An Annotated Portfolio on Doing Postphenomenology Through Research Products

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ABSTRACT
In this paper, we argue for framing the crafting and studying of research products as *doing philosophy through things*. We do this by creating an annotated portfolio of such Research through Design (RtD) artifact inquiries as postphenomenological inquiries. In our annotated portfolio, we first provide an account of the postphenomenological commitments of 1) taking empirical work as the basis of the inquiry, 2) analyzing structures of human-technology relations and 3) studying technological mediation. Secondly, we trace these commitments across six RtD artifact inquiries. We conclude with a discussion on how research products can be seen as an *experimental way of doing postphenomenology* and how HCI design researchers can work with that. As a result, the presented philosophical framing can be leveraged in HCI research to form a deeper and more dimensional understanding of the human-technology relations we craft and study. This also adds a methodological path to moving beyond foci of use, utility, interaction, and human-centeredness.

Author Keywords
Research through Design; Annotated Portfolios; Research Products; Material Speculation; Postphenomenology.

INTRODUCTION
Over the past several decades, research in the Human-Computer Interaction (HCI) community has largely focused on utilitarian technological advancements. However, there have been steadily growing concerns about the limitations that such a strong focus on utility and functionality can introduce. In particular, researchers have articulated a dominantly utilitarian focus can obscure efforts to fully account for the relations humans have with technology; and, how technology shapes human experiences in the world. As a result, there has been emerging interest in the HCI community in expanding focus beyond interaction and functionality. Design approaches, such as ludic design [e.g., 11] and slow design [e.g., 32], are emerging as alternatives to goal-driven, feature-laden, and productivity-oriented digital technologies. These works and other recent studies in HCI have shown that a move to a more contemporary philosophical orientation is needed to design novel and concrete interventions that theoretically account for the complexity of human-technology relations. As a step in this direction, postphenomenology, and its underlying concepts, have been utilized as a productive theoretical perspective in the HCI and design communities [e.g., 8,30,36,40,55,60,65,68]. Postphenomenology, a contemporary strand of philosophy of technology that views technology as mediators of human-world relations rather than as separated functional or instrumental objects, has been useful in pursuing these theoretical framings. The 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 in and of themselves. In recent works, postphenomenological framework have been helpful in understanding and analyzing human-technology relations in design-oriented HCI research [14,40,65,66]. Postphenomenology brings powerful analytical concepts to HCI and Research through Design (RtD). RtD, in turn, as an approach and set of commitments holds potential to ground and make concrete postphenomenological concepts.

There are similarities and a mutual interest between RtD inquiries and postphenomenological ones. Both approaches at their core investigate technologies and the relationships humans have with them. Further, RtD offers a promising methodological path to uncovering and investigating mutual concerns of postphenomenology, to look beyond use, interaction, and human-centeredness, to form a deeper understanding of people's experiences and relations with technology. The making and studying of research artifacts provide concrete ways to advance new knowledge on how complexities of human-technology relations can be productively approached [14,43,66]. We particularly focus on RtD artifact inquiries that are able to generate speculation through their actuality and materiality (e.g., [34]). In line with work that has come before [43], we see the inquiries of such speculative design artifacts as an *experimental way of doing postphenomenology* or in other words *doing philosophy through things*.

In this paper, we want to take a step towards generative engagements with this conceptual framing through the creation of an annotated portfolio and subsequent reflection. Annotated portfolios [5,9] is an emerging method in design-oriented HCI research that in our case helps bring together a collection of known designed and studied RtD artifacts exploring human-technology relations to show how they align with postphenomenological commitments.

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This work is motivated by two of our previously conducted RtD artifact inquiries. Our investigations with and through *table-non-table* [14] and *Tilting Bowl* [66] are early explorations with the conceptualization of our inquiries as postphenomenological. We provide details of these two inquiries and their expressions of postphenomenological commitments as introductory examples. Motivated by these works, we set out to develop an annotated portfolio of six other RtD artifact inquiries.

In what follows, we describe related work and detail our methodological and analytical approach highlighting our commitments to RtD and postphenomenology. We then explore postphenomenological commitments in design research artifacts alongside three themes through an annotated portfolio. Lastly, we reflect on what our approach holds for future work in the HCI community.

POSTPHENOMENOLOGY

Postphenomenology is the concrete and empirical study of the social and cultural roles of technologies in human existence and experience practiced by an expanding group of different scholars. This school of thought was initially developed as a contemporary and empirical strand of philosophy of technology [17–19,45,51,52,56,59,60]. In postphenomenological studies, philosophy and empiricism blend, marrying approaches of more traditional philosophy of technology including phenomenology and American pragmatism as well as Science and Technology Studies [50]. The postphenomenological approach sees technology as *transformative mediators* of human-world relations rather than separated functional or instrumental objects or alienating entities [56]. Technologies mediate humans' experiences and perceptions in and of the 'world'. The 'world' here can be seen as a placeholder for a situational holistic context such as an environment like a home. It could also be an interpretation framework, or one's understanding of the self. Through *technological mediation*, humans and technological artifacts co-shape or *co-constitute* human *subjectivity* and the *objectivity* of their 'world' in any given situation [50]. In postphenomenological studies, concrete case examples of technologies are investigated in terms of the relations humans have with them and the implications technologies have for the relations between humans and their world. Examples of studies are investigations of imaging technologies such as Verbeek's study of obstetric ultrasound [57,50]; where he shows the technology's impact on the relations between parents' and the fetus and on the parents' moral decision-making because the ultrasound *co-constitutes* the fetus as a patient, parents as decision-makers and mothers as environments. Other study examples are the impact of mobile phones while driving [46] and the mediation of implanted technologies [1]. In all of these cases, technologies help to shape both the 'subjects' that use them and the 'world' they live in.

