



Weaving Stories: Toward Repertoires for Designing Things

Doenja Oogjes

School of Interactive Arts and Technology, Simon Fraser University

Ron Wakkary

School of Interactive Arts and Technology, Simon Fraser University and Industrial Design, Eindhoven University of Technology, Eindhoven, Netherlands

ABSTRACT

While much work is underway within the context of posthuman design, this research is often described from a dominantly human perspective. It rarely accounts for the creative capacities of non-humans in design, such as materials, tools, and software. There is a need to further engage with posthuman theories conceptually, materially, and methodologically. We approach this challenge through Ron Wakkary's concept of *repertoires*: actions the human designer can take to increase participation of nonhumans in design research practice. This paper reports on potential repertoires' development by exploring three approaches from outside of HCI: *describing the landscape*, *noticing*, and *translations*. We use these methods to account for weaving events that the first author was engaged in. Through critical reflection of these accounts, we contribute three repertoires and an example of applying the theoretical framework of Designing Things.

CCS CONCEPTS

• Human-centered computing; • Interaction design; • Interaction design theory, concepts, and paradigms;

KEYWORDS

posthuman design, more-than-human, posthumanism, repertoires, first-person, research through design, e-textiles, weaving, designing things

ACM Reference Format:

Doenja Oogjes and Ron Wakkary. 2022. Weaving Stories: Toward Repertoires for Designing Things. In *CHI Conference on Human Factors in Computing Systems (CHI '22)*, April 29–May 05, 2022, New Orleans, LA, USA. ACM, New York, NY, USA, 21 pages. <https://doi.org/10.1145/3491102.3501901>

1 INTRODUCTION

HCI and design researchers are increasingly seeing limitations to human-centeredness in design. As a result, they are turning toward new explorations that emphasize the need to see design and computing within a broader set of more-than-human relations and values. In this shift toward posthumanism, related theories and philosophies have long pointed out the need to decenter the human toward more ecological, porous, and relational understandings [4, 6, 8, 13, 52, 53, 78, 110]. In design, this challenge falls to the

human designer. It requires design practitioners to rethink one's relations—critically and introspectively—to methods, tools, materials, and practices.

This challenge of decentering the human in design practices has not gone unnoticed in design research [27, 36, 60, 71, 104]. Taking a thing-perspective [12, 45, 60, 87, 113] as a strategy to oppose human-perspectives, opens the possibility for nonhuman participation, and resonates with other decentering techniques like *noticing* [72, 76, 109] *troubling* [31, 39, 52, 66, 105] and *car-ing* [5, 38, 56, 61, 75]. While there is a growing body of design work drawing from posthuman literature, the design processes themselves are often still described from a dominantly human perspective and intent that rarely account for the creative capacities of nonhumans such as materials, tools, and software. This is not to argue that human subjectivity disappears, but rather a posthuman subjectivity arises that is interdependent and interconnected with nonhumans [8]. How can we engage with posthuman discourse both conceptually and materially in a material practice like design? What are the challenges of escaping human-centeredness—or moving toward posthuman subjectivity—as a human designer?

Ron Wakkary, in his book *Things We, Could Design for More Than Human-Centered Worlds*, outlines a more-than-human design practice that he calls *design-with* [111]. Wakkary, motivated by the unsustainability of human exceptionalism and the real impact of the Anthropocene and climate change, argues for a rethinking of design that displaces the human at the center of thought and action to act interdependently with nonhumans. Toward that end, he describes the designer as an assembly of humans and nonhumans. He sees the immediate challenge in a posthumanist design of developing *repertoires*: actions that human designers can take to enable nonhuman participation in designing things. Wakkary offers examples of starting points, such as Anna Tsing's art of noticing [109], Vinciane Despret's reframing of research questions [16], Donna Haraway's multi-species kinships [51], and Bruno Latour's representations and translations of soil [65]. He argues that approaches like these could be further developed and experimented with to be mobilized within a practice of design-with. This paper takes on this challenge to explore strategies and actions that enable the participation of and collaborations with nonhumans. We do this through critical self-reflections of first-person accounts—or stories—of events from our design research.

In this paper, we propose potential repertoires. We investigate a series of weaving events across two ongoing design research projects. We draw from two of the posthuman anthropological approaches cited earlier and add a third: 1) *landscape ethnography*, drawing from Laura Watts [114], 2) *noticing*, as per Anna Tsing [109], and 3) *translations*, building on Bruno Latour's circulating references [65]. We explore their potential as a repertoire for design by guiding our focus in our active reflections on the weaving events.

Permission to make digital or hard copies of all or part of this work for personal or classroom use is granted without fee provided that copies are not made or distributed for profit or commercial advantage and that copies bear this notice and the full citation on the first page. Copyrights for components of this work owned by others than ACM must be honored. Abstracting with credit is permitted. To copy otherwise, or republish, to post on servers or to redistribute to lists, requires prior specific permission and/or a fee. Request permissions from permissions@acm.org.

CHI '22, April 29–May 05, 2022, New Orleans, LA, USA

© 2022 Association for Computing Machinery.

ACM ISBN 978-1-4503-9157-3/22/04...\$15.00

<https://doi.org/10.1145/3491102.3501901>

In our findings, we discuss the results of our experimentation with each of these approaches and the degree to which each accounted for, enabled, or increased the participation of nonhumans. As such, our research question is: *What is the potential of the anthropological methods of landscape ethnography, noticing, and translations to develop actions for the human designer to increase nonhuman participation?*

This paper provides concrete examples of *design-with* as per Wakkary's definition, thereby contributing to HCI and design an example of methods for *design-with* that positions itself as a more-than-human practice. This is an important contribution for both researchers working in the field of more-than-human design [72, 75, 84, 96, 99] as well as those exploring thing-perspectives [10, 100, 102, 113] and material driven design research [49, 67].

2 METHODS OF POSTHUMANIST DESIGN

HCI has developed an interest in the Anthropocene, more-than-human worlds, entanglement theories and posthuman design [36, 37, 40, 47, 72–75, 84, 96, 99]. Posthumanism is a branch of theory and philosophy that de-prioritizes the human as the center of knowledge and being in the world and aims to open to more porous, blurry boundaries. The term *more-than-human* was used by ecologist and phenomenologist David Abram to draw attention to the many nonhumans that preceded humans and now share the earth with humans. He also called for a new humility on the part of humankind to recognize how these more-than-humans are in community with humans and exceed human understanding [1]. Posthumanist and more-than-human design can thus include plants, animals, and micro-organisms. Still, as we will argue, it also includes design practice's things, materials, processes, and tools.

The notion of decentering the human within design and HCI, or making space for nonhuman perspectives, was an early articulated concern [27, 37, 104], yet this is no simple task. For example, Disalvo and co-authors speculate on the deep commitment it will take to overcome anthropocentrism: "This momentary overcoming of anthropocentrism requires us to imagine the world anew and involves imagining movement outside of our own patterns, outside of things like being bipedal. [...] Ultimately, it involves our overcoming the narrative fallacies and rationalizations that we use to place ourselves at the top of a chain, and instead placing ourselves in a web in which the components are impossible to isolate from the whole" [27:433]. The notion of more-than-human design has since been considered from a wider lens, including, for example, sustainability [7, 72, 75, 99], human-food interaction [11, 96], and everyday practices [62]. As we will argue in this paper, design practice itself, with its tools, materials, methods, and processes, is a practice that is already entangled with the more-than-human world. Our interest in posthumanism is in this notion of decentering the human as the center of control of events and relations in designing and bringing to the fore such materials, tools, processes, and other nonhumans that have a say equal influence in design outcomes.

Laura Devendorf's *Redeform / Being the Machine* is one example that aims to redistribute agency and control away from the human within creative practice [23, 24]. *Redeform* is a portable digital fabrication system technically similar to 3D printing techniques. The system visualizes G-Code instructions into a laser point across a

path and allows the maker to go through these points step by step. This system allows for flexibly working with 3D printing technologies and invites material and situated engagements. Devendorf and co-authors reflect on the actual product of *Redeform* as "the process of labor co-performed by human and nonhuman makers" [20:177]. In another example, Cyn Liu and co-authors set out to investigate how theories of nature-culture, the co-construction of nature by culture and vice versa, translate to material design practice [73, 74]. The authors examine the decomposition process and apply it to ceramics to give space for the agency of nonhumans. The authors encourage designers to be more willing to "listen, observe, and respond to what nature has to say, as well as learning to be vulnerable and amazed in the design process" [74:612]. There is a larger body of work focusing on enabling material expressions in design [90, 92], including aspects beyond human control such as breakage [58, 59] and traces [46]. There have also been suggestions within design research to understand and make space for the perspectives of nonhuman things [10, 12, 45, 100]. While these works are valuable and allow for the human imagination to stretch towards thing-worlds, it is vital in these instances to acknowledge what our human framings limit us to know [112]. There is a need for a more significant narrative shift that pushes material expression into participation, which accounts for the voices of nonhumans of design that do not explicitly serve human goals. Decentering the human, *as a human*, is challenging work and requires challenging self-reflection. In their auto-ethnographic work on birdwatching, Biggs and co-authors make precisely this point and frame the experience of doing so through the concept of abjection – the necessary rejection of parts of the human self and the conflict this creates about being in the world [99].

More broadly, within more than human and posthuman design research, approaches to work with nonhumans have included noticing, drawing from anthropologist Anna Tsing, and designing the tools to do so [11, 72, 76]. In another strand of research, the design of wearables or prostheses enables design researchers to experience nonhuman external events or to become part of the technology [7, 23, 30]. Researchers have also engaged in material engagements that look at framings such as decomposition, salvage fabrication, and making kin (as per Haraway) with materials [25, 26, 74]. Within these material engagements, there is a strand connecting with first-person approaches in which researchers are adopting positions that are open to sensing materials in new ways [41]. Lastly, there have been explorations of probe-like artifacts within these works to understand nonhuman agencies and participation [7, 99]. The work presented in this paper draws on these approaches. It applies first-person research that is on the lookout for nonhuman agency and investigates the more profound narrative work that needs to go along with such methods. First-person approaches offer opportunities for rendering design researchers capable of asking questions differently and are well suited for design work given their commitments to situated research, unique standpoints, and critical self-reflection. However, within a posthuman framing, the dominance of the human voice (in data collection, analysis and documentation) doesn't sit so well and needs critical navigation to ensure the inclusion of non-humans.

As a final point, we see the summarized methodological commitments as combined: design *is* first-person and *is* more-than-human centred as a material practice.

3 DESIGNING THINGS: THE SPEAKING SUBJECT, CONSTITUENCIES, AND REPERTOIRES

In this section, we elaborate on Wakkary’s conceptualization of more-than-human design. While other theoretical approaches challenge human-centeredness in design, such as ontological design [33, 115] and Redström and Wiltse’s Changing Things [101], we chose to work with Wakkary’s framework as it addresses the challenge of the human designer more squarely within a posthumanist understanding. This is well suited for our research question as it speaks directly to actions that the human designer can take.

Wakkary conceptualizes a posthuman reworking of design he calls *design-with*. This work aims to articulate a practice of *designing things* in which humans are neither central nor exceptional but are ecologically interdependent and humbled. He asks what it means to design for more than human-centred worlds, to think past human-centred design and its underlying humanist assumptions? In his rethinking design, the assumption of the designer as exclusively human is abandoned [111]. Instead, the designer is seen as an assembly of humans and nonhumans. Wakkary proposes four sensemaking terms: the designer as *biography*, the designer as *force*, and the designer as *speaking subject* and *constituencies*. Here, we focus on the notion of the designer as a *speaking subject* that refers directly to the unique capability of the human designer to speak in amongst muted nonhuman designers. In Wakkary’s view, this capacity comes with a responsibility for human designers: to represent those non-speaking nonhumans with which they are interconnected and assemble them within what he calls a *constituency*. Therefore, the speaking subject has two essential roles: 1) speaking on account of the human and nonhuman assembly that is the designer; 2) and convening a constituency.

The concept of the *constituency* is like an expanded version of design practice, however, one that is actively inclusive of the inevitable politics of designing things that shape the world or what Bruno Latour calls *thingpolitics* [64]. A constituency is a gathering or “the assembly of humans and nonhumans from which designers of things are gathered to go on to design things and form biographies” [111:120]. He makes the comparison to a kitchen in which humans are gathered with nonhumans like food ingredients, cooking utensils, pots and pans, and recipes and political commitments are made such as veganism, non-GMO, ethnicity, histories all before a cook cooks a meal or in designing things: before a designer designs a thing. Through all this, the constituency becomes a specific, unique assembly. For design research, the constituency may include design tools such as paper and pencil, post-it notes, software such as Miro, Adobe’s creative suite, machines such as laser cutters, 3D printers, jacquard looms, people such as members of the design team, university staff, external collaborators, materials such as ceramics, wood, fabric, external events such as conference deadlines, pandemics, and time-zones. The speaking subject is a member of this constituency and has a unique and active role as a *convener*, bringing together all the elements of the constituency. In what can

be understood as a form of infrastructuring, the speaking subject attends to the constituency in constructing and maintaining it, from which the designing of things can happen. Important to note for our work is that it matters *how* this convening, constructing, and maintaining takes place.

