Deployments of the table-non-table: A Reflection on the Relation Between Theory and Things in the Practice of Design Research

Sabrina Hauser[1], Ron Wakkary[1,2], William Odom[1], Peter-Paul Verbeek[3], Audrey Desjardins[4], Henry Lin[1], Matthew Dalton[1], Markus Schilling[1], Gijs de Boer[3]

[1]School of Interactive Arts and Technology, Simon Fraser University, Surrey, BC, Canada, {shauser, rwakkary, wodom, hwlin, mdalton, mschilli}@sfu.ca; [2]Eindhoven University of Technology, Netherlands; [3]University of Twente, Netherlands, p.p.c.c.verbeek@utwente.nl, g.l.a.deboer@student.utwente.nl; [4]School of Art + Art History + Design, University of Washington, Seattle, WA, USA, adesjard@uw.edu

ABSTRACT

Design-oriented research in HCI has increasingly migrated towards theoretical perspectives to understand the implications of newly crafted technology in everyday life. However, in this context, the relations between theory and understanding the things we make are not always clear, especially the degree to which the nature of research artifacts is revealed through or determined by theory. We examine a series of field deployment studies we conducted with our research artifact *table-non-table* over the course of four and a half years that we came to see as a *postphenomenological inquiry*. Importantly, our interpretations of this artifact, methodological concerns, and theoretical groundings evolved over time. We account for and critically reflect on these shifts in the relationship between theory and our design artifact. We detail how theory was enacted and embodied in our design research practice and offer insights into the complex relations between theory and things in design-oriented HCI research.

Author Keywords

Research through Design; Field Studies; Design Theory; Postphenomenology.

INTRODUCTION

In recent years in HCI, there has been productive research and discussion on the role of theory in design research. Critical questions have been asked such as: What constitutes theory in design? How is it enacted? How is it produced? How does theoretical knowledge through and in design practice define and shape the field of design research? These large epistemological questions fuel necessary internal reflections within the community on what makes design a research field. Through this questioning, an identity for design research has emerged in HCI known as Research through Design (RtD).

Figure 1. A cat in a household examining the table-non-table.

While we can and should expect ongoing discussions, definitions, and contestations around the term and practice of RtD, a key contribution of RtD is the notion that design research contributes new knowledge in ways inherent to and requiring of design methods and the making of things (e.g., artifacts, systems). RtD makes explicit that the *practice* of design is integral to the ability of the field of design to create *research knowledge*. This opens up a view of design research from the perspective of practice that provides the opportunity to give accounts of the messy interplay between theoretical groundings, the making of things, and design researchers in the service of creating new knowledge through research. Gaver [10] suggests design research has utilized and produced a wealth of diverse theoretical knowledge from new design theories [e.g., 3] to drawing on theories external to design (e.g. product attachment theory [56]), to producing manifestos (e.g., ludic design [13,14]), to frameworks (e.g., Frogger framework [54]). However, more than not, these theories are presented as complete and well-defined entities far removed from the vagaries of the design practices bound to their making, or imported theories that emerge unperturbed and unaffected from encounters with design.

We believe it is important to look under the hood of well communicated theories in design-oriented HCI research and epistemological conceptualizations of RtD to attend to the "doings and sayings" of the practices of such design research, to borrow a phrase from philosopher Theodore Schatzki [38]. From within the practices of research and making, we can better understand the relations of theory to things, and how this interweaving of theory determines, reveals, and creates new knowledge in and around the things of design research.

As a step in this direction, we offer in this paper a reflexive account of the *table-non-table*— 'a thing' or computational artifact made for design research and a series of deployment studies with it over the course of four and a half years. This long-term process with a single designed artifact allowed us to critically reflect on how theory and practice were mutually informing within our RtD approach, framing and reframing our design artifact, empirical methods, analysis, and resulting new knowledge. At the end of this lengthy period, while we had many successes along the way, we progressively aligned our theoretical tools with the ultimate research goals for the table-non-table. In short, in our last iteration of the study we conducted through RtD a successful *postphenomenological inquiry*. By success we mean that, in our view, we drew on postphenomenology to productively frame our RtD inquiry and to give precision and language for non-utilitarian notions of interaction and uncommon assumptions of human-technology relations. Further, we arrived at a methodological approach in line with RtD and postphenomenology that effectively uncovered key empirical experiences of living with the table-non-table and guided our analysis in ways that yielded new insights into human-technology relations.

However, this tidy description of the relations between theory (postphenomenology) and thing (table-non-table) was in reality a process of trial and error, methodological challenges, and shifting assumptions and theoretical positions. We began our investigations with the table-non-table informed by *everyday design* and *theories of social practice* [50,51,41,33] and engaged first in thing-oriented explorations. Secondly, informed by notions of *goodness of fit* and *unselfconscious culture* [1] we explored ethnographic accounts of lived-with experiences with the table-non-table. Lastly, years into the investigation we engaged in a deployment informed by *postphenomenology* [20,36,44] that ultimately met our aims by leading to the surfacing of mediating effects of the table-non-table that go beyond human-centered understandings of interaction.

This paper offers two contributions. First, our reflexive analysis provides HCI researchers insights into the tensions, complexities, and challenges of the necessary interplay and entanglements between theory, empirical fieldwork, and design artifacts in an RtD context. Specifically, we highlight the need to acknowledge radical theoretical commitments with deployment methods. Second, our account describes our conceptualization of a postphenomenological inquiry through RtD and what this holds for HCI research.

BACKGROUND AND RELATED WORK

Early theorizations of design are concerned with describing the practice of design through their methods, tools, materials and outcomes. Design is generally understood as a collection of sub-disciplines that includes for example architecture, product design and more recently interaction design. Seminal works like Jones' Design Methods [21] and Krippendorf 's The Semantic Turn [22] provide detailed accounts of design methods and design rationales. In particular, Jones [21] argues for the need to develop more

detailed and specific methods for design because of increasing complexity. Moreover, Krippendorf [22] describes the necessity of advancing the design discourse through research and encourages writing about design, institutionalizing it (i.e., having universities support design research) and performing self-reflection. Frayling [9] offers an epistemological way to qualify the relationships between research and design and the nature of the knowledge produced. He suggests three categories: *research into design*, *research through design*, and *research for design*. Fallman [7] also reflects on the epistemology of design research and, more precisely, the multifaceted role of design in the multidisciplinary field of HCI. He sees two categories of research in design: design-oriented research where design is used as a means to do research and produce knowledge; and research-oriented design, where design is the main goal and research is used to inform the design. Our work fits with the former and also what we see as RtD.

Zimmerman et al. [57] following Frayling present Research through Design (RtD) in the context of HCI. They propose relying on the strengths of design to frame problems with a holistic perspective, and using the design knowledge embedded in the form and materials of design artifacts [5]. Central to their model is the argument that design artifacts produced through research are representations of how a problem is framed and become design exemplars that serve as communication media to other researchers and practitioners [57]. Zimmerman et al. [58] further argue that those exemplars should be examined, replicated, used as inspiration, and seriously critiqued in order to build more rigorous discourse in HCI and interaction design theory. Gaver [10] on the other hand articulates the risk of bringing standards into RtD which might restrain this form of research. He advocates tempering the perceived needs of standards for RtD and instead proposes that RtD does not need to be verifiable or extensible. Similar to Zimmerman et al. [57], he claims that design artifacts embody the many choices made by designers and materialize implicit theories (e.g., philosophical, functional, social and aesthetic).

