Design-in-Living

by

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Abstract

This doctoral work aims at articulating and deepening our understanding of how people design and make a space they live in with the goal of informing the design of interactive artifacts. While previous research described the appropriation and transformation of design artifacts through their everyday uses, those descriptions have focused mostly on discrete artifacts or systems. In this doctoral work, my goal is to go beyond unique instances by looking at the relations between design artifacts, ensembles of artifacts, and the spaces they are in.

This dissertation puts forward the concept of *design-in-living* as a way to rethink the design of interactive artifacts and spaces. Design-in-living describes how everyday designers engage in multiple ways of designing by combining unconscious design acts, ad hoc design, and planned design activities in order to construct their built environment. Design-in-living occurs while living in a particular space over time and design acts are motivated by fit between artifacts, ensembles, and the space. As a result, the space is constantly and incrementally built, leading to an invariably unfinished space. The articulation of design-in-living emerged from the findings of four studies. Each study was previously published and the full text of those four studies is presented in this cumulative format dissertation. The four studies include 1) a critical literature review of human-computer interaction (HCI) research on the home, 2) an ethnography inspired study of the practices of design and making of three groups of non-expert designers, 3) the articulation of the conceptual construct of unselfconscious interaction, and 4) an autobiographical design project of converting a cargo van into a campervan.

In addition to the conceptualization of design-in-living, this dissertation I pose a critical reflection on how to design for people who live with the Internet of Things, at home and beyond. Moreover, I offer a methodological reflection on the use of autobiographical design as a method of inquiry. Finally, this dissertation is addressed to interaction designers and HCI and design researchers who are interested in designing interactive artifacts that can become part of the making and designing practices in lived-in spaces.

Keywords: Design-in-living; everyday designer; making; designing; internet of things autobiographical design

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Chapter 1.

Introduction

Today, our relationship to artifacts and technologies is often regimented by an economy of mass production and mass consumption. Issues of planned obsolescence, cheap fabrication, disposable technologies, and globalization frame the ways in which we choose, buy, use, and discard everyday artifacts and technologies. Simultaneously, we have recently observed a shift in the relationship between users, designers, and producers, offering an alternative narrative to mass production and consumption. The rise of movements that celebrate handmade products and local materials or resources exemplify how consumers are interested in knowing where their products are from and who made them. Some services allow for direct personal customization of products, for example in choosing the materials, colors, shapes, and functionalities of a bag[1], a bike[2], or a kitchen cabinet system[3]. Further, some users are part of a complete shift in fabrication where they also conceive and build (or hack) artifacts and technologies for themselves, for example in the Maker movement and do-it-yourself (DIY) trends. Maker spaces and fabrication labs are places where people can use tools (including digital tools like laser cutters, 3D printers, and CNC milling machines) to fabricate what they wish. Finally, everyday people have started to take on the role of designers and producers and are selling their work through online platforms like Kickstarter[4] or Etsy[5].

These previous examples show how the user can take part (at different levels) in the conception and fabrication process for making everyday artifacts and technologies. This shared agency has the benefit of leaving more space for consumers and users to

[1] http://www.freitag.ch/
[2] https://www.missionbicycle.com/
[3] http://www.ikea.com/ca/en/catalog/categories/departments/kitchen/24254/
[4] https://www.kickstarter.com/
[5] https://www.etsy.com/ca/

shape their own identity, to feel empowered, to gain control, to be creative, and to build a more meaningful relationship with the artifacts and technologies they own (Tanenbaum, Williams, Desjardins, & Tanenbaum, 2013). This shift also reconfigures the user into a maker, a creator, and a designer (Wakkary & Tanenbaum, 2009). This holds important societal implications at the level of the economy, sustainability, cultural identity, and the democratization of making. This shift can help reshape the model by which we produce and consume everyday artifacts in the future.

Previous research has described the motivations and the processes by which non-experts engage in the design and fabrication of everyday artifacts. Those studies, (often ethnography inspired), aimed to better understand who makers and do-it-yourself (DIY) enthusiasts are (e.g. (Buechley, Rosner, Paulos, & Williams, 2009; Kuznetsov & Paulos, 2010; Rosner & Bean, 2009)), what their practices are (e.g. (Desjardins & Wakkary, 2013; Wakkary, Desjardins, Hauser, & Maestri, 2013), what their tools are (e.g. (Mota, 2011)), what their physical and social infrastructures such as fab labs and Maker spaces are (e.g. (Toombs, Bardzell, & Bardzell, 2015)), and what their online sharing platforms are (e.g. (Torrey, McDonald, Schilit, & Bly, 2007; Wakkary, Schilling, et al., 2015).

In addition to maker and DIY practices, researchers have observed that creative appropriations, resourcefulness, and ad hoc improvisation with everyday artifacts have also been happening in everyday life, outside of craft or hobby practices. For instance, Wakkary and Tanenbaum (2009) describe the *everyday designer* as a creative and resourceful agent who appropriates and redesigns artifacts long after the products have left the hands of professional designers to respond to the ongoing events of everyday life.

In research about DIY activities as well as everyday design, researchers have focused mostly on the design, making, or adaptation of discrete artifacts and, on rare occasions, of unique systems composed of a few objects. The implications of these studies are often oriented towards considerations for designing interactive artifacts that can better become part of those creative and resourceful practices by non-experts. As a result, researchers have proposed to design interactive artifacts that leave more room to

the users, by designing with certain qualities in mind, such as: open-ended (Sengers & Gaver, 2006), unfinished (Seok, Woo, & Lim, 2014), and more ambiguous (Gaver, Beaver, & Benford, 2003).

While these strategies are highly relevant in the context of designing discrete artifacts, in this dissertation my interest is broader: it includes collections of artifacts and the spaces they are in. More precisely, my aim is to shift our center of attention from discrete objects to *artifacts and their relations to other artifacts and spaces*. As technology continues to evolve and with the Internet of Things (IoT) gaining traction in academia and industry, this shift is essential since the design of interactive artifacts today often involves the design of *connected* artifacts, which, by definition, requires connections to other things, systems, and spaces, as I will describe in 1.1.

1.1. The user as maker in the era of the Internet of Things

Today, the Internet is recognized as an infrastructure that allows billions of individuals to communicate and to exchange information. While people's access to the Internet will continue to grow, the Internet is also dramatically changing: it is becoming "a global platform for letting machines and smart objects communicate, dialogue, compute and coordinate" (Miorandi, Sicari, De Pellegrini, & Chlamtac, 2012, p. 1497). The Internet of Things (IoT) is the term used to describe how the Internet is expanding into the physical realm, giving new capabilities to mundane physical artifacts, such as unique identification, basic communication capabilities, and possibilities for sensing and actuating in the physical world (Miorandi et al., 2012). Examples of current IoT objects are smart thermostats, smart fridges, connected toothbrushes, context-aware umbrellas, quantified-self watches and bracelets, and connected surveillance cameras, to name only a few. Technological advancements support electronic components like processors, sensors, actuators and communication modules to be miniaturized, to become less expensive, and to consume less energy (Mattern & Floerkemeier, 2010). This progress is central to how almost anything today can become smart or connected. The expected benefit of those technological advancements will be to create artifacts and spaces that are more aware of their users, allowing for a better support to everyday activities and routines.

While the Internet of Things focuses on the design of artifacts, the underlying assumption is that through the collections of connected objects, the environments we live, work, entertain and socialize in will change as well. This vision of a technological environment is not far from previous visions within the field of HCI such as Weiser's (1991) vision of ubiquitous computing (ubicomp), pervasive computing and smart environments (or smart homes). In fact, some argue that IoT is the framework that will make computing truly ubiquitous, by adding computation and connectedness to any thing in the physical world (Mattern & Floerkemeier, 2010).

While many challenges for the advancement of the IoT are technocentric; authors have also highlighted the social and human-centered challenges that might hinder a widespread adoption of the IoT (Nicenboim, 2015). Unsurprisingly, questions of trust, security and privacy are at the center of current discussions (Miorandi et al., 2012). In addition, researchers have argued that for the IoT to truly be adopted, it should account for users actively and creatively participating in the configuration and personalization of their systems and artifacts. Even further, De Roeck et al. state: "in order for the IoT to really take off, end-users need to participate in the creation process on a larger scale. They need to have the power and control over the creation and use of applications for smart environments" (De Roeck et al., 2012, p. 170). In current research on the IoT, only a minority of researchers have chosen to take this into consideration. In rare examples, researchers have proposed strategies for end-user development in smart homes and IoT systems allowing non-experts to start engaging with concepts usually reserved for software engineers (e.g. (Coutaz & Crowley, 2016; Tetteroo et al., 2015)). Others have suggested a DIY tactic, inviting people to work on the logic of the systems (for example with *If This Then That* (IFTTT) sequences), but also encouraging them to modify and adapt the materiality of those systems as well (e.g. (De Roeck et al., 2012; Woo & Lim, 2015)). In both approaches, authors are clear on the benefit these systems could have: they would allow "people to shape their domestic space in a flexible, reliable, incremental and opportunistic manner" (Coutaz & Crowley, 2016, p. 27).

The previous examples are exceptions to the general vision of the IoT, but they illustrate a desire to invite the user to become a maker in his or her own technological

environment. This is an interesting opportunity, but a research area that is currently widely underexplored.

1.2. Motivation for this research

This doctoral work aims to further deepen our understanding of the relationship between people, their creative making practices, and how they live in the space they constantly reimagine and reconfigure. The goal is to use this new understanding to offer insightful starting points for interaction designers and HCI researchers to study and design future interactive artifacts, potentially connected interactive artifacts. In this dissertation, I extend previous research by shifting the attention from looking at discrete artifacts to looking specifically at environments and collections of artifacts—including the relations between artifacts, collections, and environments.

There are two reasons for this shift in the research focus. Firstly, as described above, there is a gap in current research on how people imagine, design, and make their own spaces. While current research provides novel and valuable insights into how people make, appropriate, or hack everyday objects, there are not many descriptions of how these objects then exist in an environment, or even less of how various objects may be transformed together to configure a new space. In addition to expanding our understanding of non-expert design and making practices, knowing better how ongoing changes of artifacts happen in a space can provide further grounding to designing connected artifacts in the IoT.

Secondly, research on the IoT contains two important gaps: 1) it rarely considers current ongoing making and design practices of users, and 2) similarly to research on DIY and making practices, it focuses mostly on the design of discrete artifacts; artifacts connected to the Internet, but not necessarily connected to each other. As Crabtree and Tolmie note, the IoT is “largely marked by the design of individual things to be placed in the home: the Internet-enabled fridge, washing machine, thermostat, kettle, etc. The development of individual things creates a fragmented ecology in which things are not connected together; they are only connected to the Internet.” (Crabtree & Tolmie, 2016, p. 1746).

In brief, to investigate how people design, make and reconfigure their everyday spaces (often through collections of artifacts) has the potential to expand our knowledge about non-expert design as well as provide strong anchor points to rethink how we design for the IoT. In a broader sense, this research is motivated by the goal of refining how we think about the design of everyday interactive artifacts to allow people to use them in reconfigurations of their everyday environments.

1.3. Context of inquiry: Lived-in spaces

The challenges described above (1.2) relate to many spaces in which people live and dwell. The questions surrounding how people design, make and reconfigure spaces they live in are relevant for various places such as homes, cars, recreational vehicles (RVs), workplaces, schools, and public spaces. Although people have been living in and adapting these spaces for decades, or centuries in some cases, it is a timely topic to investigate as those spaces are in the midst of technological shifts. For instance, the smart home holds various appliances and systems that are automated and connected. Car interiors are becoming increasingly sophisticated user interfaces. Similarly, the smart city exists with a layer of information and communication technologies superimposed onto existing infrastructures.

In this dissertation, I choose to look specifically at how processes of design and making happen in the lived-in spaces of homes. This choice helps narrow the scope of the research, which in turn provides insights that are more detailed and rich. This choice was not arbitrary. The home is personal, complex, messy, and intimate, which makes it a challenging space to study, but it is potentially the place where people have (or want) the most control over their environments, and where the configuration of this environment has deep implications for day-to-day life as well as for personal and family identity. Within the home, artifacts play a variety of roles. For instance, HCI researchers (e.g. (Crabtree & Rodden, 2004; O'Brien & Rodden, 1997; Swan, Taylor, & Harper, 2008; Taylor & Swan, 2005; Tolmie, Pycock, Diggins, MacLean, & Karsenty, 2002)) have generated an important number of ethnographic and ethnomethodological works that depict how families organize, coordinate, communicate, and understand their domestic setting with and through everyday artifacts and media. Collectively, their works have

uncovered the role and impact of artifacts and media in family routines, habits, social dynamics and activities in the home, or, in other words, how artifacts are part of the social making of the home. Of particular interest for this doctoral work is the notion that families often create their own systems and meanings over time in artful and creative ways; systems that are often only intelligible to the family members (Taylor & Swan, 2005; Tolmie et al., 2002).

In addition, the home as a lived-in space was chosen as a site of inquiry because of its history in do-it-yourself home improvements projects (Shove, Watson, Hand, & Ingram, 2007) which already underscores the small and large changes that people make to their homes and to the artifacts within their homes. For example, grounded in ethnographic studies of families in the home, Wakkary and Maestri (2007) have proposed the concept of design-in-use (which I describe in more details in 1.5.1) to look at the ongoing design processes used by everyday designers to adapt their artifacts and systems to the daily pressures of use and family members' individual needs. As a result of their study, Wakkary and Maestri see home dwellers to be designers in their homes; hence, they are renamed everyday designers. When taken together with the work by Tolmie, O'Brien, Crabtree, Taylor and Swan presented above, these works demonstrate how much home dwellers appropriate, adapt and transform design artifacts to better fit their everyday lives at home. They illustrate how everyday people's creativity and ad hoc transformations operate at the level of artifacts, but do not address how those changes impact a full reconfiguration of the space at home.

While the HCI community has investigated the home as a topic and as the context for developing interactive technologies for over three decades, the ways in which people design and make their own spaces (or their own homes) is still highly understudied. Even more so, strategies to support those people's (non-expert designers) design practices, particularly in the contexts of IoT or ubiquitous computing, is also underexplored as described in 1.2. The work presented in this dissertation aims at describing how people design and make their space; and to propose strategies to consider those practices when designing IoT artifacts or smart environments.

1.4. The format of this dissertation: A collection of four studies

The doctoral work I conducted over the past years is presented in this document as a cumulative dissertation. I present, as the core of the work, four articles previously published in international top-tier peer-reviewed venues. The articles discuss current HCI research on the home, non-expert making practices, living with interactive artifacts, and the experience of making and living in a reconfigured space. Furthermore, I offer, in the introduction (chapter 1), the discussion (chapter 6) and the conclusion (chapter 7) a retrospective reflection on the implications of this work for the fields of interaction design and human-computer interaction.

The main contribution of this doctoral work is the conceptualization of design-in-living as an extension of the concept of design-in-use as originally articulated by Wakkary and Maestri (2007). In the next section, I offer an overview of the concept of design-in-living to facilitate and structure the reading of chapters 2 to 5. The four cases presented in the four articles (chapters 2 to 5 of this dissertation) present a deepening of different aspects of how people design and make a space they live in. Together, they form the basis of the articulation of the concept of design-in-living. Moreover, at the beginning of each chapter (2 to 5), I open with a preface highlighting the important findings or concepts presented in each article, as a commentary to further guide the reader through this collection of work. Those prefaces are important because they indicate the distinction between the original aims of the individual studies and their role in this dissertation—and in the development of the concept of design-in-living. In Figure 1, I visually outline the research questions guiding my research and how they help create relations between the four studies presented in chapters 2 to 5. Each article was written in collaboration with co-authors. In appendix A, I describe the specific roles I played in conducting each study and in writing the four articles.

Main research question #1
How do people design and make a space they live in?

Main research question #2
What are the qualities of design and making in a lived-in space that are relevant for the design of interactive artifacts?

What do we already know?

Ch. 2

Research question #1
How has HCI research investigated design and making in a lived in environment?

Critical literature review of HCI research on the home

Main findings:
1. Design and making are only seldom investigated in HCI research on the home. Focus is generally on the use of technologies.
2. The genres Social Routines, Ongoing Practices, and Smart Homes show an interest in collections of artifacts and spaces.
3. HCI research on the home is dominantly conducted from an observer/interpreter perspective. It should include more 1st person perspective research.

Desjardins, Wakkary, and Odom. *Investigating Genres and Perspectives in HCI Research on the Home*, CHI'15

How do people design and make?

Beyond use, how do people live with interactive artifacts in a space?

What could we learn from a 1st person perspective of living in a space?

Ch. 3

Research question #2
How do different types of non-expert designers design and make?

Design ethnography of 3 types of non-expert designers

Main findings:
1. There are different practices of non-expert design; and they might co-exist within one practitioner.
2. Design strategies include: trial and error, experiments, serendipity, incremental changes, and creative thinking.
3. Design motivations include: foundational goals, aesthetic goals, and aspirational goals.

Desjardins & Wakkary. *Manifestations of everyday design: guiding goals and motivations*, C&C'13

Ch. 4

Research question #3
How are interactive artifacts lived with in a space?

Concept-driven interaction design research on unselfconscious interaction

Main findings:
1. Goodness of fit is the motivator for ongoing and incremental improvement to the everyday environment.
2. Goodness of fit happens at the level of ensembles.
3. Goodness of fit is supported by lived-with qualities and time.
4. Computational artifacts have resource like qualities (they catalyze improvements of everyday environments).

Wakkary, Desjardins, and Hauser. *Unselfconscious Interaction: A Conceptual Construct*, IWC, 2015

Once the artifacts are made, how do people live with them?

Beyond artifacts, how do those processes of making and designing happen in an environment?

Beyond artifacts, how are spaces lived with/in?

How do people engage with ensembles in ways beyond unselfconscious interaction?

Ch. 5

Research question #4
What is the first-person experience of designing and making in a lived-in space?

Autobiographical design project of living in a prototype

Main findings:
1. The lived-in space is materialized through ongoing and incremental construction cycles.
2. Living in a prototype points to the value of physical presence and the luxury of time.
3. A reconfigured space holds prototype qualities at the level of design artifacts, collections of artifacts, and the space.
4. A reconfigured space is invariably unfinished.

Desjardins & Wakkary. *Living in a Prototype: A Reconfigured Space*, CHI'16

Design-in-living

Outcome:	Design-in-living materializes through the ongoing and incremental making and adaptations of the space and ensembles within that space. Design-in-living may also materialize through artifact and routines.
Motivation:	Design acts respond to the catalytic pressures of everyday life. Design acts are motivated by goodness of fit within and between artifacts, ensembles, and the space.
Conditions:	Design-in-living occurs while living in a particular space over time.
Qualities of the person:	Everyday designers are creative and resourceful.
Design strategy:	Everyday designers design through appropriation and adaption of everyday artifacts and the space. Everyday designers engage in multiple ways of designing by combining unconscious design acts, ad hoc design, and planned design activities.
Qualities of artifacts and space:	The designed space and design artifacts are understood as resources for further design acts.
Level of finish:	The space is invariably unfinished; the level of finish on artifacts ranges from sketched to highly polished.

Figure 1. Design-in-living: Overview of research questions

1.5. Research approach

The goal of this dissertation is to present an in-depth analysis of how people design and make in a space they live in. I discussed in 1.2 the importance of gaining more in depth descriptions and articulations of the design and living practices of people in their homes. As a starting point to articulating the findings of my work, I use the concept of *design-in-use* (1.5.1), a concept developed in the original study of *everyday design* by Wakkary and Maestri (2007). In section 1.5.2, I describe how design-in-living departs from design-in-use and offer a short summary of what design-in-living is.

In addition to taking this analytical approach for investigating my research questions, I also found the need to be critical regarding the current trajectory of the design of interactive technologies for the home. Within research on ubiquitous computing, smart home research, and the IoT, researchers often leave out of focus 1) the need to consider user agency within the home, and 2) the importance of a holistic understanding of how the space, the elements within the space, and the inhabitants are co-shaped over time. These are topics that can radically change how HCI researchers imagine and design interactive technologies for the home. In 6.3 I propose critical reflections based on my analysis of the concept of design-in-living.

Moreover, my research approach in this dissertation also addresses a methodological gap I have observed in current HCI research on technology in the home. As I will show in chapter 2, HCI researchers often use an observer/interpreter perspective when conducting research on the home. This third person perspective implies that the researcher is in a position where he or she curates and interprets the data collected as a way to support the argument that results from their analysis. In chapter 2, I propose that removing this layer of interpretation can lead to a richer and more nuanced understanding of the home as a context for the design of interactive technologies. I propose to use a first person perspective to study the use and design of interactive technologies for the home. Adding diversity in the perspectives we take as a research community can lead to more subtleties when describing and articulating how we might want to design for intimate, complex and personal environments such as the home. In chapter 5 (as I introduce in 1.6.4), I take a first person perspective and conduct an autobiographical design project as a way to investigate the first hand experience of designing and making a lived-in space.

1.5.1. Design-in-use

In their 2007 article, Wakkary and Maestri see the home dweller "as a type of everyday designer who remakes and modifies systems and who uses design artifacts and actions around them as design and creative resources" (2007, p. 164). Design-in-use principles have further been explored by Wakkary and Tanenbaum (Wakkary & Tanenbaum, 2009) in their reflection of everyday design vis-à-vis sustainable HCI.

As a concept, design-in-use describes how acts of design happen through everyday use of artifacts and systems in the home. It portrays how everyday designers are able to see design anchors in artifacts, anchors that are the starting point for adaptation and appropriations, often in ad hoc and improvised ways. In general, the concept of design-in-use highlights user creativity at the level of the design artifacts and systems (or collections of artifacts). For everyday designers, design artifacts are seen as resources for future designs to respond to their various needs in everyday life. Examples include how everyday designers use chairs as tables or as coat hangers (see Figure 2), as well as how they use a magazine to catch nail clippings. Moreover, sometimes, those

ad hoc acts can transform into more elaborate routines or systems. For example, Wakkary and Maestri (2007) describe how a family phonebook evolved from a single sheet with emergency phone numbers for caregivers, to a binder filled with pages with phone numbers for school, work, ferries, kids' friends and more.

Figure 2. Chair as table and chair as coat hanger

Next, in Table 1, I list six characteristics of design-in-use that are the most useful in the context of this dissertation as a description of everyday design practices. The presentation of those characteristics is the result of an in-depth read of the 2007 and 2009 articles.

Table 1. Characteristics of design-in-use

	Design-in-use
Outcome	The main outcomes of design-in-use are the ongoing and incremental ad hoc adaptations of artifacts and elements of the surroundings. Those adaptations may become the center of routines (and potentially long-term systems).
Motivation	Design acts respond to the catalytic pressures of everyday life.
Conditions	Design qualities emerge over time.
Quality of the person	Everyday designers are creative and resourceful.
Design strategy	Everyday designers design through appropriation and adaption of everyday artifacts and

	surroundings.
Quality of the artifacts and space	Design artifacts are understood as resources for further design acts.

1.5.2. Design-in-living

In this section I give an overview of design-in-living. This overview should prepare and guide the reader for the reading chapters 2 to 5 by displaying concepts and terms that are central to design-in-living. In chapter 6, each characteristic of design-in-living is presented in more details and with examples from the studies presented in chapters 2 to 5. In the following paragraphs, I summarize design-in-living according to seven characteristics: the outcome of the design acts, the motivation of everyday designers, the conditions necessary for design-in-living to take place, the qualities of the designers, the design strategies employed in design-in-living, the qualities of the space, and the level of finish of that space.

The aim of this research is to investigate how people design and make in a space in which they live. The concept of design-in-living offers a structure to describe the design and making practices of everyday designers. In order to describe this practice, I shift the focus of attention from artifacts (as seen in design-in-use (1.5.1)) to a whole space.

In design-in-living, the outcome of the design process is the incremental and ongoing making and adaptations of the space itself, as well as the artifacts that are within that space. Everyday designers constantly make changes to respond to the catalytic pressures of everyday life, similarly to design-in-use. However, in addition, the focus on the whole space adds the motivation to reach a good fit between the different elements within the space. For example, it would not be sufficient to fix a light so that it can be properly hung from the ceiling, it would also need to be installed in relation to the center of a table, which in turn is aligned to the window of a living room. Moreover, the quality of the light, its brightness and temperature could also be iteratively adjusted to reach a level of fit with the atmosphere wanted in the space.

In design-in-use it is stated that design qualities need time to emerge. This is also the case in design-in-living, where time, particularly time spent living in the space, allows for new ideas, a better understanding of needs, and design actions to emerge. In design-in-living, the physical presence in the space is as important as the temporal condition. By living in the space, the everyday designer is surrounded by elements that were already designed and made, as well as elements that still need to be adjusted. The physical surroundings remind the everyday designer of the aspects of design that are around him or her and serve as a catalyst for design actions. In addition, the possibility to be constantly surrounded by the design space leads to an intimate relation between the everyday designer and the space, an intimacy that is hard to describe to outsiders and one that nourishes the growing uniqueness of the space.