As proposed in the book, the term *repertoires* point to processes of the designer and the constituency by the speaking subject aimed at committing to the participation of nonhumans. How can the speaking subject speak on behalf of the human and nonhuman assembly known as the designer and attend to, construct and maintain the constituency? Wakkary identifies the need to develop these repertoires further so that nonhumans can be “more present, more participatory, more cared-with and lively within constituencies” [111:229]. This is a collaborative effort in which the actions of the speaking subject are focused on aiding the formation of designers: “there is a need to learn more about how to speak-with, participate-with, and care-with at the level of the constituency. We need to invent ways to recruit, maintain, and attend to the relations or the mass of things that form the constituency” [111:230]. Wakkary offers starting positions or attitudes for the human designer, such as acting from a position of *not-knowing*, in contrast, to design as problem-solving, *horizontality*, a move to equalize and be alongside nonhumans and *transmogrification*, a shift in understanding the human self, often as an effect of either of these two moves that further emphasizes the porous boundaries of posthumanism. We elaborate further on these in our discussion (see 7).

This paper investigates repertoires that help us see what is being gathered as designers and how they should gather. This helps us understand who is designing and how the constituency was attended to and followed through on the commitment to be inclusive and participate with nonhumans.

4 METHODOLOGY: DESIGN AS KNOWLEDGE MAKING

Within HCI, designed things have been proposed as a contribution in itself [86], as ways of doing philosophy through design [32, 54], making trouble or problems through design [31, 43, 105] as well as fabulations and amusements [18, 103]. As the field is more broadly accepting types of design and the questions it can inquire into [91], recent works have also pulled focus from the outcomes and finished objects of design research to include its processes as forms of knowledge-making [15, 43, 55]. These works provide a more dynamic and process-oriented perspective on the knowledge-making that can happen *through* designing. The development of repertoires, collaborations with non-speaking nonhumans, and design research documentation generally do not involve participants or other people and thus rely on critical self-reflection. The work presented in this paper does not include user studies, deployments, or interviews. As such, this research can be considered first-person. First-person research prioritizes researchers’ first-hand experiences as knowledge inquiry. A range of first-person approaches is emerging in HCI, including autobiographical design [14, 83], micro-phenomenology [97], design memoirs [17], and more. These approaches are descriptive at a level of granularity that reveals mundane, intimate, and otherwise overlooked aspects of design practice. First-person methods also acknowledge the researchers’ positionality and are

therefore well suited for introspective reflection on the role of the human in more-than-human design practice. These approaches have called for a wider variety of ways of writing up research [14], with examples such as Design Memoirs that propose “an elastic connection to objective truth provides greater space for reflection and poetry” [17:2-3].

In this paper, we approach three anthropological writing methods as propositional repertoires. We use the first-person experiences of the first author, whom we refer to as FA, in three projects that involved weaving as starting points for our explorations. While the FA is familiar with textiles (mainly through sewing), she was new to weaving. She saw this beginner’s position as a possibly productive way to learn about the nonhumans of weaving practices within design research. The resulting accounts or stories can be seen as newly generated data points. We then analyze the produced stories for what they reveal of the nonhumans of design practice (their presence and participation) to assess their value as a repertoire.

5 WOVEN THINGS AND DESIGN EVENTS

The design work presented in this paper is drawn from two ongoing projects of the Everyday Design Studio and collaborators that we will briefly describe below for context. We also provide a brief overview of related works of textiles in HCI and highlight why this particular context of material research is suited for our investigation of developing repertoires. However, the contribution of this paper does not lie in the projects or their outcomes. We position *design research events* as the primary source for our stories: things that happened or are still happening during these projects. We use the term *events* to avoid a project and result-based orientation common in design but can distract from developing repertoires. For example, events may include processes and nonhumans that had no direct role in the outcome yet are insightful in revealing nonhuman agentic capacities. *Events* do not assume relations in the way clear design results do and allow us to engage with nonhumans as encountered in a process while withholding judgement on their purpose.

5.1 Textiles in HCI

The field of smart textiles and wearables is rich and growing, including examples such as project Jacquard, which brought together ubiquitous computing and textile fabrication through a wide variety of techniques [95] as well as many other examples integrating sensors, actuators, controls, and connectivity with techniques such as knitting, braiding, embroidery and weaving [35, 35, 77, 80, 81, 89]. It is possible to manufacture computational things in softer materials. However, approaches such as these have also been critiqued as techno-centric and opportunistic [22]. It has been pointed out that smart textiles, or more simply, working with soft materials in the design of computational things, is not necessarily novel as patents date back to the 1890s [93], and jacquard weaving can be seen as an early form of computation [34]. Textiles and computing have further paid extensive attention to its historical and new tools, machines, and materials [21, 28, 29, 34, 42, 94] and how these can be adapted or considered creative collaborations [3, 19, 48, 50, 82].

The intersection of textiles and HCI need not necessarily be for “smart” wearable applications - there is an opportunity to expand

design’s material focus to include fabrics. We utilize textile fabrication to design *things*, such as a WiFi-reliant object and a WiFi antenna. There is also an affluent area of related internet-connected or radio/frequency-based textile work [70, 98, 116-118]. For our research, textiles offer an opportunity for a deeper understanding of nonhuman materials through their various modes of construction, tools, and the open-endedness and possibility to change direction at different stages of construction. We see this area of material research, particularly its more speculative orientation, as a means to engage in ongoing conversations with those materials, tools, and processes - its porous boundaries resonating with our theoretical framework.

5.2 WiFi-no-WiFi

The Wi-Fi-no-Wi-Fi project investigates relations to internet-connected things. The project involves making a soft portable/luggable/wearable origami pop-up thing that can sense Wi-Fi networks and is activated only when no networks are present. The Internet of Thing-thing relies on networked connectivity but only reversely functions when it is not connected. Ron Wakkary, Tiffany Wun, Henry Lin, Mandeep Mangat, and Doenja Oogjes are involved in this project, and external collaborator Pauline van Dongen, a fashion designer and postdoctoral researcher at the Technical University of Eindhoven. The FA’s role in this project includes initial conceptualization and supporting the development of an actuation mechanism. The FA conducted explorative weaving on a TC2 jacquard loom at the TARP lab, part of Material Matters, at the Emily Carr University of Art and Design for seven 4-hour sessions in December 2019 and January 2020.

5.3 WiFi antenna

This project involves creating a textile Wi-Fi-antenna that can be attached or become part of a home router. The goal is to investigate what type of relations to the home router and the home internet might emerge if the router has a different spatial and material presence. The project team includes Ron Wakkary, Henry Lin, Doenja Oogjes, and external collaborator Milou Voorwinden, a jacquard designer at EE Labels (a label weaving company based in the Netherlands) and design researcher at the Technical University of Eindhoven. The FA’s role in this project includes project management, conceptualization, material research and acquisition, pattern and weave design, and prototyping. For this project, the FA also visited the Unstable Design Lab at the University of Boulder, Colorado, for three weeks in February and March 2020 to weave the first prototype explorations of the antenna designs. The FA collaborates with Milou Voorwinden to design the next round of weaving samples and final designs.

5.4 Weaving events

We frame our work here by the term *events*: periods in the design projects such as one 4-hour weaving session, creating a particular sample, or shorter moments and the events leading up and following to them such as the breaking of yarn or the creation of a knot. Overall, the weaving events span between December 2019 and now, as the projects are still in development. Our reasoning for framing the work through events comes from the desire to keep with design

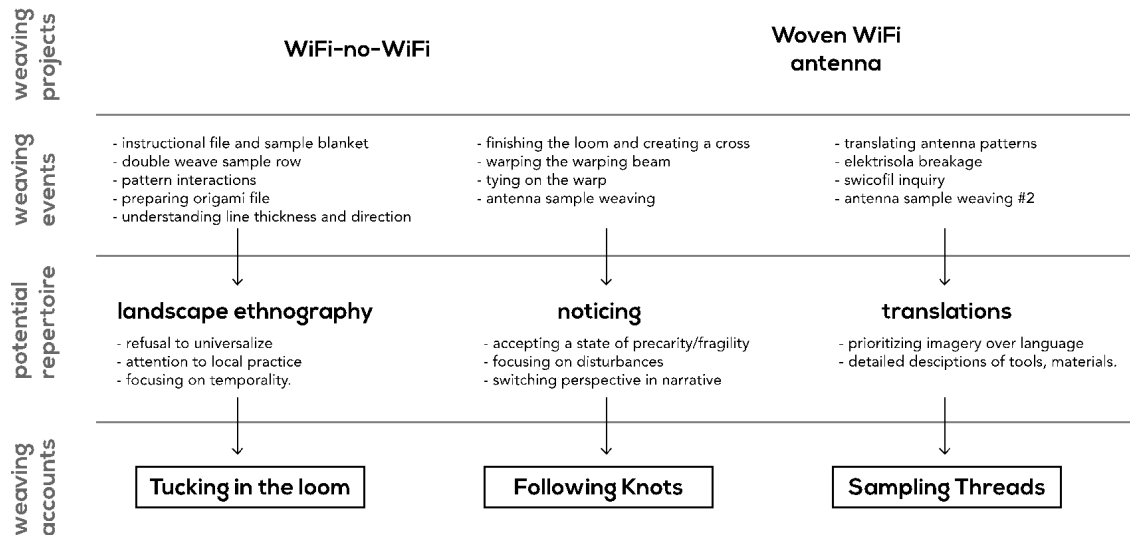


Figure 1: an overview of the process to develop our repertoires

research's ongoing-ness and dynamic nature. We wanted to find a way to talk about the design activities without being bound by the particular project or structure them by finished designs or samples. We would like to clarify that this is not a design process paper; instead, we use events as a lens to understand our practice. Looking at our projects through the events enabled us to pay attention to the relations and nonhumans at play. Data collection included the FA's notes and memories, weaving files created in photoshop, camera documentation and scans of finished samples, in-progress photos, Instagram posts, and stories, team communication, and organization such as reports, meeting notes, sketches as distributed over email, WhatsApp, Signal, Miro, Slack, Google Drive, reference files such as instruction manuals, books on weaving, and documents provided at workshops. This data—around 120 images and movie clips and 28 cells of text reflection—was compiled in an excel file. The 13 events structured the weaving stories as outlined below (see figure 1). The events were initially described from a first-person perspective of the FA. As a next step, the FA highlighted the nonhumans mentioned in the reflections and followed their trajectories through the other data. While first-person research has inherent limitations in using human memory and retrospective reflection, we acknowledge there is a particular tension in this work by its attempts to move away from human framings and perspective. Still, the epistemological commitment of thing-centeredness was present throughout the work.

6 THREE EXPERIMENTAL WEAVING STORIES

In what follows, we draw from three posthumanist anthropological approaches in which we saw an opportunity for the development of repertoires. We chose to work with two of Wakkary's suggestions: Tsing's *noticing* and Latour's *translations*, and added Laura Watts' *landscape ethnography* that shares similar critical posthumanist assumptions but inspired us further in its writing style and use of fiction (that we will elaborate on in the next section). Next, we

briefly outline the concepts behind the approaches and techniques used. In the accounts presented below, we creatively explore the three methods for the speaking subject to later reflect on their potential as a repertoire. We will switch to a first-person perspective of the FA for the weaving stories.

6.1 Approach 1: landscape ethnography

Laura Watts' *Energy at the End of the World* presents an ethnography of energy futures in the Orkney Islands [114]. Her investigation into how futures are made differently in different places is done by describing the landscape in detail and prose distinctly different from academic writing, including fiction, poetry, and ethnographic descriptions. Watts counters the typical dystopian tone of Anthropocene stories and positions her ethnographic work as studying the mundane practices that bring futures into being. She highlights a crucial point in describing the landscape: the refusal to universalize through attention to local practice. Within this, she focuses on the temporalities of the Orkney Islands. Orkney is ahead of the curve in sustainable energy futures; with its electric cars, micro-wind turbines, and extreme climate, it is a temporal present that, for others, could be considered a low-carbon future. Watts takes advantage of this opportunity and describes the professional but also mundane actions of the inhabitants of Orkney as ways of *making the future*. In our first account, we draw from Laura Watts' writing to understand design research practice through a landscape lens. What does it mean to describe a landscape of design research? How can we represent who and what is actively designing and within what constituency or gathering? And what else is revealed through describing the landscape?

6.1.1 Why landscape ethnography? In this story, I describe a series of events that unfolded over my time weaving at the TARP lab at Emily Carr University of Art and Design. This was my first time weaving on a TC2 jacquard loom. The event that led to the development of this story involved a moment when technician and

weaver Jen Hiebert showed me a sample cloth, and its corresponding presets in photoshop. The unintentional contrasts in texture on this sample cloth directly inspired my weaving explorations for the WiFi-no-WiFi project. I saw an opportunity to describe the landscape of this place, including elements such as the sample cloth and photoshop environments. With this, I wanted to broaden common descriptions of design projects with landscape elements that also participate in creating. I use Laura Watts' landscape ethnography and the strategies of refusing to universalize, paying attention to local practice, and focusing on temporality.

6.1.2 Tucking in the Loom. The TARP studio is part of Material Matters, a material design research studio led by Hélène Day Fraser at Emily Carr University of Arts and Design in Vancouver, Canada. The school is very close to my residence at the time—walking distance. I am scheduled for a series of weaving sessions, a couple of afternoons in December from 1-5 pm, and a couple more in January 2020. I walk from my place down the hill with the 'EAST VAN' sign, a few 100 meters over 2nd avenue, to get to Emily Carr.

Hélène introduces me to Jen Hiebert, who trains me to work on the TC2 loom and is on campus to assist with any weaving and loom troubles. I have written a short document to communicate the task at hand: I want to explore textural weaves, double weaves, pockets, and folding textures, for the WiFi-no-WiFi project. When I arrive, the TC2 loom is under a blanket, tucked away. Jen tells me this is to protect it from dust. The space also has a tufting area, sewing machine, winding tools, and storage. Particularly the tufting gun, a wool shooting carpet maker, produces a lot of fibre dust when in use, which can damage the TC2. And so, every session, we go through the little ritual of unpacking and tucking in the loom. We take two large denim pieces of fabric—leftovers from another project—cross them over the top of the TC2 and fold in the edges, like wrapping a present, securing the material with binder clips.

