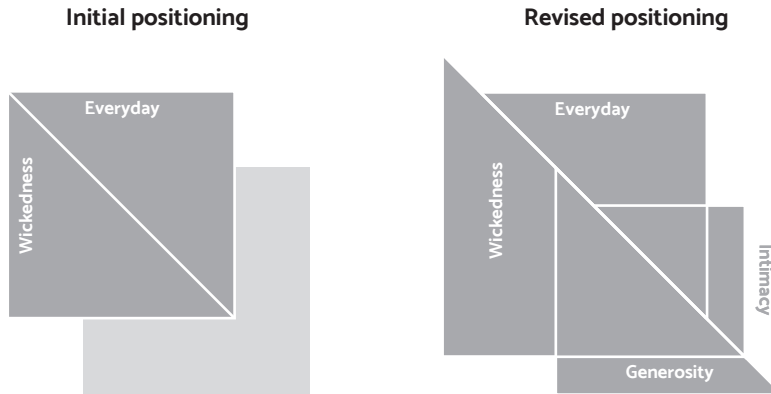
Upon revisiting key design decisions, everyday remains stable, wickedness increases to be the most prominent, intimacy is present as the least prominent, and generosity is significantly present. Everyday remains the same size through the design probes being based within home contexts and the conference video presentation initiated within a common community platform. It does not change in size because some norms within domestic care are reinforced. Wickedness increases in size by putting forth a different video format than expected, which might result in friction from a community and in not knowing how our critique will be received. Also, adding the light flicker can be seen as a wicked problem whereby care might not be seen at all or be seen as invasive. Its leakiness as a digital material and the uncertainty regarding how it and other associated data might inform future caring relations furthers its wickedness. Although this careful design does not explicitly question what it means to be human, it does raise questions regarding the privileges that Fernaeus and I have as particular humans (i.e. our identities as a Wife, a Mother, and designers). For example, a husband or father constructing such systems might receive other or more accentuated forms of judgment. Adding the light flicker in recognition of a power imbalance and crafting the collages foregrounds my power as a designer. Generosity is present through our sharing of previously unshared project materials for the collages, revisiting of tensions relative to those materials, and performing the video critique. In particular, the social generosity of our performance is risky to ourselves as design researchers who want to belong to a community and to our families for whom we want to feel loved.
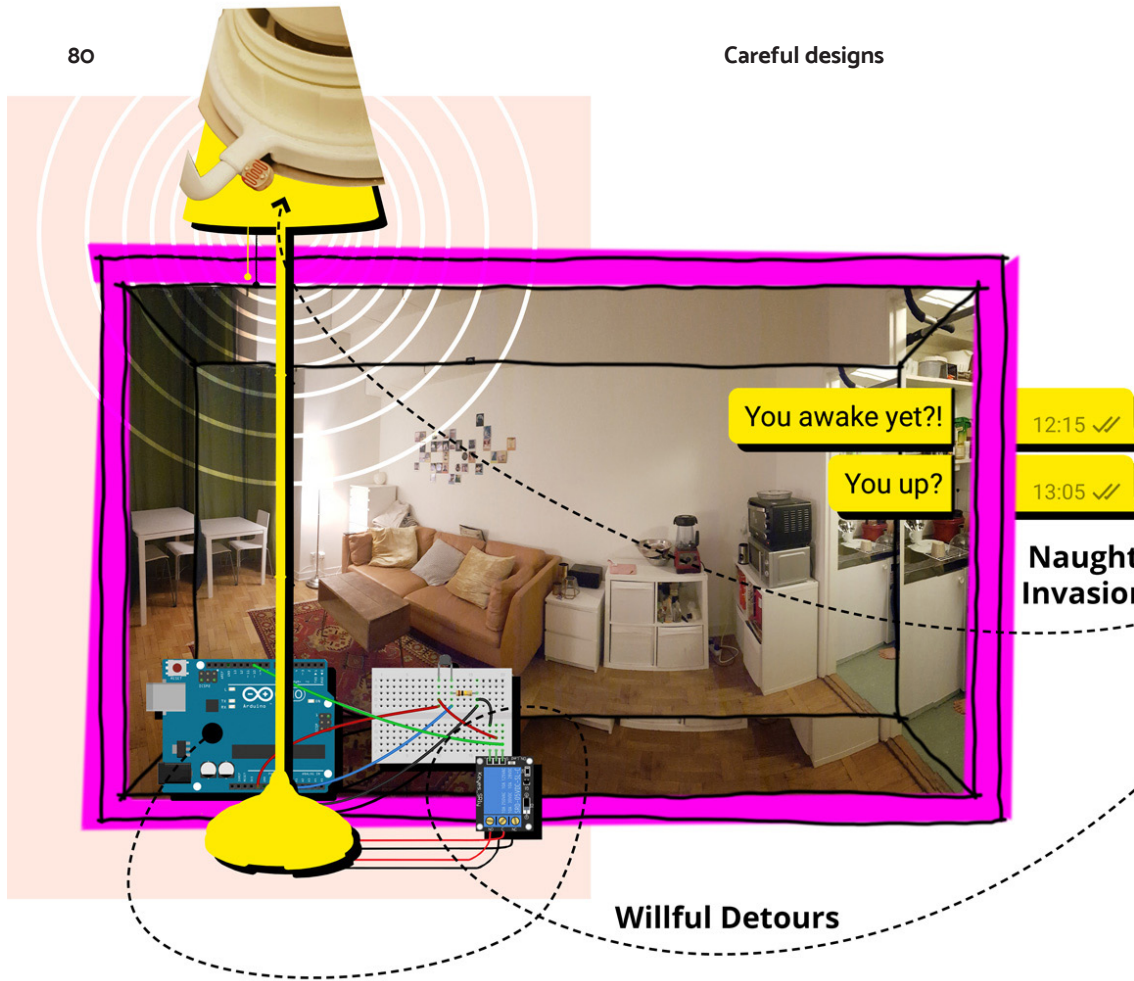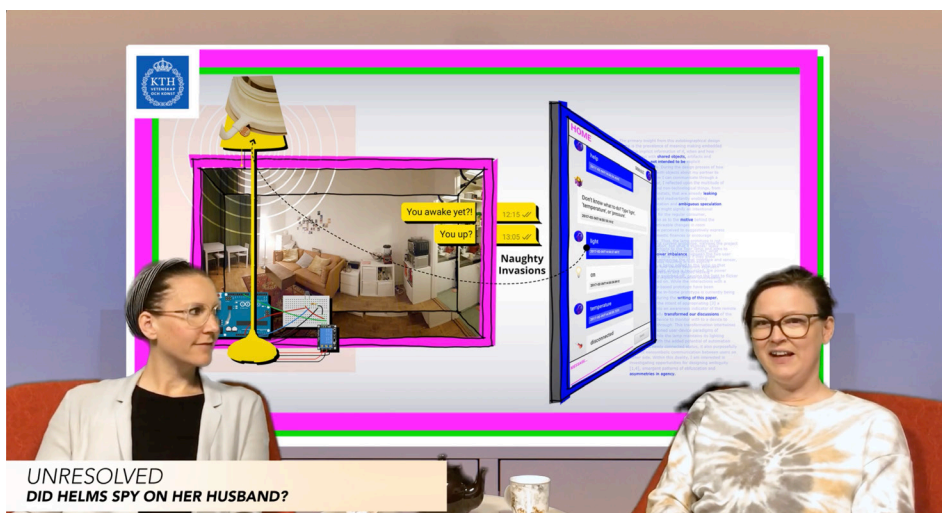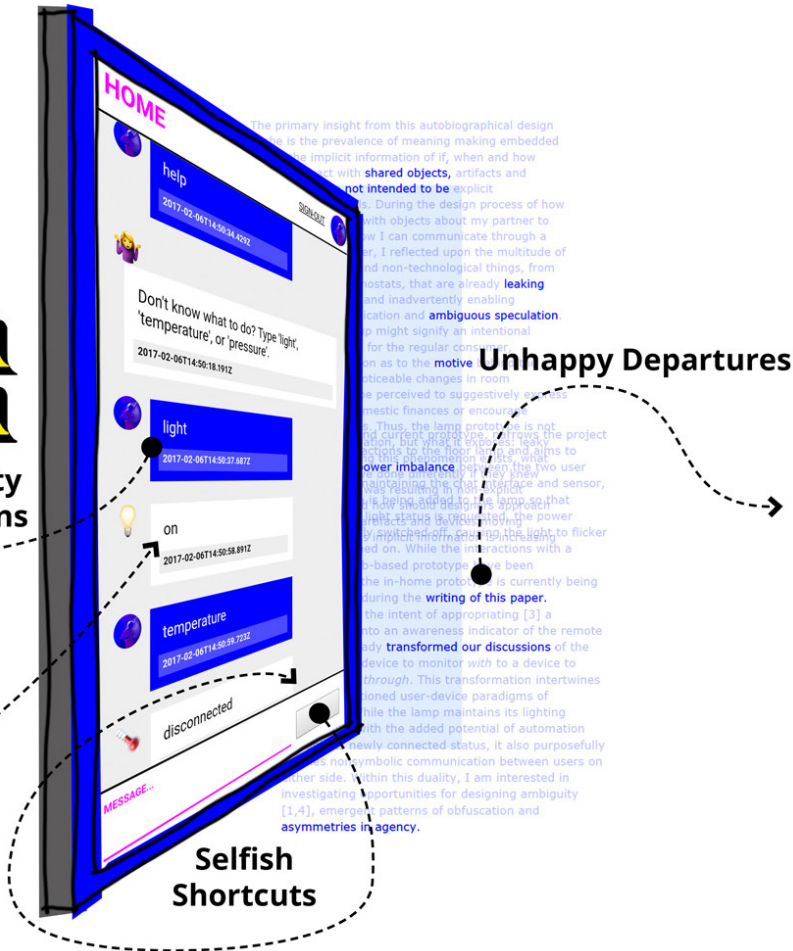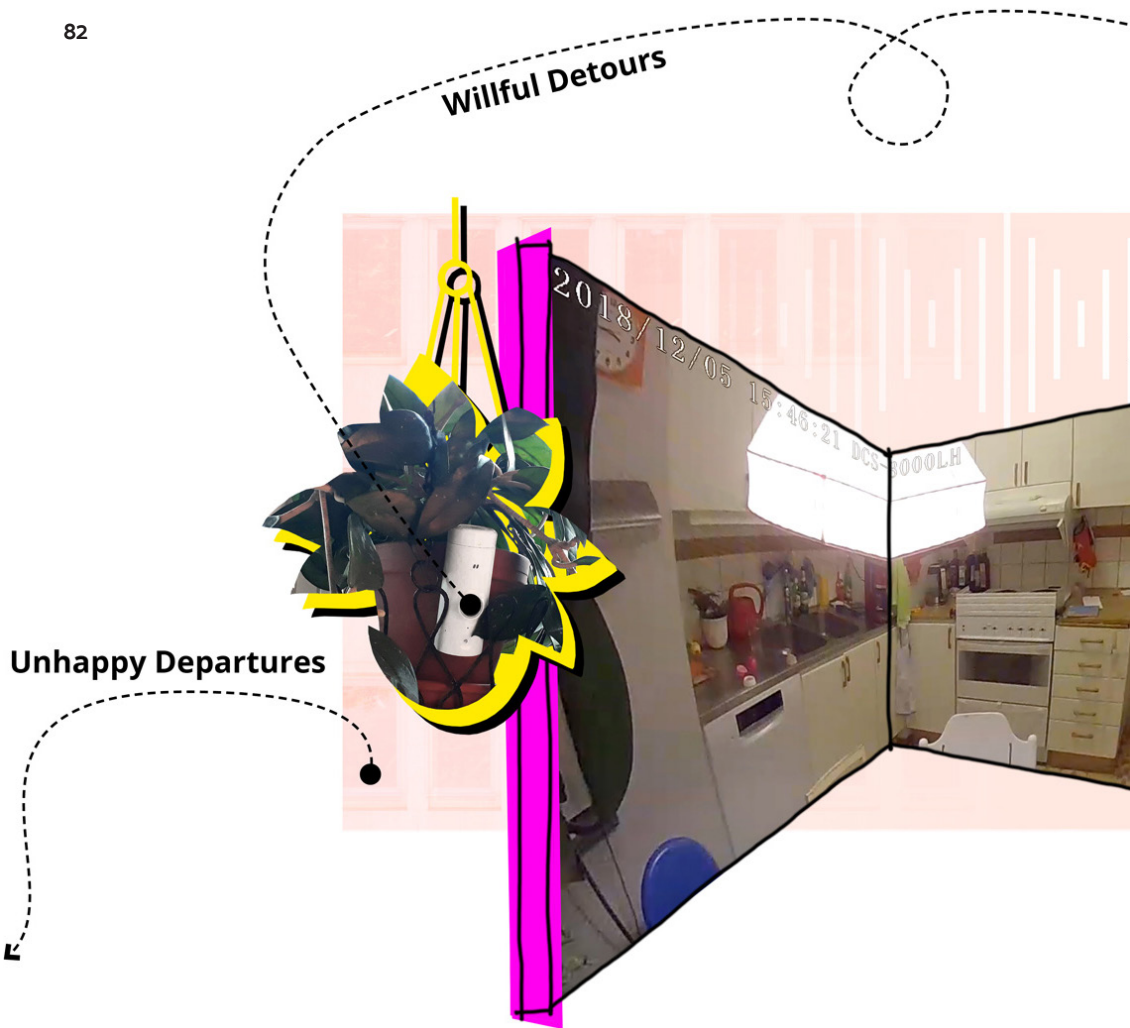
Willful detours highlight tensions in affect by violating notions of "as well as possible" through inefficient and unoptimized care. In my design, it is seen in my taking time to design and construct the system, rather than checking on my husband through a more efficient phone call.

Selfish shortcuts foreground tensions in ethics/politics through a prioritization of one's own "good" life over loved ones. My indirect inquiry into my husband's wellbeing redirected my attention towards how I felt and how I wanted him to feel.

Naughty invasions bring attention to tensions in care labor through unwelcome exposures of care doings. The light flicker invaded my husband's environment based upon when I felt moved to care about him.

Unhappy departures emphasize tensions in affect when traces of care labor diverge in new directions that do not feel good. Traces include academic presentations and publications that prompted responses that seemed to reframe my care as spying on my loved one.

HOME

SIGN OUT

help
2017-02-06T14:50:34.429Z

Don't know what to do? Type 'light', 'temperature', or 'pressure'.
2017-02-06T14:50:18.191Z

light
2017-02-06T14:50:37.687Z

on
2017-02-06T14:50:58.891Z

temperature
2017-02-06T14:50:59.723Z

disconnected

MESSAGE...

Unhappy Departures

Selfish Shortcuts

The primary insight from this autobiographical design is the prevalence of meaning making embedded the implicit information of if, when and how with **shared objects,** artifacts and **not intended to be** explicit. During the design process of how with objects about my partner to how I can communicate through a I reflected upon the multitude of and non-technological things, from thermostats, that are already **leaking** and inadvertently enabling communication and **ambiguous speculation**. might signify an intentional for the regular consumer, on as to the **motive** noticeable changes in room be perceived to suggestively ex domestic finances or encourage Thus, the lamp prototype is not and current prototype rows the project but what it exports: leaky tions to the floor lamp, and aims to this phenomenon what **power imbalance** between the two user maintaining the chat interface and sensor, was resulting in hot, which is being added to the lamp so that the power ly switched off, causing the light to flicker ed on. While the interactions with a o-based prototype have been the in-home prototype is currently being during the **writing of this paper**. the intent of appropriating [3] a nto an awareness indicator of the remote ady **transformed our discussions** of the device to monitor *with* to a device to *through*. This transformation intertwines ioned user-device paradigms of while the lamp maintains its lighting ith the added potential of automation newly connected status, it also purposefully s non-symbolic communication between users ther side. Within this duality, I am interested in investigating opportunities for designing ambiguity [1,4], emergent patterns of obfuscation and **asymmetries in agency**.

KTH

You awake yet?!
You up?
12:15
13:05

Naughty Invasions

UNRESOLVED
DID HELMS SPY ON HER HUSBAND?

Willful Detours

Unhappy Departures

In Fernaeus' design, *willful detours* are similarly seen in her taking the time to build a technological system, rather than following her twins into the other room or corralling them into a confined space.

Selfish shortcuts are illustrated in how Fernaeus was freed from being physically with her kids at all times through remote monitoring of them and could instead engage in other activities of her choice.