In design-in-living, people can be described as creative and resourceful, similarly to design-in-use. Everyday designers constantly imagine and reimagine what their living space could be. While everyday designers might think they know what each step of their design will be, it is only through the making and living with different stages of the build that clarity of the design ideas will emerge. Times of living at different stages of the build are crucial for reassessing and reimagining what the space should become. Moreover, everyday designers engage in a multiplicity of design strategies over the years of design-in-living. For instance, they may perform unaware or unconscious appropriations of objects or furniture within the space. They may also use ad hoc and improvised ways to answer to new situations or challenges within the space. Furthermore, everyday designers also engage in major changes to their environments (such as tearing down a wall, adding or removing furniture pieces, etc.), and those events require planning, design sketches, and particular tools and materials to carefully execute the design idea. In design-in-living, people are experts at managing different levels of design expertise and in applying the right level of skills for the right design actions.

Design-in-living specifically focuses on relations between artifacts, or on the space as a whole. This characteristic of design-in-living, together with the fact that making happens in different cycles, articulates why some aspects of a space might be completely finished and polished while others might still be roughly sketched or prototyped. In design-in-living polished elements can inspire everyday designers to

engage in their next design actions, but they might also have them reconsider ways of making or design decisions for future builds. In addition, living with prototype-like things (that are more rough or unfinished) allows the everyday designers to investigate and try new ways of engaging with artifacts that might not be possible for polished pieces. In the stages of building, in this context, any artifact or raw material is seen as a resource for design and can allow maker/users to navigate different strategies of making.

In the last paragraphs I have described in general terms what design-in-living is. From this description, some characteristics are important to keep in mind as the reader continues on to chapters 2 to 5. Those characteristics are: a shift from designing artifacts to designing a whole environment, the goal to reach goodness of fit between elements within a space, the need for time and physical presence in a space, a multiplicity of design strategies, the space and artifacts as resources for future design actions, and the unfinishedness of the space. These characteristics are present throughout chapters 2 to 5 and I come back to them in chapter 6, when I present the details of design-in-living.

1.5.3. Design-in-living as part of a multiplicity of design practices

Before I pursue towards describing my research questions in this dissertation, I take a pause to share my view on how design-in-living co-exists alongside other practices of design. The main assumption in everyday design (as well as in design-in-use and design-in-living) is that everyone is a designer. The range of design actions each person can—or wants to—achieve, of course, varies. However, to be clear, I do not propose that the everyday designer will take over the practices of professional designers. In fact, I propose that everyday design, alongside professional design practices, highlights the multiplicity of design practices that co-exist in our world. Within professional design practices, there are also variations in the types and scales of design actions. For example, a luxury designer might design for a very limited production with high quality materials and his practice would be very different from a designer creating products to be rapidly produced and massively distributed or from a designer who works for a private client in creating bespoke products. This view of design—as a multiplicity of practices—is beneficial in HCI research as it allows understanding more holistically how

artifacts and spaces are created, evolve, and change between the hands of multiple players beyond the professional designer.

Everyday designers can take design decisions and transform artifacts that a professional designer would never be able to achieve at the level of the each unique artifact once they are in their own context of use. The everyday designer can design at a level of precision and uniqueness that is unavailable for a professional designer who is aiming at creating a product that will be used by thousands of people. Previous research has articulated in details how design continues to happen when an artifact reaches his or her owner and how this continuous process of design is often inevitable (and often necessary and beneficial). Noteworthy examples include the work of Henderson and Kyng (1992) who discuss the need for design in use; Christopher Alexander (1964) who examines unselfconscious cultures as cultures where the profession of design did not exist, yet where design actions were part of everyday life; and Fischer and Giaccardi (2006) who propose meta-design as a framework to understand and better support end-user modifications. Together, this literature does not propose that professional design is unnecessary, but that other types of design practices exist and that they participate in shaping the relationship between people, artifacts and spaces.

In the previous paragraphs I have argued that there is a multiplicity of design practices and that professional design and everyday design are two of those practices. Next, I discuss how within design-in-living there are also different ways in which design actions are manifested—or how there is a variety of design practices within design-in-living (this is discussed further in 6.1.5). Similarly to design-in-use, design-in-living includes creative acts that are unconscious, tacit and improvised. These actions are often appropriations of existing artifacts as a way to quickly respond to a situation that has emerged. When taken in isolation, these appropriations might not fit the common design process of ideation-sketching-prototyping-implementation; however, they are part of the process of piecemeal design. In this sense, each of those ad hoc appropriations leads to the improvement of the space, and overall creates a preferred outcome—essentially the outcome any type of design aims to reach.

In design-in-living, in addition to those ongoing incremental acts of piecemeal design, I also observed the presence of more important design endeavours that were planned, sketched and often prototyped. While those examples followed a more formalized design process, they still did not necessarily require a professional designer. Hobbyists, amateurs, and DIY enthusiasts often do not have a formal design education, however they are able to develop those skills on their own (as I will describe in chapter 3). Together, the tacit appropriations and the planned projects form what I present as the practice of design-in-living.

1.6. Research questions and four studies

While each study in this doctoral work held its own research questions at their time of writing, my retrospective analysis of the four studies is structured following two main research questions and four issue sub-questions—one per study. By putting together a new list of research questions to answer, I was able to structure my reflection on the work that I have already conducted and to direct each study towards a better understanding of design-in-living. In Figure 1, I presented the relations between the studies, the research questions, and design-in-living. In the following paragraphs, I detail those relations.

To start, this doctoral work aims at articulating and deepening our understanding of how people design and make in spaces they live in with the goal of informing the design of interactive technologies. The main research questions of this doctoral work are:

MQ1: How do people design and make a space they live in?

MQ2: What are the qualities of design and making in a lived-in space that are relevant for the design of interactive artifacts?

The findings from chapters 2 to 5 allow me to answer both main research questions. To give more structure to each article presented in chapters 2 to 5, I present in the next sections one research question per chapter as a way to guide the findings.

1.6.1. HCI ways of knowing the home

Chapter 2.

Q1: *How has HCI research investigated design and making in a lived in environment?*

Desjardins, A., Wakkary, R., & Odom, W. (2015). **Investigating Genres and Perspectives in HCI Research on the Home.** In *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems* (pp. 3073–3082). New York, NY, USA: ACM.

The first step in my research process was to analyze what the HCI research community already knew about designing and making in a lived-in space. The first question is:

Q1: How has HCI research investigated design and making in a lived in environment?

The home, a lived-in environment, has been investigated through many different lenses and perspectives within HCI. With this research question, I aim at offering a portrait of the current HCI research on the home, and uncovering areas that have already touched on non-expert making or designing in the home. At the same time, by posing a critical perspective on current and past research, my intention is to open new perspectives or epistemological commitments that have potential to study how people design and make in their spaces.

Specifically, the first study I present (in chapter 2) is a critical literature review of past and current HCI research on technology for the home (Desjardins, Wakkary, & Odom, 2015). This critical literature review is based on a review of 121 works in HCI research that have for topic the design of technology for the home. The review focused on two main aspects: 1) the kinds of questions researchers asked when conducting their research, and 2) the objects of their studies. The findings of the study showcase seven genres of HCI research on the domestic experience, including 'social routines in the home', 'ongoing domestic practices', 'the home as testing grounds', 'smart homes', 'contested values of a home', 'the home as a site for interpretation', and 'speculative visions of the home'. In addition to presenting those seven genres of research, in this study we also offer two dominant perspectives observed in researchers' epistemological commitments and we articulate two complimentary epistemological commitments that can lead researchers to ask different sets of questions with relation to the design of interactive technologies in the home.

This first study is important for this dissertation as it situates my inquiry on design-in-living in relation to previous and current approaches in HCI research on the home. This critical literature review also highlights novel perspectives that have potential for exploring new territories with regards to technology in the home. One of those perspectives is the use of first person design research as a way to place the researcher at the center of the action instead of being a third-person observer, a perspective I chose for part of this doctoral work, as reported in chapter 5.

The three following studies take specific aspects of design-in-use and everyday design and offer a deepened and more precise investigation of the topics of making, living with, and living in.

1.6.2. Three practices of non-expert design and making

Chapter 3.

Q2: *How do different types of non-expert designers design and make?*

Desjardins, A., & Wakkary, R. (2013). **Manifestations of everyday design: guiding goals and motivations.** *In Proceedings of the 9th ACM Conference on Creativity &* Cognition (pp. 253–262). New York, NY, USA: ACM.

One of the findings of chapter 2 (as presented above in 1.6.1) is that the practices of design and making by non-expert designers are underexplored. The second research question is:

Q2: How do different types of non-expert designers design and make?

The second study I offer in this collection of work is an in-depth description of three types of everyday designers: families, hobbyist jewellers, and steampunk enthusiasts (Desjardins & Wakkary, 2013). Q2 aims at expanding the definition of design-in-use by investigating how different types of non-expert designers engage in practices of design. By looking at how steampunk enthusiasts and hobbyist jewellers practice everyday design, and by comparing their practices to those of families, the answer to this question allows us to expand HCI's view of what forms design-in-use can take in different practices of making. Furthermore, this question also allows for a reflection on the varied roles people can take depending on the making project at hand.

The analysis of the three practices of everyday design is grounded in Social Theories of Practice, particularly using the framework developed by Shove and her colleagues (Shove, Pantzar, & Watson, 2012). The study is structured to discuss the relations between the motivation of the everyday designers, their competences in achieving their practices of everyday design, and the materials (including artifacts, tools, and their bodies) that are part of their practice. The findings show how influential the motivation of the practice is and how much it can guide the choice of materials and the development of know-how and skills. Overall findings show three types of motivations: foundational, aesthetic and aspirational goals.

This second study is highly relevant to the development of the concept of design-in-living as it describes how design-in-use is performed by different everyday designers. This article also offers insights on how design actions can be accomplished for reasons beyond the catalytic pressures of everyday life, to include aesthetic and aspirational goals. In addition, this study highlights how everyday designers, while still being creative and resourceful, can juggle a variety of skills and competences to achieve the goals they set for their own practices of making—a central quality of design-in-living.

1.6.3. Unselfconscious interaction: goodness of fit and living with

Chapter 4.

Q3: *How are interactive artifacts lived with in a space?*

Wakkary, R., Desjardins, A., & Hauser, S. (2015). **Unselfconscious Interaction: A Conceptual Construct.** *Interacting with Computers,* iwv018.

Design-in-living has an equal focus on designing and living. By focusing particularly on the incremental and ongoing engagements people have with computational artifacts while they are living with them, this question moves away from a focus only on design or making practices as described in chapter 3. The third research question is:

Q3: How are interactive artifacts lived with in a space?

The third research question specifically focuses on interaction design artifacts and how people engage with them in a lived-in space. While the original study of everyday design mostly described appropriations and transformations of non-

computational artifacts, this question asks how it would be possible for interactive artifacts to become part of similar ongoing and incremental improvements. This question particularly extends the concept of design-in-use by including computational design artifacts as part of systems and ongoing changes in the home. More importantly, this question targets how artifacts are lived-with, beyond being transformed or made.

In chapter 4, I present an articulation of the conceptual construct of unselfconscious interaction (Wakkary, Desjardins, & Hauser, 2015). Inspired by Christopher Alexander's (1964) description of goodness of fit and unselfconscious cultures, we describe how interactive artifacts can become part of those ongoing and often unknowing processes of unselfconscious design. By analyzing three design research artifacts, we show how, with time, those artifacts play a role in the ongoing and incremental improvements to everyday settings.

While this paper holds multiple contributions to the HCI field, in this dissertation, I focus on its relevance to how home dwellers live with interactive artifacts in the home. The important findings from this study are the concepts of goodness of fit, lived-with, and ensembles. The aspects of lived-with and ensembles are revisited and presented under a different angle in the last study: Living in a Prototype (chapter 5).

1.6.4. Autobiographical design project: Living in a prototype

Chapter 5.

Q4: *What is the first-person experience of designing and making in a lived-in space?*

Desjardins, A., & Wakkary, R. (2016). **Living In A Prototype: A Reconfigured Space**. In *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems* (pp. 5274–5285). New York, NY, USA: ACM.

In this last question, I propose to look at a unique example of the concept of design-in-living. The last chapters (3 and 4) describe examples of how people live with or design artifacts. While these descriptions help develop the concept of design-in-living, they do not yet present a synthesized and concrete example of design-in-living the way chapter 5 does. In this chapter, the research question brings the

concept of design-in-use at the scale of a fully reconfigured space. Moreover, I shift my perspective as a researcher by taking a first-person perspective to answer the question. The fourth research question is:

Q4: What is the first-person experience of designing and making in a lived-in space?

In this chapter, the focus is not on how everyday designers appropriate an artifact or create a system with various artifacts, but on how they imagine, design, and make a whole environment (including artifacts and furniture) that they live in. While the concept of lived-with is developed as part of the answer to Q3, with Q4 there is a more important focus on the cycles between living and making in the reconfigured home. The answer to this question focuses on the relation between the maker/users and the space itself—describing qualities of living in a reconfigured space. Moreover, this question specifically addresses different types of making—including making that necessitates prior imagining or design, as well as ad hoc improvisation with everyday artifacts.

More precisely, this study presents an autobiographical design project of converting a Mercedes Sprinter Van into a camperized van (Desjardins & Wakkary, 2016). This study particularly looks at how maker/users live in a space they are imagining, designing, and making. The study discusses in details the qualities of the relationship between the maker/users and the space itself as they go through cycles of making and living in. The findings highlight the impact of living *in* a reconfigured space (both in relation to time and space), the implications of the juxtaposition of different levels of prototype refinements in a reconfigured space, and the invariable unfinished nature of the home.

The goal of this chapter is to study the deeply personal and rich experience of designing and making a lived-in space. In order to understand the subtleties and complexities of such an endeavor, I propose that investigating specifically what the first person experience is in such a situation is the most powerful perspective to take. Hence, autobiographical design is appropriate to investigate this question. I discuss the methodological implications of this decision more in 6.4.

This last study offers an important last chapter to the findings of this dissertation as it makes the central move from looking at design-in-use from an artifact or system perspective to looking at design-in-living in a reconfigured space. In addition, the qualities of living in a prototype showcase how aspects of making and aspects of living can co-exist when reconfiguring a whole space.

1.7. Contributions and audience of this research

1.7.1. Contributions of this research

A part of the contribution of this dissertation lies in how each study in itself makes important contributions to the HCI and interaction design research communities. Those contributions are: a critical literature review of HCI research on the home (including two new complementary research perspectives: a material perspective and a first-person perspective); the description of the making practices of three groups of non-expert designers (including families, hobbyist jewellers, and steampunk enthusiasts); the articulation of the construct of unselfconscious interaction; and the description of six qualities of living in a prototype.

While each paper had its own contributions at the time of their writing, the main contributions of this dissertation come from the combination of the four articles and the overall articulation of the concept of design-in-living. This doctoral work contributes four main points to the HCI and interaction design research communities.

The first contribution is the description of how people design and make in spaces they live in. Together, the four articles offer a detailed understanding of how people make and appropriate design artifacts (ch. 3), how they live with interactive artifacts over time and engage in incremental adjustments of the everyday setting (ch. 4), and what their experience of designing and making a reconfigured space is (ch. 5). Together, those in-depth descriptions offer a more complete understanding of who the everyday designers in design-in-living are, which complements our current understanding of everyday designers and DIY enthusiasts in design-in-use.

The second contribution is conceptual. By combining the results of four studies on how people design, make and live with design artifacts in the home, this dissertation articulates the concept of design-in-living. This novel and original concept offers an extension to design-in-use, originally defined by studies of family members as everyday designers. Design-in-living includes and brings to the forefront the importance of *living with* or *living in* as a way for everyday designers to design and make their everyday setting, as well as to co-exist with everyday artifacts in a space. More importantly perhaps is the fact that design-in-living broadens the focus of design beyond artifacts and systems to consider a whole space.

The third contribution of this research is critical and reflective. Starting with a critical literature review in chapter 2, this research provides a critical point of view on the current trajectory of research on technology for the home. Moreover, the concept of design-in-living provides an alternative vision for how people will live in (or could live in) smart environments in the future. In chapter 6, in addition to presenting seven characteristics of design-in-living, I also articulate reflections for future interaction design research. Those reflections aim at reassessing current assumptions in the design of interactive technologies and opening new avenues for future designs, for example in the Internet of Things and ubiquitous computing environments.

Lastly, this research also offers a methodological contribution. In chapter 5, I use autobiographical design as a method to investigate first-hand the experience of designing, making, and living in a reconfigured space. While autobiographical design was articulated as an HCI research method in 2012 (Neustaedter & Sengers, 2012), and while it builds on much older anthropological methods like autoethnography (Ellis & Bochner, 2000), it is still an underexplored methodology in interaction design and HCI research. In this doctoral work, I use autobiographical design in combination with a critical literature review, ethnographic studies, and concept-driven interaction design research. The results of this dissertation show that this combination of methods, and the inclusion of first person research, can lead to a strong articulation of a new concept, in this case design-in-living.

1.7.2. Audience for this research

This dissertation will be of interest to HCI and interaction design researchers who want to gain a better understanding of the role of computational artifacts in everyday settings. This work will also allow HCI researchers to better understand the relationship that exists and develops between everyday designers, artifacts in the home, and the space itself. Finally, this research will offer HCI and interaction design researchers a new starting point to rethink research and design for the IoT, as well as ubicomp environments.

In addition, for interaction design practitioners, this research will provide varied inspirational examples and precedents that show how creative and resourceful people are in their everyday settings. Through those detailed and rich examples, my goal is for practitioners to see an alternative vision of what the home, the car, or the city could be that is dramatically different from the interactive products and systems that are on the market today.

1.8. What this dissertation will not address

In this dissertation, I take the role of a design researcher. This position comes with epistemological commitments and helps direct my attention to certain topics while eclipsing other areas of interest. The main focus in this dissertation is on how people design and make in their own space, and how this can help imagine and design future interactive technologies. To keep this focus, I decided to refrain from discussing the social and psychological issues of gender and domesticity in the home, as well as the technical aspects of interactive artifacts.

Most of the studies I present in this dissertation take place in the home, a complex and contested place to study. Many psychological, social and personal issues can surface when doing research on the home, particularly matters of gender, roles, power and domesticity. I did not articulate specific questions about those topics when conducting my research, and they did not emerge organically in my studies. For this reason, I do not address them in this dissertation. However, I acknowledge their

importance in how people within a home might engage in design practices and propose that they should be part of future research in 7.3.2.

While this work aims at inspiring the design of future interactive artifacts, it is not a technical piece of work. I propose ideas and areas for future research that do not necessarily rely on current or near-future technological developments. This decision to remove the technical discussion from this research is deliberate: I did not want to constrain my design ideals by what is possible today. Rather, I hope that the ideas I propose in chapters 6 and 7 will encourage new and different areas for future technological developments.

1.9. Outline of this dissertation

Chapter 1

In the first chapter, I present the topic this dissertation addresses and offer a first overview of the concept of design-within-living as an extension to design-in-use. In addition, I present the research questions that structure the presentation of the following four studies on the design of interactive technologies for the home. This chapter aims at framing the work presented in chapters 2 to 5 in order to help the reader see the common thread between each chapter.

Chapter 2

Chapter 2 is a critical literature review of HCI research addressing designing for the domestic experience. This chapter provides an overview that shows what the HCI community already knows about how people design and live in the space they live in. This chapter also presents potential alternative research perspectives for future research.

Chapter 3

Chapter 3 is based on ethnographic observational studies that investigate three different practices of everyday design. By describing the motivations, competences and skills of

families, hobbyist jewellers and steampunk enthusiasts, this chapter offers insight on how design-in-use can be extended to practices beyond the ones observed with home dwellers.

Chapter 4

In chapter 4, I look at how interactive artifacts can be part of ongoing and often unknowing processes of design. The construct of unselfconscious interactions proposes that interactive artifacts can serve as catalysts for ongoing improvements of the everyday setting. From this construct, I particularly focus on the qualities of goodness of fit, lived-with, and ensembles as ways to further articulate design-in-living.

Chapter 5

In chapter 5, I report on an autobiographical design project called Living in a Prototype. I discuss the qualities of living in a space as it is reconfigured by presenting the project of converting a cargo van into a camper van. This chapter highlights the shift from investigating the design of discrete objects to investigating design at the scale of a space.

Chapter 6

In chapter 6, I present in details the concept of design-in-living drawing on examples from chapters 2 to 5, and show how it extends the concept of design-in-use. In addition, I address the broader implications of this research for HCI and interaction design research, I reflect on the methodological commitments of this dissertation, and I present the limitations of this work.

Chapter 7

In chapter 7, I revisit the main research questions of this dissertation. In addition, I offer five areas for future research.

Chapter 2.

HCI Ways of Knowing the Home

In this chapter, I present a critical literature review of 121 works in HCI research on the home. This critical literature review was published in the paper “Investigating Genres and Perspectives in HCI Research on the Home” (Desjardins et al., 2015) presented at CHI in 2015. I co-authored this paper with Ron Wakkary and Will Odom. The overall goal of the paper is to provide a broad portrait of past and current HCI research on the domestic experience and the design of technologies for the home. The home is chosen because it is a lived-in space that has complex, rich, and nuanced realities and because it is a context in which a variety of design practices (professional and amateur) can thrive. The focus of the literature review is to uncover questions asked in HCI research and the objects of these studies (e.g., current people’s activities in the home, the integration of a newly designed artifact in the home, etc.). As a result, the paper presents seven genres of HCI research on the home as well as five epistemological commitments that researchers take when conducting their research. In addition, based on our results, we offer two dominant current research perspectives and two complementary research perspectives to orient future research: a first-person view of the home and a material perspective.

In this dissertation, the research question addressed from this paper is: *How has HCI research investigated design and making in a lived-in environment?*

In the following paragraphs, I outline my answer to this question to guide the reading of the chapter (as illustrated in Figure 3). To start, HCI research on the home has rarely looked at people’s design and making practices in their homes. Apart from a few exceptions, most research investigates how people *use* artifacts and interactive technologies in the home rather than how they might modify, repair, or design them.

Research has focused on both existing artifacts in the home through ethnography and ethnomethodology, and on how people use newly designed technologies with field deployments.

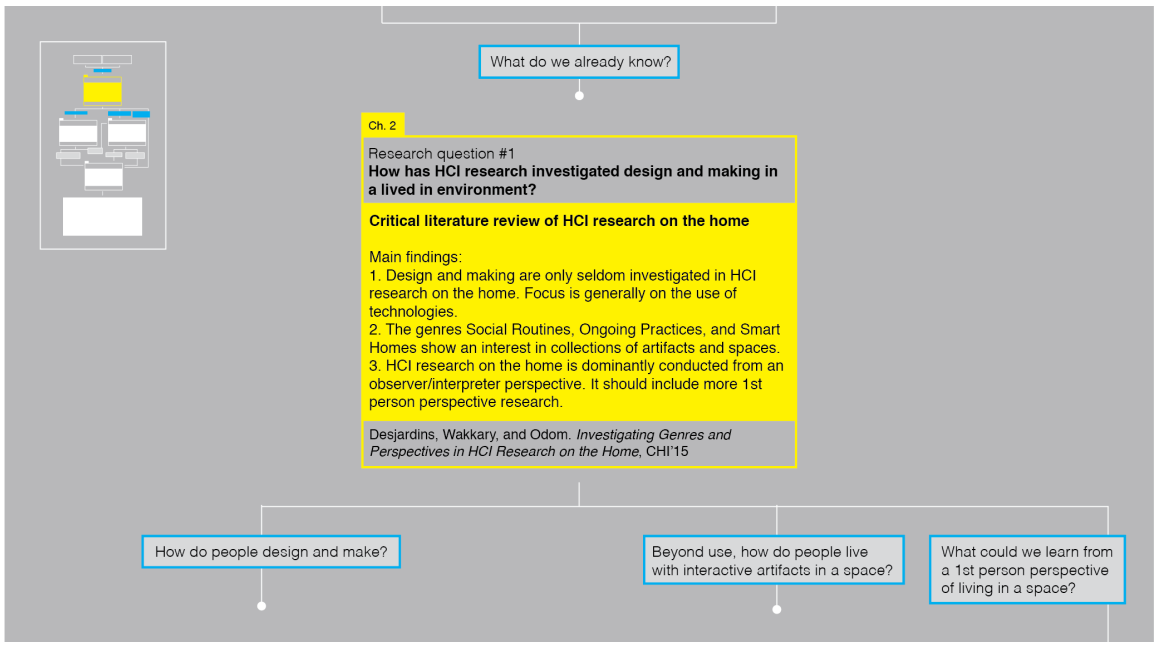

Figure 3. Chapter 2 research questions and findings (excerpt from Figure 1)

Nonetheless, in the context of this dissertation, this paper offers other insights that are relevant to how people might design and make in their homes. For instance, the seven genres of HCI research on the home show how past research has put a fair emphasis on systems or collections of artifacts and environments. Specifically, three genres have addressed relations between artifacts or whole environments: 1) Social routines in the home; 2) Ongoing domestic practices; and 3) Smart homes and home automation.