To weave on the TC2, one has to prepare the files in photoshop. As a beginner weaver, I remember feeling intimidated by this at first. The few resources I had found online were hard to follow—they use weaving terms I was unfamiliar with and are primarily focused on pictorial weaving: how to replicate an artwork or photograph in cloth. Jen walks me through the photoshop process and quickly takes away my concerns. She provides me with a library of weaving patterns, including twills, basket weaves, satins, selvages, and other resources on how to work in photoshop, such as creating double weaves and working with multiple shuttles and colours (see Figure 2). Jen also pulls out a weaving that she has made to accompany these different photoshop patterns. It reads almost like a painting swatch. Woven with white cotton weft and black cotton warp, this textile gives an overview of how the thread responds in the actual cloth (see Figure 2). There are different sections: one row of blocks of varying weaving patterns labelled with woven-in text. I can feel the different textures and see the weaving patterns' colour effect. An evenly distributed weave is grey, less even like a satin: either more black or white. The following section features an alternating twill with visual explorations of half circles and white blocks with black numbers indicating the pixel count. Next is another graphic exploration of blocks, followed by a larger woven piece that integrates these different weaving patterns and their colour effect to recreate a photograph. Jen points out to me the

sections between basketweave and broken twill. The fabric folds over each other, creating a contrasting textural quality. This is precisely what we are looking for in the project to generate origami textures and prompts me to explore contrasting weave patterns. The sample cloth has initiated a direction for my weaving.

The TC2 loom itself is prepared for me. The dense warp is tensioned around the warping beam with looped blue and green elastic, and a couple of rows of basketweaves are beaten on the cloth to secure the tension. Jen has also prepared a starting template for the loom. This file has three main sections pre-set: a black square representing 18 defective threads on the right side of the loom, a pattern-filled square for the right selvedge, and a similar one for the left selvedge. A selvedge is a pattern used at the edge of a fabric to create an even and sturdy finish to ensure equal tension throughout the cloth.

The loom itself is adorned with documentation of its module setup and warping logic. TARP's TC2 is two modules wide and 12 modules deep. These documents are held in place by magnets that say: *keep calm and loom on*. A MacBook Pro sits on top of the loom. This is where I open the photoshop file—saved as a bitmap (tiff)—in the Loom Driver Software for the TC2. All the files are black and white—corresponding to the lift schedule of the TC2. Each pixel relates to a needle, and black or white tells the loom whether it needs to lift it or stay put.

Jen shows me how to wind the bobbin to go onto the shuttle that I use for weaving. We attach the bobbin winder to a stool and use the handle to spin. We do a couple so that I can keep weaving for a while, but Jen also reminds me that running out of yarn is sometimes a good way to force oneself to take a break. Throwing the shuttle back and forth, and standing over the loom for hours, can get tough on the body. Jen shows me how to throw—it takes a certain amount of force to get the shuttle across the loom without it flying across the room. I get the hang of it, and soon enough, I'm weaving. Throw the shuttle, beat the heddle, press the foot to go to the next pixel row. Repeat.

Another material enforced break: the TC2 stops at times. Jen isn't quite sure why, but it makes a loud puff, kind of like a deep breath, and lowers all its air-suction-controlled needles. This happens a handful of times over the course of my weaving sessions, and Jen disappears into the room next door, where the vent from the pump of the TC2 goes. I'm not sure what happens in that room (part of the landscape, but obscured to me), but it is resolved whenever she comes back.

And, every day, as the clock nears 5 PM, I wrap up my last samples and call Jen: it's time to tuck in the loom again.

I keep weaving my samples—rows of origami shapes, double weaves, and contrasting patterns. I see specific weaving structures as soft and others as sturdy—rather than black, white, and grey. I get into a rhythm, adjusting the photoshop file, weaving again. It is a pretty quick design process, and it is a joy to see the photoshop files come to life on the loom. I do tests with different thicknesses of lines to understand how the file relates to the thickness of the tread I'm weaving. **And again, at the end of the day, we tuck in the loom.**

Whenever I run into issues, Jen rushes to help me. This is our setup. I am somewhat of a test weaver for TARP, a trial for future students, collaborators, or visiting artists/researchers. Jen notes

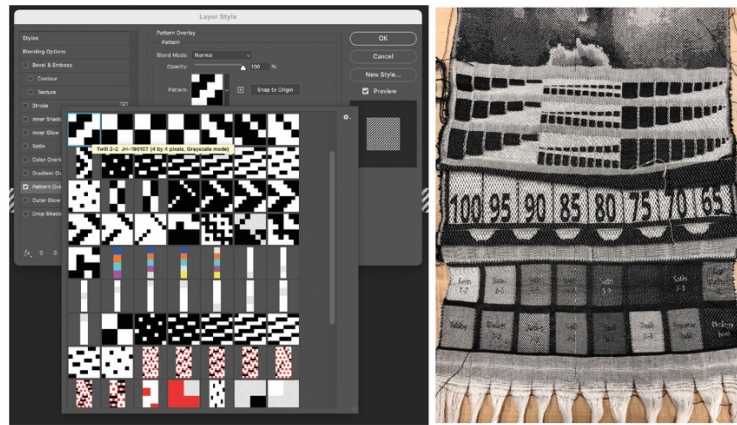


Figure 2: the weaving presets in photoshop and the sample blanket demonstrating its effects in the woven cloth.

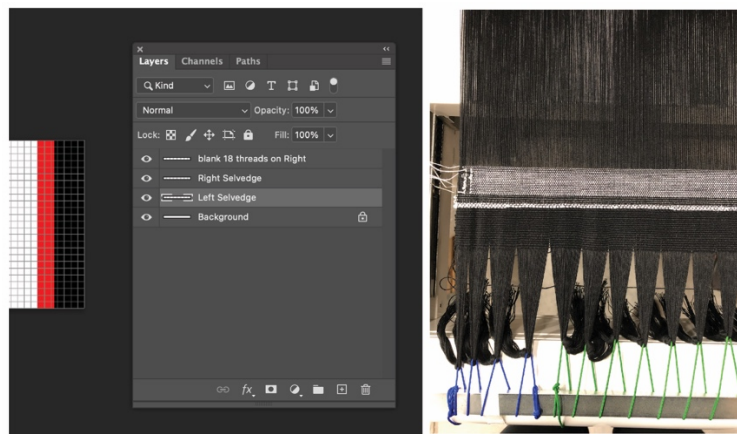


Figure 3: the photoshop template for the TC2 at TARP, including dead pixels at the end of the warp in photoshop and on the loom.



Figure 4: the loom with some first weaving samples and the MacBook pro with the TC2 software.

issues and jots down how many rows I've woven each day to get a sense of my *pixels per minute*. TARP gets to see what weavers might need help with, where the TC2 has issues, how much training is required, how much assistance is required, and how much time overall it will take Jen. And I get to weave.

During my last day at TARP, Jen and I cut off the final cloth, retie the knots around the elastic, and once again – **we tuck in the TC2**.

6.1.3 Reflection on landscape ethnography. Key sensitizing concepts applied in our account: refusal to universalize, attention to local practice, focusing on temporality

In writing this account, the sensitizing concept of refusal to universalize was easy to work into the story, as design is already a practice that explicitly deals with the particular. For example, I was not working with any yarn; I worked with black and white cotton. I was able to explore textural qualities in the way I did because the TC2 that I was working on had multiple modules and a dense warp, enabling the contrast between textures to become tangible.

As such, this method felt like an easy one to apply, not too different from other ways of describing design practice from a first-person perspective.

I paid attention to local practice by describing how Jen showed me to wind the spools, how the warp was wound to the beam with elastic to increase control over the tension distribution of the threads. Here too, the specificity of the TC2 set up at TARP plays a part in what I could explore in terms of weavings. Out of all three methods, mainly the focus on temporality, it allowed me to understand better the nonhumans participating. In describing the landscape of TARP, a nonhuman that I had previously taken for granted—the two pieces of denim fabric we used to cover the loom—exposed a temporal structure of my weaving activities. The recurring set of actions of tucking in the loom revealed not only the main activities and obvious nonhumans (the loom, the MacBook, photoshop, the cotton) but also the things of the landscape that were more tangentially related to my task at hand (the tufting gun, the sewing machine, leftover fabric of an older project). These landscape parts were less accessible to me but nonetheless actively present. The story of tucking in the loom is one of *maintaining* the constituency. The cloth draping over the loom and securing the edges to protect it from dust is a way of extending the machine's longevity for future weavers. The ritual also suggests that the participation of nonhumans (the denim cloth) need not always be toward a goal of production. But beyond a care-relation, the ritual of tucking in the loom also provided a structure, a rhythm of human to nonhuman relations that was considered so mundane it didn't even cross my mind to document it at the moment—the ritual only became present to me as a speaking subject in constructing the story. In writing the story as I did, structuring the account through the temporal events of tucking in the loom, I attempted to keep this mundanity intact but simultaneously attune to the role of the nonhuman. I wanted to maintain this quality so as not to redistribute relations in narrowly human-centred ways since focusing on one nonhuman is equally limiting as focusing on humans only. Describing the landscape and paying attention to the concerns amongst things in it allowed me to think multi-relationally.

6.2 Approach 2: Noticing

In her book *The Mushroom at the End of the World*, Anna Tsing tells the story of the Matsutake mushroom [109] as a multi-species ethnography. Tsing offers the approach of noticing differently, which has found resonance within more-than-human design research but remains somewhat challenging to make operational for designers. A key concept in Tsing's project is that of precarity, as she argues that the world we live in is defined by vulnerability, instability, and the ruins produced by capitalism. Simultaneously, her concept of contaminations highlights how new forms of multi-species relations can form *within* these ruins. She argues, rather than looking ahead to solutions, futures, or progress, we should look around and attune our abilities to notice what is newly produced in these ruins.

In her accounts, Tsing makes connections across landscapes (for her work, she follows the Matsutake mushroom through forests in China, Japan, Finland, and the US), reframes disturbances as a matter of perspective, and switches the perspective of narrators

to get to know the characters of the landscape. We integrate these strategies in our account of following knots to get to know the nonhuman characters of design. Tsing states: “telling stories of the landscape requires getting to know the inhabitants of the landscape, human and nonhuman.” [109:159]. To do this, Tsing shifts her perspective of a nematode to a pine tree, back to the Matsutake. Tsing warns us: “rather than limit our analyses to one creature at a time (including humans), or even one relationship if we want to know what makes places livable, we should be studying polyphonic assemblages, gatherings of ways of being” [109:157]. Tsing's concepts urge us to embrace heterogeneity and tension, not unified or harmonized nonhumans. Relations can be nonsensical, uninteresting, and disturbing. In drawing from Tsing's concepts and techniques, we ask what the inhabitants of design research are? How can we notice them differently?

6.2.1 Why noticing? The events inspiring this story occurred during my visit to the Unstable Design Lab, where I helped warp the TC2 loom. The main event that motivated this story was a knot formed during this process. I recognized this as a moment of non-human agency, in which something was created (the knot) that was not according to the plan or desire of the humans (us, warping the beam) and still shaped the process. This motivated me to further understand knots in the warping practice, and I saw an opportunity in Anna Tsing's noticing to understand knots differently.

6.2.2 Following Knots. I am a Wensleydale sheep. They call me the finest. Sometimes I even get mixed up with a Cashmere goat! I am from the UK, originally, but my kind can be found all over. I am known for my locks and my cheese. I suspect that is why I was saved from extinction when the humans lobbied for my survival in the 70s. My milk makes for moist, flaky, and slightly sweet cheese and my sheer don't kemp.

Why do I start this story from the perspective of a sheep? It was my first day at the Unstable Design Lab, and—prompted by a studio member—I took a quiz on a website called Woolery. Based on some questions about my hobbies, favourite colour, and ideal holiday location, it informed me that I am, indeed, a Wensleydale sheep. While there is some very clear anthropomorphizing going on here, I have also come to understand the possible benefits and unavoidability of this. So, I am curious to explore its nuances. I want to tell the story of knots, and to do so; I need to tell you about fibre. Fabrics and textiles traced all the way back are fibres. Each fibre, natural or artificial, has its properties: wool is stretchy, linen dries quickly, cotton is durable. The fact that Wensleydale's sheer doesn't kemp is great: it doesn't get into knots too quickly, it is not brittle, it can handle a bit of stretch. Fibres also have a texture, making them so suitable to weave with. Wool fibres, for example, hook into each other and keep themselves in place. These hooks and angles allow for the interaction between the weft and warp. Briefly, without overwhelming the reader with too many explanations of weaving terms, the warp is the yarn that is vertically threaded on a loom, the weft is the yarn that is added per row, thrown from one side to the other (or, as it was explained to me: weft = *left* to right). As we will see, there are times weavers want this hook and tangle interaction to happen, and there are times when they don't.