Naughty invasions are demonstrated through audio clips actuated by Fernaeus to distract her children from a potentially unsafe situations. The sounds are intrusive to the children and potential bystanders, such as other family members.

Unhappy departures are seen in Fernaeus' use of her design probe to care for other activities, such as pancake making in the kitchen, and her later discomfort at not yet knowing of one child's hearing impairment and how the system might have neglected this.

Naughty Invasions

Selfish Shortcuts

UNRESOLVED
DID FERNAEUS NEGLECT HER CHILDREN?
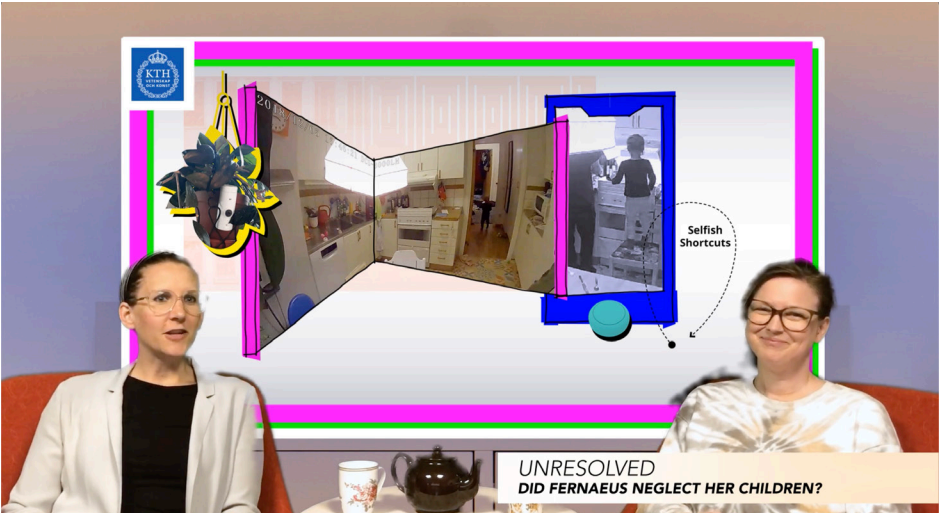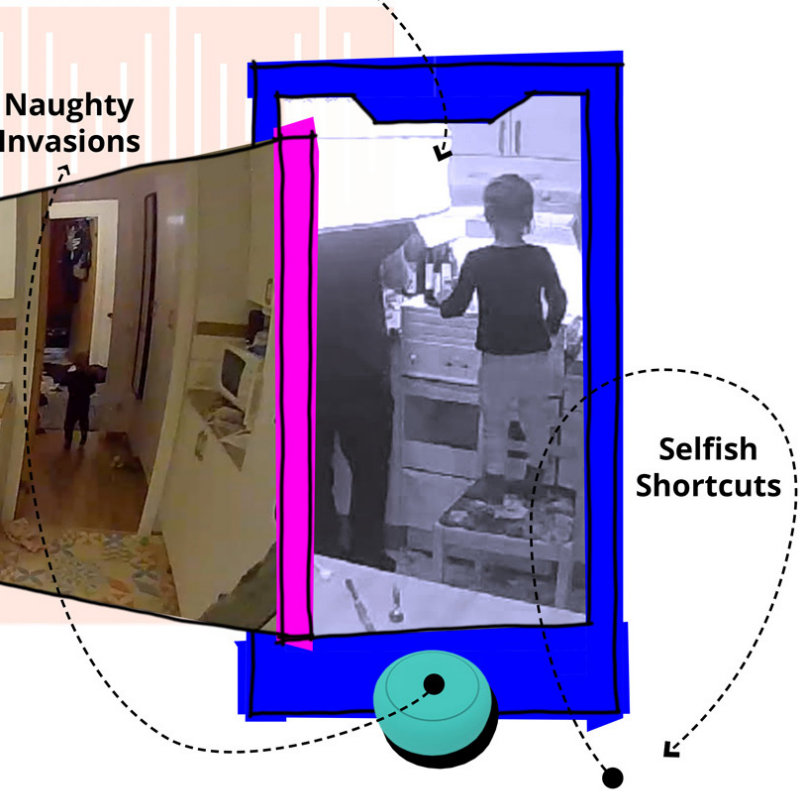
Leaky breastfeeding bodies

Leaky breastfeeding bodies explores milk as a design material and designing for bodily changes. It can be seen as relevant to interaction design through the presentation of alternative narratives of breastfeeding for the design of more inclusive technology, through a blurring of bodily boundaries in considering how technology can transform a sense of self, and through investigations with biological materials as new material pathways for HCI. It is a collection of three design explorations: *transforming milk into fiddling necklaces*, *knitting bras for lopsided breasts*, and *site-writing around breastfeeding*. The first two explorations are sets of artifacts, and the third is a poem and collection of short narratives. All three are presented in Paper IV, in which I also offer reflections on designing with bodily materials as more-than-human. In Paper III, I share and reflect upon transforming cow's and human milk to casein plastic for fiddling necklaces. In Paper VI, I share an additional experience in solidifying human milk. In the following, I first consider the types of knowledge outcomes. Next, I describe the preservation of milk for fiddling necklaces that led to pauses in my process, motivate the knitting and pattern making of bras, and present why I did site-writings and the significance of mapping as a sense-making process. Lastly, I situate these design decisions among the four ways of knowing and research program axioms.

Knowledge outcomes

The knowledge outcomes are presented in Paper III, Paper IV, and Paper VI. They include (1) material investigations with milk and a resulting fiddling necklace; (2) two knitted bras for lopsided breasts and corresponding knitting patterns; (3) a poem and compilation of short textual narratives about my breastfeeding experiences; (4) two reflections on designing with bodily materials as more-than-human; (5) my methodological process of "spatially" reflecting across explorations; and 6) the concept of *vibrant wearables*. The first three outcomes are ultimate particulars. The material investigations in the first outcome include successes in solidifying cow's milk and failures with human milk. In the second outcome, the bras are instantiations of what garments for uneven breasts might be like. Their associated patterns are intermediary knowledge that extend beyond my situation to allow for others to adapt and use them for the making of different bras for different bodies. The poem and short narratives provide insight into the social-spatial relations of places that support the presence or absence of breastfeeding. The two reflections from the fourth outcome are *generous absence* and *bodily mappings*. They are intermediary knowledge that can be extended beyond breastfeeding to guide reflections on the material consequences of design interventions and guide approaches that explore bodies as entangled. My methodological process of the fifth outcome exemplifies *bodily mappings* through a written description and video animation. The sixth outcome is the concept of *vibrant*

Transforming milk into fiddling necklaces are material experiments to solidify and preserve human and cow's milk. This is to make beads for personal ornaments to be worn during breastfeeding.

Knitting bras for lopsided breasts are two bras that account for uneven and dynamic breast sizes. One is composed of differing cup sizes and the other is an adjustable wrap.

Bathtub (18:55 Dec 4th 2020)

A generous white tub is filled with warm water.
And probably some pee. Frog, giraffe! Where did
they go? In the bucket? On the floor? There they
are! Is that a noise from the apartment above?
Frog farted. Not the only one. Big waves come by
surprise. The water stills, time pauses. The tub is
not empty, but no longer full, with droplets
shaken all over the floor.

Site-writing around breastfeeding is a poem and collection of short narratives that describe where we do and do not breastfeed. It draws attention to the particulars of places that support its presence or absence.

wearables articulated through qualities of *leakiness*, *ongoingness*, and *mutuality*. The concept and its qualities are a generative resource for designers exploring a blurring of bodily boundaries between humans and nonhuman design materials.

Design decision: Preserving and solidifying milk

My making of fiddling necklaces from milks began in early 2020 while I was on parental leave. Fiddling necklaces are personal ornaments worn by a parent while feeding a child to prevent the child from fiddling with something, such as hair, or to keep a child from being distracted. As described in Papers III and IV, I was frustrated with my child's fiddling with the other nipple. I felt guilty for taking away a breast, and desired to make necklaces out of our human milk to give something else from the breast in return. I first experimented with cow's milk by following online recipes for casein plastic, which is the extraction of a protein called casein from milk by mixing with vinegar. Using cow's milk was to avoid affecting our milk supply until I had familiarized myself with the process: I wanted to maintain a supply based upon my child's demand and without interference from my design intent. After successfully making a series of beads and a nipple, I next experimented with our milk.

During investigations, I began searching online as to why my child wants to fiddle with the other nipple. In reading that fiddling might be a mechanism to stimulate milk production, like suckling, I realized the contradiction in my attempt to not interfere. This was significant because it was the first time that I understood ontological design: by designing something for us, I was also designing us. Our breastfeeding relationship would undoubtedly be affected by fiddling necklaces regardless of the material used. This created doubt in my process, and I stopped working on fiddling necklaces. Eventually, I resumed because of a personal desire to preserve our milk, whether or not it would be fiddled with. This desire was grounded in milk as unique to each mother-child relationship, temporally distinctive, and often not without physical and emotional challenges. Temporalities of milk include changes in composition within a single feeding session to across an entire relationship. I sought to paradoxically capture this dynamism in response to uncertainties I felt regarding bodily changes we were experiencing and not knowing how our relationship would continue to unfold.

As described in Paper VI, in failing to solidify human milk by following the recipe for cow's milk, I resorted to proprietary "magic powder" bought from an online craft store (MarkyBabyMilkJewelry, n.d.). This process resulted in fear as I worried that the fumes and unknown chemicals could be dangerous to myself, my partner, and our child. This instigated another pause in my process as my understanding of ontological design extended to the materiality of artifacts. Fiddling necklaces are not only interventions because of their physical form, but also through their processes of becoming and
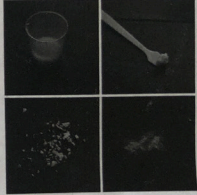
Breastmilk Preservation Instructions

Required Items:

10 ml of breastmilk
Small square of parchment paper
A small pan
Mortar and pestle (preferably) or spoon

Step 1: Put the 10ml of your breastmilk into the pot and pour the package of "Magic Powder"

Step 2: Bring to the boil and stir until the milk is like paste consistency.

Step 3: Spread your preserved milk finely in parchment paper and store in a clean, dry environment.

Step 4: Let your preserved milk dry for 24 to 48 hours. After this period, crush / grind the preserved milk and turn it into a very fine powder using a mortar and pestle or spoon. You just turned breast milk into "mommy love dust"!

The process I followed to make casein plastic from cow's milk: (1) warm a cup of milk over medium heat until steaming, (2) remove from heat and add four teaspoons of vinegar, (3) stir until curd-like solids (casein) separate, (4) add optional spices such as tumeric as dyes, (5) mold curds into forms, and (6) let cure for 24 hours.

from interactions with them: the materials that compose their form can leak, travel, and transform. For example, this includes the fumes released by the mixing of milk and magic powder, and possible toxins transferred from the solidified milk through touching. This phenomenologically (Merleau-Ponty, 2002; Höök, 2018) and materially (Alaimo, 2010; Hird, 2007) expanded my understanding of ontological design. It related my breastfeeding relationship beyond a mother-child dyad, such as to ecologies of bacteria or toxins inhaled in everyday spaces, and prompted considerations regarding what it means to design with the unknown properties of something that can change in composition, such as biological materials. The pauses were grounded in a pace reflective of uncertain and unknowable collaborations between bodies and materials.

Design decision: Knitting and pattern making

As presented in Paper IV, I began knitting bras for lopsided breasts at around 10 months postpartum in 2020. I have since completed two. Previously, I had noticed how my breasts would shift in size during a feed or a day, and then had more recently noticed that one was generally larger than the other. I decided to make a first bra that

would account for an unevenness as all of my store-bought bras were symmetrical and static in how they could (or could not) be configured. I had begun knitting while pregnant, and during early postpartum I desperately missed making things. I discovered that I could knit-while-walking, which combined with "wearing" a sleeping baby became a significant reclaiming of time as I adjusted to becoming a parent.

The first bra has three different cup sizes that I refer to as "measuring cups". The design is based upon a bikini top that is typically tied around the back and neck. I altered a free pattern (Hatcher, 2003) by adding an additional third cup below the usual two. I also constructed the three cups in different sizes. This form allows for varying pairs of cups to be worn together and easily rearranged. Practically, the measuring cups account for different volumes of milk for different sizes of breasts for different times of the day. Conceptually, the measuring cups acknowledge perceptions of fullness as defined through felt experience and assumed milk secretion. A second bra for lopsided breasts was begun in 2020 and finished in 2021. Its design is based upon a wrap, such as used to carry or "wear" a baby. It is a single piece of material that varies in width across a significant length. I designed the knitting pattern based upon measuring myself with a piece of cloth, or toile, wrapped in different configurations. As the garment is wrapped and tied around a body, the varying widths allow for subtle variations of positioning such that differing breast sizes can be comfortably supported, hidden, or accentuated. Practically, the wrap accounts for an active and continuous shaping of breasts through minor adjustments, such as pulling, or major adjustments, such as retying. Conceptually, the wrap acknowledges breasts not as separate, but in flux with one another.

The importance of knitting the bras is that I was exploring how to design for an unpredictable and personal bodily unevenness, while also exploring how to make these designs accessible and further adaptable beyond myself through pattern making. Knitting was initially a response to a lack of time. Yet while being an activity to make things, it also became an activity to remake myself. This includes responding to postpartum bodily experiences and reflecting upon the layered labors of knitting-while-walking my sleeping baby. In addition to being instrumental artifacts, I considered the bras as spatially and temporally capturing stitches, steps, and breaths of my mothering. This, combined with their in-use configuring and reconfiguring of breasts points beyond their meaning as support objects and towards our messy, complex, and uncertain everyday realities. The varying ways that the bras can be worn are shareable beyond my own bodily experiences. They are not meant to be one size or one-size-fits-all, but instead a few-sizes-in-one that recognizes similarities and differences across human bodies. This is furthered in my pattern making whereby the documentation of how they are made opens for appropriation and adaptation. In this way, I view the knitting patterns as algorithms in which data about many bodies can be used for many bras.

DROPS MERINO EXTRA FINE
TURQUOISE (UNI COLOR 29)
5 MM NEEDLES
BAND: 6 STS GARTER STITCH
CUPS: LACE EDGE, STOCKINETTE STITCH MAIN

SMALL
ROW 1 (RS): PICK UP + KNIT 42 STS
ROW 2 (WS): INC 6 (6×6×6×6×6×6) = 48 STS REMAIN
FOLLOW PATTERN UNTIL 14 STS REMAIN

MEDIUM
ROW 1 (RS): PICK UP + KNIT 43 STS
ROW 2 (WS): INC 8 (4×5×5×5×5×5×5×5×4) = 51 STS REMAIN
ROW 11: INC IN MIDDLE (M1K, K, M1K) = 51 STS REMAIN
ROW 13: ⎫
ROW 15: ⎭ REPEAT = 43 STS REMAIN
ROW 17: INC IN MIDDLE (M1K) = 42 STS REMAIN
ROW 19: INC IN MIDDLE (M1K) = 41 STS REMAIN
FOLLOW PATTERN UNTIL 13 STS REMAIN

LARGE
ROW 1 (RS): PICK UP + KNIT 45 STS
ROW 2 (WS): INC 8 (5×5×5×5×5×5×5×5×5) = 53 STS REMAIN
ROW 11: INC IN MIDDLE (M1K, K5, M1K) = 53 STS REMAIN
→ ROW 13: REPEAT
ROW 17: INC IN MIDDLE (M1K, K5, M1K) = 45 STS REMAIN
ROW 19: INC IN MIDDLE (M1K, K3, M1K) = 43 STS REMAIN
ROW 21: ⎫
ROW 23: ⎬ REPEAT = 43 STS REMAIN
ROW 25: ⎭
ROW 27: INC IN MIDDLE (M1K) = 42 STS REMAIN
ROW 29: ⎫
ROW 31: ⎭ REPEAT

FLIP/REVERSE
WHOLE BRA

TWIST

A customizable knitting pattern for a first bra and four possible configurations of the three measuring cups.