The first genre is 'Social routines in the home'. It represents a collection of works that look specifically at how social routines organize and structure the home. This is interesting in the context of this dissertation because authors have been inquiring about how systems of objects support those social routines and how artifacts, collectively, then support family communication, organization and coordination. This is one of the rare genres that look beyond discrete artifacts and start to look at how artifacts work together within a space.

The second genre is ‘Ongoing domestic practices’. It focuses on unique practices in the home and brings to light the role of design artifacts within those practices. Of interest is the fact that oftentimes researchers conduct personal artifact inventories to gain a sense of the types of collections of artifacts people engage with during their domestic practices. This genre often showcases groups of artifacts or collections of similar things that are central to ongoing practices.

In both genres, Social routines and Ongoing practices, researchers inquire about groups of artifacts and their roles in everyday life in the home. However, very rarely do they also report on how those systems or groups of artifacts are made, appropriated, or designed by the home dwellers. This gap in the research shows that this area is still underexplored in HCI. This gap may also reveal that using current research methods does not necessarily lead to understanding how collections of artifacts evolve and improve over time in the home.

The third genre is ‘Smart homes and home automation’. In this genre, researchers look directly at the house as a structure to hold various systems and technologies. In this case, the focus on a whole environment is very present. Interestingly, however, this genre of research does not discuss how new home automation technologies fit or co-exist with already present artifacts or systems in the homes. In addition, as part of this genre, a minority of researchers have looked at how everyday people might install and maintain such systems, hence starting to discuss questions of design and making in a reconfigured space. Examples include the work by Woodruff et al. (Woodruff, Hasbrouck, & Augustin, 2008) which investigated how people transform their homes to become more sustainable, and Woodruff et al. (Woodruff, Augustin, & Foucault, 2007) which investigated the influence of home automation on practices related to Sabbath. This area is still emerging and much more work is required to better understand how people engage in design activities to improve their everyday settings.

As I mentioned earlier, this paper does not only look at the object of the research, but also at the ways researchers conducted the studies. As a conclusion of the results in the paper, we propose two complementary perspectives to conducting research in the

home—one of those is a first-person perspective. This perspective is offered as an alternative and as a complement to the generalized use of the observer/interpreter perspective common in HCI research on the home. The observer/interpreter perspective relies on the researcher observing, sometimes engaging in participants' lives, and interpreting data from interviews, photographs, or observations. Conversely, a first-person perspective would allow the researcher to experience first-hand the home and to gain the most direct view of the home. In the context of investigating how people live in, design, and make a reconfigured space, this methodological choice presents advantages because the qualities of living in a reconfigured space take time to emerge, as it is through the day-to-day interactions with the space that the reconfiguration happens. Moreover, the home itself is a context that is extremely personal and intimate, and the possibility to study a phenomenon that happens in the home 'from the inside' would allow the researcher to gain fine grain details that would be difficult grasp otherwise.

Finally, I note that even though in this paper we propose to engage in a material perspective to investigate the home in HCI, this is not an avenue I decided to take in this dissertation. Hence, the material perspective is not explored in the next three chapters (chapters 3 to 5); however in chapter 7 I articulate how it could be an interesting and valuable line for future work (7.3.4).

From this paper, there are three main insights that are central to how I structure and articulate the following three chapters (which influence how I discuss design-in-living):

- Design and making are only seldom investigated in HCI research on the home. Focus is generally on the use of technologies.
- The genres Social Routines, Ongoing Practices, and Smart Homes show an interest in collections of artifacts and spaces.
- HCI research on the home is dominantly conducted from an observer/interpreter perspective. It should include more first-person perspective research.

The first insight opens two new questions. Firstly, since how people design and make is widely underexplored in HCI research in the home, the first question is: how do they design and make? This directs me to chapter 3, where I investigate the design practices of three groups of non-expert designers. Secondly, the focus on use of interactive artifacts in the home leaves open the question: how do people live with interactive artifacts in the home beyond their use? This is explored in chapter 4 with the concept of unselfconscious interaction.

The second insight shows that there is some recognition in HCI research on the home of the relation between things and between things and the environment. This point serves as an underlying reminder throughout the rest of this dissertation that artifacts never act alone in lived-in spaces.

Finally, the third insight suggests using a first-person perspective to continue investigating questions surrounding the complex topic of HCI and the home. This brings the question: what could we learn from a first-person perspective of living in a space? This question is addressed in chapter 5, where I present the autobiographical design project of converting a cargo van into a camper van.

Investigating Genres and Perspectives in HCI Research on the Home

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ABSTRACT
The home and domestic experiences have been studied from multiple points of view and disciplines, with an array of methodologies in the past twenty-five years in HCI. Given the attention to the home and the volume of research, what further areas of research might there be? Based on a critical analysis of 121 works on the topic, we present seven genres of domestic technology research in HCI: social routines in the home, ongoing domestic practices, the home as a testing ground, smart homes, contested values of a home, the home as a site for interpretation, and speculative visions of the home. We articulate dominant research perspectives in HCI, and we offer two complementary perspectives about how to investigate the domestic experience in future research: the material perspective and the first person perspective.

Author Keywords
Home; domestic; critical analysis; reflective HCI.

INTRODUCTION
Since the 1990s, the HCI community has increasingly focused on understanding the complex and evolving ways interactive technologies are situated within the home and their implications for domestic experience. As focus expanded beyond the workplace to the messy contexts of everyday life, it became necessary to critically revisit the assumptions, methods, and underlying values guiding the design of interactive systems [31,44,61,84]. This has led to the adoption of many new methods and approaches to better understand and remain sensitive to the intimate, private nature of the home. Since then, a wide range of research has emerged that has focused on, for example, how social routines bring a sense of social order to everyday life [18,19,82], how family members negotiate communication and coordination practices [12,26,58,72], how resources are consumed and managed [15,67,91], and the social nature of work that unfolds in various domestic sites (e.g., in the kitchen [7,37,83]). There has also been a movement to investigate the experience of mundane everyday practices, such as watching TV [76] or knitting and gardening [36]. Several design and research initiatives have focused on provoking experiences of reflection and interpretation in the home [34,43,55]. In some cases prior works have questioned what constitutes 'the home' and the diverse experiences that unfold within it [5,6,65,66,94]. After nearly twenty-five years of research, now is a timely opportunity to critically reflect on the genres of approaches that have been adopted to understand the complex intersection of the home, domestic experience, and interactive technology.

This paper is a critical literature review of HCI and interaction design research on the home and domestic experiences. Specifically, this paper offers 3 contributions. First, it presents a cohesive analytical summary of the current state of research on the home. We present genres of research that have emerged and become concrete. We unpack the genres by highlighting the questions researchers ask and how they proceeded to answer these questions. Second, it articulates different underlying epistemological commitments adopted in each genre and critically reflects on 2 dominant perspectives: the anthropocentric view and the 3rd person view. Third, it proposes two complementary perspectives to help expand the HCI community's attention to new areas of domestic technology research: the material perspective and the first person perspective.

THE HOME
Researchers have investigated the concept of 'the home' for over a century. This work spans many different fields and disciplines; among these, social sciences, humanities, and architecture have given special attention to exploring this concept. While their aims vary, one thing they hold in common is the belief that the home is a rich, complex, nuanced, and multifaceted setting for everyday life [2,73]. Central to this conceptualization of the home is the notion that there are multiple coexisting meanings the home carries at the psychological, social, cultural and political levels [56,57,73]. More recently, the HCI community has turned to the home along with all the complexities and subtleties that are bound to it. Using a variety of approaches, HCI researchers have focused on the social life and practices that shape domestic experience, as well as the complex and evolving role of technologies in the domestic sphere.

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The ways in which HCI has investigated the home

Methodologies for investigating the home and domestic experiences have also dramatically increased in the past decade. Commonly used to understand the social life and practices in the home are ethnographic methods (e.g. [14,77,87,90]) and ethnomethodology inspired studies [17,18,62,81,82]. Both describe in nuanced detail the observed practices in the home as a way to inform the design of future domestic technologies [20]. Field studies and prototype deployments (e.g. [10,27,34,45,48,58,63]) involve testing a new technological artifact or prototype in a real setting with participants in their home [11]. In addition, we found less prominent but still very present additional methodologies in HCI domestic technology research: cultural probes [8,28,34] and technology probes [45,53,63,68], smart home experiments [50,69,71,83], and participatory design [54,59,68]. The complex topic of everyday domestic experiences has inspired researchers to refine and reinvent investigative approaches for the home as is evident in the diversity of methodologies we encountered.

OUR METHODOLOGY

Our work is inspired by and draws on these diverse and, at times, divergent aspects of people's experiences at home. We aimed to keep a broad description and definition of the home to reflect this diversity of views and methods. Our analytic approach involved creating genres that were constructively defining yet neither rigid nor hermetic. In this way, it is possible for an individual work to span multiple genres. In the following sections, we describe 7 genres of research on the home in HCI that surfaced from our critical review of 121 peer-reviewed conference papers, journal articles, book chapters and books (all of which focused on the broad topic of technology in the home).

Selection of works

Works were selected firstly by searching in the ACM Digital Library for the keywords 'home', 'domestic', 'house', and 'everyday'. We added research found by searching specific activities performed in the home using the keywords 'cooking', 'cleaning', 'watching TV', 'video conferencing with family members', 'gardening', 'repair', 'home network', 'kitchen', 'health at home', and 'religion'. In addition, we surveyed general visions of domestic technology with the keywords 'sustainable living'[1], 'ubiquitous computing', and 'smart homes'. Motivated by our own and the HCI community's growing interest in design oriented research, we completed our selection by exploring alternative methods for designing domestic technologies, such as speculative design and critical design.

From this first selection, we branched out to include the relevant references cited in the original articles. Finally, we culled our list to include the most cited papers (according to Google Scholar), and eliminated papers that presented ideas that we felt were redundant within the corpus of research. Our goal was to create a broad landscape of the types of technologies designed for the domestic settings and to represent the range of views on what constitutes the home in order to build strong genres of domestic technology research. We do not claim to present an exhaustive list of related research done in the field, but rather we aim at representing the past and current research genres for conducting research in the home setting. A full list of the 121 references can be found on this paper's ACM Digital Library webpage (Appendix A). Finally, it is important to note that our sample is drawn primarily from North American and European research, which creates a western view of the home, a clear limitation of our analysis.

Analysis

For each work, we read the resource and summarized the goal of the research, the methodology used, the focus of the analysis, and the results presented. As we were going through this process, we created categories for research approaches. These categories are what we came to call *genres* of research on domestic experience (similar to and inspired by DiSalvo et al. [23]). To create our genres, we looked at what the goal of each work was, what questions researchers asked, and the types of things focused on in their research. The process of creating the genres followed a constant back and forth between defining the genres and seeing how they applied to the entire corpus of literature.

In addition to analyzing the works' research questions and orientations, we also wanted to know what researchers were concerning themselves with in the home. As we read the works, we took note of the type of data that was collected and what the object of this data was. This formed the basis for our description of the *objects* of the study. Moreover, we were interested not only in the textual descriptions of the results, but also in the visual reports of study findings. We conducted a preliminary visual analysis of the graphical elements that were added in each work. We took note of the format of those elements (photograph, line drawing, photomontage, floor plan, etc.) as well as the topic or focus of the visual element (people in the home, artifacts in the home, visual interface of a technological artifact, etc.). In this paper, we present some results of this visual analysis as complementary data to our original analysis, in the cases where results elevate our understanding of a genre.

We delved deeper into our analysis by identifying the inquirer's *commitments* vis-à-vis the domestic experience, for each question asked in each genre. Each genre resulted in multiple epistemological commitments; after a thorough thematic analysis, we crystalized these into 5. We then further categorized our 7 genres based on related commitments (this is summarized in Table 1).

[1] Sustainability is a major concern in the design of domestic technologies (e.g. [15,34,67,74,91]) and we found that it cut across almost all genres of research. In this paper, we do not report specifically on this topic, however we acknowledge its high importance in our corpus of literature.

GENRES OF RESEARCH ON THE HOME

We present seven genres of research on the topic of the home that are present in the CHI community. We focus specifically on the types of questions each genre asks and what is analyzed.

Social routines in the home

An influential and prominent theme in HCI research centers on the social routines and work of everyday home life. In this genre, authors tend to agree that the home is a complex collection of interrelated social routines that the HCI community needs to understand before designing interactive technologies. Researchers have articulated the crucial need to gather rich and detailed descriptions of social routines in the everyday life of the home, often using ethnomethodology inspired ethnography [18,19,61,62,75,82]. Authors of this genre have asked questions such as:

- How is the home socially organized?
- What are the elements of the social machinery that support everyday life in the home?

With an underlying goal of informing the design of domestic technology, specific attention was given to particular routines that touch on the organization and the communication within the home; two identified areas that could benefit from interactive technologies. Researchers have looked at current, often analog, systems in the home such as the positioning and migration of letters, calendars, and how documents are positioned in the home [18,75]. In the corpus of work within this genre, researchers have given an essential place to artifacts and systems as a way to reveal to social aspects of domestic life. This is evidenced by the use of photographs featuring artifacts in participants' homes. In addition, annotated maps and diagrams were also presented to represent results on where activity centers and coordinate displays [19] are and where it would be beneficial to install interactive technologies.

Ongoing domestic practices

Ongoing domestic practices refer to the wide variety of activities that people perform at home. In our corpus of works, practices are generally described in the form of observational contextual studies, often ethnographic studies, that focus on richly describing and interpreting activities, artifacts and interactions. The goal of these descriptions is to provide enough information to highlight opportunities and challenges in designing interactive technologies for those practices. Authors of works that characterize this genre have asked questions such as:

- How do practices configure the home experience?
- How do people describe and reflect on the various domestic practices they perform?
- What is the role of artifacts and technologies in the practices of the domestic experience?

Authors have described activities, materials and interactions with artifacts involved in the practices of, amongst others, gardening [36], pottering [78,93], religious practice [90,92], health monitoring [1,39], interpersonal communication [3,4,26], domestic networks management [38], and resource consumption [74]. Works in this genre often rely on an ongoing relationship between participants and researchers as a way to gain an insider's understanding of the more intimate aspects of domestic practices. This is illustrated in how researchers present results in the participants' voices, using a significant amount of verbatim quotes to support the description they provide of everyday practices. Furthermore, the commonly used method of home tours and personal artifact inventories resulted in an understanding of ongoing practices in terms of supporting artifacts. Figures included photographs where study participants were seen to be active and present in a situation within the home, as well as where they were interacting with artifacts, as illustrated, for example, by Ames et al.'s photographs of their study of family videochat [3] (fig. 1).

Figure 1. Pictures of people performing domestic practices [3,36].

The home as testing grounds

The home as testing grounds for new domestic technologies is a central part of how the HCI community investigates how to design for the home. This is an important shift departing from observational studies of *what is,* to move towards exploring *what could be* in the home. Field studies and prototype deployments are common in HCI and in the context of the home [11,80]. Questions in this genre typically include:

- How is this new designed technology used, appreciated, and adopted in domestic setting?
- What are the new activities, routines, and behaviors surrounding this new technology?

In this genre, focus is placed on the newly designed artifact and its introduction in the home. Researchers give attention to how social routines and ongoing practices might be affected by this new addition to the home, with an eye toward how changes occur. For example, Forlizzi and DiSalvo [27] explored how the introduction of a Roomba, an autonomous cleaning robot, might transform the practices and values surrounding cleanliness in the home. Other field studies have looked at new technologies for family calendars [59,68], interpersonal communication and messaging [12,44,48,58,72], and the use of surface computing in the home [52]. This genre has also seen some exploratory testing about different ways of engaging with technology in the home, such as through ludic engagement

[10,34], slowness [63], and discovery [55], relating closely to the genre of *home as a site for interpretation*, described in a following section.

In order to investigate the ways newly designed technologies might shape everyday life, authors have looked at the instances in which they were used, the position of the prototypes in the home, as well as reflections by participants in interviews. Demonstrating the prominence of the design artifact oriented view of this genre, figures showing how and where a prototype was placed in homes (fig. 2) were meant to reveal the importance of the relationship between the new artifact and the unique and intimate home of the participants. This can also be seen as a move to situate bespoke design artifacts outside of the studio or gallery, and situate them more directly in the contexts of people's everyday lives. Moreover, log data from the study usage allowed researchers to test the usability and functionality goals that are also part of this genre.

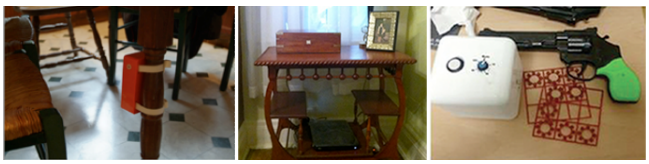

Figure 2. Pictures are taken of the deployed prototypes in the home environment [12,33,55,63].

Smart homes and home automation

The genre of smart homes and home automation is concerned with the design of the smart home itself as well as the applications and systems that are part of the home. Harper defines the smart home as "*a residence equipped with computing and information technology which anticipates and responds to the needs of the occupants, working to promote their comfort, convenience, security and entertainment through the management of technology within the home and connections to the world beyond*" [41:17]. To conduct research on smart homes, teams of researchers have built living labs (e.g. [47,51,69,71]), houses where participants can stay for a short period of time and live within this technological environment. This genre asks questions along the lines:

- What is a smart home?
- How do people live in, maintain, and install a smart home?

Studies of people in living labs have focused on their simulation of everyday routines, with an emphasis on the ways in which people utilize the various capacities of the smart home both holistically and in details (for example the usability of a specific user interface [51]). Interestingly, even though researchers looked at people's behavior in the living labs, they have rarely described the home in a similar fashion as the genres of *social routines* or *ongoing practices*. The figures included in research further support this claim and we would argue that this genre foregrounds developing technological aspects of smart homes over eliciting people's long-term lived experiences in such settings. Figures, when used, usually consisted of floor plans of the houses, sensor positioning diagrams, visual interfaces, and pictures of the exterior of the living lab house (fig. 3). Finally, in order to understand how people maintain and install home automation systems 'in the wild', researchers have also observed and interviewed people who are in the process of transforming their home or who have lived with home automation systems for some time [13,14,90]. Here, researchers paid attention to the roles played by family members, the inherent social dynamics and the material implications of home automation systems.

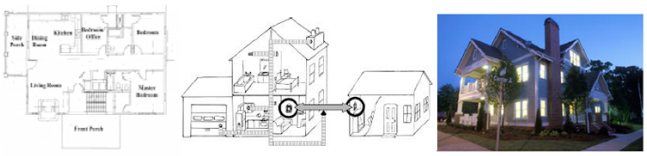

Figure 3. Smart home floor plan [50], sensing diagram [58], and the Aware Home by Georgia Tech [58].

Contested values of a home

The genre of contested values of a home is constituted of works that have touched on the assumptions the HCI community has about what is considered the home and what isn't. For example, Bell and Dourish [6] have articulated and reflected on the qualities of 'the shed'. In this, they have argued that by defining what is at the edges of the home (with qualities like masculine, dangerous, secret, chaotic), we might further our understanding of the home itself. Authors in this genre ask questions including:

- What have we overlooked when we talked about the home?
- How can we go beyond common assumptions about what the home is in a way that can tell us more about how to design interactive domestic technologies?

Authors have aimed at going beyond the traditional meaning of the home by investigating alternative family structures [64], ways of living beyond the Western European world [5,7], mobile ways of living [66,89,94], temporal qualities of the home [24], and gendered visions of the home [6,16]. This genre also provides alternative views on how, when, and why we should (and should not) introduce technologies in the home. For instance, Grimes and Harper [37] propose celebratory technologies for the kitchen instead of technologies concerned with the problematic aspects of eating, such as diets or the lack of cooking skills. Likewise, Taylor, Wyche and colleagues [78,93] have looked at the activity of pottering and conclude that sometimes, technology might not be a solution in itself for some domestic practices. This genre often relies on critique and argumentation, typically drawing from literature in fields outside of HCI, to present those new ideas and how they relate to HCI.

The home as a site for interpretation

Within the genre of the home as a site for interpretation, authors have embraced the unique, nuanced, private, messy, and creative environment of the home and aimed at designing domestic technologies that support interactions that go beyond achieving tasks and efficiency. Researchers have created and studied technologies that encourage playfulness [30,31] exploration [34], discovery [55], reflection [63], interpretation [33], speculation [43] and provocation [25] when installed in householders homes. Here, researchers have aimed to answer questions like:

- How can we encourage reflection and interpretation about technology in the home?
- How can we create technology that reflects the intimate, complex, and nuanced character of the domestic experience?
- How do people react to, use, and explore with new technologies designed for interpretation in the home?

The approach often taken by researchers is to develop finished technological artifacts with a high design quality that can be lived with for a period of time. When deployed, researchers investigated the behaviors, the attitudes (interpretation, creativity, reflection, etc.), and the adoption (or rejection) of the design artifact. Deployments were often reported in terms of researchers' observations and what participants have said about their life with the prototype. The type of interaction and the cycles of engagement with prototypes was also of interest, particularly for the long term studies of the History Tablecloth [32], the Indoor Weather Stations [34] and the Photobox [63] for which authors articulated the different phases the homeowners went through in a cycle of initial excitement, disappointment, and persisting attachment.

The attention to detail and craft that went into the creation of these artifacts show a different kind of sensibility to the way the HCI community designs domestic technologies. This is highlighted by how these artifacts were presented in our corpus (fig. 4): the use of a white background draws attention to design details in terms of the form, materials, and composition that collectively communicate the quality and craft of these kinds of design artifacts.

Figure 4. The white background in these photographs gives emphasis to the design artifacts themselves prior to becoming integrated into a domestic setting [34,35,55].

Speculative visions of the home

The final genre we present is speculative visions of the home, which is concerned with *potential domestic futures* rather than a present (or near present) conceptualization of the home. Speculative concepts and sketches offer glimpses into alternative visions of what the home could be in the future. Examples are Weiser's vision of ubicomp [88], Tolmie et al.'s [82] concept of unremarkable computing, and various descriptions of the smart home of the future [47,50]. This genre often asks questions such as:

- What is the home of the future?
- How should we configure technology for the domestic experience of the future?

Similarly to the genre *contested values of a home*, with speculative visions, authors explore ideas and critiques of current research with the aim of broadening the field. For example, Aipperspach et al. [2] present radical new design concepts that challenge the continuing trend towards homogeneous and undifferentiated domestic environments. Moreover, Gaver and Martin [29] present nine speculative sketches which represent provocative ideas for domestic information appliances as a starting point for a discussion with their project partner. Finally, Taylor et al. [77] combine ethnographic studies with sketched explorations of the findings as a way to pursue the dialogue between the research materials and future designs.

This genre is particularly defined by works that use visual methods to present and share their new concepts, such as workbooks, sketches [29], and sketchbooks [2]. The treatment of these images, particularly the inclusion of line drawings, photo montages, and the mélange of black and white with a few carefully chosen colors, demonstrates a strong design sensibility, but more importantly proposes concepts that are just at the right level of fidelity to suggest something that does not exist yet (fig. 5).

Figure 5. Illustrations are used for communicating ideas about potential future domestic technologies [2,8,29,78].

ANALYSIS OF THE GENRES

Describing HCI research on the home, domestic experience and interactive technology in terms of 7 genres provided us with two main anchors for understanding the field more comprehensively. First, it enabled us to identify *questions* the HCI community has been implicitly and explicitly asking about domestic experiences. In this, we have uncovered questions about the different configurations and definitions of the home, how social machinery and everyday practices constitute the home, what the experience of the home is, and how technology is used and lived with in the home. Second, the genres supported a description of the *objects* of the studies conducted. We reported on a focus on the visible acts that constitute routines and practices, often portrayed through images of people in action or

verbatim quotes. We have also seen an important emphasis on artifacts and technologies in the home, strongly supported by a vast amount of photos of objects in situ.

Epistemological Commitments and Perspectives

Now, we expand our analysis of the genres by articulating the *epistemological commitments* adopted when asking the questions, as seen in table 1. Each commitment shapes the way research is conducted and how results are uncovered.

Table 1. Epistemological commitments and respective genres

Commitments	Genres
Objective observer	Social routines, testing grounds, smart homes, interpretation
Third person observer	Ongoing practices, testing grounds, smart homes, interpretation
Relayed informant	Ongoing practices, testing grounds, interpretation
Author interpreter	Contested values, speculative visions
Experimenter	Testing grounds, interpretation

The *objective observer* commitment is similar to a bird's eye view: it is removed from the study situation and relies on factual visible accounts to report on domestic life. In the *third person observer* commitment, the researcher observes, asks questions, and sometimes participates in home life, allowing a deep look into the routines and practices of everyday life. The *relayed informant* commitment is characterized by a participant's verbatim quotes (from interviews or photo/text/video diaries) as relayed and selected by the researcher. In the *author interpreter* commitment, questions are asked by an attributable author who builds a reasoned argument about the domestic experience. Finally, the *experimenter* commitment refers to the questions a designer of research artifacts might ask while developing prototypes that are deployed to observe the effects of new technologies in the home.

We have also observed how two dominant perspectives emerged, as high-level patterns of epistemological commitments and genres. Since they continually surfaced as meta-level categories, it became clear they were best viewed as *dominant* perspectives that could further refine our understanding of research conducted in the home.