The Unstable Design Lab, led by Laura Devendorf, exists as a communal room with three offices: one for Laura, one for the grad

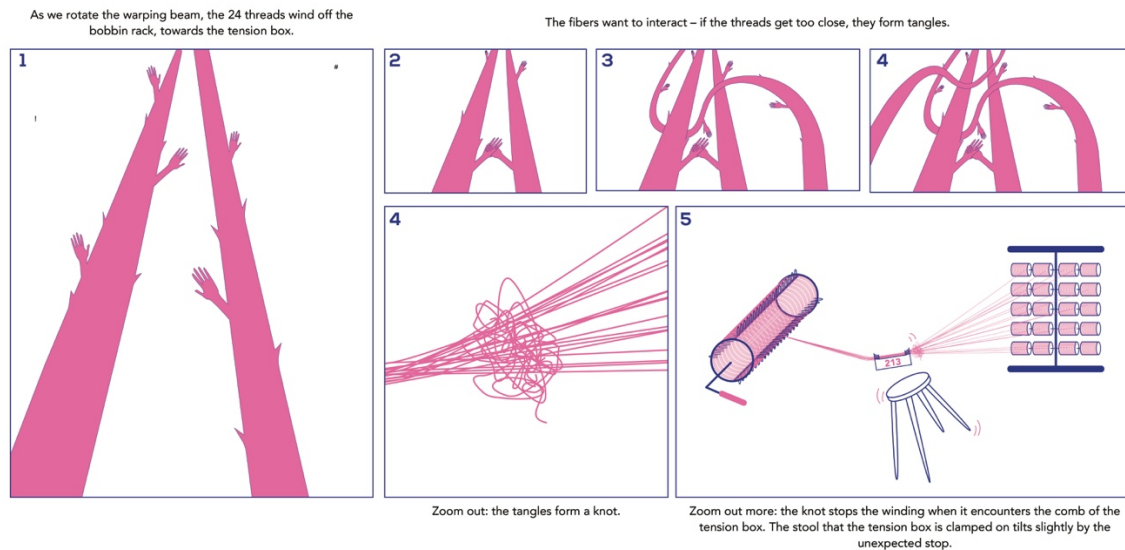


Figure 5: imagining the thread's journey.

students, and one flex-office for visitors or meetings. The main space has a long table on one end, two large whiteboards on the wall. A desk with a sewing machine and a long, narrow bar height table along the window facing the corridor that houses projects, materials, and samples. The other side of the room is loom-space. The TC2 stands on the side, with some space behind it. There is a wall filled with yarns in many colours, and in the corner of this wall, a section for conductive material. The warping beam stands in the middle of the space, in front of the TC2, and rests on two trestles with custom-made handles to rotate it. The warp on the TC2 is time-consuming and complicated to replace. It is often over 100 meters of yarn so that the TC2 can be used for a more extended time before it needs to be warped again. It is the first time the lab is attempting a sectional warp where the beam is warped in sections of thread instead of all at once. The warping beam has four wooden rods inserted with little metal dividers to accommodate this. A few other things are part of our warping setup: a bobbin rack with 24 equally weighted wound bobbins and a tension box with a counter resting on a stool.

The loom space expands as we start to warp. The communal chairs become barricades to prevent people from walking into the thread that goes from the bobbin rack through the comb of the tension box onto the warping beam. One part of the communal table has become inaccessible. It takes three people at a time to warp the beam: one to rotate the beam itself, one to keep an eye on the threads coming from the spool rack, and one to keep an eye on the counter. As a temporary responsibility, we are assigned to a part of the thread's journey. There is a fragility to the process of warping the loom, one that requires us to pay close attention. At one point, our warping is halted abruptly. I was rotating the warping beam when I suddenly felt resistance and noticed the stool that the tension box is clamped on slightly tilted under the tension of threads that have formed a knot. In figure 5, I imagine this situation from the thread's perspective.

We slowly roll the warping beam back, releasing some tension on the threads and allowing the stool to tilt back on all its legs. Pulling back the tangle of threads, we started to pull apart the knots that had appeared—for us seemingly out of nowhere. While doing so, we rolled back the bobbins on the bobbin rack to recreate tension on the threads we managed to free from the tangle, so they wouldn't find their way back in—as well as be able to follow the order of the other threads. We did this for quite some time until we decided the last few threads would take too long to separate. We cut the tangle out and bundled each side of the threads. Keeping tension on the threads that were intact through the bobbins, we began retracing the threads that had broken to tie them back in order. These knots will be encountered when the warp is on the loom: they might cause one of the threads to break again, or they may show up in a weaving.

Knots are often encountered in warping the TC2. We used a human-made knot to undo a fibre-made knot. When the winding of the warping beam is done, we move on to the next step: tying the warping beam to the existing threads on the TC2. **So. Many. Knots.** The space returns to its original setup. Chairs are back to being things to sit on, the communal table is accessible again, and the walkway is free. This is a one-person job. Tying each thread from the warping beam onto the existing threads held in order on the loom.

The back of this TC2 holds some documentation: a lifting schedule like the one I saw at TARP and a very helpful illustration of how to tie a weaver's knot: a knot that ties two threads together and allows you to pull it tight in one direction. There are scissors, a little comb to untangle threads, tape to hold threads in place. The warping beam sits below, and I use the loom to tension and tie the existing thread to the new one from the warping beam.

I am determined to get this done, so I spend the weekend tying knots. I am at about 120 knots an hour. There are threads everywhere. This may be a one-person job, but I would have done better



Figure 6: encountering tangles, knots during the warping of the TC2.

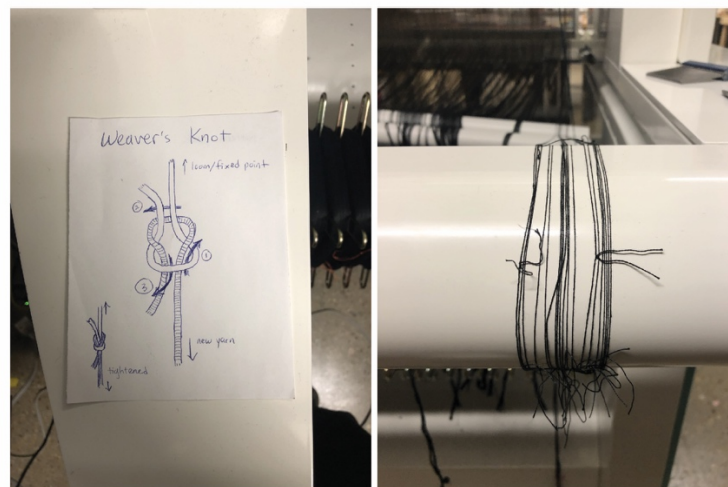


Figure 7: weaver's knots on the back of the TC2.

by stepping back. At around knot 800 out of 1320, I mess up and skip a warp section. I even documented it in a time-lapse video, but I only really notice it when I'm done, 460 knots later (3 hours and 48 minutes in human time). I confess to the others on Monday; we have a lab meeting. The good news (I tied all the knots!) and the bad news (I missed a section of about 60 threads). Laura decides it's ok—no use in retying 520 knots. I think back to the template at TARP, with the section of dead pixels at the end, and wonder how long my mistake will haunt the weavings of the Unstable Design Lab or visitors.

So far, I've told you about a knot that occurred while warping, the knots we had to tie to fix those knots, the many knots that were tied to connect the warping beam to the existing threads on the loom, and the missed knots. There are a few more knots in this

story. We guide the knots through the needles and heddle slots of the TC2, tie on the warp to the front rod, and adjust the ties to get equal tension. We weave a few rows to check for missing “pixels”—threads that are doubled up in a slot or loose threads. We use hooks, pins, magnets to hold threads in place. Loose threads are retied or pinned down. Double threads are traced to see if they are doubled in the needle or the slot. If they are double in the slot, we unweave and guide the threads again through the heddle. Eventually, we decide it's enough. There are still some errors: the one end of the loom has threads that don't lift as we anticipate, and the other side has my 60 missing threads—but it's good enough for now, and we make a photoshop template to work with these glitches.



Figure 8: working through the knots on the front of the TC2.

6.2.3 Reflection on noticing. Key sensitizing concepts used in our account: switching perspective in the narrative, accepting a state of precarity/fragility, focusing on disturbances.

Through this story of knots, I attuned myself to fibres of the threads. I used the sensitizing concept of switching perspectives in the narrative. For example, I allowed myself to anthropomorphize with the Wensleydale sheep and the illustration of hands as hooks of fibres. Speculatively tracing the material back to the sheep was an effort to understand better the fibre and its tendencies. It also made me consider how we should do this in future practice and consider the histories of the materials we choose to work with. The method of noticing allowed me to understand what was gathered and what *should have* been gathered in the constituency.

While it might be a stretch to call the warping set up precarious in the same sense as experienced by the Matsutake mushroom foragers, it was undoubtedly fragile and required care and attention throughout. For example, when winding the yarn on the beam, each of the warpers was assigned to a particular part of the journey of the thread. The attention paid to these parts revealed certain relations of nonhumans such as thread, tension, and movement that are essential in weaving but more or less taken for granted when all intact on the loom. The moment of fragility in the warping setup allowed me to understand these relations differently than when I was weaving on the loom at TARP, where the warping was done for me. It gave me insight into the constituency, what happens, and what is gathered—in particular ways—before weaving.

By following knots, I came to understand disturbances more generously. I began to see knots everywhere. It started feeling almost unreasonable to be annoyed with the accidental knots when I was tying on so many intentional ones only a few hours later. Tsing reminds us: “whether a disturbance is bearable or unbearable is a question worked out through what follows it: the reformation of assemblages” [109:160]. The retying of the loose threads as well as the salvaging of loose threads, and the acceptance of an incomplete warp and modified photoshop template are ways of embracing these disturbances as both human (the error in missing a section of knots

when tying on) and nonhuman (the behaviour of the fibre)—while still making them workable.

Using the sensitizing concepts of fragility and precarity and disturbances became more intertwined in my descriptions. I now see the incomplete warp with retied knots as a particular fragility. Weaving always requires attention to potentially retie knots, again. I came to see disturbances as a way to accept the state of fragility that I was working in, one that allowed me to notice the relations between the loom, the threads, and my weaving differently.

6.3 Approach 3: Translations

In this last explorative repertoire, we draw from Bruno Latour’s account of soil in Boa Vista [65]. In his writing, Latour describes and shows the reader the tools of soil scientists used to understand, translate, and document the soil. Through this, he aims to show us the layers of translation that happen between the soil in Boa Vista and the scientists’ lab. Through his writing, Latour reveals the networks of humans and nonhumans that collaboratively examine the soil. Latour creates a presence for nonhuman participation in his account through detailed writing of tools, materials, and translations. In the formal approach of Actor-Network Theory, these translations have particular and specified steps that we do not use explicitly but were certainly guided by. These are *problematization* (the process of a pivotal actor identifying other actors’ unmet interests and goals), *interessment* (the key actor utilizing actions to interest actors in the new goal), *enrolment* (onboarding of new actors, which can also involve resistance), *mobilization* (the activation of the network) and *dissidence* (unexpected acts by actors and destabilization or dissolution of the network) [9]. Latour emphasizes the humorous shortcomings of language—for example, when the scientists describe soil as clay-y sand or sandy clay. The tools used, Latour argues, express things that language alone can’t, but both are translations, transformations: they attempt to capture the actual thing or phenomenon but will always simultaneously bring us closer and farther away from it. They are, as he calls them, *circulating references*. By utilizing Latour’s writing as a guide, we

explore: what are the circulating references of design research? What do they help us understand, and where might they create blind spots?

6.3.1 Why Translations? In this account, I describe the weaving events in the WiFi antenna project that led us to inquire into new conductive yarn. The main event in the story is the breaking of the yarn we were working with when switching from a prototyping loom (the TC2 jacquard loom) to an industrial loom (the Itema r9500). I chose to explore Latour's method of translations, as I recognized a moment of dissidence in this event. Latour describes the practices of two pedologists, one geographer and a botanist, on their joint expedition and the common quest that drives the group of scientists in the Amazon forest to understand the soil. Using their reference systems and tools, the scientists bring back translations of the forest to their laboratories. In our case, the Everyday Design Studio is collaborating with Milou Voorwinden from EElab, a weaving company based in the Netherlands. I am also using the visit at the Unstable Design studio to weave the first samples on the TC2 jacquard loom of the lab. We are similarly making samples, bringing them back to research environments measuring, and collectively investigating a question that we share: what does a woven antenna look like? In exploring this method as a potential repertoire, I used the methods of empathizing with the tools we use, describing the translations we make, and focusing on reaching a collaborative understanding across our different locations.

6.3.2 Sampling Threads. I am at the Unstable Design Lab, carrying with me—on my laptop—a report made by Henry with a variety of antenna designs suited for 2.4GHz, the frequency that Wi-Fi operates on. I look through them to see which ones are suitable for weaving: shapes that allow the thread to travel from left to right and back. I weave text into the cloth to label the weaving structures I used (satins, twills, basket weaves), and I do the same for antenna types (metal-plated, bipolar). I attached paper labels to indicate and remind myself of the weft-material I used (Elektrisola, linen, cotton of different thicknesses, polyester). While the cloth was still on the loom, I used a multimeter to check for connectivity across patches. This quick test gave me enough insight to continue with more complex antenna patterns, as I now know that even when cut, the conductive thread strands made enough connection across the picks. The real test will come later when Henry uses his setup to test if the antennas will work with a home router. Latour describes how the soil scientists send the soil back to their labs, use tools to describe the states, make reports. I, too, write a report: which antennas were the easiest to weave? Which strategies worked well, which didn't? What are other options we could explore?

I am back in Vancouver now, and the COVID-19 pandemic has started. The Everyday Design Studio is empty; its parts and machines are distributed over people's homes. We have started relying even more on translations by working from home: photos, reports, Miro, sound recordings, and video reports of our work with the antennas. Using a vector antenna analyzer, Henry tests the different woven antennas for their connectivity at his home. To our surprise, they work quite well. In his video, he shows us how he can connect the woven router in his living room and load a YouTube video on his phone, connected to the Wi-Fi, from his kitchen. Our investigation

with these first samples was simple: can we weave antennas? Do they work?