MIDDLE AT BACK

MIDDLE AT NECK

WRAP 1
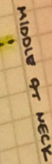
41 CM ⎫ DIAGONAL
42 CM ⎬ FROM NECK

WRAP 2
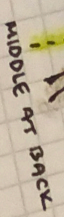
34 CM ⎫ DIAGONAL
33 CM ⎬ FROM BACK

LENGTHS

WIDTHS

95cm | 26cm | 11cm | 26cm | 11cm | 26cm | 11cm | ETC

8cm   26cm   MIDDLE

WRAP IDEA FOR APPLIED BORDER(?)
CAST ON 23 STITCHES, 3.5 MM NEEDLE
EDGE: 2 ROWS GARTER, K3
ROW: K3, 17 STO STOCKINETTE, K3 AT EDGE (M1R, M1L)
INCREASES: EVERY (2 ROWS X 17) AT EDGE
DECREASES: " " (SSK, K2TOG)
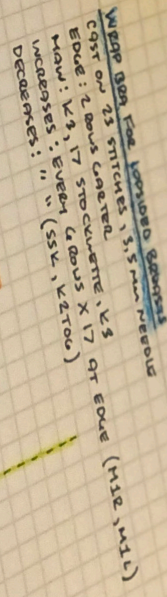
The process of creating a knitting pattern for a second bra based on my measurements and two possible configurations.

Design decision: Mapping and re-mapping pages

Site-writing around breastfeeding took place in December 2020 and was grounded in two motivations. The first motivation was a frustration with my partner often being considered as peripheral help to support breastfeeding. I felt this to be a narrow and limited acknowledging of his role, and a focus on breastfeeding as between the bounded bodies of myself and our child. The second motivation was that I was encountering judgment towards my ongoing breastfeeding from some strangers, colleagues, and friends. In response to a felt lack of support, I was curious towards what was and what else was not supporting us. *Site-writing around breastfeeding* explores these sentiments through a poem of social-spatial relations and short descriptions about nine places. The poem describes the physical locations where we do and do not breastfeed, which includes who of us, and not of us, is present and absent. The nine site-writings draw attention to the particulars of each place that support the presence or absence of breastfeeding. The poem and site-writings are shared in Paper IV.

When I began to make sense of them, I did so in relation to the other two explorations of this careful design: *transforming milk into fiddling necklaces* and *knitting bras for lopsided breasts*. As described in Paper IV, my methodology encompassed the following steps. I first placed the site-writings on individual pages according to their order in the poem. I then arranged the pages according to their approximate spatial locations as physical places. Next, I went through multiple iterations of moving the pages according to emergent themes as I added photos of the other two. This shuffling spatially and temporally considered the explorations and their content as non-linear. I could move between considering the socio-material particularities of a place, such as the relaxing environment of a bathtub or the political structures that privilege access to child-care, to conceptualizing across situations and artifacts, such as what it means to fill a space as a body among other bodies in a bedroom or as milk in a breast in a bra. From this approach, I understood the self as trans-corporeally (Alaimo, 2010) entangled and always becoming through environmental, technological, and political agencies.

In Paper IV, I suggest an arrangement of pages and present two reflections: *generous absence* and *bodily mappings*. This arrangement is one possible instantiation of relations and is suggested for readers to recreate. This suggestion and disregard to a publication format as linear invites readers to make and remake their own relations across content. It is rhetorical in acknowledging my reflective position of these explorations as limited to my own experiences and in foregrounding sense-making as knowing through the body. It reinforces possibilities to shift positions in drawing relations, discovering absence, reimagining presence, and rethinking support between a designer and an audience. It views an audience as bodily with histories, presents, and desires that inform sense-making of their own and others' experiences.

Ways of knowing

Preserving and solidifying milk for fiddling necklaces is an example of *auto-design* and *leaky materials*. It highlights the liveliness of milk as a biological material and as a design intervention: it could not be separated from its human bodily origins or intentions. My desire to avoid affecting our milk supply and recognition of this inevitability blurs boundaries between the making of and the making with milk. This is also seen in it as an intervention and the leakiness of my process through the use of magic powder. The resulting fumes and uncertain transfer of chemicals highlight how materials travel and flow among bodies and spaces. My subsequent desire to preserve our milk recognized temporalities of biological materials that contribute to its liveliness. This change of intentions and the pauses in my process are further indicative of temporal and self-centered entanglements. This use of *auto-design* and *leaky materials* focuses on the axioms of intimacy and generosity in recognition of bodies and design as

These are the spaces and places

where we breastfeed most,   (Us in the bedroom sleeping)

where we don't,   (She at preschool without me and him),

where we kind of do,   (She and him anywhere without me and with a bottle)

where we won't,   (Me on a trail running without her and him)

where we privately suckle,   (She with me in sling at the store)

where we publicly nibble,   (Us in the kitchen visible to neighbors)

where we hesitate,   (Us in a living room with others)

where we negotiate,   (Us at the table eating)

and where we unwind,   (She and I in the bathtub without him)

bodies mingling in time.
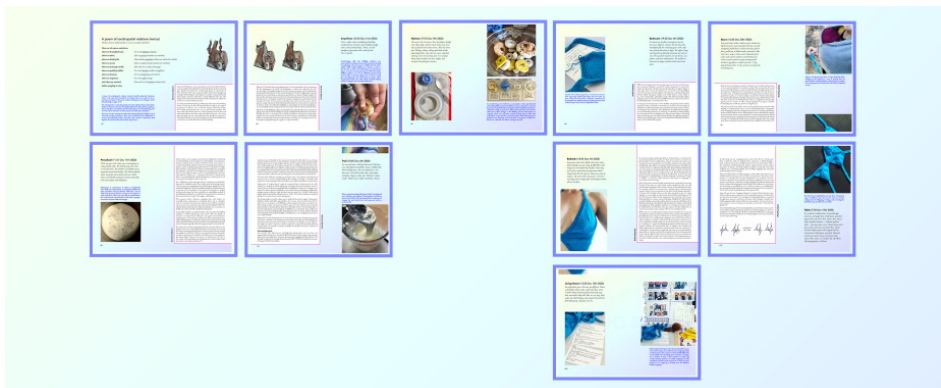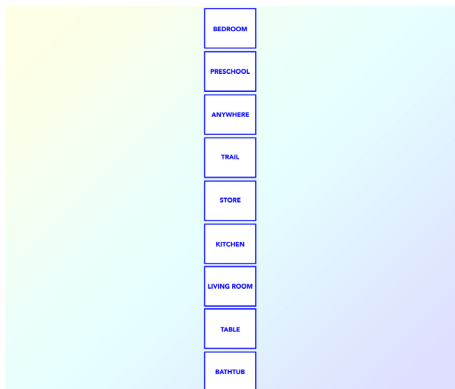
Stills from an animated presentation of Paper IV that illustrate my sense-making process of the site-writings around breastfeeding. The full video is available at https://youtu.be/-tbK7wDTVPo. A pre-arranged digital version is available at: www.kareyhelms.com/pdf/leaky-breastfeeding-bodies.pdf.

The two reflections from this arrangement are: *generous absence* and *bodily mappings*. *Generous absence* reframes absence as "nonexistence" to an inclusion of presence in unfamiliar forms and an openness towards the potential material consequences of design. *Bodily mappings* methodologically approaches bodies as entangled through a focus on layers of relations and layers of activity.

unstable, and everyday and wickedness in recognition of challenges of breastfeeding and potential harms in trying to solve them.

Knitting and pattern making bras for lopsided breasts is an example of *auto-design*. The motivation for the bras and their remaking of myself as a response to bodily experiences illustrate the self as open and changing. It is also an example of *spatial orientations*. The design of the bras accounts for a dynamic filling of space, which includes the fluctuating size of breasts and how their unevenness is not accounted for in market bras. This troubles the physical and political position of breasts and bras. It is also an example of *open speculations*. The multiplicity of configurations and proposal of patterns invites use beyond my own and opens for a diversity of experiences in the ongoing crafting of bras. These ways of knowing focus on the axioms of everyday through the design of a mundane garment, intimacy through how the bras attend to vulnerability, and generosity through openings for appropriation within the patterns.

Mapping and re-mapping pages is an example of *auto-design*. Site-writing centered my experiences to explore the social, material, and political structures that contribute to them. The physical mappings of site-writings with the other explorations attends to these complex and messy relations as an example of *spatial orientations*. It pragmatically and conceptually sought misalignment to notice what was previously obscured. Ongoing mappings as a rhetorical device in Paper IV invites readers to position themselves in relation to the explorations, which welcomes more alternative narratives of breastfeeding and is an example of *open speculations*. This explores the axioms of everyday through a focus on breastfeeding support and knowledge production, wickedness in acknowledgment of an ongoing (re)making of relations through mapping, intimacy through a sharing of reflections, and generosity through the invitation of community sense-making.

Research program

In relation to the axioms of my research program, I initially positioned *leaky breastfeeding bodies* as exploring everyday human care, intimacy with the self, and generosity of becoming. It is grounded in the everyday through its focus on infant nurturing and nutrition, and the perceived choices and challenges that parents are confronted with on a day-to-day basis. It is grounded in intimacy through a reckoning with what is often considered a significant life transition, parenthood, that can be uncomfortably unsettling towards previous self-conceptions. This might be in relation to felt experiences of time, cultural expectations of independence, social responses to parenting, and visible and invisible bodily changes as described in Paper IV. Examples of bodily changes include the noticing of lopsided breasts, feelings of being full of milk, and hormonal responses that prompt milk secretion. It is grounded in generosity

Initial positioning
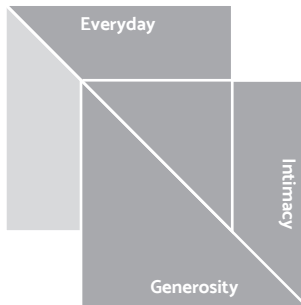
Revised positioning
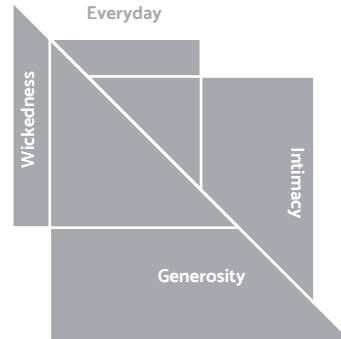
through a pre-reflective and reflective opening of myself. Pre-reflective generosity includes what is beyond my control or certainty within experiences of lactation and tampering with our milk supply through material investigations. Reflective generosity includes the deliberate and vulnerable sharing of my experiences to a research community and inviting engagement. Both open for unanticipated outcomes, such as the social, material, and communal discomforts detailed in Paper VI.

Upon revisiting the axioms relative to design decisions, everyday becomes slightly smaller, intimacy stays the same, wickedness becomes significantly present, and generosity increases in presence. Everyday decreases in size due to the emphasis on my own breastfeeding experiences. This acknowledges the explorations as alternative narratives relative to my cultural position. It highlights decisions and pauses as prioritizing myself and family, and how this situates when and how I open for collaboration and sense-making. Intimacy stays the same in recognition of vulnerability from this life transition and from perceived differences with others through sharing. Wickedness becomes significantly present in response to tensions during breastfeeding experiences, design work, and sharing of both. In designing with milk, being careful often required caring less about something else. For example, during the first pause I cared more about not interfering with our milk supply and I cared less about my frustration with fiddling. My subsequent decision to continue designing with milk further highlights care as relational and unstable. My mapping process is also grounded in wickedness. This aimed to trouble societal narratives through (un)making of relations. Generosity increases in presence because of how the design decisions contributed to my understanding of ontological design. This was through discomfort and uncertainty in navigating milk, perceptions of fullness, and socio-material structures amid the embodied more-than-human realities of what constitutes a self.

Bras for Lopsided Breasts

ANNOTATED SELFIES

DOCUMENTATION OF
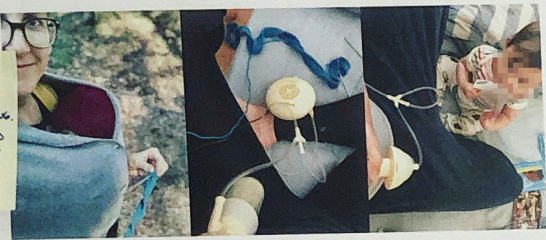[FLU]ID EXTRACTION,
[PER]CEIVED FULLNESS, AND
[SO]CIAL CONTEXT.

Right: Less pumping
Left: Left needs to feed
...to feed by hand on right.

Right: Stuffy and need
... left still empty...
where breasts Quinn didn't...
approach. Last. But want...
pump, still need to relieve...
before nap in an hour.

Right: Still need to need
Left: Big cluster feed
Notes: Ended you right, left
still feel stuffy...
sleeping, also need to
pump both.

BRA 1

THREE "MEASURING
CUPS" FOR DIFFERENT
VOLUMES FOR DIFFERENT
BREASTS AT DIFFERENT
TIMES OF THE DAY.
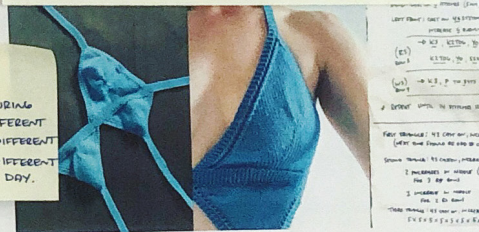
KNITTING-WHILE-

[W]ALKING & EXPRESSING.
[RE]CLAIMING TIME AND
[PER]FORMING STRANGE
[MO]THERINGS.

BRA 2

WRAP TO SMOTHER
AND SHAPE, RETIE
TO BALANCE AND BEAR,
ADJUST TO SLIP AND
SLIDE. (UNFINISHED,
PROTOTYPE)

**MOOD
BOARD**

DROPS
MERINO
EXTRA FINE
UNI COLOUR

WS (WRAP)

● START

BRA CUP SHOULD
BE 'INSIDE-OUT'
45 - 8 = 53

R3 - (51)
R4
R5 (49)
R6
R7 (47)
R8
R9 (45) LEFT O...
R10 (45) AFTER...
R11

15 × 5 × 5 × 5 × 15

R11: K3, K2TOG, P15 K3, K1K...
AFTER-ROWS: 47 STITCHES

R13

BAND: 6 STITCHES CAST ON

FIRST TRIANGLE (SMALL)
42 CAST ON   6 × ...
INCREASE 6 EVENLY — ON ROW...
REPEAT PATTERN UNTIL 14 STIT...
(SHOULD END...

SECOND TRIANGLE (MEDIUM)
43 CAST ON
INCREASE 6 EVENLY ON ROW 2 - (...
R11: INCREASE K, INCREASE
   M1SK, K, M1SK
R13: M1K, K, M1SK
R15: M1K, K, M1K
R17: M1K   INCREASE BY 1
R19: M1K   × 2

THIRD TRIANGLE (LARGE)
45 CAST ON
INCREASE 6 EVENLY ON ROW 2 (5 × ...
   = 53
R11: LACE, KB, M1K1K3, M1K, 1...

FIRST TRIANGLE: 42 CAST ON, ...
(NEXT TIME SHOULD BE ODD ...

SECOND TRIANGLE: 43 CAST ON, IN...
2 INCREASES IN MIDDLE ...
   FOR 3 E9 ROWS
1 INCREASE IN MIDDLE ...
   FOR 2 E9 ROWS
THIRD TRIANGLE: 45 CAST ON ...
5 × 5 × 5 × 5 × 5 ...

SMALL
ROW 3 (RS): PICK UP & KNIT 42 STS
ROW 5 (WS): INC 6 (K7×6×K7×6) = 48 STS REMAIN
ROW...: PATTERN UNTIL 14 STS REMAIN

MEDIUM
ROW 3 (RS): PICK UP & KNIT 43 STS
ROW 5 (WS): INC 6 (K7×6×K7×6×4) = 51 STS REMAIN
ROW 11: INC → MIDDLE (M1SK, K, M1SK) = 42 STS REMAIN
ROW 13: ...REPEAT
ROW 19: INC → MIDDLE (M1SK, K, M1SK) = 43 STS REMAIN
ROW...: PATTERN UNTIL 13 STS REMAIN

LARGE
ROW 3 (RS): PICK UP & KNIT 45 STS
ROW 5 (WS): INC 6 (5×5×5×5×5×5×5) = 53 STS REMAIN
ROW 11: INC → MIDDLE (M1K, K3, M1K) = 43 STS REMAIN
   ...REMAIN REPEAT
ROW 17: INC → MIDDLE (M1K, K3, M1K) = 43 STS REMAIN
ROW 21: ...REPEAT
ROW 27: INC → MIDDLE (M1K) = 42 STS REMAIN
ROW 29: ...REPEAT

Fiddling Necklaces

DETACHMENTS

SHIFTING AND SHARING PHYSICAL AND SOCIAL FRUSTRATIONS OF NIPPLE FIDDLING DURING BED-SHARING AND BABY-WEARING.
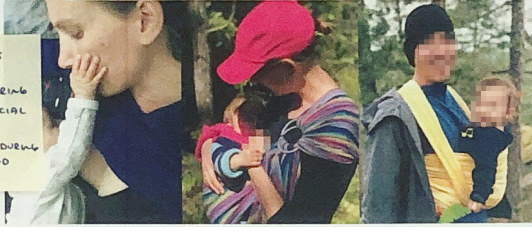
COW'S MILK BIOPLASTIC

CASEIN PROTEIN EXTRACTION TO MAKE BEADS AND NIPPLE FORMS, DYED WITH SPICES.