Dominant perspective: The anthropocentric perspective

Our analysis revealed the first dominant perspective to be an *anthropocentric perspective* that is the view that the home is uniquely human. Researchers in all 5 epistemological commitments either looked at people and their activities in the home, or investigated artifacts and technologies from the point of view of their users (householders and family members in this case). Arguably HCI research is concerned with understanding both humans and computers, and eventually interaction. However, in almost all the works of our corpus, data and analysis were centered on human experience such as people's lives, experiences, routines, activities, challenges, and motivations. Even the study of artifacts was shifted to, influenced by, or looked at through the lens of people (e.g. the focus on human usability in visual interfaces or on the impacts on human social routines in technology deployments). Although we agree that the human perspective on the home is fundamental and only natural, we see the potential if not validity of asking about alternative perspectives that do not prioritize such a human point of view. We explore this in our notion of a *material perspective* that we outline in the following section.

Dominant perspective: The observer/interpreter perspective

The second dominant perspective that was revealed through our analysis is the predominant role of the *observer/ interpreter*. The commitments of the *objective observer*, the *third person observer* and the *relayed informant* all take a view from a third person outside the domestic situation or technology studied. In the *observer/interpreter* perspective, the author is accountable for the ideas she articulates in her research no matter if she is relaying information in the voice of participants or through observations. In this case, the researcher plays the role of choosing what to include (and exclude) and how to frame quotes or images in order to better support claims based on their analysis. A concern with this perspective might be the mediating role played by the intermediary position the researcher takes between the lived experience of the home and the construction of knowledge about the home. We note that the views of the *author interpreter* and the *experimenter* commitments already offer a step towards choosing a more personal voice for presenting research work, either through argumentation or through the voice of the designer. In the complementary perspective of *first person view of the home*, we push this idea of a personal voice even further.

COMPLEMENTARY PERSPECTIVES

The two complementary perspectives we present below are a result of our analysis. They are our attempt to answer the question of what more we can understand in HCI research of the home and more specifically, what set of underexplored commitments and emergent genres might be productive in HCI. Discussing complementary perspectives in relation to the dominant perspectives was not meant as oppositional but rather was a helpful way to sharpen our exploration of new perspectives. In addition, we do not aim to be exhaustive nor do we mean to suggest these are the two 'missing' perspectives from the existing literature on domestic technologies. Rather, we propose them as possible perspectives and critical mechanisms for framing and expanding future initiatives targeted at the home in HCI.

A material perspective of the home

This perspective centers on a non-human object perspective within the home or, in other words, the *material views of the home*. Recent and growing scholarship on object oriented ontology [40] and speculative realism—a branch

of philosophy that critiques and proposes an alternative to the anthropocentric view of the world [9,22]—serves as a rationale to support this new perspective. In general, this post-phenomenological work champions an egalitarian view of all 'things' in the world, both human and non-human. Relatedly, philosophers of technology [46,85] have acknowledged the non-neutral ways artifacts meditate between human beings and reality. Viewing the home through the perspective of non-human objects could strongly support HCI in more critically considering the complexity bound to the objects we, as a community, produce, what they do, and their collective effects. Although this perspective could be adopted for several research domains in HCI, we believe it would especially benefit research on the home by moving away from traditional emphasis on humans, to acknowledge and critically engage the substantive role that objects play in shaping the domestic reality, a reality humans experience.

Investigating what non-human objects experience, see, live, and understand about the home is an endeavor that will require new ways of inquiring about the home. For example, a question like 'how does a fridge experience domestic life?' will likely call for alternative data collection and analytical and speculative approaches. Hidden cameras (e.g. the BinCam project [79]) and pet cams [49] (fig. 6) offer means of a material perspective to data collection. Inherent challenges of a material perspective will influence the ways in which research strategies and methods can be appropriately developed for this emerging area and will be a key issue framing future work.

Another intriguing dimension of the material perspective on the home is the way in which it offers a radically different scale of time for thinking about the home. For example, a house's life can span many human lifetimes and family heirlooms can be passed down for many generations [24,70]. A reflection on this alternative scale might lead HCI to investigate questions such as 'How will a domestic technology exist in 200 years?' and 'How ought we design material objects today with the idea in mind that they would be discovered or used in 200 years?' This deeper critical capacity for situating the home within a bigger temporal spectrum offers the potential to profoundly shift our thinking about the role of technologies in domestic life.

Figure 6. Views from a parcel in the mail [21], a pet cam [49] and a fridge cam (our own photograph).

A first person view of the home

A first person view of the home is the most direct way to study the domestic experience. A primary question that can be asked from a subjective perspective could be: 'Are our personal experiences of the same home different?'. Investigating the same home, space, and events with two (or more) people's experiences can lead to potentially radically different understandings of what the home is. In that case, how can the HCI community design for variations on the same theme in a home? In addition to building on HCI's understanding of the multiple meanings of the home, this perspective can be beneficial by revealing how a single setting can lead to diverse experiences.

First person views of the home can also be gained through the eyes of the researcher/author herself. Autobiographical design—"*design research drawing on extensive, genuine usage by those creating or building the system*" [60:514]—and auto-ethnography—a branch of cultural anthropology defined by the researcher studying 'his own people' [42]—are strong starting points to construct first person research as an HCI researcher. Although this method could also be used in a variety of contexts, we believe that for sensitive settings like the home, seriously considering the researcher's (and designer's) personal experience, needs, and desires can profoundly elevate the richness and value of research. For instance, Gaver's [30] Video Window is an example of how designing for oneself can produce a uniquely rich and deeply textured understanding of the effect a technology can have in the home, and the kinds of experiences this object might (or might not) lead to.

A first person view will require new modes of collecting, interpreting, analyzing, and representing data. The quantified self and life logging movements are already popular trends where people can constantly record facts about their everyday lives, such as step counts, calories spent, hours of sleep, etc. First person photography and video, and personal experience photo essays might also be visual ways to investigate the subjective experience of domestic life. Like in the material perspective of the home, first-person research methods will also carry complexities, such as the need to appropriately communicate the kinds of epistemological commitments that come with personal accounts, which vary considerably compared with more traditional or dominant approaches in HCI.

One determining characteristic of first person research is the fact that research can happen over long periods of time. By being constantly with oneself, one can reflect and investigate her relations to artifacts and domestic experience in ways that are impossible with other perspectives. This is a major opportunity to investigate further the lived-with qualities of artifacts in the home. Lived-with qualities [86] need time to emerge as they arise more through the day-to-day living together with the artifact than from specific punctual interactions, similarly to how one dwells with furniture in the home. Lived-with qualities construct a focus that can lead to a significantly new way of understanding technologies in the home and we argue that first person research might be one of the most appropriate perspectives to take for those investigations.

FUTURE RESEARCH AND CONCLUSIONS

In this paper, we have presented 7 genres of research for domestic technologies, highlighting the questions the HCI community has been asking about the domestic experience and the ways in which to design interactive technologies for the home. By looking at the epistemological commitments from which those questions are asked, we identified two dominant and two complementary perspectives that can lead us to fruitful reflections about technology in the home. The complementary perspectives offer exciting and potentially fruitful starting points for future research about the home. By shifting perspective to a material perspective, future research can bring a strong counterpart to HCI's vast and detailed research in how *people* experience domestic technology. In addition, by removing the observer's interpretation, 1st person research may lead to more personal, genuine, and nuanced first-hand experience of what it is like to live with technology at home.

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Chapter 3.

Three practices of non-expert design and making

In this chapter, I present a design ethnography of three cases of non-expert design and making: the design practices of families, hobbyist jewellers and steampunk enthusiasts. This work was previously published in a paper called "Manifestations of everyday design: guiding goals and motivations" (Desjardins & Wakkary, 2013) at the C&C conference in 2013. I co-authored this paper with Ron Wakkary during my PhD, however it is based on work I conducted as part of my master thesis (Desjardins, 2012)[6]. In the context of this dissertation, this chapter serves as a contextual contribution to support the following chapters and the development of the concept of design-in-living. The original aim of the article is to present an in-depth description of three practices of non-expert design and making. The intention behind this article is to broaden HCI's understanding of how people who don't have professional training in design engage in design and making activities in their everyday lives. The study builds on previous research on everyday design (which looked primarily at families at home), and research on DIY and Maker communities. Whereas those studies often discussed the outcomes and the intention of the practices of design, they rarely presented in details the ways in which design and making were performed. This article aimed at filling that gap.

For the purpose of this dissertation, the research question addressed in this article is: *How do different types of non-expert designers design and make?*

[6] The School of interactive Arts + Technology (SIAT) guidelines for writing a cumulative thesis (as of November 6, 2013) state: "Any submission of constituent parts that had been published/submitted/written before the student started his/her doctoral/masters studies or is primarily based on prior work may be included to contextualize the thesis if properly declared, but typically does not count towards the scholarly contribution of the thesis."

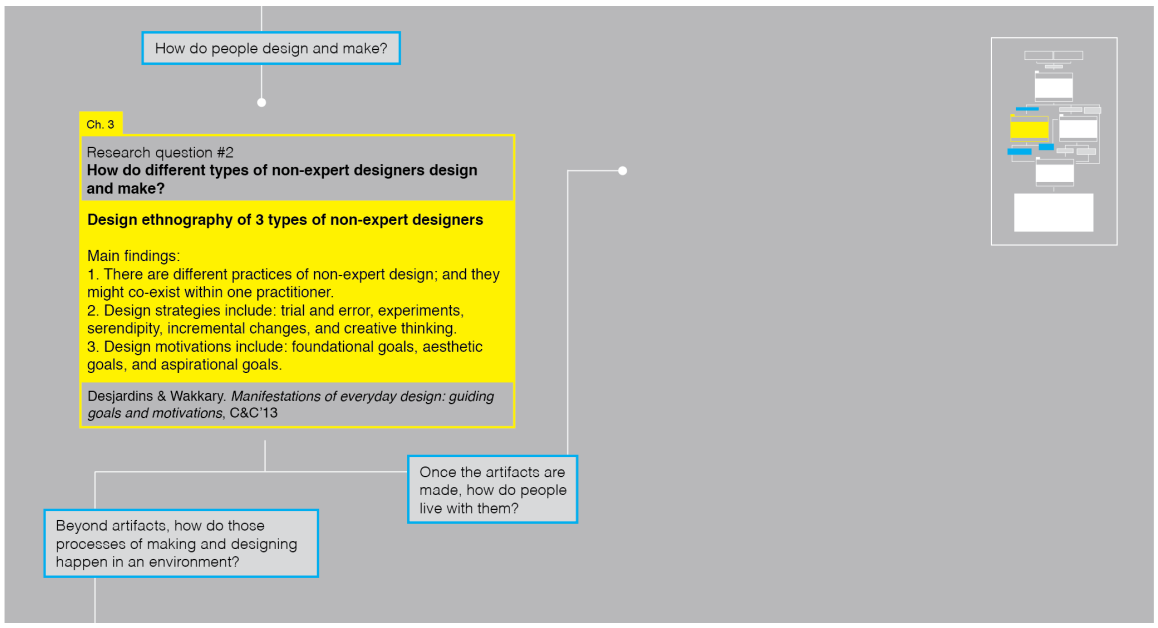

Figure 4. Chapter 3 research questions and findings (excerpt from Figure 1)

As an answer to this question (as illustrated in Figure 4), this paper's focus is on families, hobbyist jewellers and steampunk enthusiasts as three groups of non-expert designers. Those three groups were chosen because they offered a variety of practices and a multiplicity of reasons to design for. We used theories of social practices as a framework to look at the ways in which non-expert designers transform artifacts in their everyday and hobbyist practices. Following the framework proposed by Shove et al. (2012), we described the relations between the meaning (the goal and motivations) of the practices, the materials (including tools and body), and the competences needed to accomplish the practice (including skills and know-how of the practitioner).

The findings showed that each group of non-expert makers had a different goal that motivated their practices. In addition, the findings revealed that the meaning of the practice had important impact on *how* the practice was performed; hence it had an influence on the two other elements of materials and competences. In brief, families design to support their everyday dynamic routines and activities, hobbyist jewellers design for the pleasure of making something aesthetic with their own hands, and steampunk enthusiasts design and make to support the fictional world they create.

More specifically, families followed *foundational goals*. Their design actions were often in response to supporting daily activities or in reaction to events that might not have been planned. These ad hoc improvisations influenced the materials and tools they used (things that were found nearby, and hands as tools), as well as the competences they deployed, often creativity and resourcefulness, but no specific craftsman skills.

Hobbyist jewellers were driven by *aesthetic goals*. When making jewellery, their aim was to create pieces that are unique and that share their identity, but also to enjoy the process of playing with the various materials they had collected. Aesthetic motivation influenced the collection of materials, but also the choice of form-giving or assembly method, which in turn directed the types of skills that were developed through this practice. Their design strategies often included trial and error, experimentation, serendipity and letting materials speak.

Steampunk enthusiasts were animated by *aspirational goals*. Steampunk enthusiasts engaged in making practices so that they could create machines, accessories or costumes that allow them to enter a fictional world, one grounded in technologies and artifacts of today, but inspired by materials and principles of the Victorian era. Their vision is so strong that it has a dramatic influence on the types of skills practitioners are willing to learn to reach their goal. Steampunk enthusiasts also used trial and error and experimentation processes, but they also included the creation of a fictional world to drive their designs.

I acknowledge that the three motivations presented in this chapter (foundational, aesthetic, and aspirational) are only three of many possible motivations everyday designers might have. There is no end to the different types of practices of everyday design or to the goals that motivate those practices.

In addition to following a unique motivation, non-expert designers also combined multiple design practices—and multiple motivations. In social theories of practice, it is understood that every practitioner is the carrier of multiple practices. Someone is, simultaneously, a home cook, an amateur gardener, a pet carer, and a hobbyist potter, for example. With this study of practices of everyday design, it was shown that a non-expert designer can carry multiple practices of design. The fact that hobbyist jewellers

and steampunk enthusiasts also had foundational goals guiding their practices shows that various goals (attached to their own competences and materials) can co-exist within a non-expert designer. In design-in-living, I argue that everyday designers engage in cycles of living and making, where different types of design happen (see 6.1.5). This article opens up a reflection on why certain skills or tools are chosen at different times (based on different meaning of practices).

In retrospect, the description of the practices of these three groups of non-expert designers opens a discussion that will be continued in the description of the van conversion project (chapter 5). While not a main point in this paper, it is possible to see hints towards the importance of being physically surrounded in the materials of a design practice to foster creativity and resourcefulness. For instance, hobbyist jewelers often choose materials for their aesthetic qualities without knowing what they will be used for. As a result, they create a collection of many objects and materials they have an aesthetic connection to and use this collection as a starting point for design ideas. Similarly, steampunk enthusiasts accumulated astonishing collections of things that had appropriate materials, colors, feel, form, or finish so that they had the materials on hand when starting a project. In both cases, the possibility to have materials available allowed practitioners to become more creative and to support ongoing experimentations and trial and error. This proximity to materials is also present in families where, almost by default, family members would only use artifacts around them in their design acts. The three cases presented above start to show that it is in physical proximity that acts of design and of making can blossom the most.

In this article, the attention is on artifacts, not on environments or groups of artifacts. While this article does not yet display a description or examples of design-in-living, it offers three insights that help shape the principles of design-in-living and orient the research presented in chapters 4 and 5. The three insights are:

- There are different practices of non-expert design; and they might co-exist within one practitioner.
- Design strategies include: trial and error, experiments, serendipity, incremental changes, and creative thinking.
- Design motivations include: foundational goals, aesthetic goals, and aspirational goals.

The first insight shows that a person holds multiple practices of design. This finding points directly to a characteristic of design-in-living (see 6.1.5): the fact that everyday designers fluidly move between design practices (including competences, materials and tools) when designing and living in a space.

The second insight summarizes some of the design strategies used by non-expert designers when making artifacts. This prompts the question: beyond artifacts, how do those design strategies of making and designing happen in a lived-in environment? This question is examined in chapter 5 through the van conversion project.

The third insight showcases how the design practices performed by different groups of makers could be motivated by different goals. This was important for articulating how design-in-living could share similar goals to design-in-use, but still depart from it as well, as described in 6.1.2.

Finally, those three insights taken together give a strong description of how artifacts are made by non-experts, however they don't show how those artifacts are then used or lived with over time. As a final question based on this article, I ask: once the artifacts are made, how do people live with them? This question points to chapter 4, where I specifically look at how people live with and adapt artifacts in their homes.

Manifestations of Everyday Design: Guiding Goals and Motivations

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ABSTRACT
This paper explores the relationship between goals, materials and competences in the practice of everyday design. Appropriations and creative uses of design artifacts are often reported in terms of outcomes and goals; however, we observe a gap in understanding how materials, tools, and competences are also involved in these processes. We conduct a multiple case study of three groups of everyday designers: families, hobbyist jewelers, and steampunk enthusiasts. We provide a description of the aspects of meaning, materials, and competences, as well as how they are interrelated, for each case. Our findings show that amongst these three aspects of the practice of everyday designers, it is the meaning of the practice that acts as the strongest motivator for practitioners. Materials, tools, and competences are hence largely determined accordingly. The implications of this study propose ways to design for practices with different types of meaning: foundational, aesthetic, and aspirational goals.

Author Keywords
Everyday Design; Appropriation; Steampunk; Jewelry; Families; Practice Theory; DIY; Hobby.

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

General Terms
Design; Theory.

INTRODUCTION

The process of transforming and appropriating objects of design has nourished research in different areas in interaction design and human computer interaction (HCI) for the past years. Through observations and analysis, research explored how people engage with objects and systems not only to use them as they were designed, but also in different, new, innovative, and creative ways. These actions were not necessarily intended by the designer(s), yet people transform and re-design artifacts so they become personal, based on their understanding of the current and future situations [8]. Previous research has shown that once the artifacts leave the designer's drawing table, the design process does not stop: it can be pursued through customization [7], reuse [11], appropriation [3, 4, 21], do-it-yourself (DIY) projects [5, 6, 13] and everyday design processes [20, 21].

An everyday designer is a "creative agent among other everyday designers who together create and redesign artifacts long after the products have left the hands of professional designers." (p.365) [22]. The term everyday designer originated from a study of families in the home where a type of shared creativity that helps us navigate daily activities and events was observed [20]. Through their observations, the authors look at family members as everyday designers, people who show resourcefulness and adaptivity leading to unique design outcomes. Everyday design is a powerful lens for focusing on more meaningful relationships with objects because it highlights how people engage with those objects, not only through use but through the making, transformation, and adaptation of artifacts.

This research leads to a reconfiguration of who the user is that moves beyond a task-oriented perspective in order to encompass users' creativity and resourcefulness [22]. This new identity reframes the user through a more holistic lens that looks at the multiple and various goals and motivations one might have for using design artifacts. This reconfiguration of the user and this broader understanding of the life of objects after they are designed also hold sustainable implications [11, 22].

Everyday Design Practices

Most research about appropriation, everyday design and do-it-yourself communities looks at the goals and outcomes of the practices of making as well as at the communities of makers. In this paper, we propose that, to provide strong starting points to pursue research and design for a longer and more diverse product life, we need a more detailed view of the practices of everyday design. We choose to look at everyday design through the lens of social practices in order to explore the relationships between goals, tools, materials, and necessary competences or skills within a practice. Practices can be viewed as a unit of analysis for the social life. They refer to the *implicit, tacit* and

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unconscious aspects of life often underexplored in sociological studies. A practice is a routinized type of behavior that combines aspects of "body, mind, things, knowledge, discourse, structure/process, and agent" (p.250) [12].

More specifically, we base our analysis in Shove et al.'s [15] framework of social practices. The authors propose that practices are constituted of three aspects: meanings, materials, and competences. Meanings refer to goals and aspirations of practitioners, they relate to the reason and motivation for doing a practice. Materials are all physical things that are used in the practice, including the body, objects, technologies, and tools. Finally, competences cover the skills, the techniques, and the know-how needed to accomplish actions of a practice.

Our goal in this paper is to reveal how these aspects of practice (meanings, materials and competences) are interrelated in the creative practices of everyday designers and makers. Through our analysis, we seek to investigate if there is a dominant aspect that can influence and frame the other two aspects. For instance, are materials central to the practice and have such an importance that they configure the motivations one can have? Do competences and skills limit or open possibilities for manipulating materials? Do motivations and goals triumph all and materials and competences are shaped to achieve the envisioned goals? By revealing which aspect might be determinant for the others, we can leverage this knowledge to orient future design of interactive technologies.

We explore those configurations of practices within three different groups of non-expert designers: families, hobbyist jewelers, and steampunk enthusiasts. By comparing them, we uncover the differences and similarities of each practice. We also use these three cases to explore the interrelations between meanings, materials, and competences.

In the following section, we provide a brief literature review of relevant research about everyday design and do-it-yourserlf communities. In the next section, we present our multiple case study approach and the analytical framework of practice theory. Further, we present our description of the practices of everyday design of families, hobbyist jewelers, and steampunk enthusiasts, by emphasizing the relationships between the aspects of meanings, materials, and competences. We conclude with a discussion of the importance of meaning, the evolving nature of practices and the implications for the design of interactive technologies.

LITERATURE REVIEW

Everyday design

The premise behind everyday design is that people creatively and constantly appropriate and transform objects around them. Domestic studies have previously focused on understanding the creativity of home dwellers. For example, Taylor and Swan [18] observed the diverse systems used by family members to organize their homes and to communicate in their everyday lives. They argue that technologies should be designed to accommodate for the very rich and artful ways in which people organize their homes, and that designers should provide resources to foster these behaviors. Crabtree and Rodden [2] use ethnography to study domestic routines of communication and organization structures to support messaging. Tolmie et al. [19] observed routines (what they consider to be the "glue of domestic life" (p.399)) of families and neighbors as a way of finding opportunities for making technology as 'invisible in use' as routines. Wakkary et al. [20, 21, 22] have done ethnographic studies of families where home dwellers are viewed to creatively and resourcefully appropriate artifacts and surroundings in the home. The ongoing process of adapting systems to fit routines and activities in the home is described as design-in-use, which is a type of design that is in situ and in synchronicity with daily actions and routines [22].

This corpus of research highlights the everyday creativity of people, the uniqueness of designed systems, and the mutual intelligibility that flows between group or family members.

Do it yourself (DIY)

Researchers have focused not only on the appropriation of objects and surroundings, but also on how individuals (who are not designers) create explicit design projects resulting in the fabrication of objects. DIY is focused on the act of making, but it is also a reflection of who people are. Spencer [16] argues that shaping people's identity is at the heart of DIY: "the DIY movement is about using anything you can get your hands on to shape your own cultural entity: your own version of whatever you think is missing in mainstream culture" (p.11). Paulos [10] reminds us that the origin of the term amateur comes from *amator* in Latin, which means to love, and that being passionate about a project is also central to the DIY culture.

Studies of crafts and hobbies such as gardening and knitting [5], DIY communities [6], and hacker subcultures [13] also highlight the creativity and resourcefulness of individuals who create things outside of the common industrialized production model. For example, Ikea Hackers deconstruct and disassemble Ikea products to reassemble them in new personalized objects. The hackers then share their process and outcomes online with other hackers [13].

Both research in everyday design and in DIY communities demonstrate that people are creative, resourceful and most importantly that they do not use design artifacts the way designers had intended. By reading previous research, we understand that there are different types of makers and non-expert designers. However, there is a gap in our understanding of this continuum of makers. We can further explore how the goals of each groups influence their ways of doing, and their choice of material and tools. Such an

exploration would help us see the diversity of makers' practices and would lead the way to designing for these multifaceted and various practices. Interaction designers and the HCI community can learn a lot through this research by transferring these observations to different types of uses of interactive technologies.

OUR RESEARCH APPROACH

This paper is based on a larger study exploring practices of everyday designers. In this paper, we exclusively focus on the aspects of goals, materials, and competences of practitioners. We also concentrate on the relationships between these aspects and how they are linked through strategies. Our approach is in part based on the framework developed by Shove et al [15] to describe the dynamic aspect of social practices.

We chose three groups of people who design and appropriate in their practices: families, hobbyist jewelers and steampunk enthusiasts. These groups were chosen for their respective practices, but also for the range of motivations, skills and strategies used across the cases. Following is a short description of each group and the methods for collecting the data in each case.

The study of practices of families draws upon a study that was conducted in 2005-2006 [20, 21] with the goal of understanding the creativity of people in their everyday life. The original study is an ethnography of four families in East Vancouver, BC, with more than 460 hours of observation and interviews. The families studied were two married couples and two mothers with live in partners with children from 2 to 13 years old. We conducted a secondary analysis of this study by reviewing the photographs, videos, and notes from each session with the families to highlight the various aspects of the practices of everyday design. Families bring a perspective on the everyday life and on acts of making and design as part of people's routines. Most acts of appropriation are generally unconscious and tacit. This group was important for the study to represent everyday designers who design through design-in-use in order to get by daily activities and routines.