Now that we have some results, we want to move to a more refined weaving. Milou from EElab works with an industrial loom, an Itema r9500, specialized for weaving labels, like the one in your shirt telling you which brand or size it is or how to wash it (another circulating reference). The loom has a much higher density of threads than the TC2 we have woven on previously, allowing us to create much finer antenna patterns. It is automatic—no more throwing the heddle from left to right and back.

As we work across continents, we cannot touch, move, and inspect the materials we work with directly, so here we also translate. Milou and I meet on zoom to go over the more successful antenna designs. I've worked with illustrator and photoshop for weaving on the TC2, but Milou works with different software, DesignScope Victor. We work together to move these across the software. Through Latour's terms, a translation of translation as we do this work without an actual thread in sight (or well, maybe a few, in our zoom-backgrounds). The loom that Milou works on has some other differences. On the TC2, I could insert conductive yarn as an additional weft in certain sections only, but the Itema r9500 uses the yarns across the whole cloth and only from left to right (not back and forth). We adjust our designs to accommodate this. We add floats (longer sections on the cloth where the weft goes over the warp, creating long strands of yarn), rotate designs to waste less of the conductive material, and group similar antennas on the same rows.

Milou runs into a problem when she starts weaving. The Elektrisola, which performed so well in our earlier tests, keeps breaking on the Itema loom. Milou has two possible explanations: the Elektrisola is wound on a cone incompatible with the Itema r3500, and the Elektrisola yarn itself has no stretch (remember the Wensleydale sheep?).

We need to reconvene, and our questions expand. Is it possible to wind the Elektrisola on another cone? Can we build something to allow it to roll off the cone more easily? Milou is skeptical. The yarn will still not stretch and risk breaking when the Itema loom grabs it to weave automatically. I start looking for a new conductive yarn and consider its specifications. It needs to be wound on a cone compatible with the Itema r9500 loom, it needs to suit our conductivity needs, and we have a few additional requirements for elasticity, twist, and dtex. I consult with Henry to measure the conductance of stainless-steel yarn, Elektrisola, and a coax core with a multimeter to approximate what we are looking for (see Figure 15). With the information I gathered, I contacted Swicofil, a Swiss company that Milou previously worked with to acquire yarn for EElab. After a consultation and sending more translations back and forth, I opt for gold and a silver plasma-coated yarn, and we start our tests again. Milou weaves a sample cloth with antennas, sends them to Vancouver; Henry tests them with his home-router testing set up, and Ron starts using them with his home router. We make another report.

6.3.3 Reflection on translations. Key sensitizing concepts applied in our account: prioritizing imagery over language, detailed descriptions of tools, materials, and translations, dissidence of nonhumans.



Figure 9: weaving with the conductive material on separate bobbins as additional weft and measuring connectivity with the multimeter



Figure 10: A scan (stitched together in photoshop) of woven antenna sample with labels and woven text indicating the difference between swatches

In exploring Latour's translations, it became clear how the tools of my practice both enabled and limited the team's understanding of the conductive material. While we were not in a forest collecting soil, it was not difficult to spot the circulating references that mediate in design research practice: woven text labelling weaving samples, attached labels to separate the material, a vector antenna analyzer, multimeters, weaving drafts. We were not collecting soil

samples to bring back to a laboratory, but we were attempting to collect and create knowledge that we can bring back to the Everyday Design Studio and our collaborators.

The prioritizing of imagery was already present in the teams' communication: annotated imagery of what spools would work, highlighting parts of the Iteima r9500 loom and generally sharing sketches and ideas. It was, therefore, relatively easy to work into the story. On reflection, what I prioritized more than the imagery in the account was the questions that guided our practice, such as:



Figure 11: photograph of the labelled antenna sample before cutting and scanning (the observant reader may recognize some pins and knots from Figure 8).



Figure 12: Henry's set up to test the antennas, including clippers, a multimeter, and coax cables that need to be attached to each sample, and testing an antenna sample with a vector antenna analyzer.

which antennas function on the 2.4Ghz range? How do we translate an antenna design into a weave-able shape (that goes from left to right)? Is it possible to wind the Elektrisola on a different cone?

Through telling this story, I also came to see what could or should have been part of the constituency, such as tools to understand elasticity and other yarn qualities beyond just the conductivity and other antenna-related qualities we were focused on.

Lastly, the translation steps mapped easily to the design process and can be seen as cycles through which we can better understand the nonhumans that gathered. The dissidence (the breakage of the Elektrisola) followed a process of problematization (the human actors wanting to weave with a higher density), interestment (starting

a collaboration with the Itema loom and Milou), mobilization (the preparatory work of translating weaving files across software). The breakage itself started a new cycle, where the problematization was initiated by the withdrawal of the Elektrisola, leading to the enrollment of Swicofil and the new material.

7 FINDINGS

These stories were written retrospectively after the events but acted as a generative, analytical tool for the FA. She reconstructed the events and gained a new understanding through the three different approaches. An important nuance is that FA, as a visitor, arrived

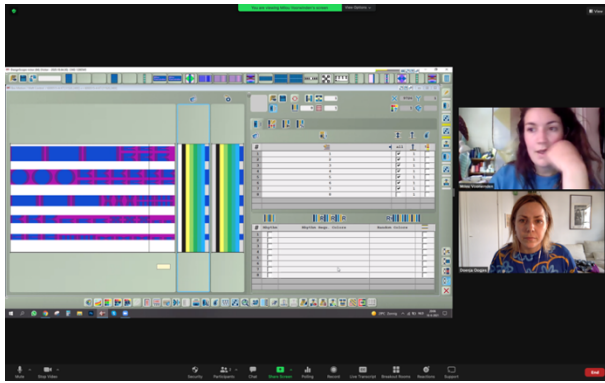


Figure 13: a screenshot of a zoom meeting between FA and Milou Voorwinden to translate antenna designs to weave on the Itema r9500.

as a designer with nonhuman designers in tow to an already existing constituency, whether that was TARP or the Unstable Design Lab. The repertoires captured and acted within the dynamic of designer and constituency. Overall, we found the methods used (landscape ethnography, noticing, and translations) mapped easily to the design research events, which further supports our argument of understanding design research practice itself as a more-than-human practice. In this section, we conclude on the potential of the approaches as repertoires. We reflect on their ability to articulate what and who was designing (speaking on account of the human/nonhuman designer assembly), what should have been gathered (convening the constituency), and what this taught us about designing-with nonhumans.

7.1 Repertoire: landscape ethnography through temporalities

The repertoire of landscape ethnography describes local practices, actions undertaken by the people of the place to maintain the constituency. Landscape ethnography also describes the particulars of design practice, such as specifics on material qualities, software, and tools, revealing the nonhumans that gathered in a broad, generous way. Lastly, landscape ethnography as a repertoire pays particular attention to the temporal scales of place. This repertoire enables the nonhumans to speak that are *tangentially* related to the task at hand. Particularly helpful for this task was the focus on temporal scales: what was in the landscape before you? What will come after you? How do the mundane events structure your activities in the landscape? Structuring the landscape through a temporal lens makes it possible to see the assembly of humans and nonhumans as it is present before design. Landscape ethnography helped make present to me nonhumans that spoke and were present in the events but initially overseen. This was retrospectively helpful, but it fell short in giving insights on which nonhumans *should have* participated. The repertoire of landscape ethnography is successful in speaking on account of the humans and nonhumans but less so in *convening* the constituency.

7.2 Repertoire: noticing through fragility

The repertoire of noticing focuses on precarity and disturbances to increase attention, to notice the relations between nonhumans differently. The method of noticing is different from the other two. It utilizes a narrower focus, following one kind of nonhuman, rather than the more equally divided attention of describing a landscape or attending to translations. We found that precarity/fragility enabled us to understand relations amongst nonhumans in design practice and see disturbances to draw our attention to this. When applying the repertoire of noticing through fragility, we suggest design researchers focus on their practice's fragile or precarious moments. We described a warping setup, but we can see similar qualities in soldering electronics, firing clay in a kiln, or setting the intensity of a laser cutter to accommodate different materials.

7.3 Repertoire: translations through questions

The repertoire of translations is made by describing design research tools, mainly through the questions asked *through* them. We found that describing tools and materials and the prioritization of images is already fairly common in design; the articulation of the questions that are asked through these actions is helpful in further articulating the nonhumans that are being invited to participate.

We see similarities between landscape ethnography and translations in what is given attention to through our descriptions: broad, inclusive, and detailed descriptions of tools, materials in design research. However, unlike landscape ethnography, we found that the repertoire of translations can also make present the material that should have been present through the use of different tools or by consulting the constituency differently. It is, therefore, also a fruitful repertoire for convening the constituency.

8 LESSONS FOR THE SPEAKING SUBJECT

This last section discusses initial lessons learned for the speaking subject. We structure our three lessons in relation to the positions or approaches of the speaking subject as proposed by Wakkary: *not-knowing*, *transmogrification*, and *horizontality* we introduced earlier (see 3). These lessons collectively illustrate how the proposed repertoires allowed us to better understand our design practice within a posthumanist framing. These insights also close the gap between non-design to actionable repertoires that the speaking subject can use.

8.1 Not knowing: assume a humble position for the speaking subject

Firstly, Wakkary suggests not-knowing as an approach for the speaking subject. Wakkary argues to go beyond common design practice of problem-framing and problem-solving, to stay with the trouble, but even more so to “act from a position of not-knowing or partial knowing” [111:246]. In our stories, we recognize the ability of the designer to act from such a position in two ways. Firstly, the FA's limited experience with weaving positioned her as a novice, one that requires them to act or learn with a starting position of not-knowing. Secondly, the FA was a visitor in the places she practiced weaving, enabling a position of partial knowing.

In the stories, we have described different places that are part of the constituency: TARP, the Unstable Design Lab, and a *space* that

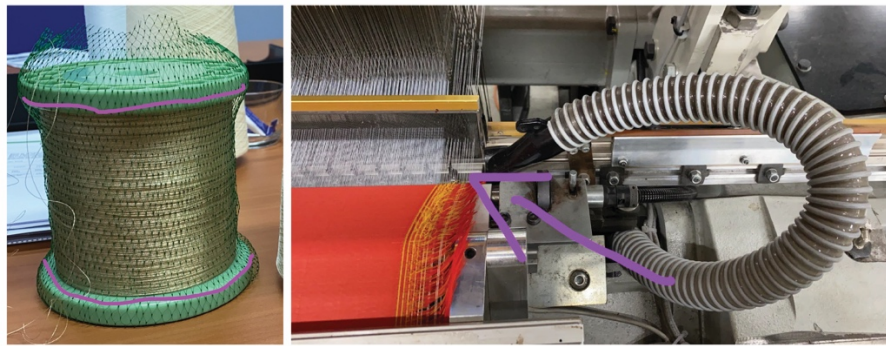


Figure 14: Part of the problem: the grabber from the Itama r9500 loom is incompatible with the non-stretch Elektrisola. The edges of the cone (on the right) make for uneven unwinding.

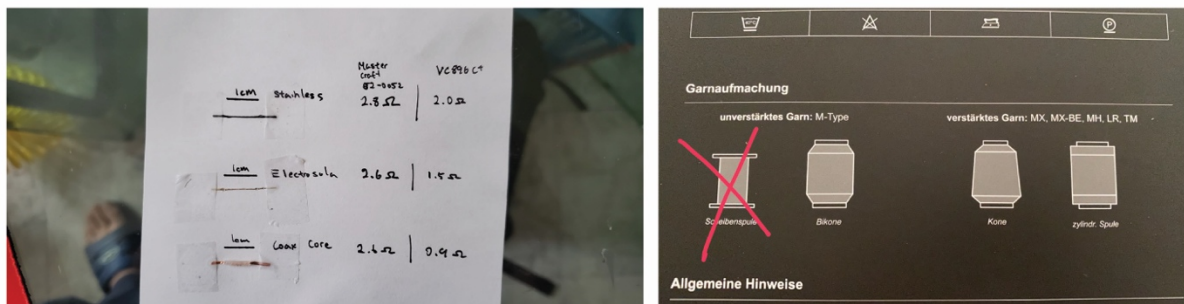


Figure 15: an overview of consults to understand the requirements of the new yarn. On the left, Henry outlines the conductivity range the new material needs to have, and on the right, Milou annotates on a document from Swicofil which spool we can't use on the loom at EElab.

existed physically across Vancouver (the Everyday Design Studio and its member's work-from-home spaces) and the Netherlands (EElab) but was primarily accessed over translations such as Zoom, Miro, WhatsApp and signal. The FA's position in these spaces was that of a visitor. In all places, the FA was there with a goal that did not entirely align with the purposes of the space. Compare, for example, TARP and the Unstable Design Lab. The TC2 at TARP was set up for weaving graphical and photographic cloth. The TC2 at the Unstable Design Lab was set up for making prototypes, exploring computation, and weaving. These intentions materialize by comparing the yarns used in the TARP and the Unstable Design Lab (black and white versus many colours and materials). The TC2 looms with their modules and respective density. While TARP was set up for detailed graphical work, with a higher density of pixels per row, the TC2 loom was meant for prototyping and larger cloths, with more space between threads. The TC2 loom at TARP was meant for semi-public use—students, visiting researchers—and the FA was there as a test subject. The TC2 at the Unstable Design Lab is there for the lab's students. The FA earned her weaving time by contributing to the warping process, and accessing these spaces as a visitor meant gaps in the FA's understanding of the relations amongst the things in them. When Jen left to fix the loom at TARP, the FA didn't know where she went or what she did to recuperate the loom. When the FA was not working on the loom, others were

in the space using the tufting gun or working at the desk. At the Unstable Design Lab, the FA was helping with the warping process that was new to her but also to most others in the lab as it was the first time the lab was attempting a sectional warp. This created a space open for questions and contestations but with a persistency to act.