BREAST MILK COMPONENTS

IN TAKING AWAY THE OTHER NIPPLE, GIVING BACK SOMETHING ELSE FROM THE BREAST IN RETURN.
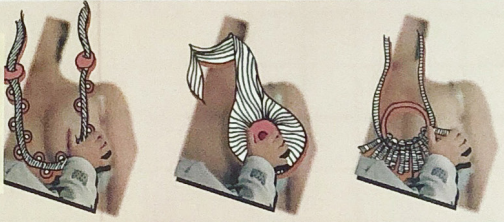
BREAST MILK BIOPLASTIC

FAILED CASEIN PROTEIN EXTRACTION DUE TO DIFFERENCE IN PROTEIN, FAT, AND SUGAR COMPOSITIONS.
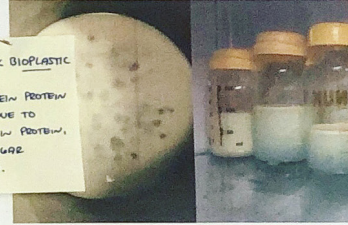
MOOD BOARD

BREAST MILK & RESIN

USING "MAGIC POWDER" TO PRESERVE MILK AND FORM WITH RESIN, RETHINKING DESIGNS DUE TO CONCERNS FOR UNKNOWN LEAKY CHEMICALS.
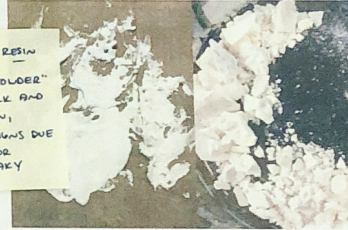
Breastmilk Preservation Instructions

Required Items:

10 ml of breastmilk
Small square of parchment paper
A small pan
Mortar and pestle (preferably) or spoon

Step 1: Put the 10ml of your breastmilk into the pot and pour the package of "Magic Powder"

Step 2: Bring to the boil and stir until the milk is like paste consistency.

... spread your preserved milk finely in parchment paper and ... ean, dry environment.

... your preserved milk dry for 24 to 48 hours. After this ... sh / grind the preserved milk and turn it into a very fine ... sing a mortar and pestle or spoon. You just turned breast mi...

CASEIN PLASTIC BEADS MADE FROM WHOLE COW'S MILK WITH VINEGAR, AND DYED WITH SPICES

SILICON MOLDS MADE BY CASTING COW'S MILK BEADS FOR FORM + TEXTURE
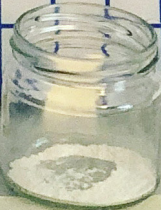
BREAST MILK SOLIDIFIED AND PRESERVED WITH "MAGIC POWDER" BOUGHT ONLINE
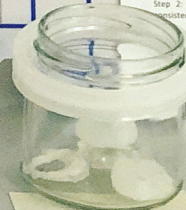
RESIN BEADS AND BANGLES TINTED WITH PRESERVED BREAST MILK POWDER

Free the Nipple

Scaling bodily fluids

Scaling bodily fluids explores designing with human bodily fluids through the creation of four visual and textual narratives that we refer to as utopian fabulations. This careful design was in collaboration with Marie Louise Juul Søndergaard and Nadia Campo Woytuk. It is relevant to interaction design by exploring humans as always entangled with nonhumans that might be technological or nontechnological. For example, this includes how digital materials, such as data, travel from and among human bodies and across scales, which can be difficult to distinguish, isolate, and contain as discrete components. It is further relevant for HCI research investigating biological materials and more-than-human agencies. The four utopian fabulations are: *magical discharge rituals*, *community menstruation practices*, *bodily fluid infrastructures*, and *spilled breast milk*. The fabulations as images and texts are presented in Paper V. In the paper we also present the conceptual motivation, give a brief overview of our design process, and offer two reflections towards different ways of valuing bodily fluids and imagining unknown entanglements. In the following, I first describe the types of knowledge outcomes. I then recount our commitment to stories of positive change and how we approached the collaborative scaling of intimate experiences. Lastly, I position the two design decisions among my four ways of knowing and in relation to the axioms of my research program.

Knowledge outcomes

The knowledge outcomes from this careful design include (1) the four utopian fabulations as visual and textual narratives, and (2) two reflections from our process. The four fabulations are each an ultimate particular as design knowledge in the form a visual collage and short written fable. They are specific examples of human bodily fluids reimagined for multispecies collaborative survival. The images as collages visually play with scale and linearity to disorient normative ways of viewing human bodily fluids as only useful for humans and to suggest other uses beyond the notion of a singular human body. The titles of each play a role in communicating our values and the qualities of bodily fluids that we highlight. The textual narratives as short written fables are proposed for others to build upon or appropriate for new design knowledge. The two reflections from our process of crafting the fabulations are intermediary design knowledge. They are: *imagining generous collaborations* and *crafting different measures*. *Imagining generous collaborations* reflects upon challenges of designing collaborations beyond known entanglements. It points to an openness of unknowable possibilities in the form of lingering questions. *Crafting different measures* reflects upon designing narratives with micro and macro scales. It points to tensions in scales as resources for different ways of considering bodily fluids as usable and useful. As reflections, they have generative potential for interaction designers in imagining unknown collaborations between humans and nonhumans.

Magical discharge rituals:
Spiritual bleeding and careful witchcraft.

The gathering of bio-data is used to craft personalized tea from a lunar analyzer, which is then distributed to all people and animals at the gathering and off the page. It illustrates the fostering of cyclical relations based upon planetary orbits.

Community menstruation practices:
Material harvesting with circular origins.

The sequential harvesting, wearing, and hanging of moss menstrual underwear frames new possibilities for interspecies collaborations. It also highlights conflicting temporalities of bodily cycles, such as between humans and forests as intergenerational.

Bodily fluid infrastructures:
Visible tubes for traveling nourishment.

Immense quantities of bodily fluids flow through exposed pipes from minor modes of collection. The specific scenes in which fluids are collected and distributed highlights how a community infrastructure could support new uses.

Spilled breast milk:
Situated flourishings among uncontained abundance.

The bottle of milk might be absurdly large or the milk absurdly powerful through its ability to foster a lush paradise. The linear progression away from climate change depicts a radical transformation of environmental conditions.

Design decision: Commitments to utopian fabulations

Alongside our own shared research interests on human bodily fluids (e.g. Campo Woytuk et al., 2020; Søndergaard et al., 2020; Søndergaard & Hansen, 2016), this collaboration was in response to an image-based call by the journal World Futures Review. The call sought "new images of the future that aim to shift perceptions and values and/or catalyze change" (Candy, 2020). It allowed for up to four images to be submitted, which could be in any static visual form and that should be self-explanatory. In response, our conceptual starting point was around notions of scale and community practices. Scale aimed to challenge perceptions of bodily fluids as associated with a singular human body. Community practices furthered this by drawing upon notions of collaboration that might include other people or species entangled in everyday flourishing.

A key alignment was for our images to be utopian: we intended for them to be interpreted as stories for positive change. This commitment is not new in design or design research (e.g. Schulte et al., 2021), but is notably counter to dystopian future narratives that often aim to critique societal values. We approached bodily fluids as valuable and abundant, from which we recognized their particular qualities that could contribute to multispecies flourishing. For example, this includes beneficial bacteria for animals from human milk, nitrogen as fertilizer from urine, and rich nutrients for plants from menstrual blood. The importance of this commitment was how we wanted to orient and frame the discussion of our work on mundane, yet often ignored, materials in everyday human life. Thus, rather than being on the defensive in response to perceived taboos, we sought to foreground uses of bodily fluids that are often absent, and in doing so, propose alternatives in which the taboos are not present. This shifted our cultural preconceptions of bodily fluids away from notions of containment, concealment, and scarcity in favor of rituals, shared knowledge, and nourishment. This grounded why, how, to whom, and to where bodily fluids might scale and travel.

Our utopian commitment influenced how we positioned the resulting images and textual narratives as fabulations in Paper V. We decided for them to not reflect a predetermined time-frame. This was despite the original journal call that required a clear time-frame, and which was canceled because the editors did not receive enough qualified submissions. Instead, we desired for them to be stories to think with now about other ways of being in the world as humans and nonhumans. As fabulations, they draw upon Haraway's notion of speculative fabulations as a "mode of attention, a theory of history and a practice of worlding" (2016), and Rosner's (2018) *critical fabulations* that bring suppressed histories and voices forward for contemplation. Although we did not surface silenced histories, we did make present silenced qualities and envisioned hopeful stories of collaborative survival. This countered notions of linear futures in design to invite an audience's own temporal interpretation and continuation of them.

Design decision: Processes of a generous collaboration

Prior to our design process, Søndergaard, Campo Woytuk, and I defined how we wanted to work together. This was within a shared understanding that we each brought intimate personal experiences and unique empirical knowledge to build upon, and from which to explore interconnections that scale beyond bodily fluids as associated with a bounded human body. In this way, the practicalities of our collaboration aligned with our conceptual goals. This resulted in outlining image making responsibilities, encouraging leaking of visual aesthetics, and a fluidity of individual versus group work through collaborative critiques.

As described in Paper V, for the first critique we each brought a collection of aesthetic inspiration and a minimum of five visual explorations. During this first step, we shared personal experiences in designing, researching, and living with bodily fluids. This focused on menstrual blood, milk, and urine. We did not try to separate types of lived knowledge, but rather generously gathered that of which was both professionally and personally present. For example, I brought a sketch-collage of a mother squirting milk from her breast to a cow in relation to my ambivalent feelings towards human-cow relations as a lactating person. Although each collaborator would take the lead

on at least one image, in discussing our material we sought to highlight shared visual and conceptual relations. For example, Søndergaard brought watercolors of building facades with tubes of menstrual blood and urine flowing down them. I brought a sketch of pipes connecting various rooms, through which discarded milk could flow from a kitchen to a bathroom sink to a scientific laboratory. From the watercolors and sketch, we saw an opportunity to foreground nourishment by making visible how they might travel and be shared within a local community. This cross-pollinating of ideas grounded the final concept of *bodily fluid infrastructures: visible tubes for traveling nourishment*.

Following the first critique, we formulated four narrative directions. In the two subsequent critiques, we each brought a work-in-progress image to be discussed for the direction(s) that we were leading. During these critiques we oriented conversations around the overarching narrative composition and specific visual details. We considered how a reader might visually navigate the story (e.g. from left to right as a literary progression, or through multiple prompts and threads) and what details convey the narrative direction (e.g. atmosphere and moments of interaction between humans and nonhumans). For example, *spilled breast milk* is intended to be read from left to right with the floating milk bank traveling away from climate change to a lush paradise, while *bodily fluid infrastructures* is intended to begin from any room and follow the associated pipes to another room(s). In considering the visual elements, we juxtaposed visual scales to disorient perceptions of bodily fluids as often associated with a singular human body. This created tensions between macro and micro perspectives to connect more-than-human material qualities, such as microbial composition, to cross-species and infrastructural pathways of collaborative survival. In Paper V, we refer to this as queer scales and uses in drawing upon Sara Ahmed (2019). This process of seeking tensions was important in decentering ourselves while drawing upon intimate experiences.

I led the crafting of the textual narratives, which made use of shared notes. In particular, I referenced notes from the second critique. These included two descriptions for each image that aligned with the focus on narrative and details. In composing the fabulations for Paper V, I aimed for a writing style that would set them apart from the academic tone in the remainder of the paper and to align them with children's books I was reading at the time. I further aimed to be clearly descriptive of each scene as a story, yet also playful to express tensions and to open for a multiplicity of interpretations through dual meanings. I also referenced our more general notes that were not specific to a particular image, such as "what happens off the page?", and reflected upon a frequent discussion in designing the fabulations as interconnected or "known" events. This prompted my ending of each textual narrative with a series of open-ended questions to seek possibilities beyond what we might know or expect, and to invite unknowable responses and possibilities. The lingering questions extended the scaling

Watercolors by Søndergaard that illustrates external pipes of traveling fluids, which were brought to the first collaborative critique.

Sketch by me that illustrates pipes of traveling milk between different rooms, which was also brought to the first collaborative critique; and a crayon drawing by me of a building facade to combine our related ideas into a singular concept.
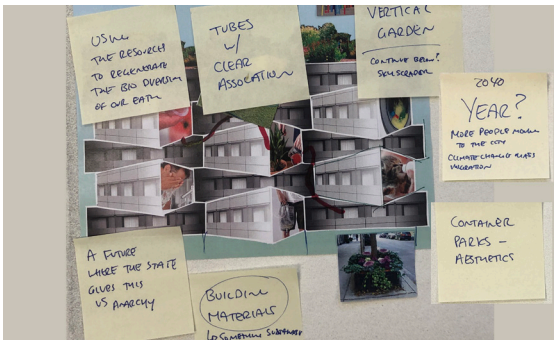
Printed digital image by me as a first iteration of *bodily fluids infrastructures* in merging shared ideas, which was brought to the second collaborative critique, with group feedback written on post-its.

of our own intimate experiences among each other to external audiences for further conceptual collaborations and a generative leakiness of experiences and ideas.

Ways of knowing

Committing to utopian fabulations is an example of *leaky materials*. Our approach to bodily fluids as valuable and abundant beyond the scale of a singular human body emphasizes them as more-than-human. This is through our relational focus on community practices. Attending to the positive and "useful" qualities of bodily fluids, such as nourishment, highlights how bodily boundaries are blurred through materials as lively. It is also an example of *open speculations*. Positioning the narratives as not temporally bound opens for them to be read as speculations about the present, past, or future. This invites a diversity of collaborations within them, which includes people, plants, animals, and other-worldly entities; and it invites a diversity of ongoing interpretations and reimagining of everyday survival beyond them. This use of *leaky materials* and *open speculations* focuses on everyday human care through the flourishing of people and other species, and on wickedness in the making of new relations that hopefully unmaking harmful taboos.

Our process of a generous collaboration is an example of *auto-design*, *leaky materials*, and *open speculations*. The bringing of personal encounters and research histories emphasizes our lived experiences as starting points for design activities. Yet our sharing and cross-pollination of knowledge illustrates how the centering of ourselves contributes to design and knowledge production beyond ourselves. This self-centered grounding highlights intimate knowledge as a leaky material for our conceptualizing and visual collaging. The narrative compositions illustrate bodily fluids as more-than-human through details of movement and traveling. For example, this includes the visual "reading" of images that illustrate growth, rituals, and transformation. Their deliberate tensions and open-ended questions invite continued speculation. This use of ways of knowing focuses on all axioms. Everyday is present through the nurturing of multispecies relations. Wickedness is present through the tensions between micro and macro perspectives. Generosity is present through our reflective sharing of experiences, lingering and unresolved questions, and imagining of how bodily fluids might be materially and pre-reflectively gifted beyond a singular human body.

Research program

In the original positioning of this careful design in my research program, I understood it as drawing upon everyday and generosity. Everyday is present in the caring for bodily fluids as necessary for human survival, and in their perceived usefulness that is often

Initial positioning   **Revised positioning**
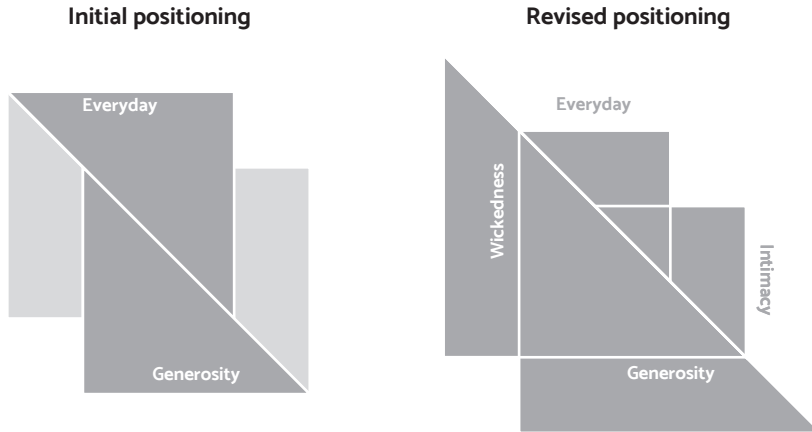
limited to an individual human or defined human-to-human relationship such as a parent and child. Their material properties and possible benefits for other humans and nonhumans are taken for granted within a normative perspective that does not consider alternative flourishings. Generosity is present through our conceptual starting point to reimagine bodily fluids as valuable and useful. For example, this includes our knowledge prior to the collaboration regarding how they might provide nutrition to other people and species. Yet it also includes our not knowing the transformative possibilities of multispecies collaborations through a material gifting of bodily fluids.