Hobbyist jewelers were chosen because the making and material aspects are central to the hobby. Six hobbyist jewelers (all female, age 23 to 50 years old) were interviewed and visited over one month. Four live in Vancouver, BC, and two live in Montreal, QC. Their professional occupations are varied: student of applied zoology, landscape architect, elementary school teacher, reporter, artist, and PhD student. All participants make jewelry as a hobby, and in one case, as a side business to her daytime job. Hobbyist jewelers were selected because they represent an amateur equivalent to the professional practice of jewelry making and silversmithing. Jewelers can take classes to learn their practice and consult a wide range of books documenting different jewelry techniques. We also chose this hobbyist group because of the important aspect of aesthetic in their creation, which is different than what we know about everyday design in families.

Steampunks are driven by a philosophy questioning the current consumption model and therefore is likely to show a different view of the *user* [17]. The steampunk subculture re-imagines a world inspired by the Victorian and Edwardian eras, where brass, leather, and wood constitute common fabrication materials and where steam is used as a main power source. Onion [9] writes in the Journal of Neo Victorian Studies: "Steampunks seek less to recreate specific technologies of this time than to re-access what they see as the affective value of the material world of the nineteenth century" (p.138) [9]. There is no professional equivalent to this practice. This group represents expert amateurs who share a common vision of the world. Eight Steampunks were interviewed and visited face-to-face or on skype. Three live in Vancouver, BC, one in Edmonton, AB, two in Toronto, ON, and two live in the Montreal, QC. Their ages range from 28 to 52 years old, three are female and five are male. Their professions are very diverse: family doctor, programmer, prop maker for movies and TV shows, psychologist, employee at a fast-food restaurant, and administrative assistant in a University department.

For the hobbyist jewelers and the steampunks, one of the authors met with each participant 3 times for 90 minutes each time. The data was collected in three different ways:

> Semi-structured interviews (addressing motivations and goals, outcomes, tools, materials, competences, and strategies).
>
> Photographic inventories [1] (including pictures of artifacts, materials, tools, environments, and actions).
>
> Video walk-through of artifacts or processes (short video where participants explain in detail why and how an artifact was made (materials, tools, and strategies), or the process for making this object).

In addition, some follow-up emails were sent to participants when more questions emerged during the data analysis.

In brief, we chose families to observe more tacit and unconscious everyday design, we selected hobbyist jewelers to understand the importance of aesthetic and the relationship to a professional side of a same practice, and we chose steampunk enthusiasts for their powerful ideological aspect and their strong community sense. We hypothesize that they all have similarities in how they view objects, and in how they appropriate and adapt artifacts, but we expected to see differences in the ways they achieved their acts of appropriation and transformation.

FINDINGS

We present the practices of families, hobbyist jewelers and steampunk enthusiasts. We describe each group through the different strategies they employ, which combines meanings, materials and tools, and competences.

Families

Supporting daily activities

The practice of everyday design in families generally aims at supporting the current lifestyle of family members. Appropriations of objects and their transformations are rarely the focus or the reason for making; rather, making is used as a way to facilitate other activities in the home. Accomplishing necessary tasks is a motivation for modifying things or reusing objects in different ways. This particularly happens in smaller spaces or when activities require a lot of space for a relatively short period of time. For example, Cate[1], a mother, uses the railing to hang washed clothing pieces that cannot go in the dryer.

In order to further describe materials in everyday practice of families, we discern attributes qualifying the objects, such as flat, hollow and protruding. Flat surfaces can invite family members to place other objects on top of them. For example, the top of the fridge was often used as a surface to either hide objects from children, or as a place to leave documents or objects that did not have another storage place. This finding was presented as part of the initial study [20] and similar conclusions were drawn from this second data analysis. Objects that have protrusions, parts that reach out of the main object, are mainly viewed as places to hang things from. Chairs and stair posts are commonly used to hang jackets, and stove and fridge handles to hold dish clothes.

Ad hoc improvisations

Spontaneous and temporary actions of appropriation help families move from one activity to another, a necessity as well. In Lori and Abe's family, it is common to leave artifacts by the door, such as garbage, Abe's equipment for a music night, or a lunch kit as a way to remember to bring them outside. This example shows that family members use different parts of the house and certain surfaces as reminders for future activities.

Figure 1. Lori uses her wallet to write as an ad hoc solution for a flat surface.

Since most appropriations happen through ad hoc events, materials are often present around in the house, ready at hand. Objects can be categorized as architectural structures (e.g. door, half wall), furniture (e.g. fridge, chair), and everyday objects (e.g. knife, bowl). We observe that these objects and materials are used as-is by the family members and that the form factor has a large influence on how families can use or not an object to continue to support ongoing activities in the house through design-in-use and spontaneous appropriations. Family members are experts at reusing objects as-is to accomplish a different function than the objects' intended ones. Hanging jackets on chairs, using the piano bench as a table, and using a magazine to collect fingernails exemplify well the variety of objects that can be resourced in the home. Similarly to reusing as is, jury-rigging entails making the best out of a current situation, and providing a quick fix. For example, Lori uses her wallet as a flat surface to write something on a piece of paper on the go (figure 1).

In general, most of the materials used do not need a physical transformation to be appropriated. Hands are typically the only tools needed to reuse artifacts, organize them differently or change their context of use. As we observed and categorized the types of materials and tools used in families' everyday design, we also understood that these choices (maybe involuntarily) do not require particular knowledge or specific skills to use. One does not need to learn how to leave things next to the entrance door, or how to hang things on a railing.

Thinking creatively, iterating, and adapting

Different types of competences related to how family members view objects were observed. Family members show the ability to think creatively, or in other words, to see opportunities presented by objects ready-at-hand in order to accomplish design-in-use. For example, Cate recognizes that a phonebook has the right shape to stretch her calves after running and Kerry sees a toy hat as a container to move other toys to a different room. Both examples require seeing objects through a new lens that can reveal new potential uses. This ability can also be seen as a common strategy that helps support everyday activities: reusing objects also means resourcing materials that are available in the context of a need. This strategy is closely related to the competence of seeing opportunities in objects.

The abilities to iterate and adapt systems are central to the practice of everyday design in families. They have ever changing routines; hence, systems need to follow this constant evolution. For example, Cate started to create a second iteration for her recipe organization system because she was not satisfied with the first one (a classifier folder divided alphabetically). The second system she developed, in addition to classifying the recipes by topic (appetizer, entrée, and dessert) like in her first system, allowed her to create two folders, one with tried and loved recipes, and one with recipes to try. As she explains, the new system prevents her from losing small pieces of paper holding recipes: once a recipe has been tried and loved, she glues it onto pages of the folder.

[1] All names are pseudonyms to preserve participants anonymity.

In summary, we observed that families' goals are usually to get by with daily activities and to continue with their routines. In order to accomplish this goal, they do not aim at developing new competences and do not try to find specific materials. Family members mostly use what is around and available to them and accomplish design-in-use while working on ever changing systems. Simple and available materials are reused, appropriated, and sometimes transformed through competences that do not require specific skills or techniques and that can be accomplished mostly by hand.

Hobbyist jewelers

Aesthetic motivation

Hobbyist jewelers' motivation resides in the possibility to accomplish something unique and beautiful with their own hands and potentially to share the finished product with others. This aspect of their practice challenges the common consumption model of buying anonymous and mass produced products. It supports the feeling that something made by hand and by someone you know is more special, meaningful and represents you better than what is available to buy in stores. In an interview, Sophie, a hobbyist jeweler, recalls creating a necklace with a miniature pocket knife for her sister and how this was more special than creating the other pieces she sells through an online store. Moreover, Veronica explains that the conceptual part of making jewelry for family and friends is the most challenging, but can also lead to the most rewarding experiences of making. She says:

I need to be observant of what they would wear, and what they like. It is very different from a mass production model, where I make 60 or 75 at a time, and the goal is to make the production cheap and fast. As a hobbyist, a necklace can take multiple hours.

The importance of creating unique pieces pushes hobbyists to collect particular materials and to pay attention to each detail of their creations. Aesthetic motivation is also an important generative goal in hobbyist jewelry. Many projects stem from materials that were acquired because of their look and feel. For example, Allison, another hobbyist, bought dried rose buds in a Chinese market because she appreciated that no two were the same. She did not have a precise idea of her project, but the materials urged her to think about how she could use them. Shape, weight, color, texture, and size are all important attributes that influence how the jewelers assemble and model pieces.

Collections of found objects also include pieces of vintage jewelry such as metallic chain, medallions, pendants, stones, and even small characters for model making. Natural materials are also used, such as dried sea stars and dried rose buds. Those unique objects and materials are generally combined with materials from scratch such as metal wire and plates, beads (acrylic, metal, glass, stone), feathers, and clay as well as basic jewelry pieces such as hooks for earrings, pins with loops or with flat ends, loops, and chains. Hobbyist jewelers show the use of an interesting combination of found objects, basic materials and pre-made jewelry pieces. They show a fluid ability for assembling pieces and are able to cleverly use modular pieces as a way to connect found objects or irregular pieces.

Figure 2: Claire conceptualizes her necklace by playing with materials.

The importance of aesthetic in jewelry making also reveals that hobbyist jewelers develop a strong ability to conceptualize their pieces sometimes through drawings or by playing with materials without assembling. For example, Claire places charms and chains on the table to see what a necklace could look like (figure 2). She moves the parts around to see different possibilities and then makes her choice. Participants mentioned that conceptualizing is often related to the need to emphasize artistic aspects such as composing and balancing textures, colors, materials and weight. Here, we observe the importance of the aesthetic goal that dictates a large part of the practice. It largely influences the materials chosen and demands certain competences in the assemblage of those materials. In the next section, we also see that the materials chosen shape what tools are used and what strategies are employed.

The pleasure of making and experimenting

A second important motivation for hobbyist jewelers is the pleasure for making things with their own hands. The simple act of assembling things, discovering techniques and overcoming challenges brings satisfaction to hobbyist jewelers. For example, Allison says that discoveries and successes in techniques are the reason why she continues doing her work: when she "*figure[s] something out*, *it's almost more rewarding than the result itself*". As demonstrated by many jewelers' projects, the ability to experiment is often at the heart of developing new techniques for jewelry making and using the unique materials collected. For example, this is how one of the authors described in her field notes Allison's cycle of iteration and experimentation for developing a way to pierce dried rose buds in order to add a hook:

Allison started to pierce dried rose buds first with a pin, by pushing on it, and turning it, but it did not work very well. So she looked for a different technique to make a good hole in the buds. All of a sudden, she thought about heat. She grabbed a candle, and heated a pin. And it worked. She says: "flash of insight, I just kind of knew. I wasn't sure it was going to work".

Experiments are not often prepared in advance and the inspiration of the moment leads hobbyist jewelers to use many tools that surround them. Before turning to using any tools, jewelers use their hands to make and assemble things in their practice. A participant explains that only when hands fail to do something she turns to other tools. A great variety of objects found around the house are used by hobbyist jewelers as a way of modeling the pieces they work on. Claire uses various objects to wrap around and shape silver wire into earring hooks. She resources glasses, small bottles, and handles of other tools like a hammer and cutters. Similarly, in order to shape Fimo, a soft colored clay that hardens when cooked, Lucia uses her dissection kit from biology class, spoons, a pill bottle to roll it, a straw as a dye, a pasta-making machine to flatten it and mix colors (figure 3), and any other tool she finds ready at hand.

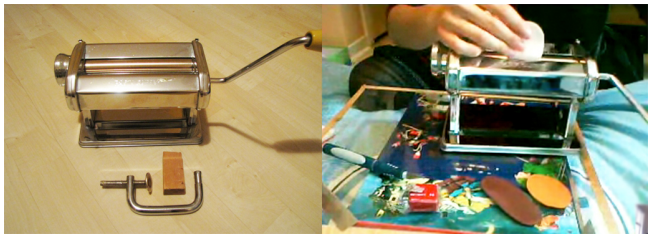

Figure 3: Pasta machine to flatten Fimo.

Letting materials speak

An important strategy for hobbyist jewelers is to let materials speak and act based on this exchange between the material and the practitioner. This strategy is directed by the aesthetic motivation of creating unique pieces with found materials and is also reflected in the motivating pleasure of making. This strategy combines both these goals and is central to the practice of hobbyist jewelers. The concept of letting materials speak was theorized by Schön who defines it as a *reflective conversation* between the practitioner and the situation (and materials) [14]. As the practitioner reframes a problem, he discovers new possibilities that then inform further action [14]. In jewelry, as practitioners move materials and try things, the materials speak back, telling the jeweler what decisions to take. This is crucial in the conceptualization of pieces. For example, in the creation of stone pendants, Allison explained that the stone itself plays a defining role for how the final piece will look. As she wraps the wire around the stone, she follows the angles created by the wire and the stone. For Veronica, materials have intrinsic properties and, as she assembles pieces, she says she cannot impose her own ideas on the materials; conversely, it is the material that leads her aesthetic exploration. Conversations between jewelers' ideas and their materials can take time, sometimes days. Jewelers sometimes let pieces sit on their desks before assembling them, to make sure they are pleased with the configuration.

In addition, serendipitous discoveries are part of what hobbyist jewelers called "*how things just happen*". There is a certain amount of unconscious action and movement in the making of jewelry, which leads to desirable outcomes by accident. Often, the materials themselves guide this process. In describing her process for the creation of stone pendants, Allison says: "*I don't pay too much attention, but the wire always ends where the hook is supposed to be*".

In conclusion, for hobbyist jewelers, a main goal is to make aesthetic jewelry pieces for themselves and for others and to enjoy the process of making them. Materials are carefully chosen, assembled and transformed with various accessible tools. Practitioners respect the nature of the materials in their creation. The pleasurable experience of making jewelry is augmented by discoveries, new techniques and challenges while modeling and assembling pieces.

Steampunk enthusiasts

Creating a steampunk world

The main motivation for steampunk enthusiasts to make their machines and costumes is to create and realize what a steampunk world could be, and to show how it would look and feel. There are deep implications in revisiting how most industrially produced objects are made and how they are represented to the world. The possibility to embody an alternative to the current mass consumption and production cycle serves a core incentive for creating steampunk machines and costumes. Even if the "cool aesthetic" first caught their eye, it is the realization that they do not need to rely on mass produced goods that constitutes the heart of why they continue to be engaged in steampunk. Participants state that with steampunk they are able to gain back a control over the fabrication of their everyday objects that was lost with industrialization. Some participants also explain how surprise and amazement are part of the realization that they are able to make much more than they thought they could.

Based on this reflection about the industrialized world, steampunks developed strategies to create their own steampunk world. For instance, the strategy of creating a character is often used to give a direction to the machines and outfits steampunk enthusiasts make. For example, Aaron, an enthusiast from Montreal, created the character Baron Celsius Von Farenheit who is the inventor of the CELL (the Compact Electromagnetic Linguistic Launcher), a compact, mobile device that can allow people to communicate. With this character, he can generate different narratives when explaining what his machine does.

In the steampunk community, we observe a high importance of the story surrounding produced costumes or machines. The ideology of steampunk strongly influences the design decisions during the creation period, as Tanenbaum et al highlight [17]. The steampunk subculture emphasizes the physical and visible aspects of machinery such as gears, coils, springs, gauges, and pipes. Hence, participants look for these antique objects as well as for materials that represent the Victorian era, and therefore the steampunk aesthetic, such as brass, copper, leather, and old

wood. Materials are acquired over a period of a few months to multiple years at flea markets, garage sales, garbage, antique shops, second hand stores, and Ebay.

In addition to real antiques and mechanical pieces, steampunk enthusiasts do not limit their imagination to finding parts or materials that could be from the Victorian era. Unique shapes displaying curves and ornamentation are also acquired, independently from the color or texture, since, as Kenneth says, "*everything can be painted!*" Objects that seem easy to disassemble are also chosen for the potential parts they hold. A large variety of objects are appropriated and repurposed into steampunk machines and costumes. As an example, in the fabrication of the CELL, Aaron repurposes a basketball pump into a piston (figure 4), a wine wood box for the core piece, a toilet ring to frame the porthole, and slow motors from cardboard displays for activating the key and piston .

Figure 4. Appropriated basketball pump for a piston.

A central strategy is to make believe both in terms of functionality and materials. Participants explain that the inside of the machines do not need to be well finished, it is only the parts that others can see that need to be convincing. Using fake materials can also help reduce the weight of some props, allowing more comfort during long days at conventions. Paint is one of the best ways to transform plastic material to make it look like metal.

In addition, some steampunk enthusiasts start to explore how to transform and reuse electronic components of artifacts. They not only change the frame (for example, on computer monitor screens), but they also appropriate controllers for electric garage doors to control small animated props. Simpler circuits with basic switches, resistors, LEDs and small motors are also created to animate the steampunk machines and costumes.

Tools and competences to support steampunk ideas

Following the variety of artifacts and materials used by steampunk enthusiasts, they also utilize a wide range of tools. In general, tools are not specific to the steampunk practice; they are handyman tools, clock repair and jewelry tools, sewing tools and craft tools. Tools generally serve for disassembling, joining, cutting, shaping, cleaning and finishing. However, similarly to jewelers, observations show that steampunk enthusiasts use their hands as basic tools for assembling, verifying and modeling parts.

While some participants use tools they already owned, others modify or create their own. For example, Adrian made his own polishing machine with a motor, a mandrel, buffing wheels, and a cookie tin that he cut in half and re-soldered together to create a protection case (figure 5). This example demonstrates the ease with which Adrian can assemble and model pieces to serve any purpose.

Figure 5: Homemade polishing machine.

Tools for joining are varied and adapted to many situations. Multiple types of glues such as epoxy, resin bond for plastic, gorilla glue for metal, fabri-tag for leather and fabric, and the hot glue gun are widely used by many of the participants. The hot glue gun is a tool that is either adored or hated by steampunk enthusiasts. It is recognized to be a great tool for quick fixes on almost any material, and it is also known to be used to fill in cavities and isolate parts of circuits. However, some enthusiasts prefer the use of the 'right' glue for higher quality projects and durability issues.

Skills are closely related to the quantity and variety of tools used and the sum of each participant's skills is understood to be greater than the individual skills themselves. The ability to combine skills is viewed as a great potential for tackling more complex and diverse projects. The ability to experiment with these skills and materials is central to the practice of steampunk. Often, new techniques are developed and reinvented to be applied to new materials. Aaron explains how he tried to curve brass plates to make an arm piece. He cut a U shape in a piece of wood to make two pieces, a male and female part for making a mold to curve the metal plates. In this extract of an update via email, Aaron explains how he jury rigged it since it was just a one time project:

As I feared, brass being quite "springy", it didn't remain as bended as I needed. Also, while it was easy to bend the centre of the sheet, it didn't work very well for the borders, especially for the larger pieces. Still, after letting the parts rest for a night while squeezed in the wooden shape under an anvil, they remained curved. If I had to do this kind of operation again, I would cut the wood shape into a more severe curve than I need to compensate for the fact that the brass will "unroll". But since it was a one-shot project, I supplemented this approach by wearing gloves and rolling the parts around a smaller spray can by hand. I didn't get exactly what I originally aimed for but I got something that works.

Experiments sometimes also include multiple attempts before reaching satisfaction. For example, Aaron was looking for a way to isolate already soldered wires in his communication machine the CELL. Following the suggestion of other steampunk enthusiasts on the web, he decided to experiment with melted wax (figure 6). He prepared small white candles and a larger red candle. After trying multiple combinations of candles and positions, he finally established that using the larger candle (which he thought would be cumbersome) is easy to handle and hot enough to melt once the candle is blown out.

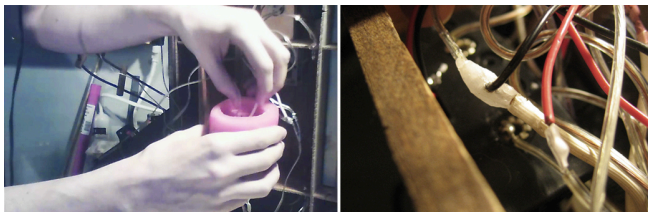

Figure 6: Experimenting with wax to isolate soldered wire.

Sharing the steampunk perspective

Finally, the perspective of participating in the steampunk community motivates all the participants. The steampunk subculture is highly active online (through blogs, Facebook pages, and websites) as well as through offline events such as annual conventions and monthly social and craft meets. Many participants created their first costume because they wanted to attend a convention. Participating in events is often augmented by the desire to promote the steampunk ideology and values. For example, a participant explains that he evolved from attendee to volunteer at the fan table and finally to sharing tips in panels at subsequent conventions. The possibility to share techniques and to inspire others is definitely an incentive for individuals to exchange with others, especially because it provides the opportunity to be inspired and learn as well.

Similarly to hobbyist jewelers, the genuine pleasure of making is also central to steampunk enthusiasts motivations and is often shared at conventions and through these online communities. For example, a participant explains that he first created a costume because he liked the look, but he concluded that the DIY approach is what motivates him to continue making projects. The contact with materials and tools is seen as both fun and challenging and the achievement of projects brings great pride to the participants. The possible outcome of having unique pieces is also a motivating element for steampunk enthusiasts. This pleasure for making also seems to be expressed to other enthusiasts and is contagious in the community.

In brief, steampunks' goals are to recreate this imaginary world of steam driven technology, where gears and other functioning parts of machines are exposed. For them, creating a character is a starting point for making future design decisions around props and costumes. Since the imaginary story around it is the most important, the materials are not chosen based on how they will be transformed but on how they reflect the ideology of steampunk. Practitioners will develop any necessary competence to model and change any materials through experiments. In addition, the goal is to share the ideology and the techniques for making with other enthusiasts who also want to pursue their quest toward an idealized steampunk representation of the world.

DISCUSSION

Meanings as a main motivator

The main finding in this research is the importance of the meaning in the practice of non-expert designers. It radically informs the types of materials and tools used, from almost no tools for families to a wide variety of tools for steampunk enthusiasts. In both cases, the goal was not directly to make something, but the making was a means to support a more important goal (pursuing daily activities, or recreating an imagined past). However, as we described, the way this was manifested is different in each practice. Meaning often includes the foundations for further acts of appropriation. These foundations rely on implied and sometimes unspoken goals of practitioners. The best example of foundational goals is represented by our case of families, where the possibility to achieve daily activities is supported by silent and common appropriations and everyday design in the house. Foundations are also part of the practices of hobbyist jewelers and steampunk enthusiasts but the awareness of their own practices makes additional goals specific and explicit. We discuss in more details the types of goals in the following section.

In addition, we see how the choice of material also has an influence on the competences and skills that are developed by practitioners. This willingness to experiment or learn a new technique is dependent on what the ultimate goal is. We saw that for both hobbyist jewelers and steampunk enthusiasts, a part of the reason for making was the implicit pleasure of making. In this case, explorations, experimentations, and trial and error processes are welcome and become part of the strategies for making. In the case of families, experimentations are also part of the practice, through jury-rigging and ad hoc appropriations, but they are not necessarily enjoyed in a conscious manner.

Foundational, aesthetic and aspirational goals

Our analysis of the three groups indicates that meaning was the determinant element in each practice. However, our analysis also reveals that the goals can be different and we present here a classification of meanings we observed: foundational goals, aesthetic goals, and aspirational goals. We explain how each group can be a stereotypical description of each type of meaning and how this can be applied to the design of interactive technologies.

Foundational goals: families and everyday life

In contrast to the other groups, families showed that their acts of appropriation were performed in order to support other goals in their everyday routines and activities. In this

case, the appropriation or everyday design act is not the central focus of the activity, and the motivation for doing it is often embedded under a different goal. We call this type of goal a foundational or unconscious meaning for this practice. By foundational, we mean that this is not a developed goal, but that it is implied as part of actions people do without the need to think about them. Foundational goals are pillars supporting other activities in the house. They are often part of routines, unarticulated, and rarely become an activity in itself. We see in families the most striking examples of foundational goals, but we also recognize that they are a part of any practice of everyday design. Hobbyist jewelers and steampunk enthusiasts also showed instances where certain acts of design were conducted to achieve underlying goals.

Foundational goals open up a question about how to design for families or other groups of everyday designers that do not necessarily have the motivation, nor the time, to deeply engage in a practice of transforming technological artifacts. How can we make technology that can be easily appropriated on the go by families or people who just want to get by while using these artifacts? Can we make simple interactive artifacts that can be used without even thinking about it? Foundational goals would imply that some interactive technologies could be used within the flow of activities, for different purposes, as simple as a chair or a knife. Designing for foundations would also support other groups of everyday designers, who can then augment these tools with additional material to reach more specific goals.

Aesthetic goals: hobbyist jewelry aesthetic

We see in hobbyist jewelry a practice motivated by an aesthetic goal. The motivation of creating unique and personal pieces for friends and family is strong and guides all the aesthetic decisions made from the choice of material to the assemblage. We propose this type of practice, oriented by an aesthetic goal, to represent all practices that focus on a specific outcome related to the look and feel of a product.

In interactive technologies, we see the Arduino lilipad as a material that combines technological capacities and aesthetic aspects so that it can be included in fabric or paper projects. This is a great example of a material that focuses on a specific aesthetic goal of a practice and, from there, multiple projects can stem and grow in the hands of practitioners. We can reflect on how to design other materials that are used for their physical look, their texture, weight, color and shape. Is there a way for interaction designers to create tools or materials that are chosen for their beauty first?