Towards Postphenomenology in HCI

As focus expanded beyond the office and technologies were increasingly becoming part of people's leisure times, there was a growing need for an alternative value set to guide the design of technology for everyday life [29,53,61,63]. Emphasis was put on the need to understand the messiness of everyday life (e.g., emotions, experience, values, new contexts outside of the office, etc.). In this context, new frameworks for understanding human "experience" [28] and "interaction" [7] provided an important foundation. In recent years, the focus on interaction and the underlying notion of functionality however has been seen as limiting, not fully accounting for unpacking the relations humans have with technology, and also how technology shapes human's existence and experiences in the world [8]. As a result, the HCI community has been expanding its focus beyond interaction and functionality, and design approaches such as ludic design [12], slow design [13,32], and undesigning [37] have been developed opposing a utility-oriented, feature-laden, and productivity-enhancing development of digital technologies. A move to a more contemporary philosophical orientation promises to support the development of theoretical framings for design that accounts for the complexity of human-technology-world relations to create novel and concrete interventions. For example, [8] discussing Borgmann's notion of the device paradigm [2] and the idea of the non-neutrality of technology-mediated experience [16,69]—a key point in postphenomenology—raises issues within guiding visions and values in HCI. Odom et al. [30] grounded in concepts of the philosophy of technology describe attachment as a key factor in human-technology relations for future design implementations. Pierce & Paulos [40,41] informed by phenomenological accounts and a defined set of human-technology relations [17] analytically uncover and describe new ways of relating to and experiencing electricity and also explore electric materiality. Furthermore, concepts like personal informatics [35] have been analytically re-examined through the utilization of the postphenomenological framework to discuss the changing agency of users. Wiltse and Stolterman [68] use the framework to analyze the interaction architectures of instant messaging and file sharing to reveal how these interactive spaces mediate human activity.

Collectively, these emerging works illustrate that philosophy of technology is becoming utilized as a productive theoretical perspective in HCI and interaction design research. Despite these developments, there is a lack of work that draws on postphenomenology in a generative way for design. Within philosophy of technology, efforts exist to make postphenomenological ideas, concepts, features, characteristics, and methodology more accessible [37]. There is now an opportunity to bring these new developments back to HCI, which is a goal of this paper. We believe a reflexive engagement with a postphenomenological framing of RtD inquiries can help with that, given the postphenomenological focus on the roles technology can play in human-world relations; and in turn, research artifacts and their resulting evaluations help advance new knowledge on human-technology relations [23,24,38]. In this paper, we focus on RtD artifact inquiries that share commitments to two of our own RtD studies that we have come to see as postphenomenological inquiries. We describe these as introductory exemplars to our annotated portfolio next.

INVESTIGATIONS OF THE TABLE-NON-TABLE AND TILTING BOWL: INTRODUCTORY EXAMPLES OF POSTPHENOMENOLOGICAL INQUIRIES

In two of our own RtD artifact inquiries [14,66] we went through processes of framing, reframing and productively working with viewing them as postphenomenological inquiries. In this section, we elaborate on elements of the studies of the *table-non-table* that allowed us to arrive at that point. We will also briefly sum up how this framing developed in our study of the *Tilting Bowl*.

Figure 1. A cat examining the table-non-table, b. A Tilting Bowl filled with fruit on a household table. © Everyday Design Studio

We see both, the *table-non-table* and *Tilting Bowl*, as *material speculations* [64], which is an RtD approach that 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.

The *table-non-table* is a table-like structure made of approximately 1000 sheets of stacked common stock paper. Each sheet of paper measures 17.5 inches by 22.5 inches with a square hole die cut in the middle to allow it to stack around a solid aluminum square post that holds the sheets in place. Almost entirely hidden, an aluminum chassis holds the stacked paper about half an inch from the floor, which gives the structure a floating appearance. When plugged into an electrical outlet, the *table-non-table* moves one to two times per day, at random times, very slowly and for less than ten seconds. The *table-non-table* diverts from assumptions around use-centric, utilitarian ideas of technologies and technology design, while retaining subtle design qualities that could enable it to easily fit in everyday domestic settings.

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 our research artifact and the relations that emerged with and through it. After this lengthy period of time, we came to see the *table-non-table* as a successful postphenomenological inquiry. We drew on postphenomenology to productively shape our capacity to theoretically and empirically articulate key qualities of the *table-non-table*. This allowed us to look past *useful use* to uncover key empirical experiences of living with the table-non-table and see the more subtle and diffuse mediations of the *table-non-table*. The utilization of postphenomenology in our studying and conceptualizing of the *table-non-table* enabled us to frame our RtD inquiry to develop precision and language for non-utilitarian notions of interaction and uncommon assumptions of human-technology relations.

In a concurrent research project, we designed and studied the *Tilting Bowl* [66], which is a ceramic double-walled bowl with a hidden motor that lets the bowl tilt occasionally. It is similar to any other ceramic bowl in that it is food safe and washable. The *Tilting Bowl* is counterfactual in that it looks and functions like a regular bowl except that counter to what is common to bowls, it tilts. By defamiliarizing such a familiar artifact through digital technologies, the *Tilting Bowl* specifically inquiries into the types and qualities of relationships beyond use and functionality that may emerge. We generatively worked with our previously articulated non-utilitarian notions of interaction, such as *intersections* and *ensembles* [33,62], to guide the design of the *Tilting Bowl*. We have been deploying six bowls in the households of philosophers to inquire into postphenomenological topics and questions. From this study, novel and rich descriptions have been emerging with respect to alterity and background relations with the *Tilting Bowl* in particular.

Our two investigations offer empirical and reflexive accounts of human-technology relations and technological mediations with counterfactual RtD artifacts. Both contribute argumentative exemplars for the value and use of postphenomenological concepts and concerns for considering RtD artifacts in HCI. This helped us see the productive postphenomenological framing of RtD-inquiries and made us aware of the similar interest between postphenomenology and RtD artifact inquiries; and further it motivated us to explore whether other RtD projects could similarly be seen as postphenomenological inquiries.