In reconsidering the relationship between the axioms, everyday becomes the least prominent, wickedness and intimacy becomes present, and generosity increases in presence. Everyday decreases in size because there is a shift from our known and lived experiences towards radical ways of being in the world. These proposed everydays are based upon queer uses and scales of bodily fluids that might not be possible. This fictive, or other-worldly, distance from our known experiences is fabulous, which spectacularly redefines the everyday. Wickedness becomes present and the most prominent because of this unsettling of everyday human care, which requires the unmaking of social, environmental, and political structures. This includes accepting bodily fluids as useful and usable, changing of how people care for the environment, and adapting infrastructures to facilitate these proposals. The fabulous, and possibly impossible, stories do not try to solve negative perceptions of bodily fluids. Instead, our utopian commitment stays with the tensions of an entangled world to instigate change. Intimacy becomes present through the support of multispecies relations, and in doing so, questions what it means to be human. This is evident in all fabulations through, for example, the inviting of animals into *magical discharge rituals*, considering how humans and forests might flourish with menstrual blood, using urine to nourish rooftop

gardens, and imagining milk as an environmental response to climate change. Intimacy is also present in our sharing of experiences with each other that is vulnerable through a rethinking of how our experiences are situated and entangled. Generosity increases in size due to how the resulting visual and textual fabulations are crafted. This is through questions and details that point to unknown encounters in and beyond our proposals.

Photo by Nadia Campo Woytuk

Bodily fluid Infrastructures:
Visible tubes for traveling nourishment

Exposed industrial pipes ebb and flow along a block of modular housing. They pulse in red, yellow, and cream as menstrual blood, urine, and human milk are transported within and from different domestic containers. The colors of the moving fluids are also in motion as they shift in hue, saturation, and opacity as a dynamic palette of pipes. From this deliberate exposure, change and variation are visible and noticeable.

In one scene, a menstrual cup is emptied. The blood and menses are diluted with water for plant nourishment inside another home while also floating upwards to fertilize a community rooftop garden. In another scene, a catheter of urine freely couples with the structural tubing, which distributes the effervescent liquid to sustain vertical gardens and cleanse clothes in a washing machine. Human milk is generously collected in another scene to carefully nurture a kitten and lavishly refresh a man.

These scenes are mundane yet spectacular. These scenes are glimpses of bodily ways of knowing and maintaining the commons.

The infrastructure continues. Fluids wander further, much further, beyond these bodies of housing and into bodies of land, bodies of water, and bodies of thought.

They are resources for plants, animals, and humans.
They are provocations for plants, animals, and humans.

Where else do bodily fluids travel? What other scenes are out of sight? What other scenes are ways of knowing? What else does this fluid infrastructure challenge and maintain? What else challenges and maintains this fluid infrastructure?

Spilled breast milk:
Situated flourishings among uncontained abundance

A tanker of human breast milk travels across an ocean. It flies a flag for universal breastfeeding and nobreastfeeding as this abundance of milk is diverse in origin and intent. Its destination is unclear, yet its orientation is obvious. In the wake of a fierce storm amid arid landscapes and melting icebergs, lightning strikes the nomadic milk bank. From the resulting spill, marine life and lush gardens flourish. Paradise is not a white beach, but instead a diverse mess of situated growth. Endangered and non-endangered species thrive in unexpected dimensions and configurations.

The ocean swells forward and backward in a circular motion. Fluids leak, nutrients drift, bodies mingle, boundaries blur. It is unclear what bodies are fluids, and what fluids are bodies.

There are conflicting narratives in this interspecies worlding:

Spilled breast milk is catastrophic if interpreted as lost labor and unrequited love. In this way, it is an apocalyptic narrative in which milk represents human exceptionalism.

Spilled breast milk is generous if interpreted as ongoing labor and open love. In this way, it is an ordinary narrative in which milk represents human accountability.

The lightning is exceptional and accountable. The spilled milk is accidental and intentional.

How are bodily fluids responsive and responsible? Through a yielding to bodily change? Or through a permeation of bodily boundaries? How are fluids bounded in collaboration? And how do bodies change in surviving?

THE REVIEWS HAVE COME IN. THEY ARE MOSTLY POSITIVE.

BUT THERE IS ONE REQUEST THAT TROUBLES ME.

IT WANTS ME TO HIGHLIGHT IT FROM CARE AND LOVE

YET WITHINSIDE A "CONTENT WARNING".

THIS SHOULD BE NEAR THE BEGINNING OF THE PAPER.

BEFORE I SHOW VISUAL REPRESENTATIONS OF BODY PARTS

IT IS TO POSITION MY INTENT. TO ACADEMIC READERS.

WOULD IMAGES OF "REAL" BODY PARTS BE OKAY?

IT SHOULD ALSO BE AT THE BEGINNING OF MY VIDEO.

THAT THESE BODY PARTS ARE FROM CARE AND LOVE.

I WILL SAY THIS TOO. SO MY VOICE IS HEARD.

BUT ONE DAY SHE WILL HEAR MY VOICE.

THAT CLARIFIES THE CARE AND LOVE.

AND PERHAPS WONDER WHY THIS IS A WARNING.

IN SAYING SOMETHING.

OR IN CENSORING SOMETHING BY SAYING TOO MUCH.

A speculative ethics

A speculative ethics probes designing with a researcher's own bodily fluids. It is relevant to interaction design through a focus on the ethics of first-person research within institutional requirements and HCI guidelines, and through its consideration of biological materials as an emerging design space. This includes considering how procedural ethics could support unplanned research grounded within the uncertainties of life transitions. It also includes knowledge production from qualitative experiences of engaging with biological materials, rather than only quantitative data about biological materials. It proposes ethical possibilities for designing with bodily fluids through the creation of "performative texts". Performative texts are autoethnographic narratives of past experiences that are performed through spatial compositions of written words and verbal readings aloud. In Paper VI, I present three performative texts about moments of discomfort in designing with milk from my breastfeeding relationship and offer possibilities for the ethics of first-person research that attends to more-than-human entanglements: *unsafe spaces*, *situated escapes*, and *censored inclusion*. In the following, I first present the knowledge outcomes. Next, I describe why I chose to revisit and share some moments of discomfort and not others. I then expand upon my process of including the pink highlights from the performative texts directly into the main content of Paper VI. Lastly, I relate these two design decisions to the four ways of knowing and describe how this careful design relates to my research program axioms.

Knowledge outcomes

The knowledge outcomes from this careful design are presented in Paper VI and include (1) the three performative texts about moments of discomfort in designing with my bodily fluids, (2) my process of creating the performative texts, and (3) three possibilities for how HCI might consider the ethics of first-person research. The three possibilities are *unsafe spaces*, *situated escapes*, and *censored inclusion*. The first outcome is an ultimate particular in the form of a performative text. Each describes a particular moment of discomfort and arranges words visually to accentuate aspects of the situation or experience. Two of the three texts also transform the paper physically through cutting or folding to animate details and verbal performances. The pink highlighting of some text draws attention to my experiences of self-performing the texts aloud, which includes key words and phrases that influenced generalized reflections. As design instances, they are specific to my experiences in designing with my bodily fluids and are examples of what following my process might yield. The second outcome is methodological in describing how to approach the creation of performative texts. It is detailed in Paper VI and was heavily inspired by the notion of critical junctures (Markham, 2006) and the general structure of my process originated in a course exercise by Annette Markham and Lisbeth Frølunde (Markham & Frølunde, n. d.). What is specific
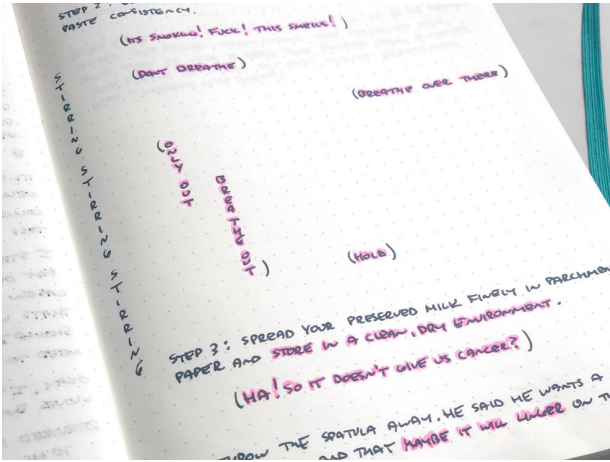
A first performative text revisits a time when I used an unknown chemical agent to solidify our milk at home.

It calls for support in designing within everyday "unsafe spaces". This acknowledges bodily fluids traveling biologically and socially, and means that separating research spaces as "safe" risks neglecting the people, contexts, and materials that fluids and bodies interact with as people move between places.
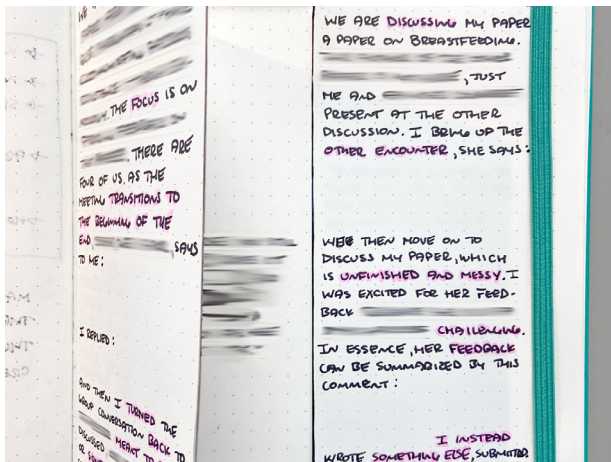
A second performative text revisits encounters with colleagues during which I didn't feel good about sharing my breastfeeding experiences as research.

It calls for "situated escapes" that support pausing, abandoning, and altering research plans. This recognizes temporalities of bodily fluids that might be unpredictable or finite, and how this might impact research decisions to be able to share, want to share, or not share.

A third performative text revisits when I was asked to add a content warning by reviewers to a publication about my breastfeeding experiences (i.e. Paper IV).

It calls for "censored inclusion" that does not suppress possible relations, and instead welcomes creative practices in which censorship is about lively inclusion. This does not advocate against content warnings, but does question how they are put into practice.

to my process is the particular ways in which I visually and spatially played with text composition and paper manipulation, and the layer of pink highlights that directly contribute to the formulation of generalized knowledge from personal experience. The third outcome is intermediary design knowledge in the form of possibilities. As possibilities for interaction designers and the HCI community, they are a generative resource for imagining how procedural ethics might be different to account for challenges in designing with bodily fluids.

Design decision: Sharing uncomfortable moments

As described in Paper VI, the first of the three performative texts was created during an online PhD course on autoethnography in summer 2021. This performative text was about a time when I used "magic powder" purchased online to solidify and preserve our milk. It resulted in fumes and potential harm to myself and my family. I felt defeated at the outcome, and angry at contradictory advice that I was given regarding how a designer might approach working with biological materials. This included phrases such as creating "safe spaces" to isolate and contain bodily fluids that might be harmful to other people. Yet outside of such "safe spaces" it is easy to find everyday office materials with toxic labels (e.g. glue) and bodily fluids being handled for the everyday care of loved ones (e.g. breastfeeding or expressing milk at the office). It also included a lack of consideration towards bodily temporalities through the assumption that certain procedures should be completed in advance of exploration, such as seeking approval to design with human milk, that might be granted after lactation has stopped. I saw this as upholding notions of "choice" relative to bodily processes that are rigorously and inconsistently positioned as possible for a person to predict and control within universal expectations of what those bodily processes should be like (Knaak, 2005).

I found the revisiting of this moment therapeutic in processing my feelings of failure and frustration. The additional two moments that are shared in Paper VI revisit an uncomfortable encounter with a colleague and the request for a content warning to be added to Paper IV. Each speaks to an individual performative text and an associated possibility for how HCI might navigate such discomforts. Together, I view them as questioning what is dominate or "real" in interaction design. That is, what is acceptable, ethical, or valued is not defined by me. Disciplinary structures such as the Swedish Ethical Review Authority (Etikprövningsmyndigheten, n.d.), established ways of working that the HCI community is familiar with, KTH policies, and the prior approvals and approaches of my colleagues all contribute towards a practical and theoretical representation of appropriate. I found my designs and research to not be acceptable and thus prompting reactions to discipline it, such as through a content warning. Yet as highlighted in Paper VI, there are no guidelines that explicitly support or recognize

first-person research with bodily fluids, which contributes to my work being out of place. This tension prompted me to propose how research ethics might be different for an intimate engagement with the self and an expansive repertoire of design materials.

The articulation of this tension grounded why I thought sharing some moments were important and how I have reasoned around not sharing others. The first performative text was performed (i.e. read aloud) to two classmates in a video call. I knew who my audience would be and that they would also be sharing moments. A discussion in the course was that this process-based activity to think about relations and potential harm, and not necessarily an activity to generate research data. I understood its value for a designer as considering the relational impact of a design. This includes evaluating possibilities of harm and if such harm is worth research aims. I believe that what I have shared is significant for furthering more expansive designs for breastfeeding, for contributing towards how designers can responsibly work with biological materials, and for supporting first-person and autobiographic methods. This decision was made in collaboration with my partner, and in recognition of my continued feelings of vulnerability. This does not mean that I have shared everything in regards to my breastfeeding experiences or familial relations. What I have not shared is based upon the perceived risks to myself and my family as being too big and not worth furthering research aims. This is not to imply regret, blame design, or advocate for fixed boundaries between where design work is done and where the consequences might be present. Instead, it points towards an ongoing consideration of relations amid unknown or unknowable outcomes for each designer and design situation.

Design decision: Performing pink text

In creating the performative texts, I highlighted key words and phrases following the readings aloud. The highlighting annotated how it felt to revisit each moment and unpacked social, material, and spatial relations of care. It was guided by questions such as: Why did I revisit this moment? How did it feel to read it aloud, and read it aloud again? What role did the text play in performing this moment? What relations or impacts should I think about? The majority of the pink highlights are also integrated into the content of Paper VI as pink text rather than black text.

In presenting the performative texts in Paper VI, there were two coinciding first steps that I followed. In one, I thought about the descriptive structure for which I wanted to share the experiences. This is the content of sections 3.1, 3.2, and 3.3 that present each text in three paragraphs. The first paragraph begins with brief description of the moment, which includes how the text and pages of my sketchbook are spatially constructed. For example, the top page of the second performative text describes two scenes and is cut to be opened like a window to review dialogues underneath that are

from each scene. The second paragraph describes why I chose to revisit this moment, which includes additional context that might be helpful for a reader in understanding the situation and how I ground my discomfort or harm. For example, I chose to revisit reviews that asked me to add a content warning to a paper on breastfeeding because I felt conflicted at the reasoning and unsure whether I should continue to include it in subsequent dissemination. The third paragraph discusses how it felt to perform the texts aloud, which includes considering my performance in collaboration with the spatiality of the text and pages. For example, the dense text on the first page of the first performative text evoked my feelings of hesitation in using magic powder to preserve milk, and the distributed rhythm and floating text on the second page accentuated my panic and uncertainty upon the release of fumes. The third paragraph concludes with how I decided to proceed immediately following this moment and subsequent to the creation of a performative text about the moment. For example, this includes my decision to include the content warning in Paper IV, but not in Paper VI.

In the other first step, I created a list of the pink highlights. For example, for the first performative text this was:

- I open the envelope containing "magic powder"
- I've done this once before
- knowing this will be my last
- without him and her
- alone together with a bottle of our breastmilk
- I have no idea how magic powder works
- it's magic
- shouldn't need to touch it
- it's smoking! fuck! this smells!
- don't breathe
- breathe over there
- only out
- breathe out
- hold
- store in a clean, dry environment
- ha! so it doesn't give us cancer?
- maybe it will linger
- maybe I still shouldn't be breathing
- what about the pot? that's our water heating pot
- turn it into a very fine powder
- "mommy love dust"

Photo of a page from Paper VI that shows the incorporation of the pink highlights from the first performative text in the publication content.