Concept-driven interaction research [42], strong concepts [16], and annotated portfolios [4] are advanced articulations of theorizing in interaction design research. They offer a shared understanding of knowledge production in design research, which we leverage and aim to directly build on. Specifically, these approaches articulate a type of design knowledge that lies between theories and design instances. Höök and Löwgren [16] characterize this as *intermediate-level of knowledge*. Stolterman and Wiberg [42] see their work as addressing a gap in design theory between practical guidelines and grander theories imported from other disciplines, namely the social and behavioral sciences, neither of which effectively inform design practices. Bowers [4] and Löwgren [23] see annotated portfolios offering design knowledge that is situated within an intermediate-level knowledge in design research [23]. We see our work as situated within intermediate-level knowledge.

As suggested by a number of scholars [e.g., 57], reflexive practice can improve design and research methodology. Schön [39] suggests that there are significant contributions that can come from the reflexive practice of design. If we attend to the practice of design research, and particularly the relationship between theory and RtD artifacts and the ways this informs our analysis, it affords a new and different perspective on the critical elements of design research. This underscores the need to provide accounts of practice to reveal that design research is built on diverse approaches and particularities of embodied, situated inquiries and creative actions that inherently resist a standardization of research practice, not unlike the practices of design. As such, we present an analysis of our developing conceptualizations and investigations of and with the table-non-table. In a reflexive analysis, we attend to our iterations on how we studied and conceptualized our artifact. Importantly, we conclude our investigation by conceptualizing the table-non-table as a postphenomenological inquiry. We now introduce this theoretical framework.

Postphenomenology

Postphenomenology emerged as a contemporary and empirically oriented strand of philosophy of technology [18–20,34,37,40,44,46,48] to understand the social and cultural roles of technologies in human existence and experience. The postphenomenological approach sees technology as *transformative mediators* of human-world relations rather than as separated functional or instrumental objects or alienating entities [44]. Technologies mediate humans' experiences and perceptions in and of the 'world'. Through *technological mediation*, humans and technological artifacts co-shape human *subjectivity* and the *objectivity* of the 'world' in any given situation [36]. The 'world' can be a situational context such as an environment like a home or also an interpretive framework, or one's understanding of the self. In postphenomenology, philosophy and empiricism blend, marrying approaches of more traditional philosophy of technology, including phenomenology and American pragmatism, as well as Science and Technology Studies [36]. Concrete examples of technologies are investigated in terms of the relations humans have with them and through "the various ways in which technologies help to shape relations between humans and the world" [36:9]. Examples of postphenomenological studies include investigations of imaging technologies, such as Verbeek's study of obstetric ultrasound [45,36]. He shows how the mediating effect of this technology can impact parents' access to the fetus and, in doing so, shape their moral decision-making. His analysis also reveals how this technology *co-constitutes* to the fetus as a patient, parents as decision-makers (subjectivity) and mothers as environments (objectivity). Other examples look at the impact of mobile phones while driving [35] and the mediating roles of implanted technologies [3].

Postphenomenology with its underlying concepts has steadily gained purchase in the HCI and design communities [e.g., 8,25,29–31,43,48,53,55]. RtD and postphenomenology share a common goal of understanding technologies, foregrounding the role of things and the relationships humans have with them. A migration towards this philosophical perspective shifts the emphasis of design research to explore the relations between humans and things, rather than human behavior or qualities of things.

TABLE-NON-TABLE

The table-non-table is a table-like structure made of approximately 1000 sheets of stacked common stock paper and an aluminum chassis. Each sheet of paper measures 17.5 inches by 22.5 inches with a square hole in the middle to allow it to stack around an aluminum square post. Almost entirely hidden, the chassis holds the paper about half an inch from the floor giving the structure a floating appearance. When plugged into an electrical outlet, the table-non-table moves slowly one to two times per day for less than ten seconds. (In an early version, it was moving constantly but extremely slowly, which ended up being too noisy for a home environment and was changed).

We see the table-non-table as a material speculation, which is a methodological approach to RtD [52]. Material speculation centers on the crafting of a counterfactual artifact to carefully and precisely inquire into research questions. A *counterfactual artifact* is a fully realized system or object that in a use-context may contradict what would normally be considered logical. Our goal in designing the table-non-table was to create a technological artifact that would divert from assumptions around use-centric, utilitarian ideas of technologies and design, while retaining subtle design qualities that could enable it to easily fit in everyday domestic settings. The table-non-table was given a specific functionality but which is not in the service of human use. Plugged in, it moves very short distances randomly, a few times a day; when moving, the hidden motor emits a muffled sound. While avoiding specific use goals in our design, we still aimed to craft the artifact in an intentional and purposeful way to give it a finished quality. Elsewhere we have described this approach as *purposeful purposelessness* [49] and the table-non-table as a *research product* [28]. Paper was used on the table-like structure to speak to people's everyday competences as it is a material that is well understood and can be taken up into all kinds of everyday practices (e.g., drawing, writing, folding, cutting, etc.). However, the paper has an unfamiliar format and a square cut in the middle to enable it to be securely stacked on the chassis. Altogether, this design approach combines familiarity with unfamiliarity. It pushes the boundary of what is common or known in terms of utilitarian and symbolic relations to technology that are often guided by established social conventions. Through this unconventional approach of designing and experiencing an artifact we aimed to investigate where boundaries of acceptability might exist with radically new design artifacts.

Inquiring with and Through the table-non-table

Theory plays a significant role in the crafting, studying, and sense-making of design artifacts [39,42]. In this paper, we

mainly focus on the studying and sense-making parts of our design research practice. (We have previously reported on the design and making of the table-non-table [e.g., 49]). HCI field deployment methods have been established to test, analyze and evaluate technology prototypes in real-world settings [17]. They have also been used to make sense of novel research artifacts that break with common assumptions of what a technology is by bringing them into everyday contexts [e.g., 10,18]. Yet, more is hidden within the novel things we make in design research [2,10]. Design research is often situated in everyday contexts to make sense of design artifacts, to study how humans experience the existence of artifacts, and ultimately, to surface broader empirical implications from these studies. Correspondingly, we have argued how material speculations are aimed at understanding the empirical phenomena that arise from living with counterfactual artifacts over time [52].

With the table-non-table we set out to inquire into how this radically unique thing could become part of people's domestic life. The unfamiliar aspects of the table-non-table make it unique but also make studying unknown qualities of the technology a complicated task with HCI methods because they have been developed to investigate the situated (human) use of technology. As a result, methodological and epistemological challenges became central concerns in our inquiry, as did the refinement of our research aim to understand *human-technology relations,* as informed by postphenomenology.