The aesthetic goal of hobbyist jewelers is also supported by allowing some space for the materials to speak and some experimentation to happen along the way. Sometimes it is the act of discovering something new and to overcome challenges that is the reward in the act of making. Can we design tools that can support multiple skill levels of practitioners? Tools that can grow and provide easier to harder challenges to the practitioner as he is developing his own skills? The goal would be to gradually guide practitioners to accomplish more complex and more rewarding projects.

Aspirational goals: steampunk ideology

With steampunk enthusiasts, the important literary, cultural, and philosophical current of steampunk serves as a motivation for making costumes and props. This strong ideology of steampunk is multifaceted and has implications not only in the making aspect, but also transforms how enthusiasts see the world around them. We see this group as an example of a practice guided by aspirational goals. This is characterized by an overwhelmingly powerful meaning that can motivate practitioners to overcome steep learning curves and long design processes.

Similarly to the practice of hobbyist jewelers, challenges are a part of practices that have a strong ideological goal. As challenges are overcome by hobbyists and amateurs, they push further the limits of what they thought was possible. In the digital world, arduino and new programming languages like Processing are great for amateurs who like to tinker and create as a pastime. In this case, we can see how these tools are developed for people who are willing to take up the challenge, experiment and through trial and error reach a satisfying point where a project is done. These tools would most likely be used by enthusiasts that have a strong goal or clear idea of what they want to achieve, such as steampunk enthusiasts. In that case, it would be this vision of a completed project that would encourage an enthusiast to persevere and learn this new technique. However, in some other cases, such as for families and jewelers, there would be too many barriers between the actual goal and the necessary learning time of the technique.

With these examples, we illustrate how certain tools, materials, or even competences, can work wonderfully well for some groups of everyday designers, and how it can miss by far the goals of other groups. We argue that interaction designers and researchers need to be aware of the audience, and particularly their goals and motivations for their practice of appropriation and everyday design. With this research, we can see a continuum of practices of everyday designers and makers. We value the diversity and the uniqueness of each practice and wish to see more practices evolve and develop into the realm of interactive technologies. Our discussion led us to reflect on different avenues for developing tools and materials that can support different types of practice's meanings (foundational, aesthetic and aspirational) that are appropriate for different types of users and different contexts of use. We acknowledge that these three types of goals do not reflect the complete continuum of everyday design practices, but that they are three points that reflect unique practices. We view this classification as a starting point that can further

our reflection on the different types of users, amateurs, and hobbyists.

CONCLUSION

In this paper, we presented the practices of three types of everyday designers: family members, hobbyist jewelers, and steampunk enthusiasts. We describe how the meanings of their practices have a great influence on the materials, tools and competences. From supporting daily activities, to sustaining aesthetic motivations, and to designing towards an imagined steampunk future, we revealed that each practice could hold very different motivations. Our contribution lies in providing this description, but also in reflecting on how foundational, aesthetic and aspirational goals can orient how we design to support creative practices with interactive artifacts.

For the interaction design and HCI communities, the importance of understanding the goals or motivations of the different groups of non-expert designers can be crucial in the creation of tools or materials. Interaction designers can design to support or allow everyday design and appropriation with interactive technologies as long as they know what to support. Do we design tools for experiments and multiple iterations? Do we design for simple, fast, ready at hand multiple uses of artifacts?

Future research can further explore new groups of everyday designers to add to this continuum of practices. In addition, we can start to design tools or materials that would support some of the types of motivations presented in this paper. Hopefully, this study and our reflection can nourish a design process where everyday design is championed and where personal creativity is revived to reconnect with design objects and systems.

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Chapter 4.

Unselfconscious Interaction: Goodness of fit and living with

Chapter 4 presents the article "Unselfconscious Interaction: A Conceptual Construct" (Wakkary, Desjardins, et al., 2015). This article was written in collaboration with Ron Wakkary and Sabrina Hauser and previously published in the Interacting with Computers Journal. The overall goal of this article is to articulate the construct of *unselfconscious interaction*. The construct was built following the methodology of concept-driven interaction design research (Stolterman & Wiberg, 2010). In the article, we analyze three concept artifacts: the table-non-table (built by the everyday design studio directed by Ron Wakkary), the Discovery-driven prototypes (Lim, Kim, Jo, & Woo, 2013), and the Indoor weather stations (Gaver et al., 2013). Unselfconscious interaction describes a novel way of engaging with interactive artifacts. It discusses how interactive artifacts can be part of ongoing and incremental adaptations in the everyday setting, to reach a goodness of fit within the context and with other artifacts. This type of interaction mirrors some of the findings from everyday design (Wakkary & Maestri, 2007) and design-in-use (Wakkary & Tanenbaum, 2009). While similar to adaptations of non-computational artifacts common in the studies of everyday design, unselfconscious interaction is concerned with how interactive artifacts can also become part of ongoing improvements of the everyday setting.

While in chapter 3 I focused specifically on the details of non-expert *making* practices, in chapter 4 I turn to how people *live with* artifacts in a reconfigured space. In this dissertation, this article is relevant to answer the question: *How are interactive artifacts lived with in a space?* Not only does this chapter investigate how people live with artifacts in a general sense, but the attention is also drawn to living with artifacts in a way that leads to incremental and ongoing adjustments to the everyday setting.

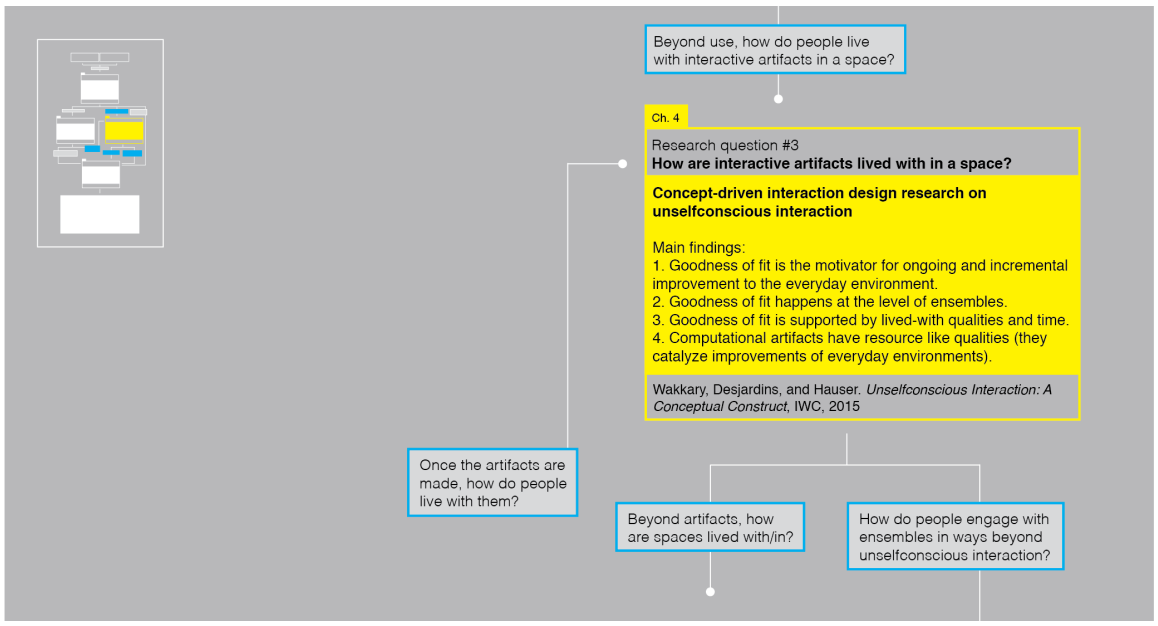

Figure 5. Chapter 4 research questions and findings (excerpt from Figure 1)

Though the article makes multiple contributions to the HCI and interaction design research communities, I want to focus on four particular points in the article that are highly relevant in articulating the concept of design-in-living: goodness of fit as a motivator for improvements; ensembles as the site of goodness of fit; lived-with quality to support goodness of fit; and computational artifacts as resources (as illustrated in Figure 5).

The construct of unselfconscious interaction is constituted by a guiding motivation: *goodness of fit*. Goodness of fit was first described by Alexander (1964) in his study of unselfconscious cultures such as Hebridean crofters or Bedouin herders. In those cultures, goodness of fit is seen as the motivator for making improvements to existing designs. In unselfconscious cultures, professional design or architecture practices do not exist; houses and everyday artifacts are built based on traditions learned from older generations, where the know-how is learned as part of everyday life and building materials are found in the surroundings. In unselfconscious cultures, improvements are the results of incremental and ongoing acts that respond to the desire of fixing misfits, to reach a level of fit between the design artifact (or the house) and the context. In this article, we argue that the goal of reaching goodness of fit for interactive artifacts is present in unselfconscious interaction. In this sense, it is through ongoing,

tacit, and potentially unknowing acts that home dwellers can reach a good fit between interactive artifacts and their everyday settings. In design-in-living, goodness of fit remains a central requirement that animates acts of designing and building in a lived in space.

Secondly, in the article we discuss how in unselfconscious interaction, similarly to Alexander's description of unselfconscious cultures, goodness of fit happens at the level of *ensembles*. By this, I mean that goodness of fit can only materialize between artifacts or between an artifact and a space. It is a question of how well an element relates to its surroundings and of how well different artifacts (or interactive artifacts) co-exist in a space. This is an important shifting point from design-in-use to design-in-living, where the focus becomes broader than the single appropriated artifact or system.

Thirdly, in the article we describe how the motivation of goodness of fit is supported by two qualities: *open-ended* and *lived-with*. Here, I particularly bring attention to the quality of lived with. Living with an interactive artifact is explained to be the ability to co-exist with this artifact in the everyday setting, similarly to how people live with pieces of furniture, or other artifacts that are kept over long periods of time. The quality of *lived with* reconfigures interactive artifacts not only as tools to serve people's needs, but as design artifacts that become part of the space we live in. In design-in-living, I turn the focus from looking at how people live *with* artifacts to how they live *in* a space. In this article, we focus particularly on the temporal dimension of living with interactive artifacts over time. In the next chapter (chapter 5), I articulate the need to also consider the spatial dimension of living in a space. In chapter 6, I discuss how the central conditions for design-in-living to happen are to have time and physically be in the space (6.1.3).

Fourth, I come back to the materials used in practices of adaptation and incremental improvement of everyday settings. In everyday design, particularly in design-in-use, Wakkary and colleagues (Wakkary & Maestri, 2007; Wakkary & Tanenbaum, 2009) propose that design artifacts are understood to be resources for further acts of design. In chapter 3, the study of three groups of non-expert designers showed that acts of design could rely on design artifacts, found objects, found materials, and raw materials, and combinations of those. In this chapter, we keep a focus on

design artifacts as resources for design, but specifically investigate computational design artifacts as resources. In this chapter, we add that the computational aspect of those artifacts serves as a catalyst for accelerating the pace at which incremental adaptations happen. I address the types of materials for design and the role of computation in those materials in chapter 6 (6.1.6).

In this chapter, the reader will also see an in-depth discussion around using concept-driven interaction design research as a way to build the construct of unselfconscious interaction. This is a methodology that proved very useful in this article, but it does not constitute a major contribution in the context of this dissertation. The methodological contribution I make in this dissertation comes from chapter 5 and addresses the use of autobiographical design.

In addition, in this chapter, we propose the strategy *purposeful purposelessness* as a way to design to support unselfconscious interaction. While this design strategy did not directly lead to the construction of design-in-living, I revisit it in chapter 6 to discuss further avenues for design in reconfigured spaces, such as smart homes or ubiquitous computing environments (6.3.2).

There are four insights (as detailed above) that are central to pursuing the investigation of how people design and make a space they live in by opening questions for chapter 5 and by starting to articulate important aspects of the concept of design-in-living. The four insights are:

- Goodness of fit is the motivator for ongoing and incremental improvement to the everyday environment.
- Goodness of fit happens at the level of ensembles.
- Goodness of fit is supported by lived-with qualities and time.
- Computational artifacts have resource-like qualities (they catalyze improvements of everyday environments).

The first insight describes goodness of fit as another motivation for design actions. This motivation was not present in design-in-use, nor in the goals of non-expert designers in chapter 3. Goodness of fit directly addresses the shift towards considering

collections of artifacts that this dissertation aims at making. This point is taken into consideration when developing the concept of design-in-living (6.1.2).

The second insight articulates how goodness of fit exists within ensembles. In this chapter, goodness of fit is reached through incremental, tacit, and almost unknowing fixes to the artifact or surroundings. By pushing further, and by considering the various design strategies presented in chapter 3, I generate another question: how do people engage with ensembles in ways beyond unselfconscious interaction? As a response, I present different strategies for designing and living within ensembles in chapter 5.

The third insight highlights the quality of living with and the necessity of time. Time was also a condition for design-in-use and is also a condition of design-in-living (6.1.3). By acknowledge its importance in chapter 4 (and in chapter 5), I show that the need for time for design qualities to emerge is omnipresent. The quality of *living with* was developed in chapter 4 with relation to artifacts. Following this idea, I ask: beyond artifacts, how are spaces lived with or lived in? This leads directly to chapter 5 where I describe the qualities of living in a camper van as it is transformed.

Finally, in this chapter I show how interactive artifacts can be design resources for future design acts. This idea follows through in design-in-living as well, where the artifacts within a space, and the space itself, also serve as resources for design (6.1.6).

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Unselfconscious Interaction: A Conceptual Construct

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In this article, we present unselfconscious interaction, a conceptual construct that describes a form of interaction with computational artifacts animated by incremental intersections that lead to improvements in the relationships among artifacts, environments and people. We draw on Christopher Alexander's notion of goodness of fit and unselfconscious culture, and utilize Erik Stolterman and Mikael Wiberg's concept-driven interaction research to analyze three interaction design concept artifacts to develop the construct of unselfconscious interaction for human–computer interaction. The resulting construct is comprised of the motivation of goodness of fit that is supported by two design qualities we name open-endedness and lived-with. We describe tensions within the construct, the notion of purposeful purposelessness in design and discuss the features that derive from Alexander's unselfconscious culture and are to be considered when designing for goodness of fit: resources, adaptation, ensembles, time and anonymity. Our main contribution in this article lies in the articulation of the construct of unselfconscious interaction.

RESEARCH HIGHLIGHTS

- Our main contribution is the conceptual construct of unselfconscious interaction. It theorizes how interaction design artifacts can enable ongoing and incremental improvements to everyday settings in ways that are similar but ultimately new and different than analog artifacts.
- We elaborate on concept-driven interaction research (Stolterman and Wiberg, 2010) by developing criteria for a conceptual construct.

Keywords: interaction paradigms: novel interaction paradigms; interaction devices: novel interaction paradigms; interaction design theory, concepts and paradigms; interface design prototyping

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1. INTRODUCTION

In this article, we define a new conceptual construct we call unselfconscious interaction. We describe this conceptual construct as a form of interaction animated by incremental intersections with interaction design artifacts that over time and even unknowingly lead to improvements in our everyday settings.

The design ethnography studies of families by Wakkary and colleagues (Maestri and Wakkary, 2011; Wakkary and Maestri, 2007; Wakkary and Tanenbaum, 2009) served as background for this investigation. This research described an ongoing process of resourcefully using and repurposing everyday artifacts to improve the home and daily routines. One example of this process is the constant knowing and unknowing adjustments to furniture, household items and other objects to create a room that fits the patterns of our everyday life and subjective needs. Another unique and more elaborate example of such incremental design is the recruitment of everyday objects like a bowl, walls, chalkboard and a refrigerator door to create an ensemble of things and environment for family messaging (Wakkary and Maestri, 2007). Importantly for human-computer interaction (HCI) and interaction design research, the researchers also found that interaction design or computational artifacts rarely contributed to this process. Our contribution with the conceptual construct of unselfconscious interaction is to theorize how interaction

design artifacts can enable such ongoing and incremental improvements to everyday settings in ways that are similar but ultimately new and different than analog artifacts.

Theorizing a new role for interaction design artifacts was inspired by Christopher Alexander's (1964) theory of unselfconscious culture and specifically the concept of goodness of fit. Alexander describes the process of incremental and unknowing interactions and corrections that over time lead to improvements in everyday life or what he refers to as goodness of fit. The combination of the unknowing nature of the interactions and that design in this manner is anonymous, i.e. not done by professional designers, led Alexander to refer to the process as unselfconscious.

Alexander's examples typically feature raw materials but imply that unselfconscious designers can treat designed artifacts similarly to resources much like raw materials. In the development of our construct, we explicitly consider designed artifacts as everyday resources; in fact this is central to our claim. Further, we situate computation as an integral aspect of the artifacts at play within our construct. Our pursuit is to re-interpret unselfconscious culture from an HCI perspective. In order to do so we develop our conceptual construct through an analysis of three interaction design artifacts that we consider as concept artifacts. Stolterman and Wiberg (2010) explain a concept artifact as a crafted artifact that manifests a theoretical concept similar to how Alan Kay's Dynabook embodied the notion of portable computing (Kay, 2011). The three artifacts we chose are the Discovery-Driven Prototypes (Lim *et al*., 2013), the Indoor Weather Stations (Gaver *et al*., 2013) and our own table-non-table. The resulting construct is comprised of the motivation of goodness of fit that is supported by two design qualities we name open-endedness and lived-with.

Our investigation in this article adopts concept-driven interaction research (Stolterman and Wiberg, 2010) to theorize generic qualities and characteristics that emerge through an understanding of the crafting of design artifacts. Our motivation for utilizing this type of theoretical argumentation is to articulate or uncover new forms of interaction experiences and computational artifacts that empirical analysis alone cannot achieve. Empirical research focuses on what already exists rather than what will exist. Our methodological aim is to extend past descriptive and analytical research in ways that are generative and productively speculative.

Our article is comprised of six sections. After this introduction, we provide a section of related literature that includes a concise summary of Alexander's (1964) unselfconscious culture and related theories of interaction. We follow this with an introduction to concept-driven interaction design research by Stolterman and Wiberg (2010). Our aim in this section of the paper is to communicate our methodological approach and explain what we mean by a conceptual construct. We then present three interaction design artifacts and their related theories. We treat each as a concept artifact and based on Alexander's unselfconscious culture we analyze the concept artifacts together to develop our unselfconscious interaction construct. We follow this with an in depth discussion of the construct and detail the structure behind it which are goodness of fit and the supporting design qualities of open-ended and lived-with. We also describe the tensions that balance the relationships between the supporting design qualities and the motivation. We conclude this section with a description of our notion of a purposeful purposeless design strategy. The article closes with a discussion of the differences and adaptations between unselfconscious interaction and unselfconscious cultures and future challenges with respect to unselfconscious interaction.

2. RELATED LITERATURE

2.1. Unselfconscious culture and goodness of fit

In this investigation, we act upon our initial resonance with the architect Christopher Alexander's (1964) description of goodness of fit and his idea of unselfconscious culture we experienced when conducting prior studies on design artifacts in the home. In short, Alexander views unselfconscious culture as a way of making that is learned informally and motivated by ongoing corrections that over time lead to improvements. This is in opposition to what he refers to as selfconscious culture in which making is learned academically and governed by explicit rules and knowingly aims at improvements and innovations (idem, 1964, p. 36).

Alexander's notion of an unselfconscious process is animated by ongoing fixes and maintenance of the built environment by its inhabitants. These actions are tacit and follow complex and often unspoken rules. Over long periods of time, the unselfconscious designer unknowingly creates significant improvements and changes of an ensemble of form and context. The unknowing nature of unselfconscious design does not require a skilled or highly competent maker—even aimless changes may contribute or eventually lead to a well fitting form or outcome. The idea of a 'goodness of fit' is the degree of equilibrium that is achieved between the form and the context:

> It is based on the idea that every design problem begins with an effort to achieve fitness between two entities: the form in question and context. The form is the solution to the problem; the context defines the problem. In other words, when we speak of design, the real object of discussion is not the form alone, but the ensemble of comprising the forms and its context. Good fit is a desired property of this ensemble, which relates to some particular division of the ensemble into form and context (Alexander, 1964, pp. 22–23).

In describing goodness of fit, Alexander draws on prehistoric building traditions and those of indigenous cultures. For example, he praises the black tents of the Bedouins, the trullo stone houses found in the Itria valley in the Apulia region and the black houses of the outer Hebrides as exemplars of

achieving goodness of fit (idem, 1964, pp. 46–47). In each case, these examples demonstrate an ensemble of resources that are of a lived-with quality or from the context in which the builders inhabit, for example, the black goatskin used for the Bedouin tents or sod used in the houses of the Hebrides. Further, these resources are easily manipulated so that the ensembles can be constantly improved upon over time to achieve a balance and quality. We argue, that these qualities speak to five main features of unselfconscious culture that enable goodness of fit: (i) resources, (ii) adaptation, (iii) ensembles, (iv) time and (v) anonymity.

(i) Resources and materials are ready at hand and to be found in nearby surroundings like the aforementioned sod, grass and straw used by the Hebridean crofter or black goatskin of Bedouin herder (idem, 1964, pp. 48–49). Additionally, there is directness in the making and repair. The unselfconscious process exploits the immediate environment for resources and they are discovered through apprehension (perceiving and understanding) and generation (making or repair), which occur simultaneously. Resourcefulness and the direct manner of making are possible since the maker inhabits the very environment in which he or she makes.
(ii) Adaptations are seen as the dynamic between misfits and good fit. Good fit is the aim of virtually every making culture and the constant addressing of misfits leads to an 'equilibrium of well-fitting forms' (idem, 1964, p. 50). Misfits are those things that prevent a good fit that are expressed in negative form; they are specific and tangible enough to talk about (idem, 1964, pp. 22–23). What allows unselfconscious design to consistently achieve goodness of fit is the motivation to constantly attend to misfits.
(iii) Goodness of fit is achieved at the level of ensembles, not a single artifact, since the design is the relationship between forms and between forms and context.
(iv) Time is the essential condition by which equilibrium of fit occurs. Without the right amount of time a form or artifact will not engender the cumulative progress toward equilibrium—goodness of fit will not occur.
(v) Alexander articulates anonymity of making as a further distinction between unselfconscious and selfconscious design. He argues that contemporary professions or selfconscious cultures of making are established on individual achievements and recognition whereas the anonymous maker of unselfconscious cultures for all intents and purposes goes unnoticed (idem, 1964, pp. 33–34). In addition, unselfconscious cultures do not distinguish nor reflect on design as a separate entity from daily living; as such there is no specialization of labor or expertise, each person is ones own builder.

These distinctive features of unselfconscious cultures get to the crux of the matter for Alexander. Goodness of fit is a goal for all good design and this was readily achieved by unselfconscious cultures; however, the rise of selfconscious design erased or abandoned the features that made unselfconscious cultures successful. In selfconscious design, rules became abstracted into universal principles rather than embodied local practices learned tacitly and experientially. Design resources and materials became generic and portable rather than lived-with and situated. Design forms became the sole focus separate from their ensembles. And the most fundamental change was that design and making became the providence of the specialized and expertise labor of the designer rather than everyone. The qualities of unselfconscious design created what Alexander referred to as a homeostatic or self-organizing structure that allowed it to consistently achieve goodness of fit, yet it is these very qualities that are minimized in selfconscious design. As a consequence, he argues that the processes of selfconscious design or professional design are broken (Alexander, 1964, pp. 37–38). The reification of the process, thinking and roles in selfconscious design, work against the organic relationships of unselfconscious cultures that as a result lack the ongoing balancing that fosters goodness of fit.

Alexander characterized contemporary architecture (he is an architect by training) as unable to consistently achieve goodness of fit and in large part the notion of selfconscious and unselfconscious cultures is a theoretical critique and explanation of the malaise he saw in the profession. In many respects, we see a similar challenge in professional interaction design and HCI. In other words, many of the current assumptions of interaction design (e.g. interaction design is the domain of professional experts or interaction design artifacts are designed for expert repair or replacement) work against or minimize qualities of unselfconscious cultures that better lead to goodness of fit. Alexander's notion of unselfconscious culture serves as a starting point for understanding goodness of fit within the context of HCI. The development of our construct of unselfconscious interaction addresses the need to understand the role interaction design artifacts can potentially play in the process of achieving goodness of fit.

2.2. Related theories of interaction

Within the view of exploring people's experiences of living with interactive technologies over time and in everyday contexts, we found prior work in HCI that we see as related to Alexander's (1964) idea of unselfconscious culture and the notion of goodness of fit. In what immediately follows, we review this related research.