The second step was combining the descriptive structure and pink highlights to write sections 3.1, 3.2, and 3.3 in Paper VI. In composing the text, I decided to directly incorporate the pink highlights. That is, I styled them as pink instead of black text and retained their arrangement if multiple words or a phrase. The result is that sentences are sometimes constructed awkwardly. For example, one line reads, "That is, I have no idea how magic powder works but already knowing this will be my last time using it too." This drew attention to meaning-making across bodies of text. It performatively relates the exercise and the paper by challenging academic standards of writing black text on a white background. It also retains the key words and phrases in their original textual form as words as a material to play with in composing the content, rather than extracting meaning from them as language and then using other words or phrases to write about them. This was important because writing and submitting Paper VI was a vulnerable experience in sharing how I might have contributed towards the harm of others and experienced discomfort myself. Incorporating the pink text stayed with

this vulnerability and performed the intimate entanglement I write about in Paper VI between the self and the relational impacts that socially, materially, and spatially transcend the immediacy of design. This includes how my failures and frustrations continue through and beyond dissemination practices, how a community responds to them, and how I respond as a designer and researcher to potential consequences.

Ways of knowing

Sharing uncomfortable moments is an example of *auto-design*. Following the first performative text, my creation of subsequent texts was primarily a therapeutic process-based activity. This centered my perspective of who my designs and research might benefit or harm. It recognizes the structures that discipline what counts as valuable and acceptable. From this centering, I shared some performative texts beyond myself to contribute to a troubling of these disciplinary structures. This blurs boundaries of knowledge production in recognition of myself as relationally constructed with family members and a research community. My sharing is also an example of *open speculations*. It is an opening for HCI and interaction design communities to collaboratively imagine how to support, rather than restrict, first-person research and designing with human bodily fluids. This includes looking forward at what our communities need and looking backward at what might be limiting the fulfillment of these needs. It hopes for a continuous critique and coming together for many alternatives. This use of *auto-design* and *open speculations* focuses on the axioms of intimacy in attending to experiences of vulnerability and wickedness through troubling disciplinary structures.

Performing pink text is an example of *spatial orientations* and *leaky materials*. The words on the pages of my sketchbook performed meaning as languag from their visual composition. This is through their spatial arrangement and the physical construction of pages that orients verbal performances of the moments. The words are misaligned through rotations, gaps, windows, and folds. This practically makes space for non-linear readings and conceptually makes space for the messy realities of discomfort. The pink highlighting of some text was initially to annotate key aspects for further reflection on relations of care. My process and its integration into Paper VI was a rhetorical decision to accentuate words as more-than-human through their traveling between bodies of text and to illustrate the felt entanglements between myself, my family, and my research communities. In this way, the pink text is a fluid material that continues to travel and blur boundaries through ongoing performances and sense-making. This use of *spatial orientations* and *leaky materials* focuses on the axioms of everyday through a playful approach to publication practices and generosity through an open dispossession and sharing of myself that is a risky to my integrity.

Initial positioning   Revised positioning
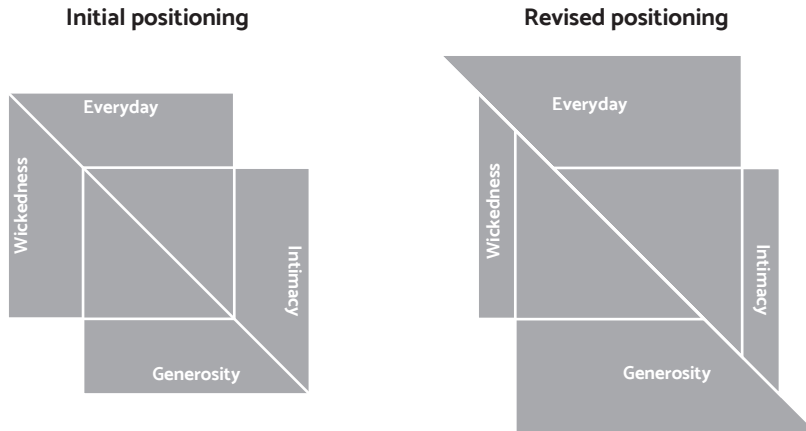
Research program

Relative to the four axioms of my research program, I initially positioned *a speculative ethics* as equally exploring all axioms. It is grounded in the everyday through its focus on knowledge production. This includes where design work takes place, who it impacts, how it is disseminated, and from what criteria it is evaluated. It is grounded in intimacy by paying attention to how the self is trans-corporeally situated in knowledge production. This includes considering how design materials, whether human bodily fluids or nonhumans, are interacted with, might harm a body, and travel between spaces. It considers entanglements between sociocultural norms and structural inequalities that prevent certain research from being possible and a lack of accounting for a diversity of experiences. It is grounded in wickedness through an appeal for divergent care practices in knowledge production to attend to design and research that is currently unaccounted for. It recognizes the unmaking of disciplinary structures to instigate change, yet also recognizes that the making of new structures should remain open for ongoing critique amid no perfect solution. It is grounded in generosity through its consideration of risks during design processes and in sharing of discomfort. This humility recognizes uncertain outcomes and unknowable possibilities through a reflective and pre-reflective gifting of oneself in design experiments and dissemination practices.

Upon revisiting the axioms in relation to key design decisions, everyday and generosity increase in prominence, and intimacy and wickedness remain the same. Everyday increases due to the variety of ways that knowledge production is challenged. This includes my choice of font color and sentence structures. These mundane practices are routinely accepted as standards, and the performative pink text in Paper VI highlights how attending to these differently might contribute towards new knowledge. Generosity also increases in size because of the uncertain outcomes from

sharing the moments. Although sharing them was amid a thoughtful consideration of risks, I cannot anticipate how my research and the designs presented will continue to travel and be received. This not only includes how a community might respond, but also how my child might be impacted. This might be from the gifting of moments, the ongoing propensity of design and research, or the hopeful yet uncertain impacts on research ethics to transform interaction design. Intimacy stays the same through a continued consideration of the self as unstable and inseparable from other humans and nonhumans. Wickedness also stays the same through its engagement with tensions of care, and in particular, by not suggesting a new set of ethical practices. Instead, the sharing of uncomfortable moments acknowledges unequal relations and calls for continued engagement.

STEP 1: PUT THE 10ML (50ML) OF YOUR BREASTMILK INTO THE POT AND POUR THE PACKAGE OF "MAGIC POWDER"

(CHECK!)

STEP 2: BRING TO THE BOIL AND STIR UNTIL THE MILK IS LIKE PASTE CONSISTENCY.

(ITS SMOKING! FUCK! THIS SMELLS!)

(DON'T BREATHE)

(BREATHE OVER THERE)

STIRRING STIRRING STIRRING STIRRING

(ONLY OUT

BREATHE OUT)

(HOLD)

STEP 3: SPREAD YOUR PRESERVED MILK FINELY IN PART PAPER AND STORE IN A CLEAN, DRY ENVIRONMENT.

(HA! SO IT DOESN'T GIVE US CANCER?)

I THROW THE SPATULA AWAY. HE SAID ME WAN ONE ANYWAY AND THAT MAYBE IT WILL LINGER

THE SAME EVENT, TWO DIFFERENT ENCOUNTERS

WE ARE DISCUSSING A ~~████████████████~~ ~~████████████████~~ ~~████████████████~~ ~~████████████████~~ ~~██████~~. THE FOCUS IS ON ~~████████████████~~ ~~██████████~~. THERE ARE FOUR OF US. AS THE MEETING TRANSITIONS TO THE BEGINNING OF THE END, ~~████████████~~, SAYS TO ME :

I REPLIED :

AND THEN I TURNED THE GROUP CONVERSATION BACK TO ~~████████~~ MEANT TO BE DISCUSSED, ~~████████████~~, OR SOMETHING ELSE THAT I CONSIDERED RELEVANT + APPROPRIATE.

WE ARE DISCUSSING MY PAPER, A PAPER ON BREASTFEEDING. ~~████████████████~~ ~~████████████~~, JUST ME AND ~~████████████~~ PRESENT AT THE OTHER DISCUSSION. I BRING UP THE OTHER ENCOUNTER, SHE SAYS :

WE THEN MOVE ON TO DISCUSS MY PAPER, WHICH IS UNFINISHED AND MESSY. I WAS EXCITED FOR HER FEEDBACK ~~████████████████~~ ~~██████████~~ CHALLENGING. IN ESSENCE, HER FEEDBACK CAN BE SUMMARIZED BY THIS COMMENT :

I INSTEAD WROTE SOMETHING ELSE, SUBMITTED.

WE ARE DISCUSSING A

~~[illegible]~~

~~[illegible]~~ . THE FOCUS IS ON

~~[illegible]~~ . THERE ARE
FOUR OF US. AS THE
MEETING TRANSITIONS TO
THE BEGINNING OF THE
END, ~~[illegible]~~ SAYS
TO ME :

I REPLIED :

AND THEN I TURNED THE
GROUP CONVERSATION BACK TO
~~[illegible]~~ MEANT TO BE
DISCUSSED ~~[illegible]~~
OR SOMETHING ELSE THAT I "
CONSIDERED RELEVANT + APPROPRIATE.

~~[illegible]~~

"I DON'T THINK
YOU ARE SAYING WHAT YOU
REALLY WANT TO SAY. WAIT
TO SUBMIT IT."

V. Discussion

This chapter is a discussion of my contributions. I first summarize the research program *designing with care* for interaction design otherwise. This includes an articulation of wickedness and generosity, four methodological approaches, and five careful designs. Next, I discuss three possibilities for interaction design otherwise: engaging with unrecognized topics, doing design work where the consequences would be present, and reconsidering how the formats of research publications could better reflect positionality. From these, I reflect upon the relevancy of self-centered research beyond oneself in *designing with care* for more sustainable worlds. This includes attending to absence, critiquing oneself, and collaborating with many selves.

Summary of contributions

In this thesis, I make four contributions for interaction designers and design researchers interested in alternative ways of thinking and working within industry and academia. These matter for interaction design and HCI because of a continued shift away from a centralized computer and classic turn-taking interaction. That is, the "C" in HCI is becoming harder to define. This means that interactions with distributed digital materials are not always synchronous and the results cannot often be mapped directly to a defined moment of human experience. My contributions address two implications from this.

      First, what do interaction designers consider as materials? As digital materials become more dispersed and entangled with nondigital matter, such as sensors in people's bodies or bits of information scattered throughout everyday environments, it is unclear if the material focus should remain digital. For example, consider data about human milk versus human milk as data. The former points towards bits of quantified and measured information, such as protein composition or secreted quantity, while the latter points to immanent and dynamic sensations, such as being full or indistinguishable agencies beyond human experience. Through this example, I am not proposing that nondigital materials should be described in digital terms, but rather using it to illustrate a difference in what interaction designers might turn their attention to as shapeable and expressive: materials as more-than-human. This relational

perspective draws attention to expressions that continue to unfold and transform human experience. This perspective does not prioritize nondigital over digital materials, but argues for an inclusion of designing without explicit technology and a recognition of what designing with technology can learn from engaging with nondigital processes and agencies. For example, Paper III contributes the concept of *vibrant wearables;* Paper IV contributes the reflections of *generous absence* and *bodily mappings*; Paper VI contributes the ethical possibilities of *unsafe spaces*, *situated escapes*, and *censored inclusion*. These contributions are all generalized for designing with technology.

Second, how can interaction designers responsibly shape the expressions of digital and nondigital materials? It is difficult for interaction designers to know when and how to intervene with interactions between people and materials that are always unfolding and unique to each person's experience. It is also difficult to predict and evaluate the potential implications of designing these interactions, and when and how values embedded from design might be expressed. HCI and interaction design have historically prioritized values of universalism, objectivity, and efficiency (Rosner, 2018). Universalism promotes designing for everyone as the same within a possible "one size fits all", and fails to consider how humans are different and how particular humans and nonhumans have been excluded. Objectivity upholds the belief in scientific knowledge as true and real, and fails to consider from whom and how such knowledge was generated, and for whom and how such knowledge contributes to some realities being more "real" than others. Efficiency considers progress as forward moving and that quicker or more is better. It fails to recognize the importance of unmaking problematic relations and that some humans, nonhumans, and environments suffer in response to Western notions of "growth". These values, among others, continue to permeate ways of doing and evaluating design. They are difficult to challenge when interactions have no clear beginnings, endings, or boundaries. My contributions address a designer attending to their own values (e.g. my change of positionality in Paper I and orientations of care in Paper II), the structures that discipline ways of designing (e.g. ethical possibilities in Paper VI), and what lives and futures might be affected by oppressive legacies and hierarchies (e.g. alternative narratives of breastfeeding in Paper IV).

In the following, I briefly summarize each of the four contributions. This includes situating each in industry and academia, giving examples of how interaction designers and researchers can use them, and describing why they might wish to use them.

Research program: *Designing with care*

The first contribution of this thesis is the research program *designing with care,* which is a design space for prototyping interaction design otherwise. It draws upon care ethics and posthumanism to ground four axioms: everyday, wickedness, intimacy, and

generosity. Everyday assumes everyday human care as important for interaction design. Wickedness highlights care as not evenly distributed and attending to its tensions as not problems to be solved. Intimacy foregrounds a deliberate and uncomfortable questioning of what it means to be human. Generosity positions a questioning of oneself as an open dispossession and material sharing with unanticipated outcomes and risks. These four axioms ground two propositions, which can be used by interaction designers and design researchers in generatively and analytically shaping exploration and knowledge production. The two propositions are:

Interaction design should wickedly attend to human everyday care
Interaction design should intimately and generously question what it means to be human

The outcomes from my research program are (1) the inclusion of a diversity of everyday care needs and desires of humans, (2) the noticing of tensions in attending to everyday human care, (3) the extending of everyday human care beyond hierarchical notions between humans and among other species, and (4) the flourishing of social, environmental, and technological relations. The first, for example, might include supporting toileting practices outside of normative and able-bodied experiences. The second might include considering how the support of particular toileting practices impacts social spaces and physical places. The third might include considering how the quantification and standardization of bodily urges can unsettle individual autonomy. The fourth might include engaging with the uncertainties of urges and idiosyncrasies of needs as desired and celebrated. These examples are human-centered in reference to *technologies of human waste* and its focus on the digital management of human excretion. Other examples would point towards outcomes and benefits to nonhumans, which includes other species and environments, and towards the changing of disciplinary structures, which includes ethical guidelines and dissemination formats.

These outcomes cannot necessarily be measured as they lie within a relational ontology. This means that they are not bounded or discrete, but would result in changes that are possible to register. For example, they might manifest as digital applications that provide information about toilet facilities to redefining access needs as expressions of bodily urges; they might manifest as algorithmic knitting patterns to redefining bras as a shareable artifact between multiple bodies in flux; or they might manifest in more research on the unknowable uncertainties of bodily fluids, materials, and changes.

Designing with care aligns with notions of activism and feminism in the challenging of normative assumptions and oppressive hierarchies — desiring change — and it differs by proposing alternatives to what already exists. That is, "designing with" acknowledges design as a change making practice that through the manifestation of

ideas, prototypes, and examples puts forward difference. This difference can be for how the world should change, or how design should change. The former can be seen as how design engages in politics and the latter can be see as how politics engages in design. Both are entangled within my research program, but my focus is on the latter. That is, in this thesis, *otherwise* refers to the challenging of established ways of doing interaction design that include its values, methods, and disciplinary structures. Yet in prototyping interaction design otherwise by *designing with care*, I also prototype how the world should change. This points towards my research program being of use to interaction designers from either or both perspectives, while acknowledging a delimitation in that I have focused on how design should change. It also recognizes that it is not easy to separate the two because design is always situated and disciplined.

The benefits and limitations of my research program are as follows. I have prototyped *designing with care* in an academic setting, within which I have experienced hesitation, discouragement, and skepticism. Yet, I have also been granted opportunities to critically discuss alternative ways of thinking and significant freedom to explore alternative ways of designing, and my work has been published and well-received by many. Putting my research program into practice in industry settings might result in more push-back than academia, where challenging existing design paradigms is more established and challenging hegemonic structures is more accepted. In this way, I see it as useful for a company that is deliberately seeking to restructure their values, methods, or outcomes. *Designing with care* would be beneficial in a teaching environment as a master's design program. For example, a two year degree program could have the first year dedicated to design experiments on each axiom that probe their strengths, weaknesses, and societal implications. The first semester of the second year could combine all axioms to explore different stereotypes, and the final semester of the second year could be a design brief that attempts to break the boundaries of the research program. For example, what happens if everyday care becomes spectacular care? Or the notion of the human is over questioned and has melted away, what hard boundaries might be needed among people and between technology?