Over the course of four and a half years, we conducted iterative field studies, reflections, and conceptualizations that, over time, helped us to better make sense of the table-non-table and the relations that emerged with and through it. Next, we describe details and insights that emerged across this trajectory of research. This account is guided by the questions: *How are theory and design enacted together in this RtD project? How does theory inform how we study and make sense of the artifact? And in turn how can this inform theory?*

OVER FOUR YEARS OF FIELD DEPLOYMENTS
In our research with the table-non-table we conducted a long series of field deployment studies. Between December 2013 and June 2017, it was deployed in people's homes through three study series with six different case instances (#1 - #6). In what follows, we briefly summarize each case, reflect on each series, and offer insights into the trajectory and iterations of the study series.

First Series: Letting the Thing Do the Talking
As an initial step, we put the table-non-table into three different homes. Two were brief *self-deployments* in households of members of our group (summarized under #1) and one was a 6-week deployment with a professional couple unfamiliar with the artefact (#2).

Theoretical groundings in the making (and our first theory)
The design of the table-non-table was informed by the notion of *everyday design* and conceptualizations of

Theories of Social Practice. Everyday design [51] relies on the resourcefulness of home dwellers, the ability to creatively repurpose common artifacts in the home, and an ongoing process of adaptation. Through engagement and refinements of the ideas of everyday design, we incorporated concepts of Theories of Social Practice [33,41] into our work [50]. A compositional framework of practices consisting of the interrelated elements of materials (artifacts, technologies, etc.), competences (skills, know-how etc.), and meaning (motivations, symbolic value, etc.) [41] informed our design propositions that led to the creation of the table-non-table. It steered us towards designing an artifact that could be taken up in practice by speaking to everyday competences through material (paper), while being unfamiliar and not targeted at specific use contexts [49]. This theoretical framing also shaped initial deployments.

Theory and Protocol
Informed by everyday design and theories of social practice, we wanted to know whether the table-non-table could be taken up in people's domestic practices. In this endeavor, we were, *letting the thing do the talking.* We placed the table-non-table first into our own homes taking photographs, and then with a participant couple instructing them to share their experience on a private blog with us acting as silent*,* remote observers.

#1 Two Researchers' Homes – For a Few Days – 2013
Two members of our research group lived with the table-non-table for a few days. This step was for us to get a sense of how it could possibly become part of domestic settings and practices. Documentations of the table-non-table in their homes were later discussed and analyzed as a group.

#2 One Participant Household – For 6 Weeks – 2013/14
As a second step, the table-non-table was deployed with a professional couple for six weeks. Todd and Marie were working in landscape architecture and were recruited by referral (all names used in this paper are pseudonyms). We simply asked them to live with 'an artifact we designed' not mentioning any other details. We asked them to report on their experience through photographs and text entries on a private Tumblr blog that we set up for them. We primed them with these questions*: How do you use the prototype? What do you think about the prototype? What does it make you think about? How does it affect your life?* We received four text entries and 16 images from them.

Study Findings
In the first study, the table-non-table was placed in the living room of two homes for a few days only. For us, it merged with the rest of the home. In deployment #2, our participants engaged with the table-non-table in numerous ways. The participants had a cat that immediately began investigating it: *"day 1: […] The cat finds it quite puzzling, she can look at it for long periods, especially when* [and after] *buzzing. A big fan of paper, she also chewed the corners and took a couple of sheets off the thing. Marie and I haven't figured what to use it for".*

Later, the cat engaged further with the paper, ripping and chewing it, and using it as a bed (see Fig. 2). The cat's playful interactions with the artifact, invited our participants to use the paper themselves. Since it was around Christmas, they made snowflakes (see Fig. 2). Early on, Todd and Marie plugged the table-non-table into a power-bar in order to better control its buzzing sound. (Note, in this early version the table-non-table was always moving, emitting a constant buzzing sound. This was changed after the first series). In summary, the table-non-table found a place in the different homes and was taken into several domestic practices by our participants (and their cat).
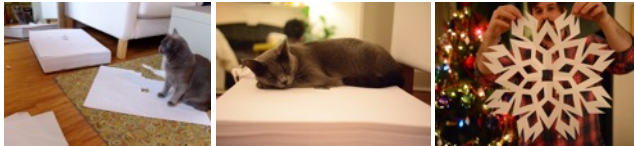

Figure 2 The participants' cat playing with the table-non-table

Meta-Reflection and Shift in Theory

Through this first series of deployments, we began to see how the table-non-table could become part of domestic settings and everyday practices. The paper was used for crafting snowflakes and the cord taken up into the practice of plugging in and as a way of controlling sound. With the theoretical frameworks of everyday design and social practice dominating our initial conceptualizing of the table-non-table as an object with qualities speaking to domestic practices, we initially considered the deployment as a success. However, we felt unsatisfied with the knowledge this generated on the unknown aspects and relations coming about through the table-non-table in domestic settings. In further post-study reflections, we began to think about the setting of our participant's homes. We discussed whether the table-non-table was 'a good fit' in their home, which led to our first theoretical shift. We began to investigate 'fit' as a concept for research artifacts in the home; and wondered whether it was possible for the table-non-table to achieve *fit*. Christopher Alexander's description of *goodness of fit* and his idea of *unselfconscious culture* [1] resonated with us after conducting the first series. Alexander describes the process of incremental and unknowing interactions and corrections that lead to improvements in everyday life— what he refers to as *goodness of fit*. The combination of the unknowing nature of the interactions and that the 'design' is done unknowingly (i.e, not by professional designers) led Alexander to refer to the process as *unselfconscious*.

We critically assessed our findings and study approach, prompting us to recognize the need for a more thorough account of the lived-with experience with the table-non-table and to inquire more into the human perspective. Ethnography is what we knew could get us there.

Second Series: Ethnographic Accounts of Living with the table-non-table

Next, the table-non-table was deployed in three different participant households: once for six weeks (#3) and twice for three and a half months (#4, #5).

Theory and Protocol

Informed by Alexander's notions of goodness of fit and unselfconscious cultures, in the second series of deployments, we wanted to get a better grasp on our participants' lived-with experiences with the table-non-table and to inquire into the fit of it in their homes. In order to get such an account from our participants, we migrated towards using established HCI-oriented ethnographic methods [c.f., 13,17,18] to guide our investigation.

We developed a protocol for ethnographically-oriented interviews to inquire into our participants' experiences. At the drop-off, we inquired into our participants' everyday routines. With the table-non-table deployed, participants were invited to live with the artifact and do with it whatever they wished. They were also asked to report thoughts and experiences on a private Tumblr blog, which we set up for each household. At the end of the deployments, we conducted one final interview with each of the households. We mostly asked about activities related to the table-non-table as well as thoughts and critical explorations on its behavior. We also inquired into tensions and thoughts on aesthetics and material qualities of the artifact, comparisons to other technologies, reactions to the table-non-table's *otherness*, as well as complications and difficulties over reconciling what it 'is' and what it is supposed to 'do'.