OUR METHODOLOGICAL APPROACH

In developing an annotated portfolio of RtD artifact inquiries, we aim to bring out particularities of enacted postphenomenological dimensions. A first selection criterion was that the RtD artifact inquiries were in line with two methodological commitments to RtD pursued in the crafting and studying of *table-non-table* and *Tilting Bowl*: *Material Speculation* and *Research Products*.

To further elaborate, in *material speculations* [64], artifacts are designed to be lived with over long periods and are crafted to embody research questions or propositions through what we call counterfactual artifacts. A counterfactual artifact is a fully realized functioning product or system that intentionally contradicts what would normally be considered logical to create given the norms of design and design products. This countering of norms, opens the possibilities to empirically investigate multiple alternative existences (or what-ifs) as lived-with realities of the counterfactual artifacts. In addition to counterfactuality, material speculations rely on crafted research products to perform the inquiry.

Odom et al. [34] describe *research products* through four qualities of *inquiry driven, finish, fit,* and *independent*. The artifacts are designed to drive a research inquiry; they have a high quality of finish such that people engage with them as they are, rather than what they might become and such that they can fit among other things and into everyday environments; and lastly, they operate independently in everyday settings over time. The term and concept of research products “emphasizes the actuality of the design

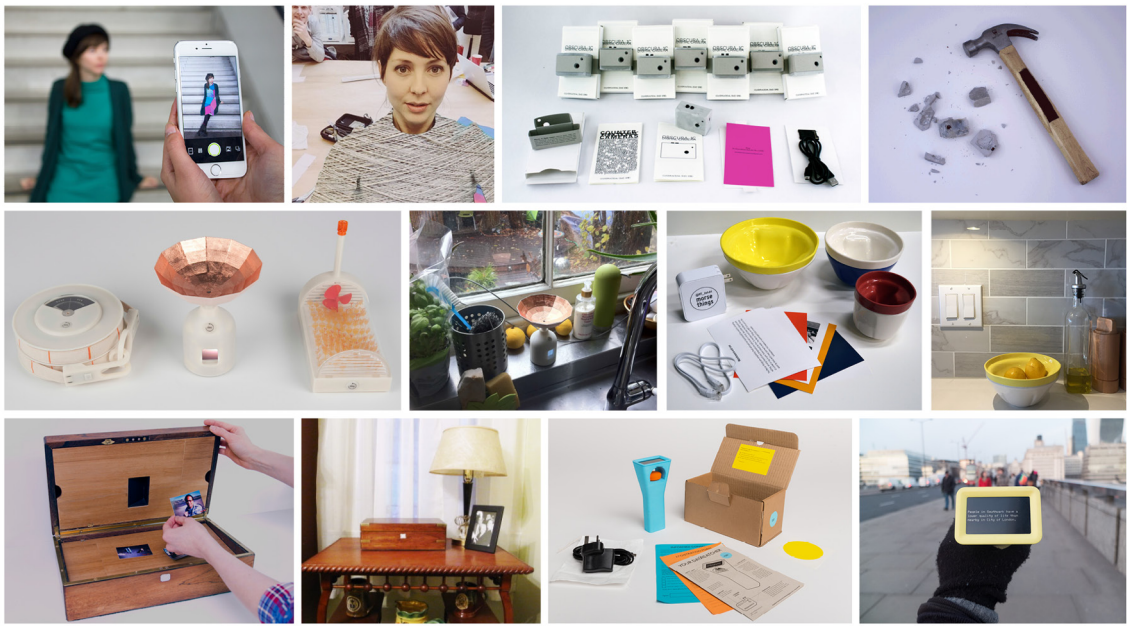

Figure 2. The Selected Research Products. Top, Middle, & Bottom (L to R): T1&2. Greenscreen Dress; T2&3. Obscura 1C Digital Camera; M1&2. Indoor Weather Stations; M3&4. Morse Things; B1&2. Photobox. B3&4. Datacatcher. Image credits: T1&2 © Angella Mackey, T3&4 © James Pierce; M1&2, B3&4 © Interaction Research Studio; M3&4 © Everyday Design Studio; M3&4; B1&2 © William Odom.

artifact helping to overcome the limitations of prototypes when investigating complex matters of human-technology relations over time, which is of growing interest in the HCI community" [34:2550].

Our selection process began by first collecting RtD artifacts without specific curation criteria. We searched for published articles, images and videos of them and ended up with over thirty artifacts. We then determined which held up against the criteria of research products and material speculation. We made sure that there were published articles or videos of them reporting on real-world placements or experiences with the artifacts (e.g., participant deployments or auto-ethnographic self-deployments). We also wanted our chosen RtD projects to be from various sources, including different design research studios [70,71] and design researchers [e.g., 27,43].

The Selected Research Products

Next, we offer brief descriptions of our final choices of RtD inquiries and refer to publications that report on each project in more detail.

Greenscreen dress (T1&2) is a long-term investigation into the wearing of dynamic textiles [26,27]. With the use of a chroma key mobile application, content is digitally displayed on green fabric. The design researcher, Mackey started with wearing a green dress and expanded this to other green garments she bought or made. Mackey et al. report on her day-to-day experiences of wearing green dynamic clothing for ten months.

Obscura 1C Digital Camera (T3&4) is a camera with a concrete housing that would have to be destroyed in order to view the pictures [42–44]. The designer-researchers Pierce and Paulos have reported on Pierce's own experiences of using the *Obscura 1C*. They produced around 20 cameras of which 10 were distributed purposefully through craigslist ads, bulletin boards and local stores. They did not follow up on the deployment of these design artifacts.

Indoor Weather Stations (M1&2) is a set three objects aimed at playfully exploring environmental awareness of the home [6,11,22]. The *Wind Tunnel* measures gusts of air near the device and visualizes these through a small fan that creates storms through paper film trees. *Temperature Tape* resembles a measuring tape but visualizes different temperatures within the home through screen-printed stripes that change color from yellow, orange, red and black corresponding with temperature. The *Light Collector* measures and recreates the color of the ambient light in the home. Over 20 sets were batch-produced and deployed to more than 20 households over the course of a year.