Definitions of wickedness and generosity

The second contribution is definitions of wickedness and generosity. In the following, I first give a written explanation of each that is framed through my careful designs and included papers. Both are ethical stances that can be taken by interaction designers or design researchers. An ethical stance is the position that a person takes in approaching design situations, which can also be described as the values they draw upon in making judgments and reflecting upon possible implications. I then describe possible outcomes from each, which positions my definitions apart from general theory that describes

what is, and instead positions my definitions as transitional design theory "to make sense of a vast range of possibilities" (Redström, 2017, p66). They can also be taken in other research programs as axioms in formulating a worldview. For example, wickedness might not be taken alongside a posthumanist commitment, and generosity might not be taken in design situations of everyday care.

   Wickedness is the deliberate engagement with care as unevenly distributed and not a problem that should or can be solved. In my analysis of *technologies of human waste* (Paper I), it is defined through the exaggerated frictions between a human and the three "pee-ometer" provocations. In *spying on loved ones* (Paper II), it is defined through the critique of two autobiographical designs for the caring of family members. It is further illustrated through the light flicker as an attempt to redistribute tensions, and through the video talk show format as an attempt to emphasize tensions. In *leaky breastfeeding bodies* (Paper III & Paper IV), wickedness is defined through the contradiction of my design intent to make fiddling necklaces first from cow's milk, decision to continue designing with milks amid a recognition of tensions, and the mapping of pages that seeks a continued shifting of relations. In *scaling bodily fluids* (Paper V), it is defined through our utopian commitment to instigate change and the fabulations' possibly impossible (un)making of relations between humans and nonhumans. In *a speculative ethics* (Paper VI), it is defined through the performative texts' engagement with discomfort as a pathway to notice intimate relations. It is also illustrated through the pink text's troubling of academic writing.

   These illustrate tensions in care as unstable and unsolvable, which includes human and nonhuman entanglements as always in flux. The outcomes from taking wickedness as an ethical stance include attending to divergent care practices, such as through considering what relations are being prioritized and why; subverting disciplinary structures, such as through the troubling of established ways of doing design and research; and unmaking oppressive relations, such as through seeking to unsettle humanist hierarchies or violent histories. Inherent to these outcomes is a lack of resolution, which might be frustrating for a designer, and who might also experience possible objection from the relations being challenged or sustained. This might be difficult to navigate without support, which means that taking wickedness as an ethical stance is based upon social and material privileges to dissent.

   Generosity is the open disposition of oneself that is a threat to bodily integrity due to unknown social and material consequences. In *technologies of human waste* (Paper I), it is defined through the self-tracking of my urinary routines and impact on my design intentions from the noticing of my changed positionality. In *spying on loved ones* (Paper II), it is defined through the risky sharing of our care for family members, uncomfortable revisiting of tensions, and the vulnerable performing of the talk show.

In *leaky breastfeeding bodies* (Paper III & Paper IV), generosity is defined through the pre-reflective tampering with our milk supply through material investigations, reflective intention to reciprocate something else to fiddle with without understanding the potential consequences, noticing of how designing for "being away" is materially transformative, and continuation of the project to preserve our milk amid unknowable temporalities of lactation. It is also illustrated through the vulnerable sharing of my breastfeeding experiences to external audiences. In *scaling bodily fluids* (Paper V), it is defined through our gifting of personal experiences with bodily fluids and conceptual scaling of them beyond a bounded human body. It is also present in the fabulations as lingering questions and unresolved details. In *a speculative ethics* (Paper VI), it is defined through the performative texts' consideration of risks in designing with milk, and my humble gifting of these risks to a research community without knowing how they will be received by my child and others.

Each of these illustrate specific social and material risks of challenging human-centered approaches, which includes normative perspectives on being human and the inclusion of relations as more-than-human. The outcomes from taking generosity as an ethical stance include noticing what was previously considered absent, such as unconsidered care practices or nonhuman agencies; navigating perceived risks, such as temporalities of harm to oneself, peripheral people, or interconnected environments; and collaborating from openness, such as new knowledge from intimate sharing or generative opportunities from traveling materials. These outcomes are not discrete, nor will they necessarily be positively received by a designer, loved ones, or a community. For example, noticing what was previously absent might foreground material harm, collaborating from openness might result in new forms of exclusion, or navigating perceived risks might involve seeking an end to a collaboration.

Four methodological approaches to designing with care

The third contribution is the synthesis of my four methodological approaches to designing with care: *auto-design*, *spatial orientations*, *leaky materials*, and *open speculations*. Each draws upon related methods that are generative and analytical pathways towards careful designs. In the following, I give a brief overview of each and discuss its relevance in industry and education.

Auto-design **engages with the self as mutable.** This means that *auto-design* attends to blurry boundaries or transformative relations between oneself, design, and other humans and nonhumans. It differs from related approaches through its critical and temporal engagement with positionality and its performative practice of sense-making. It extends academic practices of disclosing positionality to evoking a richer discussion on how a person experiences, designs, and writes about a topic. This includes

considering the self as not static and liable to change, which can be a resource for a rigorous critique. Furthermore, performative practices of *auto-design* differ from presentations of facts. Its engagement with theory is significant for cultivating a critical perspective on how a self is situated, and through storytelling to invite an audience to collaboratively experience an experience as many selves.

Auto-design could be picked up and used in the following way. In industry, *auto-design* would be useful to notice and reflect upon a designer's situatedness. For example, the tracking of intimate activities, could prompt private reflections or discussions among a team to consider what values are being embedded in design artifacts. This is in contrast to practices of building empathy by focusing on understanding a designer's own positionality. *Auto-design* is similar to a reflective design practice and in particular the idea that "[d]esigners should use reflection to re-understand their own role in the technology design process" (Sengers et al., 2005). *Auto-design* differs through its methodological diversity in exploring situatedness, which might not directly involve technology and might incorporate performance. In addition, its rigorous centering of the self does not necessarily intend to map reflections or values from a designer's situatedness to a design situation. For example, rather than reflecting on "what could be better in the design?", it aims to reflect upon how better is defined and for whom, and might be "tinkered" (DiSalvo, 2022) with as a situated term. This shifts from solving a particular problem or designing for a particular experience, to considering "good" as temporally entangled in decisions, motivations, and positions.

Spatial orientations **attends to how bodies are oriented in physical and digital space.** This means that *spatial orientations* investigate the relations of humans and nonhumans, which includes abstract, material, and political positions of people, things, and materials. It differs from similar approaches through its relational focus and impact on how a designer, artifact, and values are situated. For example, it is not about cultivating a somatic awareness or considering how a human body experiences space to transfer perceived qualities into a design. Instead, by approaching bodies as situatedly entangled, it explores the making and unmaking of relations, that is, how and why particular ways of inhabiting space might be experienced. *Spatial orientations* is both an analytical and generative approach.

Spatial orientations could be used in the following way. Within industry, it could be used as a mapping exercise to investigate relations of a design situation. The starting point could be physical spaces, such as the room that a device is in or the places that a human body travels to and from. From an initial mapping of physical proximity or corporeal orientation of bodies, a designer might conceptually layer how design materials "break" spatial boundaries, transform power imbalances, or challenge temporal assumptions about interactional immediacy. This extends literal conceptions of

space, such as how physically close a device is or how a human body traverses a room, to an engaging with the ethics and politics of design. This is useful beyond critical reflection to pragmatically maintain or trouble harmful relations. It would also be useful in education to integrate secondary theory into design activities. For example, the mapping exercise could be used with a theoretical lens to discuss the orientations of bodies in performing critique and unsettling assumptions.

Leaky materials **accounts for the vibrancy and fluidity of materials in disordering bodily boundaries and autonomy.** This means that materials are more-than-human through how they inform relations between what are often considered discrete entities, such as an individual human or technological device. It aligns with materialist perspectives in HCI (e.g. Dourish, 2017; Wakkary, 2021) and interaction design (e.g. Redström & Wiltse, 2018) that consider the arrangements and traveling of computation things in new digital forms. It differs through a focus on the relevance of nondigital materials, and in particular those that are often considered living due to their biological properties, such as human bodily fluids. This emphasizes how particular materials are conceptually and pragmatically leaky, which highlights the relevance of nondigital materials for interaction design, and raises the question if some materials, design, or relations are *more* more-than-human than others.

Leaky materials could be used in the following way. In industry or education, a first step might be annotated concept sketches to unpack relations and investigate how materials move among bodies and spaces. A next step could be considering how boundaries are troubled based upon the relations observed. A third step could be a playful imagining of how such devices, infrastructures, or systems might be different if a digital material was substituted with a nondigital material, such as blood, bacteria, saliva, or dirt. This exercise would prompt discussions regarding the differences between material qualities and how they might contribute towards aesthetic experiences, rituals, or unforeseen expressions. The intention would not be material substitution through an analytical examination of difference. Instead, it would highlight the agencies of materials as relational and design as unstable.

Open speculations **materialize incomplete possibilities for an ongoing and collaborative reimagining.** This means that the designing of alternatives is one possibility of what might be preferable, and that many other possibilities and perferabilities might be imagined in response to what has been put forth. It builds upon futuring, storytelling, and unmaking approaches that do not view design as only future-oriented and that incorporate hope amid critique. It is unique through its invitation for audience engagement and the putting forth of non-linear temporalities. It aligns with participatory practices of speculative design, yet is not deliberate regarding when ongoing reimagining might unfold. That is, collaborative imagining does not need to be

synchronous or from engagement with an intentional person(s). *Open speculations* are not limited in form as possibilities and can manifest as, for example, knitting patterns, lingering questions, or a deck of abstracts.

Open speculations could be used in the following way. In industry, it would be useful as an early or retrospective process-based activity. As an analytical exercise, it could be helpful in considering unaccounted for user groups or imagining how a product itself participates as agentic. For example, it could involve narrating the lineage of an artifact or system, such as in these workshop prompts (Jenkins et al., 2018): A prototype is left on a bus, what happens? Where is the bus coming from, where is it going? Who or what else is on the bus? How did the prototype get on the bus, how does it get off? As a generative exercise, *open speculations* could involve a workshop in which "holes" in the product are deliberately designed to open for alternative voices. For example, this might be about a piece of code, packaging, or a button being unfinished or undefined. These exercises could be used for a product that a designer is responsible for, or in education in a design brief about an existing market product.

Careful designs as examples of interaction design otherwise

The fourth contribution is the careful designs presented in this thesis: *technologies of human waste*, *spying on loved ones*, *leaky breastfeeding bodies*, *scaling bodily fluids*, and *a speculative ethics*. Each explores the axioms of my design program differently, through which they each make individual contributions as examples and provocations of alternatives to what already exists. The contrasts between them illustrate the scope and benefits of the research program. In the following, for each I discuss what it aims to change in the world, and what it aims to change about interaction design and in what form these changes might be registered as outcomes.

*Technologies of human waste* **investigates the everyday care of human excretion.** This is through the speculative devices that predict a person's urinary urge. In the world, this careful design aims to change normative and universalized views of how human bodily excretion should be managed. For interaction design, it aims to change how intimate and somatic data is collected, analyzed, and used by digital systems. This change could be possible to register in the design of physical products and digital applications. For example, it might include the ability to label "false" data about a urinary urge to avoid social exposure of an accurate urinary prediction. If this concept was presented by students, I would also expect a reflection upon the additional labor in labeling false urges and the trade-offs of creating new relations through this solution. This possible change to interaction design could also impact value changes in the world, such as what counts as "truthful" and if accuracy should always be desired in digital technologies. In research dissemination practices, *technologies of human waste* also aims

to change the presentation of author positionality as dynamic. This does not assume that a person's positionality will always or ever change, but calls for a recognition of design and research as unfolding over time. A result of this change might be reflections instead of labels that attend to authors as dynamic.

Spying on loved ones **explores tensions in the caring of loved ones.** This is through the critique of two autobiographical design probes. In the world, this aims to change perspectives of care as always feeling "good" to give and to receive, and thus often devalued or optimized. In interaction design, this careful design aims to change how digital artifacts orient ways of caring for loved ones. This is in opposition to devices being perceived as neutral and passive in affecting how people inhabit space and situate themselves towards objects. A possible way that this change could be registered is in product manuals or virtual simulations that illustrate spatial arrangements alongside potential consequences. For example, these might depict the conceptual removal of a wall to show how two different rooms become spatially closer as temporality is transformed. This might prompt considerations of a power imbalance that motivate an obfuscation feature, or it might prompt thinking about material traces of interactions that motivate using a different material. In education, I would expect a student to show me reflective materials that document what they are proactively choosing to care and not care for as a designer. *Spying on loved ones* also aims to change dissemination practices. This change also focuses on positionality, yet in relation to when and how an author position themselves in research. For example, a result might be experimental formats with conference presentations, whereby performance and the foregrounding of oneself becomes more acceptable. While this might create more work for authors, it aims for more presence and accountability of positionality.

Leaky breastfeeding bodies **investigates milk as a design material and a blurring of bodily boundaries**. This is through three explorations from my breastfeeding relationship that include bras, necklaces, and written narratives. In the world, this careful design aims to change narratives of breastfeeding as only between a cis-woman and a child, a devaluing of reproductive labor, and notions of breastfeeding as a predictable human choice and exchange of matter. For interaction design, it aims to change materials as either human or nonhuman to more-than-human, unaccounted for material consequences of design interventions, and approaches towards bodies as individual and discrete. These changes could be registered as follows. The first is through the designing of fiddling necklaces differently. They could be designed to display traces of interaction that might include material wear, finger imprints, or color fading. This recognizes the presence of design as an intervention by accounting for agencies of fiddling in transforming bodies, temporalities of milk, and the multi-directionality of interactions between parents and children. The second possible registration is how bras
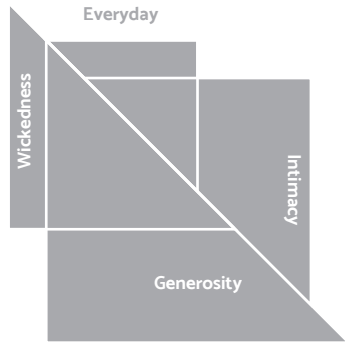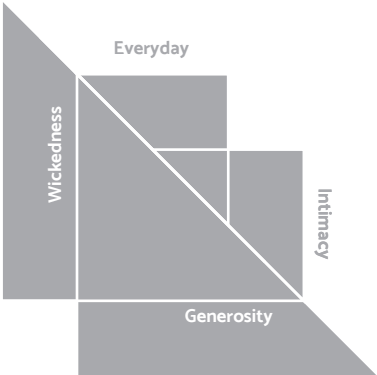
Technologies of human waste
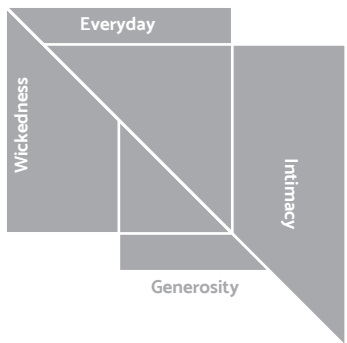
Spying on loved ones
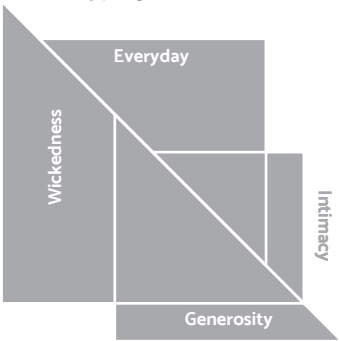
Leaky breastfeeding bodies

Scaling bodily fluids

The careful designs in their revised positioning in my research program. In their initial presentation, all four axioms were given equal weight in diagrammatic size and not all were always present in each careful design. This was to illustrate difference in speculating about key assumptions.

Their revised positioning based upon my analysis of key design decisions illustrates that my research program did not just emerge from the articulation of propositions, but was a conversation between designing particulars and thinking about how they relate to one another. The axioms are no longer binary in their presence or absence, nor are they conceptually uniform.