#3 One Participant Households – For 6 Weeks – 2014

For this deployment, we recruited a family in Vancouver, Canada. The Kensington's were a family of four including two adult sons (28 and 30 years old) and a dog. We asked them to live with our *research prototype* (not mentioning its name or what it does, i.e. that it moves) and to report back what they thought of it and did with it. They shared seven photographs and four written long reflections. We visited the participants for the drop off, a midterm interview, and a final short interview and pick-up.

#4 Home of Two Researchers – For 3½ Months – 2014/15

To be more informed about lived-with experiences with the table-non-table for longer than six weeks, we put it in the home of two of our group members (Lisa 31 and Johnny 32 and their cat and dog) for three and a half months. Lisa and Johnny shared 19 photographs and 12 short text entries on their blog and were interviewed. This self-deployment influenced the following deployment.

#5 One Participant Household – For 3½ Months – 2015

With a slightly revised protocol informed by the previous deployment, we set out to deploy the table-non-table with a family with young children which we recruited through flyers distributed through various channels. The Wentworth's received one from a friend and contacted us. They are two adults and five children (5-year-old twin girls, a 9-year-old girl, a 10-year-old girl, and a 12-year-old boy). We conducted an initial interview at the drop-off and later a final interview. The Wentworth's shared 12 photos, one video, and nine short text entries on their blog.

Study Findings
Besides being visited and interviewed, all participant households shared photographs of the table-non-table in their home and text entries with reflections, thoughts, and descriptions of interactions with it. In #3, each of the Kensington household members spent considerable time engaging with the table-non-table or 'papier machine' as they named it (inspired by the French word). These engagements include both direct interactions with the table-non-table and more reflective contemplation over what its purpose is, and more generally what it is. Interactions consisted of tinkering with the paper, getting guests to 'sign it' like a guestbook, moving it to different parts of the house, and inviting or encouraging their dog to play with it. Other reported experiences included casually walking past it and taking note that it had (or hadn't) moved. Ms. Kensington often noticed the sound and movement of the table-non-table when working in her office next to the living room (where it largely resided). What was most clear in interviews with the Kensington's was that the table-non-table occupied a tense and somewhat frustrating place within the household. In several instances, Ms. Kensington described how it made her feel "inadequate" in that she had not resolved what it is supposed to do and why (a common sentiment held by other household members): *"it 'demands' your attention because its purpose and functionality are unclear, so it requires a good amount of 'work' to figure out what it's supposed to be for, or to figure out a new use for it* […] *It seems like a lot of bandwidth will have to go into* [figuring it out]*."* After four weeks, they put the table-non-table aside under a bed. It seemed to us that the Kensington's would have needed more time to achieve a better fit for themselves. We therefore decided to put it in one of our own homes for longer than six weeks, and then do another deployment with another participant household.
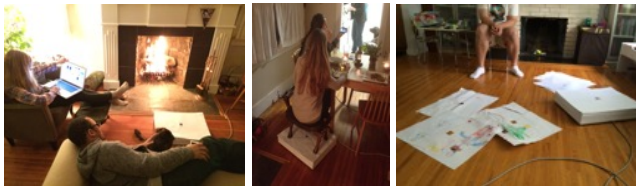

Figure 3 The table-non-table in households 4 and 5

In #4, we created our auto-ethnographical account of living with the table-non-table. In this household, it was placed in the living room in front of a fireplace (see Fig. 3) and used in various ways; once as a stool extension, and in several occasions with their dog and cat. The paper was used for the fireplace and to wrap a present. After two months, it was moved in the background underneath a magazine stand next to the couch until it was removed. In #5 the table-non-table was investigated by taking the paper off to see what's 'inside', used as a performance stage by the children, the paper for drawings (see Fig. 3), and to create snowflakes. After two months, it was moved into the closet.

Across these deployment studies, there was an initial phase of excitement, followed by an exploration centered on use,

and a reflection on whether or not the artifact fits in one's home. This latter stage could entail frustration over not being able to make sense of it, and ended in putting it aside.

Meta-Reflection and Theoretical Conceptualizations
Christopher Alexander's description of *goodness of fit* and his idea of *unselfconscious culture* [1] led us to inquire into people's lived-with experiences with the table-non-table. Our ethnographic approach steered our investigation from a strong focus on our artifact (first series) towards looking closer at details of participants experiences. This ethnographic approach focuses much more on the human—in this case, on our participants and their human-centered experiences with and perception of the table-non-table. The way our participants tried to make sense of the artifact was through use-centric explorations and thoughts around it.

Since the table-non-table is designed to be purposeless, trying to make sense of it through use-centric methods was not fruitful. However, on a theoretical and conceptual level, these insights shifted our thinking more clearly away from use toward the broader set of human-technology relations.

Successful Theoretical Conceptualizations
Grounded in our investigations on Alexander's 'goodness of fit' and 'unselfconscious cultures', we theoretically developed *unselfconscious interaction* [49], a conceptual construct that describes a form of interaction with computational artifacts animated by incremental engagements that lead to improvements in the relationships among artifacts, environments, and people [49]. Through this lens, we were able to describe the design of the table-non-table as an interaction design artifact that emphasizes actuality over functionality, having neither an explicit interface nor computational awareness of its owner's presence or actions. We termed such interaction design artifacts as *unaware objects* and described the concept of *unawareness* [27]. We further developed a notion of non-functional engagement with design artifacts, which we term as *intersections* [27]. We found that as intersections accumulated around unaware objects, dynamic configurations of artifacts, contexts and human actions emerged, which we refer to as *ensembles* [27].

Wrestling with the table-non-table and Theoretical Enactments
In the design of the table-non-table, several aims come together with the most common or normative ideas about a technology being either weakened or lacking entirely. Our generative stance to theory complemented this approach of wanting to investigate design research artifacts as alternatives to existing assumptions and utilizing theory as a starting point with the aim of moving past the normative framings of the theories themselves. Even though in our theoretical conceptualizations we were successful, our way of inquiry did not seem fully appropriate. We were getting at information and generated knowledge from our studies, but it did not seem adequate to inquire with traditional, largely use-centric ethnographic methods into concepts like unawareness, intersections, and ensembles.

Another Shift in Theory

After the earlier deployments #1-5, we brought the table-non-table back into our research studio and placed it in front of a couch where it seemed most fitting given traffic of people and our floor space. We kept it plugged in and lived with it this way for over 16 months. Although not a direct deployment, over this time period studio members experienced living with the table-non-table in their work space and we used this time to continue reflecting on it.

Migration Towards Postphenomenology

During that time and initiated through HCI developments [e.g., 47,25], collaborations, as well as other projects in our research group, we migrated towards the postphenomenological school of thought and its underlying understandings of technologies and human-technology relations. As previously mentioned, this strand of philosophy aims to understand the role technology plays in human existence and experience, viewing technologies as *mediators* of human-world relationships. It provides salient insight on technologically mediated situations in everyday life, placing emphasis on an encompassing look at humans, technology, and the world. Postphenomenological investigations are empirically grounded and focus on real world cases, which we see as in line with our own research.

Third Series: A Postphenomenology-informed Inquiry

As a third step, the table-non-table was deployed once more in a new approach with one household for 11 weeks.