Through these stories, we have come to understand the position of a *visitor* and *novice* to enable working with *not-knowing* and *humility*. We see this in line with approaches such as inarticulacy [43], in which the authors report to work through their design process with “a degree of chutzpah” [43:2125]. Still, this position of productive not-knowing is in stark contrast with common approaches within HCI that invite experts or domain professionals. More broadly, and in relation to our theoretical framing, posthumanist, critical race theory and postcolonial literature have proposed approaches of unlearning [92] to overcome deeply rooted humanist framings in knowledge inquiry that we suspect are also present in the conceptual ‘expert.’ We propose the position of visitor and novice as a fruitful way to practice humility, unlearn and not-know in design research.

8.2 Transmogrification: allow nonhuman temporalities to guide practice

Wakkary introduces the concept of transmogrification as an often-experienced side-effect to positions of not-knowing: “*a seemingly magical change of who we are in relation to things and nonhumans*” [111:248]. In the weaving stories, this transmogrification was experienced explicitly when taking the perspective of a thread, but also more subtly in the FA’s shifting experiences of time and material traces.

Throughout the stories, we have woven in nonhuman temporalities such as *rows-per-minute*, *knots-per-hour*, *material enforced breaks*, and *rituals that structure practice*, such as tucking in the loom. We see this as transmogrification in how hierarchies are restructured. For example, rows-per-minute and knots-per-hour prioritize rows and knots over minutes and hours: the human weaver is put in service of the nonhuman designer, the constituency.

In describing the forming of knots, the FA attended to the perspective of the yarn. This allowed the FA to understand the nuances of the relations between yarn and weaver, or more broadly, material and designer. The FA wrote: there are times weavers want this to happen, and there are times when they don’t. The FA described knots made by the yarn, undesired by the weaver, and many knots tied by her as part of the weaving process. But what does the yarn want? By zooming in on the perspective of the yarn, it becomes clear that it performs similarly across the warping and weaving process: it is the human weaver imposing on the material that changes the situation. The attention paid to the knots and errors while warping the beam at the Unstable Design Lab can also be seen as a material-temporal commitment. The way a loom is warped determines what the loom is for some time. This is clear in the commitment to the material that is warped with and in the glitches in the photoshop templates, observed at both TARP and the Unstable Design Lab, as traces of warping events that continue to be present in weavings. Recruitment within the constituency has a temporal element. Longer-term commitments to materials are a way to enable nonhuman temporalities to guide practice.

Nonhuman temporalities could be applied in design projects in other ways by prioritizing materials and their temporal structures over other concerns. This connects to works in HCI such as Odom and co-authors choice to work with wood from a fallen tree [85], the processes of clay and its drying time that are prioritized in Liu’s work with decomposition [74], and explorations of material traces by Giaccardi and co-authors [46]. There is an opportunity to extend this work and commit to the temporalities of materials not just in their recruitment at the start of a project but to understand it as ongoing and integrate rituals to maintain the materials. We see an opportunity here to connect the lens of nonhuman temporalities to design research tools that can serve as tools for noticing during the design process, such as measuring or recording devices that have a timespan or end-of-life expression. Enabling nonhuman temporalities also means adjusting our own pace: nonhumans might take longer to speak or disclose themselves over different time structures. Allowing nonhuman temporalities to guide practice could look like integrating moments of doing nothing, stepping back, and practicing patience.

8.3 Horizontality: embrace disturbances as moments of listening to members of the constituency

Wakkary offers the metaphor of horizontality for a more generous designing-with. Horizontality, in contrast to verticality, gives up the powerful position of an all-seeing human and calls for “a fall to the ground” [111:251], to be alongside other humans and nonhumans. Through this, the contact points between humans and nonhumans are expanded, increasing the multiplicity of relations. In the weaving stories, we recognize this horizontal position of the FA when experiencing and reframing moments of disturbance.

In the story of *Following Knots*, we told a story about an event that allowed us to pay attention, to notice the knots that abruptly stopped our warping process. But it is essential to understand that this was a disturbance *for us*, the humans warping the beam and not necessarily for the thread itself. Anna Tsing proposes disturbances as an analytical tool that requires awareness of the observer’s perspective. It was simply an interaction for the fibre, expected and even desired by the weaver later on in the process. Disturbances have the potential to be seen as a generative tool for understanding relations.

In our third story, we can see disturbances as generative in practice. Our tools, such as the multimeter and the antenna vector analyzer, allowed us material insights—even in materials that were yet to be acquired. Still, using these tools and not others made us oversee other yarn qualities such as elasticity and the cone the material was wound on. In the story of the conductive yarn, we learned that nonhumans could initiate the process of recruiting for the constituency. In our case, the coming together of the Itema r9500, the Elektrisola, and the spool it was wound on prompted a re-assembly within the constituency. The recruitment of new material, a new member of the constituency, required preparatory work that resulted in requirements such as choice of the spool and a range of conductivity. This clarifies the work of the speaking subject as ongoing: recruiting, maintaining, and attending to the constituency happens before design but is open to contestation. The Elektrisola expressed its non-participation, and the speaking subject chose to find a different yarn to work with. Recruiting for the constituency can also mean excluding and choosing one nonhuman over another. In this case, the speaking subject prioritized working with the Itema r9500 loom, which excluded the Elektrisola from the constituency.

We see the commitment of understanding disturbances within design research more deeply as an ontological opportunity, in line with Leahu’s investigation into machine learning glitches. Leahu highlights not only the chance for approaching such surprises as ontological opportunities but also the particular commitments needed to consider thingly expressions (such as glitches, errors, crashes, and breakdowns) as learning moments or even simply as the revealing of human-centred blind spots. Other design research has considered such expressions though primarily for its potential for aesthetic interactions, such as breakdown and repair [59], wabi-sabi [108], impermanence and patina [68, 69, 107], traces [46, 102], decomposition [74, 79], un-crafting and fragility or magic [2, 63]. There is also an area of research reporting on mistakes, unintentional aspects, and re-framings in design research practice [44, 57, 88, 106]. The

notion of disturbances within designing things is a way of horizontalizing, revealing, and generating aspects of the constituency.

9 CONCLUSION

This paper developed *repertoires*: actions the human designer can perform in a posthuman understanding of design. We explored three anthropologically derived methods to provide accounts of weaving events the first author was involved in. We contribute three repertoires that can increase nonhuman participation in design practice through critical reflection of these accounts. We also contribute an example of applying the theoretical framework of *Designing Things*. Future work will include using these repertoires in other design research projects and further developing repertoires with different approaches, such as Vinciane Despret's reframing of research questions [16] and Donna Haraway's multi-species kinships [51]. We also invite design researchers to explore other approaches beyond Wakkary's suggestions that share similar posthuman assumptions, as we did by including Watts' describing the landscape [114]. While we have provided one way to develop repertoires, we acknowledge that there are possibly many more. Our work currently lacks clarity on the selection criteria of such starting points. The work of developing repertoires is explorative in understanding what they are and how they relate to other activities of design and HCI.

ACKNOWLEDGMENTS

We thank our colleagues and collaborators of the Everyday Design Studio, the TARP lab at Material Matters, Emily Carr University of Art and Design, the Unstable Design Lab at the University of Boulder, Milou Voorwinden and Pauline van Dongen. We thank the reviewers for their insightful comments and encouragement. NSERC and SSHRC funded this research. The work is created on the unceded ancestral territory of the $\chi^w m \theta k w \acute{o} y \acute{a} m$ (Musqueam), Skwxwú7mesh (Squamish), and $S \acute{a} l i l w \acute{o} \acute{a} l$ (Tseil-Waututh) Nations. We acknowledge that the knowledge of more-than-human-centred worlds, while only recently introduced to the field of design and HCI, has always been foundational in many Indigenous forms of knowledge and practices. Therefore, we see it as essential to approach it from humility and generosity.

REFERENCES

- [1] David Abram. 1997. *The Spell of the Sensuous: Perception and Language in a More-Than-Human World*. Vintage, New York.
- [2] Kristina Andersen and Ron Wakkary. 2019. The Magic Machine Workshops: Making Personal Design Knowledge. In *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems* (CHI '19), 1–13. <https://doi.org/10.1145/3290605.3300342>
- [3] Kristina Andersen, Ron Wakkary, Laura Devendorf, and Alex McLean. 2019. Digital crafts-machine-ship: creative collaborations with machines. *Interactions* 27, 1: 30–35. <https://doi.org/10.1145/3373644>
- [4] Karen Barad. 2007. Meeting the Universe Halfway: Quantum Physics & the Entanglement of Matter & Meaning. Duke Univ Pr, Durham.
- [5] Maria Puig de la Bellacasa. 2017. *Matters of Care: Speculative Ethics in More than Human Worlds*. Univ Of Minnesota Press, Minneapolis.
- [6] Jane Bennett. 2009. *Vibrant Matter: A Political Ecology of Things*. Duke Univ Pr, Durham.
- [7] Heidi R. Biggs and Audrey Desjardins. 2020. High Water Pants: Designing Embodied Environmental Speculation. In *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems* (CHI '20), 1–13. <https://doi.org/10.1145/3313831.3376429>
- [8] Rosi Braidotti. 2013. *The Posthuman*. Polity, Cambridge, UK; Malden, MA, USA.
- [9] Michel Callon. 1984. Some Elements of a Sociology of Translation: Domestication of the Scallops and the Fishermen of St Brieuc Bay. *The Sociological Review* 32, 1_suppl: 196–233. <https://doi.org/10.1111/j.1467-954X.1984.tb00113.x>
- [10] Wen-Wei Chang, Elisa Giaccardi, Lin-Lin Chen, and Rung-Huei Liang. 2017. "Interview with Things": A First-thing Perspective to Understand the Scooter's Everyday Socio-material Network in Taiwan. In *Proceedings of the 2017 Conference on Designing Interactive Systems* (DIS '17), 1001–1012. <https://doi.org/10.1145/3064663.3064717>
- [11] Janghee Cho, Laura Devendorf, and Stephen Volda. 2021. From The Art of Reflection to The Art of Noticing: A Shifting View of Self-Tracking Technologies' Role in Supporting Sustainable Food Practices. In *Extended Abstracts of the 2021 CHI Conference on Human Factors in Computing Systems* (CHI EA '21), 1–7. <https://doi.org/10.1145/3411763.3451838>
- [12] Lorenzo Davoli and Johan Redström. 2014. Materializing Infrastructures for Participatory Hacking. In *Proceedings of the 2014 Conference on Designing Interactive Systems* (DIS '14), 121–130. <https://doi.org/10.1145/2598510.2602961>
- [13] Gilles Deleuze and Felix Guattari. 1987. *Thousand Plateaus: Capitalism and Schizophrenia*. Univ Of Minnesota Press, Minneapolis.
- [14] Audrey Desjardins and Aubree Ball. 2018. Revealing Tensions in Autobiographical Design in HCI. In *Proceedings of the 2018 Designing Interactive Systems Conference* (DIS '18), 753–764. <https://doi.org/10.1145/3196709.3196781>
- [15] Audrey Desjardins and Cayla Key. 2020. Parallels, Tangents, and Loops: Reflections on the "Through" Part of Rtd. In *Proceedings of the 2020 ACM Designing Interactive Systems Conference* (DIS '20), 2133–2147. <https://doi.org/10.1145/3357236.3395586>
- [16] Vinciane Despret. 2016. *What Would Animals Say If We Asked the Right Questions?* Univ Of Minnesota Press, Minneapolis.
- [17] Laura Devendorf, Kristina Andersen, and Aisling Kelliher. 2020. Making Design Memoirs: Understanding and Honoring Difficult Experiences. In *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems* (CHI '20), 1–12. <https://doi.org/10.1145/3313831.3376345>
- [18] Laura Devendorf, Kristina Andersen, Daniela K. Rosner, Ron Wakkary, and James Pierce. 2019. From HCI to HCI-Amusement: Strategies for Engaging What New Technology Makes Old. In *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems* (CHI '19), 35:1–35:12. <https://doi.org/10.1145/3290605.3300265>
- [19] Laura Devendorf, Katya Arquilla, Sandra Wirtanen, Allison Anderson, and Steven Frost. 2020. Craftspeople as Technical Collaborators: Lessons Learned through an Experimental Weaving Residency. In *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems* (CHI '20), 1–13. <https://doi.org/10.1145/3313831.3376820>
- [20] Laura Devendorf, Abigail De Kosnik, Kate Mattingly, and Kimiko Ryokai. 2016. Probing the Potential of Post-Anthropocentric 3D Printing. In *Proceedings of the 2016 ACM Conference on Designing Interactive Systems* (DIS '16), 170–181. <https://doi.org/10.1145/2901790.2901879>
- [21] Laura Devendorf and Chad Di Lauro. 2019. Adapting Double Weaving and Yarn Plying Techniques for Smart Textiles Applications. In *Proceedings of the Thirtieth International Conference on Tangible, Embedded, and Embodied Interaction* (TEI '19), 77–85. <https://doi.org/10.1145/3294109.3295625>
- [22] Laura Devendorf, Joanne Lo, Noura Howell, Jung Lin Lee, Nan-Wei Gong, M. Emre Karagözlü, Shihō Fukuhara, Ivan Poupyrev, Eric Paulos, and Kimiko Ryokai. 2016. "I Don't Want to Wear a Screen": Probing Perceptions of and Possibilities for Dynamic Displays on Clothing. In *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems* (CHI '16), 6028–6039. <https://doi.org/10.1145/2858036.2858192>
- [23] Laura Devendorf and Kimiko Ryokai. 2015. Being the Machine: Reconfiguring Agency and Control in Hybrid Fabrication. In *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems* (CHI '15), 2477–2486. <https://doi.org/10.1145/2702123.2702547>
- [24] Laura Devendorf and Kimiko Ryokai. 2015. Redeform: Participatory 3D Printing in Public Spaces. In *Proceedings of the Ninth International Conference on Tangible, Embedded, and Embodied Interaction* (TEI '15), 423–424. <https://doi.org/10.1145/2677199.2690880>
- [25] Kristin N. Dew and Daniela K. Rosner. 2018. Lessons from the Woodshop: Cultivating Design with Living Materials. In *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems* (CHI '18), 585:1–585:12. <https://doi.org/10.1145/3173574.3174159>
- [26] Kristin N. Dew and Daniela K. Rosner. 2019. Designing with Waste: A Situated Inquiry into the Material Excess of Making. In *Proceedings of the 2019 on Designing Interactive Systems Conference* (DIS '19), 1307–1319. <https://doi.org/10.1145/3322276.3322320>
- [27] Carl DiSalvo and Jonathan Lukens. 2011. Nonanthropocentrism and the nonhuman in design: possibilities for designing new forms of engagement with and through technology. In *From Social Butterfly to Engaged Citizen Urban Informatics, Social Media, Ubiquitous Computing, and Mobile Technology to Support Citizen Engagement*. MIT Press.
- [28] Pauline van Dongen, Ron Wakkary, Oscar Tomico, and Stephan Wensveen. 2019. Beyond Functionality in Wearables: A Material Aesthetics Analysis. Technical University of Eindhoven.