Morse Things (M3&4) are sets of connected cups and bowls that communicate solely to each other in Morse Code and over Twitter [65]. They were deployed for six weeks with designers and design researchers with an interest in the IoT.

Photobox (B1&2) is an antique chest that prints four or five randomly selected photos its owner's Flickr collection at random intervals each month [31,32]. Three *Photoboxes* were created and then deployed in three households for 14 months respectively.

Datacatchers (B3&4) are mobile devices that collect and display topical information about their surroundings (e.g., house prices, typical incomes, etc.) [3,4,10]. Scrolling the wheel one way will display messages and turning the other way accesses a poll. 100 *Datacatchers* were deployed for two months. Two filmmaking teams collected over 2 hours of footage of the participant's lived experiences of the devices in context.

Creating the Annotated Portfolio

Annotated portfolios are "a means for capturing the family resemblances that exist in a collection of artifacts, simultaneously respecting the particularity of specific designs and engaging with broader concerns" [5]. In the context of our work, the utilization of annotated portfolios

provides us with a concrete way of showing conceptual themes we viewed as generalizable to other designs (based on prior work). As Bowers describes further, "Annotated portfolios are *descriptive* (of past occurrences) and intended to be *generative-inspirational* (of future possibility) with their primary business constituting a portfolio in close contact to […] the actual artifacts themselves" [5:76]. Annotated portfolios allow for a way to explore what postphenomenology holds for design researchers by not simply giving prescriptions.

Alongside concept-driven interaction research [54] and strong concepts [15], annotated portfolios [5] offers a method for theorizing in interaction design research. These approaches are related in their goal of supporting the development of design knowledge that lies between theories and instances. Höök and Löwgren [15] explicitly characterize this as *intermediate-level knowledge*. Bowers [5] and Löwgren [25] define annotated portfolios as offering intermediate-level knowledge for design research. Our work extends these approaches by providing an interpretive account of methodological commitments through annotations of RtD artifact inquiries.

Annotation Themes of Postphenomenological Commitments

For our annotation process, we developed three themes based on descriptions of how postphenomenological studies methodologically operate [50]:

1) Empirical work as the basis of the inquiry
2) Structures of human-technology-world relations as a starting point
3) Technology co-constitutes objectivity and subjectivity of any given situation (mediations or implications)

For our annotated portfolio, we analyzed how the selected research products express these commitments by going through their respective published works and annotating them in a lengthy process. From this, we developed our final annotated portfolio of postphenomenological research products, which we describe next.

ANNOTATED PORTFOLIO OF POSTPHENOMENOLOGICAL COMMITMENTS IN RESEARCH PRODUCTS

For each of the three annotation themes, we first describe the postphenomenological commitment and key examples; and, then describe how the selected research products express it.

1) Empirical work as the basis of the inquiry

Central to postphenomenological studies is that empirical work is the basis for the philosophical reflection. Rather than applying philosophical work to technology in a broader sense, postphenomenological insights are derived from actual experiences with certain technologies. As Rosenberger and Verbeek describe, the purpose of the empirical work is "to investigate the character of the various dimensions of the relations between humans and these technologies, and their impact on human practices and experiences" [50:31]. Empirical work in postphenomenological investigations can include both self-conducted studies and first-person experiences and studies conducted by others. Frequently the two types of investigations are combined.

First Person Experiences

Investigating the implications of a technology through a first-person experiential account is most common in postphenomenology. Ihde has reported on his experience with hearing aids [20] and a heart stent [21]; Verbeek on his and his wife's experience with obstetric ultrasound [57,59].

Self-conducted studies

An example of a postphenomenological investigation basing its philosophical reflections on self-conducted study data is Rosenberger's investigations of the politics of park benches and other public-space objects [47,48]. Over several years, he has collected several hundreds of pictures of public-space objects from all over the world [49], which he argues are being designed against homeless populations.

Empirical Work by Others

Many postphenomenological investigations are based on empirical work by others or at least involve such data alongside self-gathered data. In his investigation, Rosenberger [46] studies data gathered by cognitive scientists to make an argument around the mediation of cell phones while driving including when on speaker phone and against the use of cell phones in any way while driving. Although using empirical work by others, Rosenberger additionally brought in his own first-person experiences in the study. Wellner [67] also conducts a postphenomenological inquiry into cell phones, however on a broader level looking back at the history of cell phones studying the role they play in contemporary everyday life.

Next, we discuss how research products represent this theme by describing: *What kind of empirical work is done with and through the selected research products?*

Empiricism in Research Products

The Datacatchers [10] were batch-produced and deployed to around 100 participants. The researchers were specifically interested in semi-random approaches to the deployment to be able to get responses from a broad demographic. They commissioned a service consultancy to form a deployment team, who recruited participants at local markets. Once participants agreed to be part of the study, a package containing a manual, a charger and a Datacatcher was given to the participants on the spot. The participants lived with the devices for two months, after which filmmakers (briefed by the research team) made a short documentary (1-5 minutes) of each participants' experience with the devices.

The *Indoor Weather Stations* [11] were also batch-produced and deployed in 20 homes. The researchers recruited participants that lived near the research studio through posters in the area and websites of local interest. Participants first participated in a cultural probe study to encourage reflection on their indoor climate [6]. After this, the packaged *Indoor Weather Stations* were given to participants either at group events, at the research studio or during individual drop-offs. Data collection included home visits and prompts. During the study, the researchers created a web-platform for visualizing the data of the *Indoor Weather Stations* of participating households to enable further engagement between participants and the devices.

Approximately 20 *Obscura Digital Camera* 1*C*'s [44] were created, including packaging and instructional material that allowed the camera to be stand-alone: they can be understood and used without scaffolding or interference of a research team. In such, the empirical account builds on the specific actuality of this counterfactual and counterfunctional artifact. In addition, 10 packages were distributed through approaches such as bulletin boards, local stores, and craiglist ads. Pierce [39] also reflects on his own experience with the *Obscura 1C*.