(Early) Protocol and Theory

Postphenomenology begins its analyses with particular technological encounters and their structure of human-technology relations. It then usually moves into an analysis of technological mediations in human-technology-world relations. Ihde, a key pioneer of the postphenomenological school, argues that we establish a range of bodily-perceptual relationships with technologies [18], encountering them as an *embodiment*, as an *alterity*, through a *hermeneutic* relation, or as a *background* relation. Verbeek [44] describes, mediations happening on a *hermeneutic* or experiential level and on an *existential* level; the former detailing "[h]ow reality appears to humans" or humans' 'perception', and the latter "[h]ow humans appear in their world" or humans' 'action' [44:196]. With postphenomenology informing our thinking, we set out to inquire about a more holistic account of the table-non-table and the relations occurring with it as well as underlying and emerging qualities, aspects, and implications of those relationships. We engaged in another deployment with the aim to let postphenomenological commitments guide us. We initially stuck with an ethnography-inspired approach.

Unlike previous deployments, we explained in full to our participants the nature of the table-non-table and the research study to remove any guessing about the artifact or study. We asked our participants to use a private Facebook group blog to report images, videos, thoughts, and questions. We chose this medium because it was most convenient for the participants.

The deployment consisted of a drop off with a short interview, an interim interview, and a final interview. We also developed priming exercises for the participants to engage with specific themes like 'fit' or 'paper as a material'. We shared those on cards by either bringing them along or presenting them on the blog. The initial interview focused on gaining an understanding of our participants, their beliefs, and their everyday routines. This we did to later have reference points to relate mediating aspects to in our analysis. We asked about their home, life, the role of things in their life and their attitude towards them. We left them with the request to give the table-non-table a place in the home for the duration of the study (11 weeks).

#6 Professional Couple Household – For 11 Weeks – 2017

Our last participants were Amy, 30, an industrial designer and Tom, 34, an architect, who we recruited by referral.

Initial Study Findings

Amy and Tom live in a small urban apartment and are serious about not keeping too many things in their home. Similar to previous participants, they tried to make sense of the table-non-table by determining what it could be *used* for and how that compares to ways of using other things. Their trained background in user-centered design also had an effect on that. Tom described: "*the role of the designer and ethical responsibility to create objects that add value to people's lives stands in contrast to making objects to sell things or add meaningless things to people's lives* […] *you see it all the time with stupid apps.*" For a while, Tom felt we were testing their reaction to a meaningless object added to their life.

Figure 4 Rats Cheeky & Chewey engage with the table-non-table

Their two pet rats immediately took advantage of the table-non-table when outside of their cage. This resonated well with Amy and Tom. Apparently, it is valuable for rats to have new things in their environment to interact with. "*Cheeky loves a crinkle tunnel. He took paper inside there*". "*He* [also] *created a tunnel with the table-non-table's paper and peeked through the 'window'* [the cut square]*"* (see Fig. 4). Chewey, the other rat, continually dragged sheets of paper underneath the couch and into a corner, where he ripped them in pieces to create a little nest. Tom put paper on the top of the cage for them, a place where they could not reach it. Besides being a toy for the rats, however with odd features, Amy consistently rejected the table-non-table.

Initially, it was tough for us, the design research team, to have our participants reject the table-non-table or see it as a badly designed rat toy; especially so explicitly and quickly within the study period. At some point, Tom and Amy stopped engaging with our priming exercises. Nevertheless,

in the second half of the study, after the interim interview, we began to see past these initial tensions.

Overcoming the Focus on Human-centeredness & Useful Use
As researchers, we found it harder than expected to shift away from the human-centered orientation of ethnography. We had to overcome the strong focus on 'useful use' (by our participants) and look at our study more holistically. We had a keen sense that postphenomenology could support this endeavor because it emphasizes a more holistic understanding of human-technology relations. Yet, this theoretical framework is not normally used to analyze unfamiliar technologies, like the table-non-table, that do not have social norms established around them. After two weeks, we had invited our participants to explore the idea of *using* the table-non-table, which caused us to slip into exploring its relations and mediations with 'use' as a starting point.

Ultimately, the design of the table-non-table, our participants' rejection of it, and, in turn, our overcoming of that rejection with a postphenomenology-informed framing led us to the deeper realization that the relations we have with things and technologies may not solely be based on or begin with 'use'. As soon as an artifact becomes part of a home, whether in front of a fireplace or under a bed, it shapes a new reality and mediates people's existence and experience regardless of the perception of its usefulness. It will co-constitute particular human-technology-world constellations and a certain subjectivity and objectivity dynamic, even in the case of the table-non-table. We had to critically reflect on and take into account that postphenomenological inquiries typically look at available user-centered technologies. Through the design and deployments of the table-non-table, the research team broke with this kind of normative approach to designing technology and their human-technology relations.

Further Developed Protocol
In the interim interview with Amy and Tom we discussed the location, behavior, and fit of the table-non-table in their home. We also talked about their impressions on 'use' which led to a conversation around *indirect use* and subtle ways the table-non-table could be having an impact on their everyday life. In the final interview, we further explained how we were looking at relations, perceptions, actions, and practices that do not revolve around functions for human use. We characterized the table-non-table as part of a background relation and other things occupying the participants background, such as a waffle iron in their cupboard. This catalyzed conversations about things in the home that serve no immediately apparent function.

Further Findings: Rejection of Our Participants' Rejection
Up until the final interview, our participants mainly rejected the table-non-table, which was largely based on their assumptions of it being useless. After the interim interview, it became more and more apparent to us that the table-non-table had subtle mediating effects on Amy and Tom's life. Shortly after the drop-off, Amy felt there were too many

things in a corner area in her living room. She moved the table-non-table underneath the side cabinet and moved the lamp. She later got rid of a decorative typewriter and a yellow chair she had possessed for years. Amy and Tom seemed to become more reflective and aware of the things in their living space. After being asked whether she thinks the table-non-table influenced her movement and dispossession of belongings, she replied: *"it may have."*

Paper as a material also seemed to spark reflection: "*there's something to be said about paper. There's nothing that can replace the analog. [...] If I had only one medium, it would be paper [...] you can build things with it, [...] like structural forms just by folding [...] it's the ultimate.*" Amy also pointed to a documentary about paper she had seen, and shared more about her personal background growing up in a small remote town without many belongings. In her youth, she was able to express herself with pencils and a sketchpad, which she saw as all that she needed. She still has her first sketch book. Amy then remarked about the table-non-table: "*If you focus on this, the element of paper, and the relationship to paper, and have that be the focal point I think that the whole product could change and it could be of value.*"

Meta-Reflection and Final Theoretical Conceptualization
Grounded in postphenomenology, we developed a more holistic understanding of our artefact and its mediating effects. The relations that developed between our participants and the table-non-table however, were unlike any kind of interaction with technology we were familiar with studying. Next, we describe our postphenomenological account and conceptualizations of the table-non-table that we arrived at through our last study.

A Postphenomenological Account of the table-non-table
Technologies mediate between humans and the world, changing a person's experience amplifying some aspects of perception and reducing others [18] and changing the environment it becomes part of—even a technology seemingly useless as the table-non-table. We were able to detect this in our last *mediation-centered* study by actively looking beyond use-centeredness to bring the nuances of human-world relations mediated by the table-non-table into focus. This made clearer why the artifact- or human-centered approach of our earlier studies did not uncover these mediating effects.