- [29] Pauline van Dongen, Ron Wakkary, Oscar Tomico, and Stephen Wensveen. 2019. Towards a Postphenomenological Approach to Wearable Technology through Design Journeys. <https://doi.org/10.17028/rd.lboro.9724649.v1>
- [30] Judith Dörrenbächer, Diana Löffler, and Marc Hassenzahl. 2020. Becoming a Robot - Overcoming Anthropomorphism with Techno-Mimesis. In *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems* (CHI '20), 1–12. <https://doi.org/10.1145/3313831.3376507>
- [31] Enrique Encinas, Mark Blythe, Shaun Lawson, John Vines, Jayne Wallace, and Pam Briggs. 2018. Making Problems in Design Research: The Case of Teen Shoplifters on Tumblr. In *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems* (CHI '18), 72:1–72:12. <https://doi.org/10.1145/3173574.3173646>
- [32] Enrique Encinas, Abigail C. Durrant, Robb Mitchell, and Mark Blythe. 2020. Metaprobes, Metaphysical Workshops and Sketchy Philosophy. In *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems* (CHI '20), 1–13. <https://doi.org/10.1145/3313831.3376453>
- [33] Arturo Escobar. 2018. *Designs for the Pluriverse: Radical Interdependence, Autonomy, and the Making of Worlds*. Duke University Press Books, Durham.
- [34] Ylva Fernaeus, Martin Jonsson, and Jakob Tholander. 2012. Revisiting the Jacquard Loom: Threads of History and Current Patterns in HCI. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (CHI '12), 1593–1602. <https://doi.org/10.1145/2207676.2208280>
- [35] Tiago M. Fernández-Caramés and Paula Fraga-Lamas. 2018. Towards The Internet of Smart Clothing: A Review on IoT Wearables and Garments for Creating Intelligent Connected E-Textiles. *Electronics* 7, 12: 405. <https://doi.org/10.3390/electronics7120405>
- [36] L. Forlano. 2016. Decentering the Human in the Design of Collaborative Cities. *Design Issues* 32, 3: 42–54. https://doi.org/10.1162/DESI_a_00398
- [37] Laura Forlano. 2017. Posthumanism and Design. *She Ji: The Journal of Design, Economics, and Innovation* 3, 1: 16–29. <https://doi.org/10.1016/j.sheji.2017.08.001>
- [38] Laura Forlano. 2017. Maintaining, Repairing and Caring for the Multiple Subject. *continent*, 6, 1: 30–35–35.
- [39] Sarah E. Fox, Meredith Lampe, and Daniela K. Rosner. 2018. Parody in Place: Exposing Socio-spatial Exclusions in Data-Driven Maps with Design Parody. In *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems* (CHI '18), 322:1–322:13. <https://doi.org/10.1145/3173574.3173896>
- [40] Christopher Frauenberger. 2019. Entanglement HCI The Next Wave? *ACM Transactions on Computer-Human Interaction* 27, 1: 2:1–2:27. <https://doi.org/10.1145/3364998>
- [41] Mikhaila Friske, Jordan Wirfs-Brock, and Laura Devendorf. 2020. Entangling the Roles of Maker and Interpreter in Interpersonal Data Narratives: Explorations in Yarn and Sound. In *Proceedings of the 2020 ACM Designing Interactive Systems Conference* (DIS '20), 297–310. <https://doi.org/10.1145/3357236.3395442>
- [42] Mikhaila Friske, Shanel Wu, and Laura Devendorf. 2019. AdaCAD: Crafting Software For Smart Textiles Design. In *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems* (CHI '19), 1–13. <https://doi.org/10.1145/3290605.3300575>
- [43] Cally Gatehouse and David Chatting. 2020. Inarticulate Devices: Critical Encounters with Network Technologies in Research Through Design. In *Proceedings of the 2020 ACM Designing Interactive Systems Conference* (DIS '20), 2119–2131. <https://doi.org/10.1145/3357236.3395426>
- [44] William Gaver, John Bowers, Tobie Kerridge, Andy Boucher, and Nadine Jarvis. 2009. Anatomy of a failure: how we knew when our design went wrong, and what we learned from it. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (CHI '09), 2213–2222. <https://doi.org/10.1145/1518701.1519040>
- [45] Elisa Giaccardi, Nazli Cila, Chris Speed, and Melissa Caldwell. 2016. Thing Ethnography: Doing Design Research with Non-Humans. In *Proceedings of the 2016 ACM Conference on Designing Interactive Systems* (DIS '16), 377–387. <https://doi.org/10.1145/2901790.2901905>
- [46] Elisa Giaccardi, Elvin Karana, Holly Robbins, and Patrizia D'Olivio. 2014. Growing Traces on Objects of Daily Use: A Product Design Perspective for HCI. In *Proceedings of the 2014 Conference on Designing Interactive Systems* (DIS '14), 473–482. <https://doi.org/10.1145/2598510.2602964>
- [47] Elisa Giaccardi and Johan Redström. 2020. Technology and More-Than-Human Design. *Design Issues* 36, 4: 33–44. https://doi.org/10.1162/desi_a_00612
- [48] Maas Goudswaard, Abel Abraham, Bruna Goveia da Rocha, Kristina Andersen, and Rong-Hao Liang. 2020. FabriClick: Interweaving Pushbuttons into Fabrics Using 3D Printing and Digital Embroidery. In *Proceedings of the 2020 ACM Designing Interactive Systems Conference* (DIS '20), 379–393. <https://doi.org/10.1145/3357236.3395569>
- [49] Bruna Goveia da Rocha and Kristina Andersen. 2020. Becoming Travelers: Enabling the Material Drift. In *Companion Publication of the 2020 ACM Designing Interactive Systems Conference* (DIS' 20 Companion), 215–219. <https://doi.org/10.1145/3393914.3395881>
- [50] Bruna Goveia da Rocha, Johannes M. L. van der Kolk, and Kristina Andersen. 2021. Exquisite Fabrication: Exploring Turn-taking between Designers and Digital Fabrication Machines. In *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems*. Association for Computing Machinery, New York, NY, USA, 1–9. Retrieved August 23, 2021 from <http://doi.org/10.1145/3411764.3445236>
- [51] Donna J. Haraway. 2003. *The Companion Species Manifesto: Dogs, People, and Significant Otherness*. Prickly Paradigm Press, Chicago.
- [52] Donna J. Haraway. 2016. *Staying with the Trouble: Making Kin in the Chthulucene*. Duke University Press Books, Durham.
- [53] Graham Harman. 2010. *Towards Speculative Realism: Essays and Lectures*. Zero Books, Winchester, UK.
- [54] Sabrina Hauser, Doenja Oogjes, Ron Wakkary, and Peter-Paul Verbeek. 2018. An Annotated Portfolio on Doing Postphenomenology Through Research Products. In *Proceedings of the 2018 Designing Interactive Systems Conference* (DIS '18), 459–471. <https://doi.org/10.1145/3196709.3196745>
- [55] Sara Hauser, Ron Wakkary, William Odom, Peter-Paul Verbeek, Audrey Desjardins, Henry Lin, Matthew Dalton, Markus Schilling, and Gijs de Boer. 2018. Deployments of the Table-non-table: A Reflection on the Relation Between Theory and Things in the Practice of Design Research. In *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems* (CHI '18), 201:1–201:13. <https://doi.org/10.1145/3173574.3173775>
- [56] Sara Heitlinger, Nick Bryan-Kinns, and Janis Jefferies. 2014. The Talking Plants: An Interactive System for Grassroots Urban Food-growing Communities. In *CHI '14 Extended Abstracts on Human Factors in Computing Systems* (CHI EA '14), 459–462. <https://doi.org/10.1145/2559206.2574792>
- [57] Noura Howell, Audrey Desjardins, and Sarah Fox. 2021. Cracks in the Success Narrative: Rethinking Failure in Design Research through a Retrospective Triethnography. *ACM Transactions on Computer-Human Interaction* 28, 6: 42:1–42:31. <https://doi.org/10.1145/3462447>
- [58] Miwa Ikemiya and Daniela K. Rosner. 2014. Broken probes: toward the design of worn media. *Personal and Ubiquitous Computing* 18, 3: 671–683. <https://doi.org/10.1007/s00779-013-0690-y>
- [59] Steven J. Jackson and Laewoo Kang. 2014. Breakdown, Obsolescence and Reuse: HCI and the Art of Repair. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (CHI '14), 449–458. <https://doi.org/10.1145/2556288.2557332>
- [60] Tom Jenkins, Christopher A. Le Dantec, Carl DiSalvo, Thomas Lodato, and Mariam Asad. 2016. Object-Oriented Publics. In *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems* (CHI '16), 827–839. <https://doi.org/10.1145/2858036.2858565>
- [61] Cayla Key, Fiona Browne, Nick Taylor, and Jon Rogers. 2021. Proceed with Care: Reimagining Home IoT Through a Care Perspective. In *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems*. Association for Computing Machinery, New York, NY, USA, 1–15. Retrieved September 9, 2021 from <http://doi.org/10.1145/3411764.3445602>
- [62] Lenneke Kuijer and Elisa Giaccardi. 2018. Co-performance: Conceptualizing the Role of Artificial Agency in the Design of Everyday Life. In *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems* (CHI '18), 125:1–125:13. <https://doi.org/10.1145/3173574.3173699>
- [63] Hanna Landin. 2005. Fragile and magical: materiality of computational technology as design material. In *Proceedings of the 4th decennial conference on Critical computing: between sense and sensibility* (CC '05), 117–120. <https://doi.org/10.1145/1094562.1094578>
- [64] Bruno Latour. 2004. Why Has Critique Run out of Steam? From Matters of Fact to Matters of Concern. *Critical Inquiry* 30, 2: 225–248. <https://doi.org/10.1086/421123>
- [65] Bruno Latour and Centre de Sociologie de L'Innovation Bruno Latour. 1999. *Pandora's Hope: Essays on the Reality of Science Studies*. Harvard University Press.
- [66] Shaun Lawson, Ben Kirman, Conor Linehan, Tom Feltwell, and Lisa Hopkins. 2015. Problematising Upstream Technology Through Speculative Design: The Case of Quantified Cats and Dogs. In *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems* (CHI '15), 2663–2672. <https://doi.org/10.1145/2702123.2702260>
- [67] Lucian Leahu. 2016. Ontological Surprises: A Relational Perspective on Machine Learning. In *Proceedings of the 2016 ACM Conference on Designing Interactive Systems* (DIS '16), 182–186. <https://doi.org/10.1145/2901790.2901840>
- [68] Moon-Hwan Lee, Seijin Cha, and Tek-Jin Nam. 2015. Patina Engraver: Visualizing Activity Logs As Patina in Fashionable Trackers. In *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems* (CHI '15), 1173–1182. <https://doi.org/10.1145/2702123.2702213>
- [69] Moon-Hwan Lee, Oosung Son, and Tek-Jin Nam. 2016. Patina-inspired Personalization: Personalizing Products with Traces of Daily Use. In *Proceedings of the 2016 ACM Conference on Designing Interactive Systems* (DIS '16), 251–263. <https://doi.org/10.1145/2901790.2901812>
- [70] Erin Lewis. 2020. Disobedient Antennas: Breaking the Rules of Textile Antenna Design. In *Companion Publication of the 2020 ACM Designing Interactive Systems Conference* (DIS' 20 Companion), 461–464. <https://doi.org/10.1145/3393914.3395843>