Participants for the *Morse Things* [65] were recruited through personal contacts of the research team. The team was looking specifically for trained designers and researchers with an expertise in the area of connected things. The participants received a box containing a manual, instructions for deployment, a router and three *Morse Things* (one red, one yellow, one blue). Participants were asked to describe what it is like to live with the *Morse Things* from the perspective of the things and to create design proposals for things that could co-exist with the *Morse Things*. After living with the artifacts for six weeks and self-reporting on the experiences, and sharing and discussing the experiences and design proposals in a workshop, the participants and researchers were able to speculate on new types of connected things in the home.

The *Greenscreen Dress* [26] was studied for seven months as an autobiographical design and auto-ethnographic study. The first author incorporated green clothing in her outfits daily during this time and took pictures and videos that she shared on social media. The actuality of wearing the dynamic fabric daily allowed the authors to reflect on real-life implications of such a technology, e.g. the possibilities and limitations in expressing personal style.

With the aim of exploring topics such as anticipation, reflections and re-visitation, *Photobox* was part of a long-term deployment in which three nearly identical photoboxes were deployed in three households for fourteen months respectively [32]. The participants were recruited with the requirement of having a large Flickr account. *Photobox* was described to participants only briefly to allow for them to create their own interpretations over time. To collect these temporal accounts, home visits and interviews were conducted bi-monthly. This longitudinal study allowed the researchers to reflect on the mediations *Photobox* brought forward with the Flickr archive and on how the artifact took on different roles over time.

Concluding Remarks about Empiricism in Research Products

The RtD artifacts that we have discussed are bespoke to the inquiry and counterfactual in nature. Studies of them rely on the actual existence of the artifacts and the fact that they can be taken as is. Through these combined commitments it becomes possible to study not merely a new artifact, but also the newly constituted world in which this artifact exists. The presented studies enable the researchers to inquire into the lived experiences of this new world. These experiences can form the basis of uncovering mediations and relativistic accounts. We will elaborate on how this is the case in our selected RtD works in the forthcoming sections.

2) Structures of Human-Technology Relations as Starting Points

Postphenomenological studies begin their analyses with particular technological encounters and the structure of human-technology relations at play. They then usually move into an analysis of technological mediations in human-technology-world relations (theme 3). Ihde, a key pioneer of the postphenomenological school of thought, argues that we encounter technologies through four bodily-perceptual relationships [17]: as an *embodiment*, as an *alterity*, through a *hermeneutic*, or a *background* relation. In the next sub-sections, we will work our way through these four relationships, which are neither exhaustive nor mutually exclusive.

The Embodiment Relationship

A technology is being *embodied* when a part or an aspect of the world is experienced or perceived *through* the technology. Classic examples that postphenomenological philosophers have examined are glasses or wearable technologies such as hearing aids [20]. The mobile phone, for instance, enables a person to experience a conversation through a phone; in this case, the phone is embodied and almost moves into the background [46]. In embodiment relations, technologies, or aspects of them, fade to a certain degree in the background. Ihde describes this as *transparency*. For example, if someone has grown very accustomed to their glasses, they may be barely noticed [50].

The Hermeneutic Relationship

When a technology is hermeneutically encountered it is '*read'* and reveals a certain aspect of the world to humans who *interpret* it. For example, a thermometer lets humans hermeneutically know that it is cold or hot. Through such technological encounters, humans receive access to an aspect of the world by being provided with a representation of it, which then requires interpretation to be made sense of.

The Alterity Relationship

When a technology is *being interacted with* and becomes '*quasi-other*' or *'quasi-autonomous'* postphenomenologists characterize this as an alterity relation. In this case, humans interact with a technology whereas the world moves in the background. Examples that have been used in postphenomenology include GPS navigation systems and ATM machines.

The Background Relationship

A background relation is at play when a technology is operating but not calling for focal attention; nevertheless, it is still shaping people and their surroundings or contexts [17]. Ihde calls this *contextual* state an '*absent presence'* when a technology is not directly used but still being experienced becoming "a kind of near-technological environment" [17:108]. We are typically not aware of such technologies when they function or are in operation (e.g., much like today's smart technologies, IoT devices, or cloud technologies). The technological mediation of background technologies is often more through the "indirect effects upon the way a world is experienced" [17:112]. Key examples in this context that postphenomenologists draw on are semi-automatic machines, such as a fridge or a heating system.

Collectively, these bodily perceptual relationships that come about between humans and technology show how technolo-

gies in such structural relationships can go from being very close to the body, i.e. embodied, towards moving further, i.e. hermeneutic, and further, i.e. alterity, away from the body towards being unnoticed and moving into the background.

Cyborg Relations

Verbeek extended these relationship structures with three more *cyborg* relationships [58] to cover additional contemporary human-technology structures. First, in the *Fusion Relationship*, a technology merges with the human in a way that is more intimate than an embodiment relation. Examples of this relation are implanted technologies like brain implants. Second, in an *Immersion Relationship*, a technology merges with the environment in a way that they are in the background not for our existence but also interactive contexts. Examples of this relation include ambient technologies that detect human presence or smart toilets that generate health reports. Third, *Augmentation Relationship* is an embodiment relation and a hermeneutic relation combined which is the case with, for example, Google Glass.

Next, we show how research products represent this theme by describing: *What structures of relationships are at play?*

Relationship Structures in Research Products

Photobox can be seen as dominantly in a background relation; (indeed, Odom et al. describe the *Photobox* as a "background device"). For example, consider the following quotes from Odom et al.'s participants in which they reflect on living with *Photobox*: *"[It's] in the backdrop of our life, not distracting, just there. ...like many of the things we keep out on the mantle or put up on the wall"* [32:1968]. Another participant described the fading into and out of the background: *"it's awesome to find new photos, but [Photobox] doesn't make me crazy to run over and check it every time I get home. […] I can walk past it. I can come back later. […] in that way it has quite a different character"* [33]. Importantly, there was a period of time participants needed to get used to the *Photobox* in their life and as it is. Odom et al. describe this in their study: "*Despite the relative simplicity of the Photobox, it provoked a range of reactions across households—many of which were characterized by initial frustration and disappointment, which slowly shifted towards acceptance, and pleasurable anticipation"* [32:1965]. After several months of living with it, a participant described the technology as *"one that could be closed up and fade away, not demanding nor requiring the owners' attention"* [32]. Lastly, human-technology relations with *Photobox* being somewhat uncommon in that users cannot control how often or when it is printing photos can be seen as entailing alterity aspects.