Human-Technology Relations
The closest known technology similar to the table-non-table is a coffee table or side table, hence the name. From a postphenomenological view, tables in homes usually are encountered through *background relations*, which are at play when a technology is operating but not occupying or calling for focal attention. Nevertheless, it is still shaping people and their experiences [18]. Ihde refers to this as 'absent presence'–when a technology is not directly used but still being experienced, becoming "a kind of near-technological environment" [18:108]. Technological mediation of

background technologies works often through their "indirect effects upon the way a world is experienced" [18:112]. Verbeek [44] describes dining tables, when absorbed into the practice of eating, as actively shaping a certain culture around eating, communal behavior, making conversation, and hierarchy. Yet, the table-non-table does not fall into the category of the 'familiar' technologies that are nearly always at the center of postphenomenological analyses.

Although seemingly designed to be in the background, upon entering a home the table-non-table catalyzes or introduces unknown and uncertain relations that participants try to understand and make sense of. Unlike typical background technologies (e.g. a refrigerator), the table-non-table puzzles people and thereby asks for attention when it occasionally moves without a recognizable reason or function. Over time, the unique nature of the table-non-table emerges through the background to find a place in everyday life. The rejection, friction-laden path that we saw in our deployments can be seen as similar to what Rosenberger [35] refers to as *sedimentation*–the habits that emerge with a given human-technology relation can reveal the subtle and diffuse mediations that go well beyond use and instrumentality. We see this as the very point of the table-non-table.

Mediations or Co-Constituted Subjectivity and Objectivity
We learned that even if not directly used or seemingly useless, a technology like the table-non-table still shapes the environment and lives of people living with it albeit in subtle or weak ways. It co-constitutes a particular reality and human *subjectivity* and *objectivity* of the world. In hindsight, this appeared to be the case for all our participants. For example, while trying to make sense of the table-non-table, Amy reflected on its materials, i.e. paper and what it means to her. Amy and Tom also engaged with the space in their apartment by ridding themselves of some furniture. Regardless of where it was placed (e.g., in the living room, closet, or underneath a bed) the table-non-table became part of people's environments and lives.

DISCUSSION AND IMPLICATIONS
We have described how our interpretations of the table-non-table and framing of our deployments iteratively changed. Next, we reflect on the lessons learnt through our research trajectory with a focus on implications for future work.

Reflecting in and on our design research practice
Thus far in this paper we have offered a reflexive account of our RtD process and the underlying interplay among the design artifact, field deployments, theory, analyses, and reflections. Our goal is to establish and contribute to a discussion among design-oriented researchers for constructive critical reflection and to deepen an understanding about the nature and value of design practice as a form of inquiry in HCI research.

Things and Theory
We contribute a rare account of insights into how our research was informed through oscillations between the making of a design artifact which was informed by theory,

as well as how theory also informed our ways of studying it in the field. An evolving theoretical backdrop in dialogue with ongoing field deployments enabled us to better grapple with and make sense of our research inquiry. Crucially, it was through this process that theory ultimately enabled us to understand and articulate key qualities of the table-non-table and to better align the aims of the theory with the aims of our design practice. Gaver [10] argues that theory underspecifies the artifact—there is a maturity to real, actual things in the world that theory cannot fully articulate nor account for. In this paper, we concretely demonstrate this point. The theory never over-determined our work. In our early deployment studies, the norms of the theory were not quite aligned with what we sought to do in the practice, and this produced frictions. It led us to believe we had a theory that contained the norms that we desired, but later it became clear that initially we had not applied theory in practice sufficiently. In the final stage of our RtD inquiry, we found that the theoretical framing and design artifact came into alignment; it enabled us to articulate and understand the particular quality and nature of the table-non-table more clearly. We did not need to 'redesign' the table-non-table to figure out a way it could better 'fit' with theory. Rather, our theoretical framing helped us surface, articulate, and critically reflect on the table-non-table and better understand it through its existence in the world. Our work makes clear that there is a need for future works to account for and unpack how theory relationally shapes and is informed by the practices of design research through the making and studying of design artifacts. Furthermore, as design researchers we need to acknowledge and respect the notion that the things we make often exceed the articulations and normative assumptions of theory.

Empirical Approaches for RtD
In this investigation, we wrestled with our empirical approaches. We do not claim that we have found the 'ideal' way of studying and uncovering postphenomenology-informed ways of conceptualizing our or others' design artifacts. Rather, we aim to stress the importance of deployments for providing empirical data for actual realities with research artifacts and the need to look at mediations. Postphenomenology is an empirically-oriented philosophy and derives its insights from actual experiences with technologies [36]. Nevertheless, the main focus is on mediations giving a more active role to things that co-constitute reality. Deployments in our studies reveal important accounts of living with the table-non-table (i.e., different accounts of human-technology relations and mediations). However, we had to overcome the ethnographic account that centered on participants voices. Although experiential accounts are needed, we had to move our attention to mediations ascribing a more active role to an artifact. For example, in the second study series we focused on how our artifact could fit in a home, but through a postphenomenological approach, the artifact became the starting point and is seen as co-constituting (i.e. 'changing') the home, and urges to understand such mediations. We see a

need for more inquiries into the methodological commitments of RtD deployments dealing with the complex nature of human-technology relations in everyday life.

Designing and Studying Beyond Use or Functionality

As interest in HCI continues to expand into everyday life, our concerns move beyond making things that solve problems and make tasks efficient. The table-non-table offers an explorative investigation into this expanding design space by inquiring into human-technology-relations *beyond use* through itself. By conceptualizing and carving out particulars across our studies, we made progress in our design research practice, methodologically and theoretically by conceptualizing and carving out particulars across the design artifact, field deployments, and theory.

Figure 5 The first day (left) and last day (right) of study #7

With postphenomenology, we were able to develop a more holistic and clearer perspective on the table-non-table; this theoretical framing aided us in understanding how the table-non-table shapes and mediates human experience through moving beyond use and utility. It helped us see beyond the 'rejection' of our participants, and embrace it instead. We intuitively knew this is where we wanted to drive our inquiry but there were initial frictions in arriving there. It became clear that *mediations do not speak to us*, as researchers, like ethnographic data does. In the table-non-table case, our early focus on human-centeredness obscured what we aimed to investigate. This is illustrated in Figure 5 where the storing of the table-non-table in the closet at the end of the study was at first seen as a failure, whereas Tom interacting with the artifact at the beginning of the study with enthusiasm (that later waned) was seen as success. However, we came to see this interaction as obscuring the broader human-technology relations that mediate the world of their apartment. The success of the table-non-table in the closet is that it reveals the subtle mediations and various shared relations that determine the values and desires of not only the different belongings, but their impact on domestic life.