- [71] Ann Light, Alison Powell, and Irina Shklovski. 2017. Design for Existential Crisis in the Anthropocene Age. In *Proceedings of the 8th International Conference on Communities and Technologies (C&T '17)*, 270–279. <https://doi.org/10.1145/3083671.3083688>
- [72] Jen Liu, Daragh Byrne, and Laura Devendorf. 2018. Design for Collaborative Survival: An Inquiry into Human-Fungi Relationships. In *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems (CHI '18)*, 40:1-40:13. <https://doi.org/10.1145/3173574.3173614>
- [73] Szu-Yu (Cyn) Liu, Jeffrey Bardzell, and Shaowen Bardzell. 2018. Photography As a Design Research Tool into Natureculture. In *Proceedings of the 2018 Designing Interactive Systems Conference (DIS '18)*, 777–789. <https://doi.org/10.1145/3196709.3196819>
- [74] Szu-Yu (Cyn) Liu, Jeffrey Bardzell, and Shaowen Bardzell. 2019. Decomposition As Design: Co-Creating (with) Natureculture. In *Proceedings of the Thirteenth International Conference on Tangible, Embedded, and Embodied Interaction (TEI '19)*, 605–614. <https://doi.org/10.1145/3294109.3295653>
- [75] Szu-Yu (Cyn) Liu, Shaowen Bardzell, and Jeffrey Bardzell. 2019. Symbiotic Encounters: HCI and Sustainable Agriculture. In *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems (CHI '19)*, 317:1-317:13. <https://doi.org/10.1145/3290605.3300547>
- [76] Szu-Yu (Cyn) Liu, Jen Liu, Kristin Dew, Patrycja Zdzarska, Maya Livio, and Shaowen Bardzell. 2019. Exploring Noticing As Method in Design Research. In *Companion Publication of the 2019 on Designing Interactive Systems Conference 2019 Companion (DIS '19 Companion)*, 377–380. <https://doi.org/10.1145/3301019.3319995>
- [77] Yiyue Luo, Kui Wu, Tomás Palacios, and Wojciech Matusik. 2021. KnitUI: Fabricating Interactive and Sensing Textiles with Machine Knitting. In *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems*. Association for Computing Machinery, New York, NY, USA, 1–12. Retrieved August 23, 2021 from <http://doi.org/10.1145/3411764.3445780>
- [78] Timothy Morton. 2013. *Hyperobjects: Philosophy and Ecology after the End of the World*. U of Minnesota Press.
- [79] Martin Murer, Verena Fuchsberger, and Manfred Tscheligi. 2017. Un-Crafting: De-Constructive Engagements with Interactive Artifacts. In *Proceedings of the Eleventh International Conference on Tangible, Embedded, and Embodied Interaction (TEI '17)*, 67–77. <https://doi.org/10.1145/3024969.3024993>
- [80] Sara Nabil, Lee Jones, and Audrey Girouard. 2021. Soft Speakers: Digital Embroidering of DIY Customizable Fabric Actuators. In *Proceedings of the Fifteenth International Conference on Tangible, Embedded, and Embodied Interaction (TEI '21)*, 1–12. <https://doi.org/10.1145/3430524.3440630>
- [81] Troy Robert Nachtigall. 2019. Materializing data: craftsmanship and technology for ultra-personalization. Technische Universiteit Eindhoven, Eindhoven.
- [82] Troy Nachtigall, Oscar Tomico, and Ron Wakkary. 2019. ONEDAY Shoes: A Maker Toolkit to Understand the Role of Co-Manufacturing in Personalization. In *Proceedings of the Thirteenth International Conference on Tangible, Embedded, and Embodied Interaction (TEI '19)*, 105–115. <https://doi.org/10.1145/3294109.3295637>
- [83] Carman Neustaedter and Phoebe Sengers. 2012. Autobiographical Design in HCI Research: Designing and Learning Through Use-it-yourself. In *Proceedings of the Designing Interactive Systems Conference (DIS '12)*, 514–523. <https://doi.org/10.1145/2317956.2318034>
- [84] Greg Nijs, Giulietta Laki, Rafaella Houlstan, Guillaume Slizewicz, and Thomas Laureysens. 2020. Fostering More-than-Human Imaginaries: Introducing DIY Speculative Fabulation in Civic HCI. In *Proceedings of the 11th Nordic Conference on Human-Computer Interaction: Shaping Experiences, Shaping Society (NordCHI '20)*, 1–12. <https://doi.org/10.1145/3419249.3420147>
- [85] William Odom, Ishac Bertran, Garnet Hertz, Henry Lin, Amy Yo Sue Chen, Matt Harkness, and Ron Wakkary. 2019. Unpacking the Thinking and Making Behind a Slow Technology Research Product with Slow Game. In *Proceedings of the 2019 on Creativity and Cognition (C&C '19)*, 15–28. <https://doi.org/10.1145/3325480.3326567>
- [86] William Odom, Ron Wakkary, Youn-kyung Lim, Audrey Desjardins, Bart Hengeveld, and Richard Banks. 2016. From Research Prototype to Research Product. In *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems (CHI '16)*, 2549–2561. <https://doi.org/10.1145/2858036.2858447>
- [87] Doenja Oogjes and Ron Wakkary. 2017. Videos of Things: Speculating on, Anticipating and Synthesizing Technological Mediations. In *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems (CHI '17)*, 4489–4500. <https://doi.org/10.1145/3025453.3025748>
- [88] Doenja Oogjes, Ron Wakkary, Henry Lin, and Omid Alemi. 2020. Fragile! Handle with Care: The Morse Things. In *Proceedings of the 2020 ACM Designing Interactive Systems Conference (DIS '20)*, 2149–2162. <https://doi.org/10.1145/3357236.3395584>
- [89] Patrick Parzer, Adwait Sharma, Anita Vogl, Jürgen Steimle, Alex Olwal, and Michael Haller. 2017. SmartSleeve: Real-time Sensing of Surface and Deformation Gestures on Flexible, Interactive Textiles, using a Hybrid Gesture Detection Pipeline. In *Proceedings of the 30th Annual ACM Symposium on User Interface Software and Technology (UIST '17)*, 565–577. <https://doi.org/10.1145/3126594.3126652>
- [90] James Pierce. 2009. Material Awareness: Promoting Reflection on Everyday Materiality. In *CHI '09 Extended Abstracts on Human Factors in Computing Systems (CHI EA '09)*, 4459–4464. <https://doi.org/10.1145/1520340.1520683>
- [91] James Pierce. 2021. In Tension with Progression: Grasping the Frictional Tendencies of Speculative, Critical, and other Alternative Designs. In *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems (CHI '21)*, 1–19. <https://doi.org/10.1145/3411764.3445406>
- [92] James Pierce and Eric Paulos. 2010. Materializing Energy. In *Proceedings of the 8th ACM Conference on Designing Interactive Systems (DIS '10)*, 113–122. <https://doi.org/10.1145/1858171.1858193>
- [93] Irene Posch. 2020. Burglar Alarm: More Than 100 Years of Smart Textiles. In *Companion Publication of the 2020 ACM Designing Interactive Systems Conference (DIS' 20 Companion)*, 473–476. <https://doi.org/10.1145/3393914.3395847>
- [94] Irene Posch, Liza Stark, and Geraldine Fitzpatrick. 2019. eTextiles: reviewing a practice through its tool/kits. In *Proceedings of the 23rd International Symposium on Wearable Computers (ISWC '19)*, 195–205. <https://doi.org/10.1145/3341163.3347738>
- [95] Ivan Poupayev, Nan-Wei Gong, Shihou Fukuhara, Mustafa Emre Karagozler, Carsten Schwesig, and Karen E. Robinson. 2016. Project Jacquard: Interactive Digital Textiles at Scale. In *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems (CHI '16)*, 4216–4227. <https://doi.org/10.1145/2858036.2858176>
- [96] Sebastian Prost, Irina Pavlovskaya, Kahina Meziant, Vasilis Vlachokyriakos, and Clara Crivellaro. 2021. Contact Zones: Designing for More-than-Human Food Relations. *Proceedings of the ACM on Human-Computer Interaction* 5, CSCW1: 47:1-47:24. <https://doi.org/10.1145/3449121>
- [97] Mirjana Prpa, Sarah Fdili-Alaoui, Thecla Schiphorst, and Philippe Pasquier. 2020. Articulating Experience: Reflections from Experts Applying Micro-Phenomenology to Design Research in HCI. In *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems*. Association for Computing Machinery, New York, NY, USA, 1–14. Retrieved September 8, 2021 from <http://doi.org/10.1145/3313831.3376664>
- [98] Afroditi Psarra and Audrey Briot. 2019. Listening space: Satellite Ikats. In *Proceedings of the 23rd International Symposium on Wearable Computers (ISWC '19)*, 318–321. <https://doi.org/10.1145/3341163.3346932>
- [99] Heidi R. Biggs, Jeffrey Bardzell, and Shaowen Bardzell. 2021. Watching Myself Watching Birds: Abjection, Ecological Thinking, and Posthuman Design. In *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems (CHI '21)*, 1–16. <https://doi.org/10.1145/3411764.3445329>
- [100] Anuradha Reddy, A. Baki Kocaballi, Johanna Nicenboim, Marie Louise Juul Søndergaard, Maria Luce Lupetti, Cayla Key, Chris Speed, Dan Lockton, Elisa Giaccardi, Francisca Grommé, Holly Robbins, Namrata Pirmilani, Paulina Yurman, Shanti Sumartojo, Thao Phan, Viktor Bedő, and Yolande Strengers. 2021. Making Everyday Things Talk: Speculative Conversations into the Future of Voice Interfaces at Home. In *Extended Abstracts of the 2021 CHI Conference on Human Factors in Computing Systems (CHI EA '21)*, 1–16. <https://doi.org/10.1145/3411763.3450390>
- [101] Johan Redström and Heather Wiltse. 2018. *Changing Things: The Future of Objects in a Digital World*. Bloomsbury Visual Arts, London.
- [102] Holly Robbins, Elisa Giaccardi, and Elvin Karana. 2016. Traces As an Approach to Design for Focal Things and Practices. In *Proceedings of the 9th Nordic Conference on Human-Computer Interaction (NordCHI '16)*, 19:1-19:10. <https://doi.org/10.1145/2971485.2971538>
- [103] Daniela K. Rosner. 2018. *Critical Fabulations: Reworking the Methods and Margins of Design*. The MIT Press, Cambridge, MA.
- [104] Nancy Smith, Shaowen Bardzell, and Jeffrey Bardzell. 2017. Designing for Co-habitation: Naturecultures, Hybrids, and Decentering the Human in Design. In *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems (CHI '17)*, 1714–1725. <https://doi.org/10.1145/3025453.3025948>
- [105] Marie Louise Juul Søndergaard and Lone Koefoed Hansen. 2018. Intimate Futures: Staying with the Trouble of Digital Personal Assistants Through Design Fiction. In *Proceedings of the 2018 Designing Interactive Systems Conference (DIS '18)*, 869–880. <https://doi.org/10.1145/3196709.3196766>
- [106] Nick Taylor, Jon Rogers, Loraine Clarke, Martin Skelly, Jayne Wallace, Pete Thomas, Babitha George, Romit Raj, Mike Shorter, and Michelle Thorne. 2021. Prototyping Things: Reflecting on Unreported Objects of Design Research for IoT. In *Designing Interactive Systems Conference 2021 (DIS '21)*, 1807–1816. <https://doi.org/10.1145/3461778.3462037>
- [107] Vasiliki Tsaknaki, Marisa Cohn, Laurens Boer, Ylva Fernaeus, and Anna Vallgård. 2016. Things Fall Apart: Unpacking the Temporalities of Impermanence for HCI. In *Proceedings of the 9th Nordic Conference on Human-Computer Interaction (NordCHI '16)*, 1–3. <https://doi.org/10.1145/2971485.2987680>
- [108] Vasiliki Tsaknaki and Ylva Fernaeus. 2016. Expanding on Wabi-Sabi As a Design Resource in HCI. In *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems (CHI '16)*, 5970–5983. <https://doi.org/10.1145/2858036.2858459>

- [109] Anna Lowenhaupt Tsing. 2017. *The Mushroom at the End of the World: On the Possibility of Life in Capitalist Ruins*. Princeton University Press, Princeton, NJ.
- [110] Peter-Paul Verbeek. 2010. *What Things Do: Philosophical Reflections on Technology, Agency, and Design*. Penn State Press.
- [111] Ron Wakkary. 2021. *Things We Could Design: for more than human-centered worlds*. MIT Press, Cambridge, MA.
- [112] Ron Wakkary, Sabrina Hauser, and Doenja Oogjes. 2018. Displacement and Withdrawal of Things in Practices. In *Social practices and more-than-humans*. Palgrave Macmillan, London.
- [113] Ron Wakkary, Doenja Oogjes, Sabrina Hauser, Henry Lin, Cheng Cao, Leo Ma, and Tijs Duel. 2017. Morse Things: A Design Inquiry into the Gap Between Things and Us. In *Proceedings of the 2017 Conference on Designing Interactive Systems* (DIS '17), 503–514. <https://doi.org/10.1145/3064663.3064734>
- [114] Laura Watts. 2019. *Energy at the End of the World: An Orkney Islands Saga*. MIT Press.
- [115] Anne-Marie Willis. 2006. Ontological Designing. *Design Philosophy Papers* 4, 2: 69–92. <https://doi.org/10.2752/144871306X13966268131514>
- [116] Tribe Against Machine Wiki | Afroditi Psarra swatch. *Tribe Against Machine Wiki*. Retrieved August 23, 2021 from http://tribe-against-machine.org/wiki/tiki-index.php?page=Afroditi_Psarra_swatch
- [117] Claire Williams. Retrieved August 23, 2021 from <http://www.xxx-clairewilliams-xxx.com/projets/an-electromagnetic-walk/>
- [118] The Knitted Radio. *Irene Posch*. Retrieved October 2, 2020 from <http://www.ireneposch.net/the-knitted-radio/>