The *Indoor Weather Stations* were designed to be part of a hermeneutic relation. Gaver et al. describe that they "*reveal the home's microclimate by highlighting small gusts of wind, the colour of ambient light, and temperature differentials within the home*" [11:3451]. More specifically, *"[t]he temperature measure […] tells you something about your energy use. In my room I was quite shocked at the temperature difference from one end of the room to the other, how cold it was in the middle of the room with the central heating on*" [6:7]. Similar as with the *Photobox*, there was a time period in which participants had to get adjusted to the new (and different) design artifacts in their lives. A participant described that the constant whirring of one of the weather stations changed from being irritating to soothing, something he only noticed in its absence [11]. Another participant made the remark that she loved things that *"haven't quite settled down yet into what they are going to be"* [11:3455].

In another remark Gaver et al. [11] describe that they thought their design artifacts were failing because their participants were not engaging with them. However, they realized that there was an attachment that had built while the devices had found a place in the background: "*Moreover, even though it was not uncommon for participants to tell us that they no longer engaged with the devices after a month or two, they were still adamant that they did not want to return them, but preferred for the devices to stay in their homes. They had become part of the home's 'background' and in a desirable way*" [11:3458].

Morse Things operate mainly in the background but also have alterity aspects to them. For example, participants thought of them as having human qualities and as being like pet cats: present and interactive but not always interested in humans. One participant "*thought the Morse Things would be happy with their new home, and as [they] made sounds when she and Noah entered the house, she imagined them to be happy to see them: 'they were here and they spoke a little bit and then we went out for dinner […] we came back […] and as we entered the door, someone, one of them was like bipbipbip, and I was like, Oh! He's so happy to see us!"* [65:508].

Greenscreen Dress can be seen as becoming part of a fusion relationship. Mackey et al. describe how Mackey responded to the merging of the green garment and her body from her first-person perspective: "*I observed that being completely covered in the green fabric from my neck to my knees was too strong in that I felt overpowered by the complete digital transformation of most of my body. Some days I only wanted a pocket or collar that was green, a green-striped print or just green pants*" [26:55]. While physically arguably less intrusive as brain implants, the fusion of the green garments was obvious and even overwhelming to Mackey. Her reflections on responses of the select group of people who were aware of the study illustrate further the intimate relation with and through the garments that goes beyond embodiment: *"Only colleagues, friends and family members intimately aware of this study recognized the greens I wore as 'active' and were able to experience the live, AR [augmented reality] versions of the clothing through my smartphone. Mostly, this awareness provoked a heightened attention to what I wore each day and sometimes a question like 'Oh, you're not wearing green today?' would bring attention to this. I would respond by pointing to the subtle green leaves within the pattern of my shirt, or the green hue in my 'blue' pant"* [26:57].

Datacatchers give access to an aspect of the world by providing a representation of information about the near environment which users then interpret. This represents a hermeneutic relation. Additionally, users can move around

with the device in hand and see added aspects of their environment through the devices through an additional layer of information. This can be seen as combining an embodiment, hermeneutic and even augmentation relation.

Lastly, the *1C Camera* is mainly a background relationship. With the use being limited towards not being able to access or experience the images taken with the camera, the 1C has an absent presence in the life of its user.

Concluding Remarks about Relationship Structures in Research Products

Collectively, through our annotations we described the structures of human-technology relations across our selected research products. We have shown that artifacts can become part of several relationship structures and can further entail subtle relational aspects. Importantly, the novelty in research products commonly results in relationships and their dynamics to evolve over time. This way, research products may, unlike the commonly studied things in post-phenomenology, cause a low sedimentation or transparency in relationships. Additionally, research products can also challenge common postphenomenological understandings of human-technology relations.

While it is true that any technology can be analyzed for their relational aspects, we believe that such analyses for RtD artifacts specifically hold promise for HCI. Postphenomenological structures can bring new insights into future RtD analyses. Traditionally, in HCI there is a focus on alterity relations. The presented nuanced structures give ways to the more complex and meaningful relations coming about between humans, technologies, and the world.

3) Technology Co-Constitutes Objectivity and Subjectivity of any Given Situation (Mediations)

In addition to the structure of relations at play between humans and technologies, postphenomenology looks at the accruing implications or *mediations*. Verbeek [56] describes mediations happening on an *existential* level meaning "[h]ow humans appear in their world" or their actions and practices, and on a *hermeneutic* or experiential level meaning "[h]ow reality [or the world] appears to humans" or their perception and experience [56:196] (see Figure 3). In this, technologies work to *amplify* and *reduce* human perception and experience, and *invite* and *inhibit* human action and practices. In other words, this part of an investigation focuses on how, in the relations that arise around a technology, a specific "world" or objectivity and a specific "human" or subjectivity is constituted; and what are the implications of that?

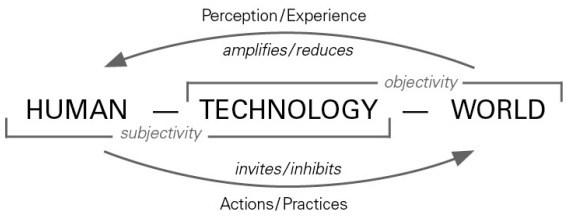

Figure 3 Technological mediation (based on Verbeek's descriptions)

In the previously mentioned study of obstetric ultrasound [57,50], Verbeek 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* the fetus as a patient, parents as decision-makers (subjectivity) and mothers as environments (objectivity). The questions guiding our analysis of the research products for this theme are: *What are mediations of the technology in people's lives? What kind of 'world' (objectivity) and what kind of 'human' (subjectivity) is co-constituted by the technology?*

Mediations of Research Products

Odom et al. share a vast amount of insights about the mediating or co-constitutional dimensions of *Photobox*: *"While households were initially frustrated by the slow rate of photos being printed, over time they appreciated how this pace created time to reflect on an individual image and the memories it triggers [...] participants described how, over time, the relative slowness of our prototype provoked them to consider the rate at which other domestic technologies operate"* [32:1966]. Further, Photobox *"provoked some participants to critically consider the role of technology in their everyday lives"* [32:1968] as one of their participants took a break from Facebook.