Pets and Research Artifacts

Additionally, we acknowledge observations of the different participants' pets as an important non-human-centered way of generating insight. Through our participants' accounts of their pets' behaviors, we discovered a usefulness of the table-non-table without rejection or predisposition. This

revealed a path towards a less human-centered way of thinking. The pets, including cats, dogs, and rats, were part of deployment households (i.e. worlds the table-non-table had an effect on) and thus influenced our participants' subjectivity and engagements with the table-non-table.

Crafting a Stronger Place for Postphenomenology in HCI

We see RtD artifact inquiries as an experimental way of doing postphenomenology and therefore conceptualized our own *RtD project as a postphenomenological inquiry*. Our work shows the opportunity for future design research to open up new ways of inquiring into the diverse nature of human-technology relations in everyday life through the crafting and studying of design artifacts. In this way, postphenomenology can operate both as a generative lens to frame the crafting of design artifacts, as well as a framework to analyze empirical studies of them, which deepens and broadens our understanding of human-technology relations.

More broadly, we see postphenomenology as an under-utilized yet productive framework for the HCI community and, in particular, for design researchers. There is an opportunity for work to draw on postphenomenology to better support analytical accounts of things, especially ones that move beyond an explicit focus on use or utility–an ongoing and important area of inquiry in HCI [12,14,15,32]. This could enable the HCI community to develop better accounts and understandings of the complex and dynamic range of relations that form between humans and technologies, and, how technology mediates people's experiences and actions in the world. Indeed, an important part of supporting this (and other) nascent and growing work is acknowledging the failures and struggles among design researchers. Such accounts advance the practice of design research as a knowledge generating activity [11].

CONCLUSION

This work contributes an in-depth account of how, through empirical studies, a theoretical grounding can be enacted and embodied to reveal new insights on a design artifact that, in turn, can shape how studies of it are conducted and analyzed. Our reflexive analysis provides HCI researchers insights into the tensions, complexities, and challenges in the necessary interplay and entanglements between theory, empirical fieldwork, and design artifacts in an RtD context. We described how postphenomenology offered salient insights into this process and productively shaped our capacity to theoretically and empirically articulate key qualities of the table-non-table—an artifact explicitly diverting from utilitarian assumptions. We proposed opportunities for future design research inquiries into the complex, nuanced, dynamic nature of human-technology relations in everyday life.

ACKNOWLEDGMENTS

REFERENCES

1. Christopher Alexander. 1964. *Notes on the Synthesis of Form*. Harvard University Press.

2. Davis Baird. 2004. *Thing Knowledge: A Philosophy of Scientific Instruments*. University of California Press, Berkeley, Calif.

3. Kirk Besmer. 2012. Embodying a Translation Technology: The Cochlear Implant and Cyborg Intentionality. *Techné: Research in Philosophy and Technology* 16, 3: 296–316. https://doi.org/10.5840/techne201216319

4. John Bowers. 2012. The Logic of Annotated Portfolios: Communicating the Value of "Research Through Design." In *Proceedings of the Designing Interactive Systems Conference* (DIS '12), 68–77. https://doi.org/10.1145/2317956.2317968

5. Nigel Cross. 2006. *Designerly ways of knowing*. Springer, London.

6. Tom Djajadiningrat, Ben Matthews, and Marcelle Stienstra. 2007. Easy doesn't do it: skill and expression in tangible aesthetics. *Personal and Ubiquitous Computing* 11, 8: 657–676. https://doi.org/10.1007/s00779-006-0137-9

7. Daniel Fallman. 2003. Design-oriented Human-computer Interaction. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (CHI '03), 225–232. https://doi.org/10.1145/642611.642652

8. Daniel Fallman. 2011. The new good: exploring the potential of philosophy of technology to contribute to human-computer interaction. 1051. https://doi.org/10.1145/1978942.1979099

9. Christopher Frayling. 1993. Research in Art and Design. *Royal College of Art Research Papers* 1, 1. Retrieved September 18, 2017 from http://researchonline.rca.ac.uk/384/

10. William Gaver. 2012. What should we expect from research through design? In *Proceedings of the 2012 ACM annual conference on Human Factors in Computing Systems* (CHI '12), 937–946. https://doi.org/10.1145/2208516.2208538

11. 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

12. William W. Gaver, Jacob Beaver, and Steve Benford. 2003. Ambiguity As a Resource for Design. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (CHI '03), 233–240. https://doi.org/10.1145/642611.642653

13. William W. Gaver, John Bowers, Kirsten Boehner, Andy Boucher, David W.T. Cameron, Mark Hauenstein, Nadine Jarvis, and Sarah Pennington. 2013. Indoor weather stations: investigating a ludic approach to environmental HCI through batch prototyping. 3451. https://doi.org/10.1145/2470654.2466474

14. William W. Gaver, John Bowers, Andrew Boucher, Hans Gellerson, Sarah Pennington, Albrecht Schmidt, Anthony Steed, Nicholas Villars, and Brendan Walker. 2004. The Drift Table: Designing for Ludic Engagement. In *CHI '04 Extended Abstracts on Human Factors in Computing Systems* (CHI EA '04), 885–900. https://doi.org/10.1145/985921.985947

15. John Helmes, Alex S. Taylor, Xiang Cao, Kristina Höök, Peter Schmitt, and Nicolas Villar. 2011. Rudiments 1, 2 & 3: Design Speculations on Autonomy. In *Proceedings of the Fifth International Conference on Tangible, Embedded, and Embodied Interaction* (TEI '11), 145–152. https://doi.org/10.1145/1935701.1935730

16. Kristina Höök and Jonas Löwgren. 2012. Strong concepts: Intermediate-level knowledge in interaction design research. *ACM Trans. Comput.-Hum. Interact.* 19, 3: 23:1–23:18. https://doi.org/10.1145/2362364.2362371

17. Hilary Hutchinson, Wendy Mackay, Bo Westerlund, Benjamin B. Bederson, Allison Druin, Catherine Plaisant, Michel Beaudouin-Lafon, Stéphane Conversy, Helen Evans, Heiko Hansen, Nicolas Roussel, and Björn Eiderbäck. 2003. Technology Probes: Inspiring Design for and with Families. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (CHI '03), 17–24. https://doi.org/10.1145/642611.642616

18. Don Ihde. 1990. *Technology and the lifeworld: from garden to earth*. Indiana University Press, Bloomington.

19. Don Ihde. 1993. *Philosophy of Technology: An Introduction*. Paragon House Publishers, New York, NY, USA.

20. Don Ihde. 1995. *Postphenomenology: Essays in the Postmodern Context*. Northwestern University Press.

21. John Chris Jones. 1992. *Design methods*. Wiley, New York, NY.

22. Klaus Krippendorff. 2006. *The semantic turn: a new foundation for design*. CRC/Taylor & Francis, Boca Raton.

23. Jonas Löwgren. 2013. Annotated portfolios and other forms of intermediate-level knowledge. *interactions* 20, 1: 30–34. https://doi.org/10.1145/2405716.2405725

24. Leah Maestri and Ron Wakkary. 2011. Understanding Repair As a Creative Process of Everyday Design. In

Proceedings of the 8th ACM Conference on Creativity and Cognition (C&C '11), 81–90. https://doi.org/10.1145/2069618.2069633