Alexander's concern with how we live with designed artifacts as part of our everyday life is in line with the evolution of interaction design from the design of tools for specialists to technologies that are lived with. Forecasting

the embeddedness of technologies everywhere, Weiser (1991) coined the term Ubiquitous Computing, a vision that aims at integrating computers seamlessly into our everyday lives. Building on this, Weiser and Brown (1997) introduced calm technology looking at how technology can engage and mediate people's attention, with an emphasis on presenting information in unobtrusive and subtle ways. AmbientRoom (Ishii *et al*., 1998) is an early concrete example of this concept as a personal interface environment of ambient media displays and controls subtly presenting information using light, sound and movement to office workers. Tolmie *et al*. (2002) discuss unremarkable computing as an investigation of ubiquitous computing in the home. In large part, their work is a critique of the techno-centrism of ubiquitous computing. Based on ethnomethodologically informed analysis of routines in the domestic life of families, Tolmie *et al*., reframe the notion of invisible technology to be embedded in and conditioned by everyday routines such that technology becomes as unremarkable as the routines, artifacts and environments of our everyday lives. We take inspiration from Tolmie *et al*.,'s critique and emphasis on the hybridity and ecology of actions, artifacts and environments.

Other works in HCI and interaction design have critically examined experiences with technology in its various dimensions. Most importantly, McCarthy and Wright (2004) draw on pragmatist philosopher John Dewey and literary theorist and philosopher Mikhail Bakhtin to argue that 'we don't just use technology, we live with it' (p.ix, preface). Technology has become deeply integrated into our everyday lives and lived experiences. Motivated by a growing interest to design technologies for contexts outside the work place, McCarthy and Wright critically unpack interactions with technology to allow it to incorporate the sensual, emotional, intellectual and spatio-temporal threads of felt experience. Of interest in this article are the temporal thread and the underdeveloped exploration of the trajectory of experience over long periods of time. This exploration is in contrast with common interaction design efforts that focus on immediate and short-term interactions. McCarthy and Wright's work informs our assumptions expressed in this article of an underlying pragmatist view of experience with interaction design artifacts.

When people experience and live with artifacts in an everyday setting it becomes clear that artifacts are interpreted and appropriated in their practical context in ways that designers cannot foresee or control. Ihde (2008) a contemporary philosopher of technology, terms this the 'designer's fallacy' and proposes that designers should take into account unintended uses and their consequences. This idea of fostering the unknowns and creative misuse in designed artifacts as a resource quality is present in some HCI related works. Redström (2006) supports the idea of 'unintended use by unintended users' as it 'is close to impossible to take into account at least systematically speaking and designs are constantly being used in unintended ways and this is not a bad thing' (p. 130). In fact, appropriation is often seen as a sign of acceptance of a technology. Dix (2007) advocated for awareness of this type of creative misuse and proposed guidelines for designing for appropriation. Dix points out, 'whilst you cannot design for the unexpected, you can design so that people are more likely to be able to use what you produce for the unexpected' (p. 28). However, 'design for appropriation is not always what is desired' (p. 28) since some products are designed with a very specific purpose like an espresso machine. Embracing appropriation offers a new way of understanding the user. Wakkary and Maestri (2008) found appropriation to be 'a key action in everyday design' (p. 479) looking at four families and how they appropriated artifacts to design everyday household systems. Moreover, Gaver *et al*. (2003) showed how ambiguity can be seen as an opportunity as well as an esthetic and conceptual resource for design. Allowing ambiguity, which is present in our everyday world (Ihde, 1979), 'to be reflected in design has several advantages' (Gaver *et al*., 2003, p. 233). For instance, in Gaver *et al*'s view, '[t]he ability for ambiguity to evoke personal relationships with technologies is particularly relevant as digital technologies are designed to support activities outside of work. Traditional concerns for clarity and precision are superseded in such systems by the need to provide rich resources for experience that can be appropriated by users' (ibid, p. 233). On a general level, the appropriation of artifacts aligns with Alexander's articulations of the activities in unselfconscious culture and the goal of goodness of fit. In our view, unselfconscious interaction embraces the unknowns in designed artifacts as a resource quality.

The incremental changes and slow improvements in design presented by Alexander (1964) as unselfconscious design find resonance in the concept of slow technology. Hallnäs and Redström (2001) argue in their influential article on slow technology that 'creating technology that surrounds us and therefore is part of our activities for long periods of time' (Hallnäs and Redström, 2001, p. 161) aims to expand the notion and practice of creating tools to make people's lives more efficient to a design practice for more reflection and slowness. Mazé and Redström (2005) add to the slow technology philosophy by discussing how designing computational artifacts requires interaction designers to 'investigate what it means to design a relationship with a computational thing that will last and develop over time—in effect, an object who's form is fundamentally constituted by its temporal manifestation' (Mazé and Redström, 2005, p. 11). This work reveals and explores how design things inhabit our intimate surroundings in ways that enable people to make sense of them over time. More recently, Odom *et al*. (2014) conducted a long-term study that placed a slow technology called 'Photobox' for 14 months in multiple homes that randomly and infrequently prints out photos. The research explored the experiences over time witnessing a trajectory from frustration and a desire for more control toward an

acceptance and 'pleasurable anticipation'. Speaking about the design of the Photobox, Odom *et al*. (2012) describe the notion of creating design artifacts intentionally with 'lived-with' qualities in describing rationale for using a chest with patina as opposed to a more ambiguous or unfamiliar form. Our work on unselfconscious interaction relates to slow technology and aims to contribute to this research. However, we emphasize a set of interrelated factors in addition to time, including a more direct even if unknowing engagement with artifacts and an experience that may have little or no reflection.

3. CONCEPT-DRIVEN INTERACTION RESEARCH AND CONCEPTUAL CONSTRUCTS

In this section, our aim is to communicate our methodological approach drawn from concept-driven interaction research (Stolterman and Wiberg, 2010). We explain our characteristics of a construct and describe our process for developing the construct. We also discuss related alternatives in design research, including, Höök and Löwgren's (2012) strong concepts, and annotated portfolios by Gaver and Bowers (Bowers, 2012; Gaver and Bowers, 2012).

3.1. Concept-driven interaction research

As stated earlier, Stolterman and Wiberg (2010) argue that concept artifacts are the careful crafting of artifacts that embody desired theoretical ideas of interaction qualities and characteristics within a synthesized composition. They discuss examples of concepts to help illustrate their ideas. One example is the Dynabook by Alan Kay and researchers at the Xerox Palo Alto Research Center. The Dynabook is a concept design that Stolterman and Wiberg (2010, p. 106) claim inspired the design of the contemporary laptop computer. In creating the design concept the researchers had to describe new forms of interaction, interfaces, physical forms, software and technology. Another example of a concept artifact that the authors discuss is Active Badges (Want *et al*., 1992) that conceptualized the notion of interpersonal awareness systems and similar to the Dynabook spawned many instances and variations of the concept.

A key claim of concept-driven interaction design research is the need to theorize through the creation of interaction design artifacts outside of relying on 'user studies' or more traditional modes of empirical evaluation. The core point is that a conceptual construct frames the creation of concept artifacts, which themselves are explorations of new forms that do not yet exist. Through this process design can concretely create new forms through subjective reasoning: 'The observable world is not necessarily "there," it is "becoming" as a result of design efforts' (Stolterman and Wiberg, 2010, p. 99). We draw on and extend this reasoning in the approach we adopt described in this article.

The basic principles of concept-driven interaction design research are as follows (Stolterman and Wiberg, 2010, p. 99):

(i) 'Concept design research means to design and create a concept and an artifact that manifests desired theoretical ideas as a compositional whole'.
(ii) 'The final artifact has the potential power to function as an argument for the quality of the proposed concept and the intended theoretical argument'.
(iii) 'The quality of the artifact as a reflection of the concept and as an argument is a consequence of the careful crafting of the underlying theoretical ideas, the concept and the artifact'.
(iv) 'The careful crafting of the artifact is a process of refining and including essential characteristics of the concept while excluding features and functions that do not add to the understanding and evaluation of the concept and the theoretical argument'.

From these principles, the authors make clear that the design of artifacts is central to the theorizing based on the embodiment of concepts that together advance theoretical arguments. The 'compositional whole' of the theoretical idea is found in the manifestation of the concept in the artifact. The concept is supported by but not wholly expressed in words or descriptions. Thus, concept-driven interaction design research is a matter of simultaneous 'theoretical grounding' and 'artifact crafting' (Stolterman and Wiberg, 2010, p. 111). The requirement to carefully craft artifacts is shared with traditional design and design research artifacts. However, the latter are typically in the service of a use situation and subject to empirical validation whereas the design of concept-driven artifacts is in the sole service of advancing an idea and measured by its theoretical contribution. As a result, as Stolterman and Wiberg state 'whether such theoretical advancements lead to improvements of a situation is of lesser interest, or maybe even of no interest at all' (idem, p. 101). The value of concept-driven interaction design research is the mobilization of designerly competences to research challenges not design problems.

The making of design artifacts whether with emphasis on theory or use is a series of divergent and convergent paths that make it difficult for practices to be reductive or instrumental. Given this, we read the last principle of concept artifacts (Stolterman and Wiberg, 2010, p. 111) that expresses the crafting of the essential characteristics of the concept more generously to mean an emphasis on the theoretical qualities filtering out the inevitable other concerns and effects of the design artifact and its making.

3.2. Developing the conceptual construct of unselfconscious interaction

Stolterman and Wiberg (2010, p. 112) articulate the need to eventually combine concept artifacts into broader theoretical

notions they refer to as conceptual constructs. They do not give an example of a conceptual construct and this in part motivated our inquiry. However, Stolterman and Wiberg do explain that conceptual constructs combine individual theoretical concepts and artifacts that can either be discovered anew through the concept-driven approach or based on earlier findings of other concept artifacts.

In our use and interpretation of concept artifacts in the role of constructs, we are not concerned with the simultaneity of 'theoretical grounding' and 'artifact crafting' at the time of making. In fact, a theoretical claim can be made after the fact in that a well-crafted artifact can precede a theoretical claim and vice versa. In part, this is because the exactitudes of the relationships between making and theorizing will likely be unknown to those making the argument for a construct. More importantly, these details are irrelevant if concepts and artifacts can be tightly read together as a well-reasoned argument at the time of arguing for a construct. What follows from this is that artifacts may initially be crafted with only a seed of a theoretical idea in mind or none at all and that subsequently or iteratively, the concept emerges more clearly and is further refined in the form of the artifact or series of artifacts. Conversely, a designer may have a clear theoretical idea that is to be designed and embodied in an artifact.

We set about developing our construct by analyzing three different concept artifacts that together advance the theoretical idea of unselfconscious interaction. The claim behind this construct is that it is a new form of interaction for lived-with interaction design artifacts that enables a goodness of fit that to date has been rare for computational artifacts. The validity of the construct is in our ability to demonstrate its potential for theoretical insights. This approach is jointly informed by theoretical and designerly knowledge and competences.

While Stolterman and Wiberg only lightly touch on the idea of a construct at the end of their article, we extend their ideas to our definition of a conceptual construct. The following are our characteristics of a conceptual construct. A conceptual construct:

(i) relies on a synthesized analysis of a collection of concept artifacts or equal manifestations of design artifacts and theories;
(ii) is a non-empirical approach to discovering or constructing new intermediate-level knowledge;
(iii) is an intermediate level knowledge understanding of phenomena regardless of the phenomenon's relevance to design, design practice, interaction or any other known domain.

Our strategy to develop the construct of unselfconscious interaction followed four logical steps. First, we chose the three different concept artifacts: the Discovery-Driven Prototypes (Lim *et al*., 2013), the Indoor Weather Stations (Gaver *et al*., 2013) and our own table-non-table. Our selection was based on a review of literature in the field of interaction design and HCI in the past years, with an eye toward highly resolved prototypes deployed in everyday settings that resonated with the concept of unselfconscious culture as described by Alexander. Once our choice was made, we did a thorough analysis of the artifacts to reveal their design qualities and their interaction qualities (see Section 5 for a summary of each artifact). The qualities were extracted from the way their authors presented them in publications, as well as our own reading of the objects, grounded in the tradition of design critique. The qualities of each artifact were then combined into a larger affinity diagram that illustrated the commonalities and differences between the three artifacts. Through multiple iterations and refinements, our understanding of the clusters in the affinity diagram led us to the higher-level model of the concept of unselfconscious interaction. In Section 6, we present the result in our description of the construct.

3.3. Related alternatives to concept-driven interaction

We chose concept-driven interaction research among related alternatives, namely strong concepts (Höök and Löwgren, 2012) and annotated portfolios (Bowers, 2012; Gaver and Bowers, 2012). Strong concepts (Höök and Löwgren, 2012) can be seen as a concrete elaboration on Stolterman and Wiberg's (2010) concept artifacts. Annotated portfolios (Bowers, 2012; Gaver and Bowers, 2012) are a collection of artifacts with specific and linked commentary explaining related comments, ideas, and critiques. Collectively, these approaches to theoretical analyses in interaction design research are part of a broader set of analytical strategies for design from pattern languages (Erickson, 2000), design criticism (Bardzell, 2009), critical approaches to design (Dunne, 2008; Sengers *et al*., 2005) to longstanding efforts to develop models and guidelines (e.g. Carroll, 2003). More broadly, our approach is also related to research through design since both are concerned with the design and analysis of design artifacts with the goal of generating new interaction design knowledge (Frayling, 1993; Zimmerman *et al*., 2007).

Concept-driven interaction research, strong concepts and annotated portfolios are arguably the most 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 aim to articulate a type of design knowledge that lies between theories and design instances. Höök and Löwgren (2012) explicitly characterize this as intermediate-level of knowledge. Stolterman and Wiberg (2010, p. 112) see their work as addressing a gap in design theory between practical guidelines and checklists and grander theories imported from other disciplines, namely the social and behavioral sciences. Bowers (2012) defines annotated portfolios as design knowledge with limited rationality that relates strongly to the notion of an intermediate-level

knowledge in design. As such, intermediate level knowledge makes no claims to universality (Gaver, 2012).

A second distinction among these approaches is that designed artifacts and the crafting of these artifacts are the central concern and the crucial point of departure for the inquiry. Similar to research through design, concept-driven interaction research assumes that design artifacts embody the many choices made by designers and materialize implicit theories whether they be philosophical, functional, social or esthetic (Gaver, 2012). With strong concepts, the authors concentrate on the artifact's 'interactive behavior' (Höök and Löwgren, 2012, p. 23); and with concept-driven interaction design research, the authors look for 'an ordered and structured way [that] tells us something about the generic qualities and characteristics of interaction in a way that explains the range of instances of interactions' (Stolterman and Wiberg, 2010, p. 100). Annotated portfolios inextricably link annotations to design artifacts (Bowers, 2012; Gaver and Bowers, 2012).

Despite these commonalities, we chose concept-driven interaction since it suggested the furthest degree of abstraction that nonetheless still adheres to the notion of intermediate-level knowledge. While strong concepts directly relate to concept-driven interaction, Höök and Löwgren focus too narrowly for our purposes on use situations and interface elements (Höök and Löwgren, 2012, pp. 23:5–23:6). Similarly, annotated portfolios see the link between annotations and the artifacts as direct. To understand the entirety of what an annotated portfolio is communicating, it is necessary to see the linkages between artifacts and their annotations and understand how they mutually inform and illustrate each other (Gaver and Bowers, 2012). This indexical link between artifact and annotation is typically presented graphically and benefits from knowledge of the process of designing the artifacts (not to mention designing the portfolio itself). Concept-driven interaction and the idea of conceptual constructs are one step removed from the artifacts in that constructs utilize artifacts already synthesized with concepts or some level of theoretical knowledge. It is this knowledge from which another level of interpretation or formalization occurs.

Our selection notwithstanding, we would argue that either strong concepts or annotated portfolios could have been utilized in a similar type of theorizing as our own. We speculate that the results would likely be different however not significantly or with some degree of overlap.

4. CONCEPT ARTIFACTS

In this section, we describe three concept artifacts that informed our construct of unselfconscious interaction: Discovery-Driven Prototypes (Lim *et al*., 2013), Indoor Weather Stations (Gaver *et al*., 2013) and table-non-table.

Each of the three concept artifacts exemplifies a theoretical concept: discovery and openness for the Discovery-Driven Prototypes, ludic design for the Indoor Weather Stations and everyday design for the table-non-table. As previously discussed, the relationship between concept and artifact is non-hierarchical and not reductive, and so it is not a concern for us how one informed the other. More importantly, the concept artifacts can be read together, as acknowledged by the designers themselves who explicitly identify the concepts in relation to the artifacts discussed below. Additionally, constructs are retrospective reasoning on concept artifacts and so it is not expected or relevant whether designers of the concept artifacts were aware of or expected to be aware of unselfconscious interaction, since the role of a construct is to uncover new ideas and formulations not yet articulated. A construct is of course only one form of analysis of a concept artifact.

4.1. Discovery-Driven Prototypes

Lim *et al*. (2013) designed a set of three Discovery-Driven Prototypes for a home environment (see Fig. 1).

Aeng-aeng-yee is a timer that plays music when it senses light. It is a white cube with rounded edges with an on/off button, a dial to set the timer and a light sensor indicator on the side. The prototype is described as being bulky and thus different than typical timers. The interaction is simple: people set the time for how long music should play when the light sensor senses light. Once they are satisfied with the timing they can turn the timer on.

Deol-deol-yee are two artifacts that vibrate and signal with a blinking LED light. The two objects communicate wirelessly with each other. The prototypes are shaped like smooth rocks and colored in a polished dark red or blue. Each artifact has only one button. When pressed, a wireless signal is sent to the accompanying artifact to vibrate and blink its LED light. The ostensible goal, what we later refer to as a 'weak' goal, is to encourage communication between family members and the generic shape is intended to allow people to use Deol-deol-yee in different ways (Lim *et al*., 2013, p. 77).

Tong is a sound recorder in the form of a small neck-less bottle that is shaped to differentiate it from traditional sound recorders. The bottles are white with a colored stripe, a cork cap and a record button at the bottom of the bottle. People record a sound for up to 20 seconds by pushing on the record button and speaking into the bottle. They can listen to the recording sound by lifting the cork cap from the bottle.

The design of the Discovery-Driven Prototypes (Lim *et al*., 2013) was informed by a study of daily routines and aimed at discovering functionalities of prototypes that would foster creative use. The prototypes were each designed to look different than known objects in the hopes of opening up new possibilities of use. The design aim is to create an open-endedness and incompleteness for users that allows for unpredictable explorations of unknown use scenarios and possible physical and conceptual alterations that would extend the ideas behind the prototypes.

Figure 1. The Discovery-Driven Prototypes (Lim *et al*., 2013) consist of three artifacts: (from L to R): Aeng-aeng-yee is a music timer; Deol-deol-yee is communication device and Tong is a sound recorder.

The Discovery-Driven Prototypes conceptualize discovery and creativity. These concepts are presented as an approach to learn meaningful interactions of users that can inform the design of interactive artifacts. Inspired by cultural probes and the value of uncertainty (Gaver *et al*., 1999), Lim and her colleagues' approach (2013) is based on the idea that designers do not assume to know what people will value, rather they support the discovery of these values through user-driven creativity. The goal of the discovery approach is to allow users to explore and discover what they need and desire themselves, through their interactions with a prototype *in situ*. The primary goal of this approach is the uncovering of 'human-centered application ideas or usage ideas' (Lim *et al*., 2013, p. 75). Since discovery and creativity are at the center of the relationship between the users and the artifacts, Lim *et al*. (2013) argue that designers should not establish or prompt a predetermined 'right' way of using the artifacts.

In summary, the Discovery-Driven Prototypes pursue an open-ended, incomplete and unpredictable design to foster discovery of uses through combination with other objects and creative discoveries. The functionality of each prototype is purposely very simple. The artifacts bear the concepts of discovery and creativity of users.

4.2. Indoor Weather Stations

Gaver *et al*. (2013) designed the Indoor Weather Stations, a set of three devices that represent domestic microclimates. The set consists of the following artifacts: a Temperature Tape, a Light Collector and a Wind Tunnel (see Fig. 2). The weather stations are intended to be placed around the house to allow for exploration of simple climatic events: temperature gradients, light over time and wind currents that 'highlight potentially overlooked aspects of the home environment by displaying the outputs of sensor readings taken by the device' (Gaver *et al*., 2013, p. 3453).

Figure 2. The Indoor Weather Stations (Gaver *et al*., 2013) consisting of (L to R) the Temperature Tape, the Light Collector and the Wind Tunnel. ©Interaction Research Studio, Goldsmiths.

The Temperature Tape consists of two 2.5-m long fabric ribbons that can be extended from the spool to span an area of the home and visualize or uncover temperature gradients across the span. Each attachment contains a temperature sensor, which are connected to the spool with wires that run along the ribbons. A needle on the side of the spool moves towards the side that is warmer based on the readings from the temperature sensors. Also, on each ribbon, the stripes of screen printed thermo chromatic ink change color depending on the temperature, shifting from yellow (15°C) to red (25°C).

The Light Collector is a cylindrical container topped with a funnel lined with copper leaf. It presents a history of how the color of light changes over the course of the day. A light sensor at the bottom of the funnel collects the data every 5 min, which is then represented on a small screen on the cylindrical base as a one pixel thick line of the color sensed. The screen displays the colors of the past 2 h.

The Wind Tunnel consists of a small forest of paper film trees enclosed in a clear plastic casing. At one end, a vertical pipe holds a wind sensor, and a small fan recreates the wind sensed and makes this visible by blowing on the paper film trees.

Conceptually, the Indoor Weather Stations embody the concept of ludic design. Ludic design presents an alternative model for computing and a way to move beyond usability (Gaver, 2009). Ludic design is an approach that sees people as playful creatures who are characterized by 'our curiosity, our love of diversion, our explorations, inventions and wonder' (idem, p. 165). Gaver argues that playfulness is not about frivolity and mindlessness, it is instead a valuable and rich way to learn about the world and to engage with it. Ambiguity as a resource for design and supporting multiple interpretations (Gaver *et al*., 2003; Sengers and Gaver, 2006) are strategies that support a playful approach by allowing multiple perspectives to form depending on who is interacting and in what context. In ludic design, surprise, improvization and exploration are valued as important elements to engage with complex and serious issues (Gaver *et al*., 2013).

In summary, the Indoor Weather Stations aimed to playfully explore environmental matters in contrast with utilitarian or persuasive approaches to sustainability. They carry or embody the concepts of ludic design.

4.3. Table-non-table

Our third concept artifact is the result of our own approach to design for everyday competences. In previous studies, we looked at practices of everyday design and their composition of material, competences and meaning (Wakkary *et al*., 2013). Everyday design relies on the resourcefulness of home dwellers, the ability to creatively repurpose common artifacts in the home and an ongoing process of adaptation. The table-non-table is one of the artifacts that we designed based on those studies. It is a slow and random moving stack of paper (see Fig. 3) supported by a motorized aluminum chassis on wheels. The paper is common stock that is similar to photocopy paper. Each sheet 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. There are close to 1000 stacked sheets per table-non-table. The chassis lifts the stack about a half-inch from the floor. The wheels are small and set toward the center of the chassis hidden from view giving the appearance that the stack is floating. The chassis and motors are strong enough to support stacking heavy objects on it and even a person sitting or standing on it. The paper sheets can easily be removed, drawn on, folded, cut or manipulated like any paper. Of course, new sheets of paper can also be added. The table-non-table is powered through an electrical cord plugged into a wall socket. The main functionality, so to speak, is movement. The movement is random yet it stays within an area of less than a meter square. The movement is nearly imperceptible, however, over a period of time of living with the artifact, it becomes noticeable.

Figure 3. The table-non-table, a stack of close to 1000 sheets of paper on a moving aluminum chassis.

The table-non-table, informed by the notion of everyday design, manifests an approach that sees interactive artifacts as resources for creative use and reuse. The concept of everyday design emerged in studies by Wakkary and colleagues of various everyday practices such as family life (Wakkary and Maestri, 2007), repair (Maestri and Wakkary, 2011), sustainability (Wakkary and Tanenbaum, 2009; Wakkary *et al*., 2013) and hobbyists (Desjardins and Wakkary, 2013). In essence, this research argues that everyone is a designer. The implications of this claim for professional interaction design and designers are directly discussed in (Wakkary and Tanenbaum, 2009), and especially in (Wakkary *et al*., 2013) where the term 'hybrid designer' is explored. Nevertheless, design in everyday design is comprised of a multiplicity of practices that within their respective and different abilities manipulate their designed worlds to improve fit and quality through ongoing transformations and adaptations. The implications of this shift include the design of technological artifacts as resources, the simplification or minimization of interaction to fit the competences, materials and motivations and meanings of the respective practices such as home life; and the notion that interaction design outcomes are assessed for their interpretive potential as much as their promised utility.

In summary, the table-non-table aimed to explore the relations between everyday competences and people for cumulative interactions over time. The table-non-table embodies the concept of everyday design.

5. THE CONSTRUCT OF UNSELFCONSCIOUS INTERACTION

In this section, we discuss how the analyzed concept artifacts form our conceptual construct.

5.1. Description of the construct

Unselfconscious interaction as a construct is composed of a motivation and two supporting design qualities (see Fig. 4). The motivation is what we describe as goodness of fit. Based on Alexander (1964), this is the degree of equilibrium between things, people and contexts. As we would expect of a motivation, goodness of fit is what explicitly or unknowingly animates and motivates the interactions with and among things. Specific to the construct is the theoretical goal of articulating one path in which interaction design artifacts can better achieve goodness of fit. Supporting design qualities of the construct include open-ended and lived-with. These design qualities are desired theoretical attributes, which are manifested in the artifacts and are essential to the construct.