Odom et al. specifically speak to the changes in the experiences and perceptions across Photobox owners describing *"how [their] participants' perceptions of the Photobox changed over time as it transitioned from a perplexing and, at times frustrating, device, to one that was eventually understood and integrated into the home"* and thereafter *"how, over time, the Photobox supported experiences of anticipation, reflection, and meaningful interactions with participants' Flickr archives*" [32:1967].

Pierce shares his own account of living with an *Obscura 1C* describing a co-constituted subjectivity of himself: *"In my own use of the Obscura 1C, I have occasionally sat and held the camera while I vaguely imagined what might be inside. I also have distinct memories of images I believe I captured but that I know I may never actually see. In several instances, I consciously chose not to capture a corresponding image with a conventional camera* [39:126]. When sharing a post on craigslist to offer the *Obscura 1C* as a form of distribution [43], Pierce and Paulos also created a reality or world (objectivity) with the *Obscura 1C* existing in other people's lives. In the post, they asked people to motivate why they wanted to own *an Obscura 1C* and how they envisioned using it. The received responses further support the legibility of the world created through the artifact.

The *Indoor Weather Stations* emphasize that the home can be seen as a microclimate, changing the perception of this environment. One participant shared: "*My lightbulb moment was when I thought about the house as being an ecology – that it's not a sealed homogeneous box* "[6:7]. In terms of implications around the subjectivity of their participants, Gaver et al. also share unexpected implications: *"While the stations only marginally aroused the kind of investigative curiosity of the microclimate of the home we had expected, we found participants using them to make sense of their homes in other ways–particularly when they could see their*

own data over more extended time periods than the device's replay buttons allowed" [11:3455].

The Datacatchers short statements reveal information about the surrounding area appearing every few seconds. The statements are on topics like average housing prices, typical incomes, and the number of pubs or GP surgeries nearby [10:1598]. Gaver et al. describe that the statements "*simultaneously draw attention to the sociopolitical topology of the lived environment and to the nature of big data itself* [10:1597]. The *Datacatchers* were seen by many of Gaver et al.'s participants as *"extending the environment, however, by adding 'a new layer to the city with the data and information that you can't really see when you walk around'"*[10:1603]. This had an effect on their user perceptions of the environment. For example, one participant of Gaver et al. shared: "*I think the thing that really shocked me first was what a depressing area I live in, because all the statistics are about crime and health and how unhealthy the people are in my neighbourhood and in my community. You know that immediately starts you thinking: 'Is this the place that I live in'"*[10:1604].

Participants of the *Morse Things* study experienced tensions with making sense of the non-human-centeredness of the artifacts. Their perspectives of the cups and bowls shifted back and forth between anthropomorphized and withdrawn: *"While Olivia 'loved imagining' that the Morse Things talked and cared for her and her partner, she realized that 'that's not what they're saying at all, and they don't care about us at all'"*[65:510]. Another participant described how he did not perceive the *Morse Things* as different from other cups and bowls, yet mentioned that it may take more time to understand them and considered learning Morse Code to follow their conversations. Although the *Morse Things* were used in households among other bowls and cups, to hold food, liquids and trinkets, they garnered special attention. One participant reported: *"I continue to keep trying to grab the bowls while they are "tweeting." I don't know why I'm doing this, because I can just wait and check Twitter to see which bowl it was … guess I feel like I might be able to learn if they have different sounds? Maybe I'll be able to tell them apart eventually."*[65:509]. Further, in their proposed design concepts, the things supposedly co-existing with the *Morse Things* were often more human-centred and connecting with human practices. Through both study engagements, participants were trying to find new ways to constitute the relationship between them and the *Morse Things*.

In the *Greenscreen Dress* study, Mackey et al. report on how Mackey's perception of and experiences with the system moved from being "gimmicky" to an exploration into regaining control and expressing identity. In her study, the color green is constituted as something with virtual potential. Through this, and through her commitment of wearing a dynamic fabric every day, Mackey built her wardrobe with green as a main consideration: *"The resulting wardrobe was a product of rebuilding my personal identity through clothing that confronted the constraint of green fabric and allowed for the chroma-keying action to happen"*[26:55]. This process allowed her and her co-authors to further understand the nuances of green fabrics in combination with the interaction possibilities of the mobile application: *"She used the sensitivity slider in the application interface to render fabrics less "effective" to the keying-out, so that shadows and textures could remain. She found that dark greens and pastel greens gave a "grainy" effect to the digital content. She found that sheer materials worked in surprising ways whereby they could hold a faint layer of the digital content while still remaining transparent"*[27:449].

Mackey et al. [26,27] further report on how most of the digital content Mackey 'wore' came from captures from her surroundings. They describe how she collected and stored these images and videos as 'things to wear'. They elaborate on how she started thinking of these as patterns, similar as how one would think of patterned fabric. In such, her environment was constituted as wearable through the system of *Greenscreen Dress*.