25. William Odom, James Pierce, Erik Stolterman, and Eli Blevis. 2009. Understanding why we preserve some things and discard others in the context of interaction design. 1053. https://doi.org/10.1145/1518701.1518862

26. William T. Odom, Abigail J. Sellen, Richard Banks, David S. Kirk, Tim Regan, Mark Selby, Jodi L. Forlizzi, and John Zimmerman. 2014. Designing for slowness, anticipation and re-visitation: a long term field study of the photobox. 1961–1970. https://doi.org/10.1145/2556288.2557178

27. William Odom and Ron Wakkary. 2015. Intersecting with Unaware Objects. In *Proceedings of the 2015 ACM SIGCHI Conference on Creativity and Cognition* (C&C '15), 33–42. https://doi.org/10.1145/2757226.2757240

28. 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

29. Fredrik Ohlin and Carl Magnus Olsson. 2015. Beyond a Utility View of Personal Informatics: A Postphenomenological Framework. In *Adjunct Proceedings of the 2015 ACM International Joint Conference on Pervasive and Ubiquitous Computing and Proceedings of the 2015 ACM International Symposium on Wearable Computers* (UbiComp/ISWC'15 Adjunct), 1087–1092. https://doi.org/10.1145/2800835.2800965

30. 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*, 4489–4500. Retrieved June 7, 2017 from http://dl.acm.org/citation.cfm?id=3025748

31. James Pierce and Eric Paulos. 2011. A Phenomenology of Human-electricity Relations. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (CHI '11), 2405–2408. https://doi.org/10.1145/1978942.1979293

32. James Pierce and Eric Paulos. 2015. Making Multiple Uses of the Obscura 1C Digital Camera: Reflecting on the Design, Production, Packaging and Distribution of a Counterfunctional Device. In *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems* (CHI '15), 2103–2112. https://doi.org/10.1145/2702123.2702405

33. Andreas Reckwitz. 2002. Toward a Theory of Social Practices A Development in Culturalist Theorizing. *European Journal of Social Theory* 5, 2: 243–263. https://doi.org/10.1177/13684310222225432

34. Robert Rosenberger. 2009. The Sudden Experience of the Computer. *AI Soc.* 24, 2: 173–180. https://doi.org/10.1007/s00146-009-0190-9

35. Robert Rosenberger. 2012. Embodied technology and the dangers of using the phone while driving. *Phenomenology and the Cognitive Sciences* 11, 1: 79–94. https://doi.org/10.1007/s11097-011-9230-2

36. Robert Rosenberger and Peter-Paul Verbeek. 2015. A Field Guide to Postphenomenology. In *Postphenomenological investigations: essays on human-technology relations*, Robert Rosenberger and Peter-Paul Verbeek (eds.). Lexington Books, Lanham, 9–41.

37. Robert Rosenberger and Peter-Paul Verbeek. 2015. *Postphenomenological Investigations: Essays on Human–Technology Relations*. Lexington Books.

38. Theodore R. Schatzki. 2002. *The site of the social: a philosophical account of the constitution of social life and change*. Pennsylvania State Univ. Press, University Park, Pa.

39. Donald A. Schön. 1983. *The reflective practitioner: how professionals think in action*. Basic Books, New York.

40. Evan Selinger (ed.). 2006. *Postphenomenology: A Critical Companion to Ihde*. State University of New York Press, Albany.

41. Elizabeth Shove, Matt Watson, and Mika Pantzar. 2012. *The Dynamics of Social Practice: Everyday Life and how it Changes*. SAGE, Los Angeles.

42. Erik Stolterman and Mikael Wiberg. 2010. Concept-Driven Interaction Design Research. *Human–Computer Interaction* 25, 2: 95–118. https://doi.org/10.1080/07370020903586696

43. Nynke Tromp, Paul Hekkert, and Peter-Paul Verbeek. 2011. Design for Socially Responsible Behavior: A Classification of Influence Based on Intended User Experience. *Design Issues* 27, 3: 3–19. https://doi.org/10.1162/DESI_a_00087

44. Peter-Paul Verbeek. 2005. *What Things Do: Philosophical Reflections on Technology, Agency, and Design*. Penn State Press.

45. Peter-Paul Verbeek. 2008. Obstetric Ultrasound and the Technological Mediation of Morality: A Postphenomenological Analysis. *Human Studies* 31, 1: 11–26. https://doi.org/10.1007/s10746-007-9079-0

46. Peter-Paul Verbeek. 2011. *Moralizing technology: understanding and designing the morality of things*. The University of Chicago Press, Chicago ; London.

47. Peter-Paul Verbeek. 2015. COVER STORY: Beyond Interaction: A Short Introduction to Mediation Theory.

interactions 22, 3: 26–31.
https://doi.org/10.1145/2751314

48. Peter-Paul Verbeek and Petran Kockelkoren. 1998. The things that matter. *Design Issues* 14, 3: 28–42.

49. Ron Wakkary, Audrey Desjardins, and Sabrina Hauser. 2015. Unselfconscious Interaction: A Conceptual Construct. *Interacting with Computers* 28, 4: 501–520. https://doi.org/10.1093/iwc/iwv018

50. Ron Wakkary, Audrey Desjardins, Sabrina Hauser, and Leah Maestri. 2013. A Sustainable Design Fiction: Green Practices. *ACM Transactions on Computer-Human Interaction* 20, 4: 23:1–23:34. https://doi.org/10.1145/2494265

51. Ron Wakkary and Leah Maestri. 2007. The Resourcefulness of Everyday Design. In *Proceedings of the 6th ACM SIGCHI Conference on Creativity & Cognition* (C&C '07), 163–172. https://doi.org/10.1145/1254960.1254984

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

53. 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

54. S. A. G. Wensveen, J. P. Djajadiningrat, and C. J. Overbeeke. 2004. Interaction Frogger: A Design Framework to Couple Action and Function Through Feedback and Feedforward. In *Proceedings of the 5th Conference on Designing Interactive Systems: Processes, Practices, Methods, and Techniques* (DIS '04), 177–184. https://doi.org/10.1145/1013115.1013140

55. Heather Wiltse and Erik Stolterman. 2010. Architectures of Interaction: An Architectural Perspective on Digital Experience. In *Proceedings of the 6th Nordic Conference on Human-Computer Interaction: Extending Boundaries* (NordiCHI '10), 821–824. https://doi.org/10.1145/1868914.1869038

56. John Zimmerman. 2009. Designing for the Self: Making Products That Help People Become the Person They Desire to Be. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (CHI '09), 395–404. https://doi.org/10.1145/1518701.1518765

57. John Zimmerman, Jodi Forlizzi, and Shelley Evenson. 2007. Research through design as a method for interaction design research in HCI. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (CHI '07), 493–502. https://doi.org/10.1145/1240624.1240704

58. John Zimmerman, Erik Stolterman, and Jodi Forlizzi. 2010. An Analysis and Critique of Research Through Design: Towards a Formalization of a Research Approach. In *Proceedings of the 8th ACM Conference on Designing Interactive Systems* (DIS '10), 310–319. https://doi.org/10.1145/1858171.1858228