A speculative ethics
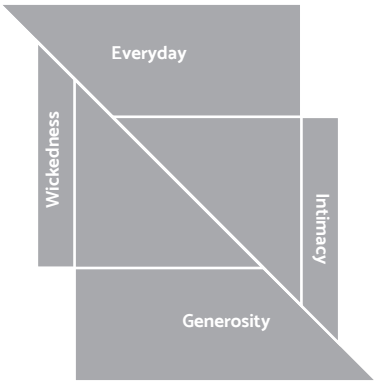
could be designed through an algorithmic process whereby a person approximates a range in fluctuation. The result would be a bra of many cups that accounts for entangled material agencies of milk and hormones in participating alongside data in crafting dynamic, wearable experiences. *Leaky breastfeeding bodies* aims to change dissemination practices into non-linear paper formats, rhetorical strategies, and bodily engagement that invites community sense-making. A result might be the addition of "shuffle" track at conferences whereby a selection of papers are printed and cut apart (physically or digitally) to create new knowledge arrangements within a single paper or across multiple papers. This would trouble optimized formats and diversify what knowledge is valued in publications.

Scaling bodily fluids **imagines unknowable possibilities of multispecies collaborations.** This is through four utopian fabulations as visual and textual narratives. In the world, this careful design aims to change perceptions of human bodily fluids as only useful and usable by a single, bounded human body. In interaction design, this careful design aims to change what matter is perceived as a useful and usable design material, and how to imagine an unknowable sharing and traveling of materials. The first change could be registered through more design explorations of nondigital materials, and in particular, in materials that are often categorized in relation to a specific species or a specific body. For example, a breast pump could be redesigned to not focus on milk extraction, but rather pleasure activation through hormone stimulation. This would shift perspectives of milk as a product by one person for another person, to milk as byproduct of an unseen and uncertain relational exchange. The second change might be registered through more explorative ways of envisioning non-linear temporalities, troubling hope, and blurry encounters. I see this change as more relevant for research and education. It might take form through more open-ended research contributions and unanswerable research questions.

A speculative ethics **reflects upon moments of discomfort in designing with my own bodily fluids.** This is through the creation of "performative texts". In the world, this careful design aims to change research gaps on felt experiences of human bodily fluids and what are often considered vulnerable populations. In interaction design, it aims to change institutional requirements and ethical guidelines regarding first-person research and designing with one's own bodily fluids. This change in interaction design could be registered through new approaches by formal authorities, such as less focus on regulations and more focus on discussing trade-offs between imaginable impacts. For example, this might include workshops in which researchers engaging in first-person methods or designing with bodily fluids map foreseen benefits and risks. It could also include scheduled discussions in which the mappings and a researcher's well-being are revisited. It might also involve support in setting up labs or equipment

in homes or other intimate spaces that are significant for the bodily fluids being investigated and in recognition of the many toxins embedded throughout all spaces. In dissemination practices, *a speculative ethics* aims to change perceptions of only shareable data as valuable data and how autotheoretical performance might be integrated into publications. The first change highlights how an intimate engagement with first-person experiences might be valuable privately for a design researcher in navigating relational impacts. This change would be difficult to register, but could be integrated into previously mentioned workshops. The second change highlights how research "data" could be performatively integrated into dissemination to cultivate reflexivity, diffraction, or engagement with an audience. A result of this change could be practical changes to paper templates, such as seen in the ACM pictorial tracks.

Interaction design otherwise

In the following, I discuss three possibilities for interaction design otherwise. As interaction design is responding to oppressive legacies and environmental disaster, new outcomes, values, methods, and materials are needed to consider a multiplicity of ways of being that are plural and interdependent. This includes grappling with gender, race, ethnicity, class, sexuality, disability, and multispecies worlds. This thesis is a response to what is considered acceptable design and research by the communities, institution, and groups that I am a part of. What one is allowed or expected to do or not do, disciplines what interaction design is and how I argue it should change. This includes acceptable outcomes by the research community, institutional practices regarding ethical guidelines, and ways of working within a research group. These contribute to a disciplining of interaction design and design research, whereby uncomfortably pushing the boundaries or wildly challenging what is accepted can create tensions that prohibit work or limit outcomes.

Engaging with mundane yet unrecognized topics

The first possibility is engaging with mundane yet unrecognized topics. In this thesis, this includes urinating and breastfeeding, yet also the diverse ways that we monitor and track our loved ones. These are often either absent or universalized in interaction design, yet extremely present and particular for many people. In engaging with such topics, I argue that more can be learned about how interaction design has and continues to shape ways of being in the world.

This possibility calls for not enforcing regulations on design and research that results in topics remaining unrecognized. For example, this includes content warnings and ethical restrictions as blanket procedures that are put forth to protect some people

without discussions regarding who or what is harmed from such measures. This includes taboo topics within everyday settings that are often considered sites of vulnerability and undoing, or interpersonal family relations that do not align with normative notions of care, which contributes to expectations of potential harm to research subjects who might be participants or researchers. A result of this is that many basic realities of human living, and in particular marginalized groups and diverse needs, have not been recognized or are explicitly recognized as marginalized. Instead, more structures should be put in place to promote and support such topics. This includes acknowledging uncomfortable vulnerabilities and unfamiliar temporalities. It also recognizes that caring for this research can be difficult and not always positive.

In engaging with mundane yet unrecognized topics, I do not position my research as directly engaged with fighting taboos, but instead within a recognition of the taboos, considering what is at stake among entangled and transformative relations. This is also why I consider my research firstly "activism of design", or doing design differently, and secondly "design for activism", or designing different things. For example, I am not trying to promote or advocate for more breastfeeding or more technology for breastfeeding, but rather asking what can be learned about design by designing within breastfeeding? What does such a site of everyday intimacy and wicked generosity teach us about interaction design? How might this knowledge contribute to new values and outcomes? In taking this approach in my research, I've found it difficult at times to separate between what I'm advocating for, and being able to articulate for myself and others what to pay attention to. This is indicative of an entanglement between the pragmatics and politics of design (Dourish, 2021), whereby engaging with such topics involves a constant considering of the relations a designer is attending to and why. As described in *inventive problem-making*, doing design differently can also be about shifting attention "*someplace other than design* to address problems" (DiSalvo, 2022, p165).

Not separating where things are designed and researched

The second possibility is not separating where things are designed and researched. This means doing design work in the context where the consequences of design work are present. In particular, this is specific to mundane yet unrecognized topics and an intimate questioning of oneself. This recognizes that people and places are not isolated socially or materially, and that artificially avoiding harm risks omitting the particular knowledge most worth gaining.

This possibility calls for not isolating design and research spaces from the everyday settings where a topic is experienced. This focuses on previously mentioned topics, such as human bodily fluids or interpersonal family relations, and recognizes that many other topics and types of design and research are not separated. For example,

this possibility includes the designing with intimate materials in a person's home and sharing of intimate experiences in a person's research. This recognizes that people and places are not isolated: humans breath, move, talk, leak, and absorb among each other and nonhumans. This also highlights that design and research are part of a designer's and researcher's everyday reality. The institutional structures in place (e.g. Swedish Ethical Review Authority) are not equipped to consider a blurring between research subjects and objects, which is indicative of established power relations and understandings of what are acceptable design situations and acceptable design materials. This also includes an understanding of what it means to design with a material in an artistic practice aimed at what is often considered scientific research.

In not separating where I have designed, researched, and experienced an intimate and generous questioning of myself, I have encountered emotional discomfort and material unease. Yet I have also gained a rich understanding of these risks and the potential trade-offs in intervening in more-than-human entanglements. By contrast, omitting the risks, risks changing the results; and changing the conditions of the risks, risks changing what is learned about the risks. This is significant in relation to calls for generosity in more-than-human design that recognize a human humbling and vulnerability as risky (Wakkary, 2021) because it unpacks how, why, and what these particular risks are. It grounds the risks of more-than-human approaches in the particulars of design, and from which established ways of handling risk need to be questioned and new ways need to be supported.

Alternative narratives of dissemination

The third possibility is alternative narratives of dissemination. This includes considering how the written formats of research publications could better reflect knowledge and the positions from which it is created as situated and dynamic. It also includes considering how meaning is made from publications as ongoing artifacts and how particular formats orient meaning-making. In response, I argue for exploring different ways of inviting engagement and unmaking rules of production in research dissemination.

This possibility calls for not listing positionalities of authors and researchers as the only disclaimers of situatedness. The descriptive qualifiers of a person's positionality can only go so far in expressing entanglements of the personal as political. Obligatory labels fulfill community expectations by disclosing a standpoint, but risk not engaging with why a standpoint is significant, how it informs knowledge production, and what relations might be excluded. For example, this possibility includes the welcoming of creative interpretations of publishing formats to open for alternative narratives of positionality within dissemination. Alternative narratives emphasizes interconnections between particular situations and processes to reflect aims, values, and histories. This

call is targeted at HCI and Interaction Design conferences and journals, such as the ACM proceeding series, and promotes not enforcing strict paper templates. It is in-line with special tracks such as pictorials or alt.chi, but differs in not promoting the categorization of particular research as "different". Push-back to this possibility would be in response to the extra work required by chairs and reviewers in aligning publication expectations amid uncertain diversity.

Self-centered research

In the following, I consider the relevancy of self-centered research in *designing with care* towards more sustainable worlds that includes a diversity of humans and nonhumans. Centering myself understandably appears at odds with research aimed to reach beyond a human center and is further in tension with increasing calls to decenter particular humans or humans altogether in design. Inherent to my feminist posthumanist commitment, centering myself is rather a starting point in questioning what it means to be human, which includes the particular ways of being human in the world that I have experienced and the social and material agencies of hormones, fluids, data, devices, and artifacts that blur bodily boundaries and dichotomies. It is to "become undone [as] a chance—to be addressed, claimed, bound to what is not me, but also to be moved, to be prompted to act, to address myself elsewhere, and so to vacate the self-sufficient 'I' as a kind of possession" (Bulter, 2009, p136). Thus, this intimate and generous approach is a radical act of noticing and attending to the subjectivities, discomforts, and uncertainties of becoming and mattering. Centering is a situated perspective to open for a more responsible sustaining and unsustaining of relations among more-than-human worlds. Each of the three relevancies discussed explicitly relates to a previously discussed possibility for interaction design otherwise. This speaks to interconnections between changing design and changing worlds.

Including who or what is often excluded or absent

A first relevancy of self-centered research is that it contribute towards including who or what is often excluded or absent within making mundane yet unrecognized topics recognized. It recognizes not just the topics themselves, but also the very particular details within a diversity of human everydays. Self-centered research notices and attends to the presence and absence of objects, beings, processes, and relations that might have been obscured or not previously foregrounded as important.

Historically, many humans and nonhumans have been excluded in design. This has been directly through intentional biases and hierarchies, and unintentionally through established ways of working that have instilled the absence of many as

normative. Absence can undoubtedly be harmful in omitting voices, ways of living, or the basic acknowledgment of existence. Furthermore, as described in Paper IV, absence often carries a negative connotation in that someone or something is missing, incomplete, or invisible. This implies that absence should be fixed or avoided if noticed, and that the making of presence is the optimal solution. Yet absence might also be desired and the making of presence might create other undesirable absences. The former might be a break from technology, wanting to be different, or removing something that does not feel good. The latter might be an unintended social or material consequence of a design intervention, such as removing "going to the bathroom" as an excuse to escape a social situation or inadvertently tampering with the making of milk. These perspectives are inclusionary in that the recognition of absence does not always necessitate change, and are ontological in that the creation of change is never neutral.

Including who or what is often excluded or absent stays with the (un)making of relations as always in tension. Through deeply felt participation and living with design, self-centered research notices absences that might have already been there or might be there because of an intervention. In my thesis, documenting my urinary routines, making with my own bodily fluids, and integrating a light flicker are all examples of negotiating inclusion of what was previously not evident to myself or a consequence of my making change. These span from bodily urges to multispecies relations to power imbalances. Through this noticing of absence, I reflected upon how I wanted to continue as a designer in attending to the mundane details of human everydays.

Critiquing of oneself as a designer and researcher

A second relevancy of self-centered research is the role it can play in an active and ongoing critique of oneself as a designer and researcher. This conceptually does not separate between where things are designed and researched by engaging with the self as a changeable subject and situatedness as an ongoing process. It keeps open what is presented as otherwise and from what subjective standpoint otherwise is defined, which is an ethical obligation in knowledge production.

Critique in design is often presented in relation to how a person sees and interprets things in the world. This includes critiquing design through a rigorous analysis of values and designing critique by putting alternatives forward for discourse. Both approaches are grounded in a designer or researcher acknowledging the position from which a critique is composed. This aligns with a reflective design process whereby a designer makes judgments about the unfolding of response to a design situation based upon tacit knowledge that is acquired through the culmination of previous experiences. Yet like the making of designs or the making of worlds, a designer is not static. The human self is mutable in that it can have affect and be affected by. Within

design decisions, this includes when and how a designer enters relations, what relations are revealed, and what relations are prioritized. These moments of reflection are not isolated, but entangled and substantial to design as a culturally process (Dourish, 2021) and designs as always ongoing in impacting lives and the well-being of others.

Critiquing of oneself as a designer and researcher acknowledges the ongoingness of a designer as a self. Self-centered research engages with the temporality of always becoming by revisiting positionality and situatedness across different stages of a design process. That is, *auto-design* and related first-person approaches are not only a starting point from which the self is centered. For example, this might be through defamiliarizing with designs through the lens of a life change or critiquing one's own design through a secondary theory. These are ethical opportunities to reflect upon, revisit, and question design decisions that have already been made relative to how a self has changed or what is noticed now that was not noticed before.

Collaborating with many selves

A third relevancy of self-centered research is that an acknowledging of a self as socially and materially entangled, opens for collaborations with many selves. This relational perspective rejects self-centered individualism in favor of self-centered communities that are grounded upon a multiplicity of interconnections. I view these communities as including other designers and researchers in sharing experiences and crafting together rich worlds through alternative narratives of dissemination, yet also as taking seriously the more-than-human agencies that ontologically collaborate in shaping selves. My communities have also included my partner and child as intimate collaborators.

In autobiographical design and first-person research, there is often the assumption that generalized knowledge will be abstracted through intimate access to personal experiences. This can be through shared contemplation of an experience put forth or the evaluation of an artifact designed for one person by other people to consider differences or align similarities. These approaches maintain the integrity of a self in experiencing the world, yet risk maintaining the human self as individual and discrete. An individualist approach is more broadly seen in trends to personalize interactions, and in doing so, often rely upon abstracted information of experiences in the form of data. This emphasizes quantity of interactions between a person and an artifact or a quantity of people interacting with an artifact. Yet, human experience and the becoming of a self are not so easily contained and these perspectives do not account for the intra-actions between human and nonhuman beings that blur bodily boundaries through social and material agencies. This relational perspective shifts from promoting the self as individual to promoting the self as autonomous, whereby self-creation is within the conditions for "confident relating and greater sharing" (Escobar, 2018, p233).

Collaborating with many selves attends to the self as a trans-corporeal subject that is always becoming at vastly different scales: from cellular to interpersonal to infrastructural to political. These can be difficult to measure, articulate, and isolate; as well as scope what to attend to when everything is interdependent. Self-centered research grounds a starting point: a seemingly one-to-one interaction with something else, yet its relational focus attends to how many ways of living in the world are entangled. Thus, it is not necessarily about more one-to-one designs, interactions, or evaluations. Instead, approaches such as performative invitations to unknown audiences, open questions for shared imagining, involving family in material experiments, and bodily mappings of personal artifacts scale beyond the self as individual to the self as always collaboratively situated.

Conclusion

This thesis responds to two issues: oppressive legacies in interaction design and digital materials becoming more dispersed with nondigital matter in everyday life. The first includes values of universalism, objectivity, and efficiency that contribute towards particular ways of living and discipline particular ways of designing. These are difficult to challenge when digital materials are entangled within bodies and environments. This grounds the importance of attending to a designer's values in affecting futures and nondigital materials in affecting experiences.

My response is *designing with care* as a pathway towards interaction design otherwise. This research program draws upon care ethics and posthumanism to establish four axioms: everyday, wickedness, intimacy, and generosity. Together, these axioms ground two propositions for exploring everyday human care as always in tension and a questioning of oneself as human in more-than-human worlds. The results from my response are five careful designs as examples of interaction design otherwise by *designing with care*. Yet, my axioms as lines and careful designs as dots are relational in the formation of my research program. The axioms are defined from my position and a selective feminist history, and their conceptual precision is not neutral or absolute. This means that an ongoing revisiting and appropriating by myself and others would result in new pathways and configurations of otherwise. This thesis makes a hopeful invitation for an ongoing remaking of *designing with care* for more sustainable worlds.

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