Concluding Remarks about Mediations of Research Products

Through our annotations we have described how the selected research products mediate people's lives and worlds, i.e. shape new subjectivities and objectivities. Investigating these mediations allows researchers to holistically inquire into the role of technology in people's lives. Another important aspect that the notion of mediation offers is being able to look beyond human-centeredness. While within postphenomenology, artifacts are indeed seen for their mediations rather than their mere instrumental or functional purposes, the studied technologies do also have clear functionalities with at times close-ended purposes. This further highlights the potential we see for RtD approaches to engage in philosophical work. Where postphenomenological studies report on the role and implications of functional technologies in people's life, e.g. mediations of existing ultrasound technology, RtD artifacts are often more open-ended and therefore able to forecast with detailed descriptive accounts. Importantly, this entails how research products shift not only existing relations to digital technologies but may even challenge them and shape *new mediations* given their novelty (e.g. new ways of experiencing archived photos with *Photobox*, new ways of relating to clothing through *Greenscreen Dress*, or new ways of seeing an urban environment through *Datacatcher*).

DISCUSSION

Thus far in this paper we have described and unpacked an annotated portfolio of research products or RtD artifact inquiries revealing how they align with key postphenomenological commitments. We described empirical approaches across the research products, structures of human-technology relations they become part of, and, emphasized that they mediate human-world relations in any given situation. In this, we have established a postphenomenological vocabulary and concepts in the context of HCI and RtD, and sought to make the argument that research products can be seen as *doing postphenomenology* albeit in a more experimental way. Next, we discuss this in more detail and describe the constructive roles HCI researchers can take on in their RtD inquiries.

RtD as Doing Experimental Postphenomenology

First, we can consider RtD as an 'experimental' way of doing postphenomenology specifically due to its main commitment of the *crafting* of an artifact being an integral part of the inquiry. The actuality and high level of finish of research products allows them to be encountered and taken 'as they are' which means, in postphenomenological terms, that they mediate or co-constitute subjectivity and objectivity in any given situation. The crafting of research products allows HCI design researchers to investigate human-technology-world relations and technological mediations by not only studying them but also taking part in creating them. In this, research products can also challenge common postphenomenological understandings of human-technology relations and subjectivity and objectivity.

Second, the context in which research products are *studied* is co-constructed by the *choices* made around deployments, which extends postphenomenological ways of studying. Postphenomenological studies take empirical accounts of existing artifacts as the basis for their philosophical reflections. This offers a variety of existing contextual settings to be studied that have evolved around an artifact. Postphenomenological accounts often take on first person perspectives and, in a philosophical nature, are highly interpretative. This is in contrast to many HCI works that aim to produce a more objective account of the crafted and studied artifacts. The artifacts that we have discussed are unique to the inquiry and counterfactual in nature. In such, it is not merely a new artifact that is studied but, with it, usually a newly mediated '*world' (objectivity)* and '*human' (subjectivity)*. Based on our annotated portfolio of six research products, we aim to offer an exemplifying (but not definite) account of how HCI design researchers can take on the co-constructive and multifold roles in their inquiries (Fig.3).

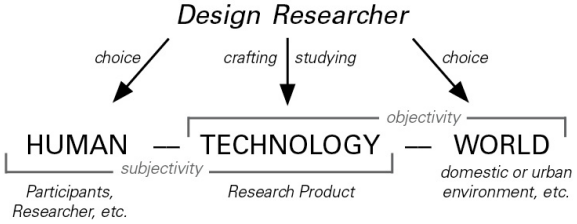

Figure 4 Constructive roles of HCI design researchers in their RtD inquiries

The design researcher can intentionally *choose* an environment (*world)* for the artifact to exist in (e.g., a domestic environment with the *Photobox* and *Morse Things* or an urban environment with the Datacatchers). The researcher's choices also determine who encounters the technology. An empirical account can, for example, come from deployment studies with participants. As described, this can involve researchers choosing specifically skilled or trained participants (e.g., design experts in the *Morse Things* study, or philosopher households living with a *Titling Bowl*) or through introducing an additional interpretive voice (e.g. the service-design team for recruitment and the documentary moviemakers for data collection with the *Datacatchers*). Further, the researcher can choose to analyze her/his own experiential accounts as a *researcher-participant* (e.g., Pierce's experiences with the *Obscura 1C* and Mackey's experiences with the *Greenscreen Dress*), which further entangles empirical accounts, design artifacts, and theory. We believe this type of *interpretive empiricism* can better support efforts in the HCI community to reflexively report on lived experiences, relativistic accounts and mediations.

In summary, research products and their commitments to the *crafting* and *deploying* of artifacts is a generative, bespoke, and more experimental way of investigating into human-technology-world relations and technological mediation. RtD artifact inquiries allow for philosophical reflection similar to postphenomenological inquires; and, they are also able to extend postphenomenological methodology in two ways. First, through their ability to *craft the object of inquiry.* Second, through their unique approach to studying technological mediation, and as a result creating inquiries that are experimental, generative, constructive, and anticipative. Accordingly, HCI design researchers can be seen as performing a kind of *radical empiricism* through the design and study of research products.

Through our annotations and further discussions, we hope to have created a more graspable, design-oriented way of understanding postphenomenological commitments and concepts, which can further aid in this process of purposefully crafting technologies that mediate and become part of human-world relations. The theoretical nature and abstract concepts of postphenomenology as well as the novel way we used this framing impelled us to create a rather text-heavy annotated portfolio; although we had initially anticipated it to be more visual. We see an opportunity for future work to engage with the theoretical foundation and language we have laid out in a more visual way.

CONCLUSION

In this paper, we have offered an account of postphenomenological commitments and concepts through an annotated portfolio describing and articulating how they are expressed across a number of RtD artifact inquiries. Our goal was to advance the idea of seeing the empirical efforts of research products as an *experimental way of doing postphenomenology* or in other words *doing philosophy through things* by making this theoretical framework more intelligible and actionable to other HCI researchers. Particularly, the utilization of annotated portfolios enabled a concrete way of showing conceptual themes that we found could be scalable to HCI research. As a result, these philosophical concepts can be better leveraged in future HCI research inquires, particularly with attention to forming a deeper understanding of people's "interactions" with technology and looking beyond human-centeredness. Moreover, the demonstrated value of postphenomenology advances HCI particularly in the way it speaks to the understanding, discussions, and positioning of RtD and more generally human-technology relation studies.

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