The relationships between the motivation, goodness of fit and the supporting design qualities of open-ended and lived-with are not static but dynamic. This is expressed by what we refer to as tensions among supporting design qualities and the motivation of the construct (see Fig. 5). The tension between open-ended and goodness of fit can be described as the balance between an artifact being familiar and alien with respect to interaction. The tension between lived-with and goodness of fit can be described as the balance between an artifact being passive and active.

Lastly, in understanding the crafting of an unselfconscious interaction artifact, we present the idea of purposeful purposelessness. This notion defines the need for purposeful design, crafting and esthetics that expresses the potential value of an artifact even when its purpose of use is unclear or undefined. We explain further the idea of purposeful purposelessness in Section 5.4.

5.1.1. The motivation: goodness of fit

As Alexander (1964) makes clear, it is often the inhabitants who dwell in the environment they change that best achieve

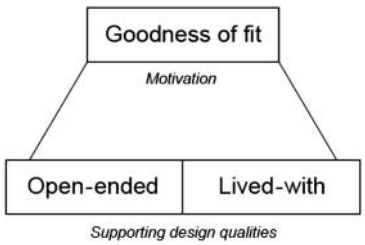

Figure 4. The construct is comprised of a motivation, goodness of fit and supporting design qualities, open-ended and lived-with.

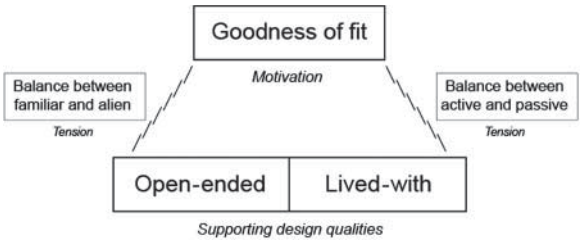

Figure 5. The relationship between supporting design qualities and motivations are described as tensions in which opposing attributes are balanced.

goodness of fit. For example, the arrangements of a living room exemplify the process of goodness of fit in the classical sense. Home dwellers may purposely set out to design the living room by choosing furniture, curtains, rugs, wall colors and so on within the constraints and opportunities of their particular situation. However, it is often over time, after a period of settling in or having been lived with, that the living room takes on the desirable qualities sought after. This is a result of incremental additions, subtractions and adjustments, whether it is changing the angle of furniture or replacing a single item or combining items. Each action often goes unnoticed but the cumulative change will eventually make itself known.

Goodness of fit is not an attribute of any one thing rather it is a composite result of myriad combinations of actions, things and people. Further, it is dynamic and even once known there are always further improvements to be sought. Lastly, to add unequivocally to its elusiveness, at the level of unselfconscious interaction it is subjective. It can be collective but then it is collectively subjective, among family members, for example, and the values may not be felt or noticed by outsiders. Arguably, goodness of fit can collectively emerge on a cultural level as Alexander (1964) argues with indigenous architecture to the point that it is recognizable to an outsider with an adequate level of social and cultural knowledge.

As we discussed, goodness of fit is a subjective process that is difficult to articulate in particular instances. However, we can look for positive signs that goodness of fit is being sought and that unselfconscious interaction is at play with interaction design artifacts. One such sign is the incremental combination of interaction design artifacts with other artifacts as forms of interaction and engagement in what we refer to as an ensemble based on Alexander (1964). These signs were clear in all of our selected concept artifacts. For example, the Light Collector from Indoor Weather Stations was situated in a room with stained glass windows to record the shifting colors of filtered daylight (Gaver *et al*., 2013, p. 3456). For the table-non-table (see Fig. 6), books and other objects are readily placed on top of the artifact. The deol-deol-yee of the Discovery-Driven Prototypes is attached to a TV remote control with a rubber

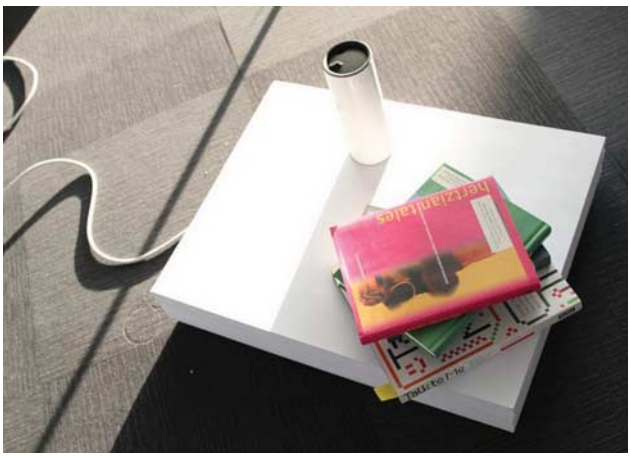

Figure 6. Books and other objects on the table-non-table.

Figure 7. Discovery-Driven Prototype Deol-deol-yee combined with a TV remote and a seatbelt (Lim *et al*., 2013).

band in case it is lost and in another case it is used together with a seatbelt to keep a driver alert (Lim *et al*., 2013) (see Fig. 7).

In the case of unselfconscious interactions, it is often the simplest of functionality that becomes a starting point for interaction that holds the potential to contribute to goodness of fit, e.g. placing objects on top of the table-non-table. This is crucial and without it, unselfconscious interaction might not be possible. As discussed earlier, Alexander (1964) argued something similar for unselfconscious culture, in which there is a directness of making and the need for materials to be ready at hand. For our construct, we can interpret this as the need for interaction design artifacts to be able, ready and

Figure 8. The on/off button and timer dial of the Aeng-aeng-yee (Lim *et al*., 2013).

quickly be put to use as a resource. If this need is not met a ready alternative will be found. Additionally, the directness of making suggests that interactions are by hand and infrequently require the simplest of tools that are also readily available, e.g. the rubber band in Figure 7. Further, we expect that no learning is required to use the artifacts or if so it is quick and informal. This means that interaction design artifacts are mapped to existing competences and skills that are of the simplest and everyday kind.

This design approach of simplicity mapped to everyday competences is evident in the concept artifacts. For example, the simplest is the table-non-table that has no elaborate computational user interface; there is only an electrical cord. One of its owners added to it an electric power bar to give it an easy switch for turning it on and off. A more 'complex' computational interface among the Discovery-Driven Prototypes (Lim *et al*., 2013) can be found in the Aeng-aeng-yee music player that includes an on/off button, a timer dial, and a light sensor indicator (see Fig. 8). The Light Collector from the Indoor Weather Stations (Gaver *et al*., 2013) has a screen yet only two buttons, one to playback the day's data collection on the screen and the other to pause the display while still collecting light data (see Fig. 9).

Simplicity is such an obvious concept that it is often overlooked or considered without precision. Interaction designers argue that they design for simplicity of use or aim for simplicity of an interface. However, this often refers to the elements of the interface or tasks and sub-tasks with the intention that the cumulative addition of many simple elements will remain simple in its entirety. However, this is not typically the case. Our concept artifacts can be seen to achieve a holistic simplicity or simplicity in its entirety. As a result, the artifacts are minimal and seemingly single-purposed despite, as we shall see, their open-endedness and long-term viability.

5.1.2. Supporting design qualities: open-ended and lived-with

Simplicity mapped to everyday competences and skills together form a very important design criterion for

Figure 9. The screen display on the Light Collector (Jarvis *et al*., 2012). ©Interaction Research Studio, Goldsmiths.

Figure 10. The Tong used as a sound amplifier (Lim *et al*., 2013).

unselfconscious interaction. This necessary but not sufficient criterion sets the basis for two supporting qualities of interaction that altogether enable the potential for unselfconscious interaction: open ended and lived-with.

5.1.2.1. Open-ended quality: Open-ended interaction shifts the nature of the interaction design artifacts to be resources for new and unknown interactions or intersections rather than prescribed means to an intended interaction. This speaks again to Alexander's (1964) idea of readily available materials and resources for unselfconscious culture. Like many everyday things that become appropriated for new uses, consider a chair used as a coat rack or a ledge that becomes a shelf, the designed artifacts are utilized for their potential to be manipulated into a new or modified end. The notion of adaptation that is central to unselfconscious culture plays out with unselfconscious interaction through interaction design artifacts that are resources to be adapted or enable adaptation in achieving goodness of fit—this was evident in our analyzed concept artifacts.

Open-endedness is central to the Discovery-Driven Prototypes. The names of each artifact utilize Korean onomatopoeias to encourage discoveries of meaning and use (Lim *et al*., 2013, p. 77). Lim and her colleagues argue for a quality of incompleteness that allows room for adapting the use of the forms and their meaning. The Tong sound recorder was used as a sound amplifier for a family member who is hard of hearing in interactions between a grandparent and grandchild (see Fig. 10). The Indoor Weather Stations explore representation and output in that its displays play between accuracy and ambiguity. Rather than numerical output, the displays utilize color gradients on the Light Collector and fabric tape striped with thermo chromatic ink. The Temperature Tape also allows for simple manipulations with hooks on either end of the tape (see Fig. 11).

Figure 11. The Temperature Tape with fabric tape striped with thermo chromatic ink, a needle dial and hooks on either of the fabric tape (Cameron *et al*., 2014). ©Interaction Research Studio, Goldsmiths.

The table-non-table is simple in its form and purposelessness which invites openness. Its presence, sound and subtle movement constantly puzzle the owners. For example, in one home, owners allowed their pet cat to explore the table-non-table and documented the interaction in numerous photographs (see Fig. 12). The cat became a surrogate for their own curiosity and its manipulation of the table-non-table. By

Figure 12. Owner's cat inspecting, playing with and tearing the table-non-table.

tearing and removing sheets of paper the cat gave the owners 'permission' to remove sheets to fold and cut into large paper snowflakes (see Fig. 13)!

Open-ended quality in unselfconscious interaction does not stand on its own since it requires time for the qualities to emerge. The resourceful opportunities of the artifacts show themselves through a degree of familiarity as well as opportunity that arises from having lived-with the resources, similar to the goatskins of the Bedouin tents or sods of the roofs of the Hebidrean houses (Alexander, 1964). While these are raw materials and we are examining designed interaction artifacts, notions of simplicity, open-endedness and lived-with qualities are common to both. Additionally, the ongoing designing over lifetimes and generations in unselfconscious cultures strongly implies the role designed elements play as resources and sources for adaptation. We explore the temporal and familiarity aspects in the next section on lived-with quality that also reveals how together, open-endedness and time lead to goodness of fit.

5.1.2.2. Lived-with quality: Lived-with quality supports the idea that unselfconscious interaction requires time to emerge and take shape. The idea in terms of design is to consider

Figure 13. We remembered how to make snowflakes' says an owner with a paper snowflake made from the table-non-table.

the experience of living with an interaction design artifact similar to how someone might live with furniture or even simple items like a ceramic bowl or a lamp for years, possibly decades or even a lifetime. Such artifacts become resources with which we co-inhabit and jointly dwell within our environments. As we discussed in Section 2.1, time is an essential condition for goodness of fit and the cumulative progress toward equilibrium and transformative designs in Alexander's (1964) unselfconscious culture. This is equally true of unselfconscious interaction.

Designing for unselfconscious interaction means to focus on the experience of being lived with. A key consideration is how an artifact would co-inhabit our environment, such as how the table-non-table unlike any another piece of furniture is nestled between a couch and a bed just in front of a mirror. The materials and size allow it to fit yet not disappear into the environment (see Fig. 14). With the Indoor Weather Stations, the Light Collector in one home is ensconced on a window ledge in among other artifacts like plants and fruits that benefitted from proximity to daylight (see Fig. 15). In such cases, where there is a balance between novelty and comfort, an artifact can be lived-with such that relationships can be formed and evolve over time and an artifact can become parts of ensembles. Indoor Weather Stations, for example, endured a lengthy participant study and many commented on their attachment to the artifacts despite having little explicit use for them. Most tellingly one participant commented: 'They had become part of the home's background and in a desirable way' (Gaver *et al*., 2013, p. 3458).

Designing for emergence over time is central to the Discovery-Driven Prototypes. With no intended purpose, meaning and interactions were discovered or emerged. Discoveries can be seen as transformations in that the nature of the artifact and its relations to other artifacts, people and the environment change. For example, the movement of the table-non-table is so subtle that it can be very hard to detect even after living with it for some time. When motion is 'discovered', the nature of the table-non-table changes reframing its potential contribution to goodness of fit. A telling example of the transformation in meaning of unselfconscious

Figure 14. Table-non-table nestled in front of the mirror between the couch and the bed.

Figure 15. Light Collector from Indoor Weather Stations ensconced on a window ledge (Gaver *et al*., 2013). ©Interaction Research Studio, Goldsmiths.

interaction is the painted portrait of the Light Collector in the quote (see Fig. 16):

> The stations ultimately did not surprise people, a condition that led to initial disappointment, but for some a more subtle surprise, or at least awareness, built up over time. Tim described this slow creep of surprise when he related how he had made an oil portrait of the [Light Collector]. In painting the [Light Collector], Tim described having to study it, seeing things that might have been unnoticed and to think about it for an extended period. He likened the process as similar to what any painter does, and how the act of painting transforms the object (Gaver *et al*., 2013, p. 3457).

5.2. Tensions

In Section 5.1, we explained how the relationships among supporting qualities and motivation are dynamic. The differences

Figure 16. Light Collector from Indoor Weather Stations next to a painted portrait (Cameron *et al*., 2014). ©Interaction Research Studio, Goldsmiths.

in the range may be fine but it is a balance that can easily snap or break, hence we refer to this relationship as a tension. The tension between the supporting quality of open-ended and the motivation of goodness of fit can be described as the balance between an artifact being familiar and alien with respect to interaction. The artifact needs to embody both aspects yet with the right degree of tension. Familiarity makes the artifact approachable and sensible. Appearing alien creates feelings of otherness and curiosity. If an artifact is too familiar, its interaction qualities and potential are framed and confined by known experiences that limit creativity and exploration. If it is too alien, it remains incomprehensible and lacks meaning. The balance between sensible and otherworldly creates a catalyst for incremental engagements, intersection or interactions that are potentially open-ended and supportive of the motivation for equilibrium and or transformation.

The tension between the supporting quality of lived-with and the motivation of goodness of fit can be described as the balance between an artifact being passive and active. A passive

interaction design artifact paces the interaction over time and becomes part of the environment. An active interaction design artifact creates a presence and solicits attention. Again, too much in either direction works against the supporting quality of lived-with. An artifact that is too passive fades into the background disappearing and one that is too active is very difficult to live with over a period of time.

Negotiating these tensions requires designerly judgment. It is not a matter of quantification but requires the qualitative crafting of artifact and concept to the point of balance. Mediating these tensions and finding the particular 'sweet spot' is the role of the interaction designer, it is at this point that the designer modulates through design and computation the successful or unsuccessful experiences of unselfconscious interaction. However, it is very important to note that the mediating of tensions by the interaction designer is experienced and in varying degrees reasoned upon by unselfconscious designers or 'users'. In this sense, mediation of tensions is a tandem relationship between selfconscious and unselfconscious designerly judgments.

5.3. Intersections

Throughout this paper, we have made references to engagements, interactions and intersections with artifacts and ensembles. To clarify, we use the term engagement to refer to any general consideration of a relationship with an artifact, whether simple reflections to a direct interaction. Interaction is used in the common sense of a knowing manipulation with an artifact. Intersections refer to the unknowing or unnoticed crossing of paths of artifacts and people in which a manipulation may or may not occur. Unlike engagements and interactions, intersections lack awareness or knowing of the relationship between person and artifact. Our construct encompasses engagements, interactions, and intersections.

5.4. Purposeful purposelessness in design

Interaction design acts as a catalyst that motivates ongoing incremental engagements and intersections within unselfconscious interaction. Implicitly, we discussed in the preceding sections, under motivations, supporting design qualities and tensions, how interaction design shapes catalytic interaction through materials, form and computing. For example, the movement of the table-non-table is shaped through computing to find the balance between the artifact being familiar and alien as well as between passive and active. One of the owners of a table-non-table only realized that the artifact moves after a week of living with it. In a variation of Alexander's (1964) idea of misfit, our participant notes that his 'architect eyes were unhappy to see that the thing was always crooked and not parallel to the couch!'. However, rather than repair the misfit in the sense that Alexander's theory would expect, this led to the discovery of the artifact's very subtle movement. As a result, the table-non-table was moved to the center of the living space to replace the coffee table to see what could arise from this newly discovered quality.

This exemplifies a principle in designing for unselfconscious interaction: interaction design artifacts are designed with non-existent or weak use goals while being designed with purpose. Our understanding of use goals is a use situation or known goal of potential users, e.g. composing and sending an email or managing project tasks of a group. Use goals are not only not required in unselfconscious interaction they are not desired. However, an alternative to no use goal is a weakened use goal. For example, often chairs are designed with a weakened use goal. The ostensible goal is to design an artifact to support sitting. Yet some chair designers except in the case of special purpose chairs like office chairs pay more attention to other design goals like materials, fabrication, fashion and expression. Little time is spent studying the requirements of sitting.

Purposeful purposelessness in the design of the concept artifacts we discussed bring to light the qualities of crafting and design that are essential to manifesting the construct. The strategy requires purposeful design with a design goal that should not be confused with a use goal, purposeful crafting of the artifact and a purposeful esthetic. Combined together these forms of purposing create a quality artifact that will be accepted into environments alongside other designed artifacts.

Each of the concept artifacts was purposefully designed. The aim of the Discovery-Driven Prototypes (Lim *et al.*, 2013) is to let users creatively discover a use for each of the prototypes. The Indoor Weather Stations (Gaver *et al.*, 2013) aim through ludic design a playful and reflective engagement with environmental concerns that is an alternative to utilitarian or persuasive approaches to sustainability. Our table-non-table is designed as a design resource for everyday designers in which their competences, know-how of materials and motivations can be creatively engaged. The purposeful crafting of an artifact employs an equally rigorous design process to that of crafting a traditional interaction design artifact despite not knowing the use or particular requirements of a use situation. For example, the Indoor Weather Stations endured an involved design process (Jarvis *et al.*, 2012) that included multiple iterations and variations of form studies realized as 3D printed studies. Design workbooks were generated to document the process and provide formative and ongoing reflections/evaluations of the design decisions and moves. Great attention was given to the assembly and integration of electronics while at the same time; aspects of the devices were made by hand in addition to 3D plastic fabrication (see Fig. 17).

The table-non-table focused its efforts on the possible proportions and material qualities of the artifact. Several types and weights of white paper were explored, as were multiple cardboard mockups to determine the proportions of the stack, dimensions of the paper and height from the floor. We explored

Figure 17. Various design studies, iterations and variations of the design elements of the Indoor Weather Stations (Jarvis *et al*., 2012). ©Interaction Research Studio, Goldsmiths.

different types of movement to refine the pattern, distance and pace to establish the right balance of passiveness and activeness. The chassis was fabricated in aluminum after different materials were considered and after several iterations it was decided that a single square aluminum post with a centered die cut in the paper would be designed to hold the stack in place yet allow for simple removal and placement of the paper (see Fig. 18).

The purposeful esthetics of each artifact is precise and with clear intent. The Discovery-Driven Prototypes utilized esthetics as a counterpoint to the 'unpredictability' of the use and meanings of the prototypes: 'with unpredictability, the 'clarity' requirement becomes esthetically pleasing. In other words, despite its simplicity, the prototype becomes engaging and provocative' (Lim *et al*., 2013, p. 75). Each of the Indoor Weather Stations selected at least one feature that is 'noticeably detailed to indicate the purposefulness of the overall esthetic' (Gaver *et al*., 2013, p. 3454). The designers of the Indoor Weather Stations referenced Dieter Rams' Braun Pocket Radio T-41 as an inspiration and esthetic point of reference. Coincidentally, the table-non-table, references and is inspired by Florence Knoll's sofa and chair set in which upholstered seating rests upon an aluminum frame that gives the appearance of floating above the floor similar to the table-non-table. The esthetic purpose of the table-non-table is to provide a structurally coherent and minimal object that intentionally utilizes materials with little transformation in the studio, e.g. non-anodized aluminum and common paper stock, to create a sense of existing as both a potential resource and a complete product.

The cumulative results of the purposeful design, crafting and esthetics creates an identity and quality such that the value of clarity of use is replaced by the value of richness of potential. This potential is warranted by the investment of design effort. For example, the designers wanted the intentional crafting of the Indoor Weather Stations to be noticed and to make participants aware of the design effort and work done by the studio (Gaver *et al*., 2013, p. 3457). The designers of the Discovery-Driven Prototypes state, they 'carefully controlled the prototypes' physical properties so people could think creatively' (Lim *et al*., 2013, p. 78). The benefit of controlling for identity and quality is that the artifacts stand a better chance of engaging in the dynamic of goodness of fit by being adopted by people even if the reasons for doing so are not clear.

We should be clear that we do not intend to confuse lack of a use goal with lack of functionality. Each artifact is functional yet to what end the functionality serves remains ambiguous. This concept relates to the common, broader idea of appropriation in HCI (see Section 3.2). However, our focus here is on the specific strategy of purposefully designing with weak use goals in mind, which we see in all three of the concept artifacts presented in this article. In parallel to this strategy, Seok *et al*. (2014) have focused on and unpacked the notion of 'non-finito' products in the context of HCI. Borrowing the term non-finito from deliberately unresolved artworks originating

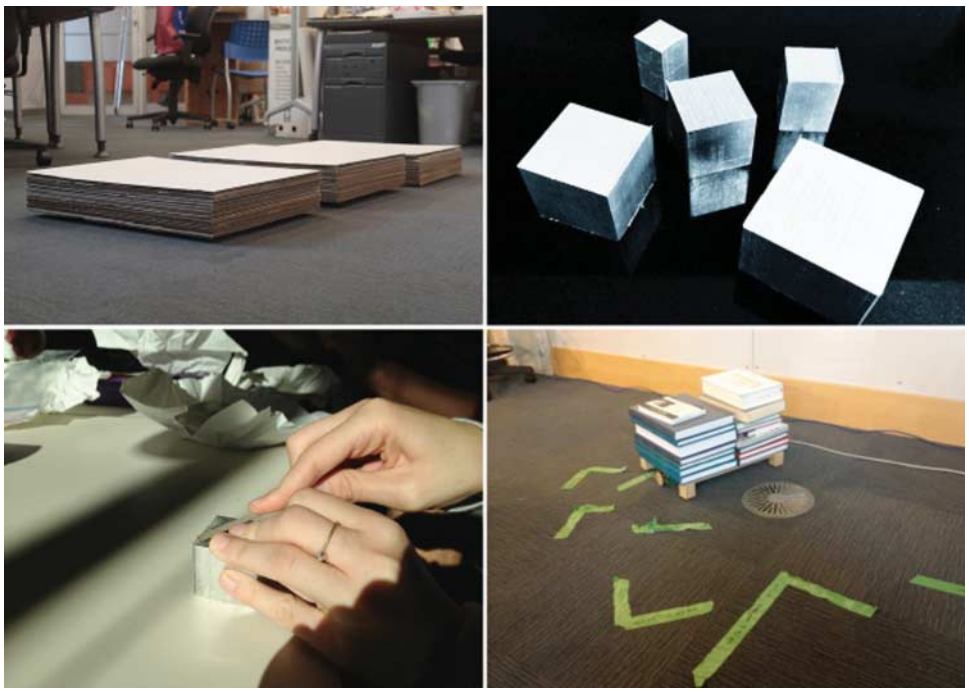

Figure 18. (Clockwise from upper left) cardboard mockups of table-non-table for different proportions; different sized aluminum squares for the chassis; early prototype for movement studies; filing aluminum square for die cut tests.

in the Renaissance, they define non-finito products in HCI as 'intentionally unfinished products, fostering new creations by end-users in their actual instances of usage for their personal user experiences' (Seok *et al*., 2014, p. 659). The authors argue that non-finito products are characterized by the balance of purposelessness with clear functionality.

We also see continuity between the articulation of purposeful purposelessness in design and non-finito products, and the well-known argument presented by Sengers and Gaver (2006) on multiple interpretations, where they define purpose as one's understanding of an object's embodied values and socio-cultural meanings—how it reflects the identity of the person using it. The authors propose strategies to design toward multiple interpretations, including specifying usability but not use. This implies that how the system works and how it can be controlled is clear, but that the higher level purpose of the system is open to subjective meaning and a variety of different uses (idem, p. 102).

The benefit of foregoing or weakening use goals in unselfconscious interaction is that an explicit or constantly reinforced use goal restrains the open-ended and lived-with design qualities. By being precise and defined, use goals minimize alternative uses. By purposely designing without a purpose, designers can aim to reach the middle ground between familiar and alien and between active and passive. Purposeful purposelessness is a tool to balance the tensions that are inherent in the construct of unselfconscious interaction.

6. DISCUSSION

At this stage of the paper, we come full circle to review our unselfconscious interaction construct in light of the five features of unselfconscious culture we highlighted at the outset (see Section 2.1): (i) resources, (ii) adaptation, (iii) ensembles, (iv) time and (v) anonymity. This exercise helps us understand the commonalities between unselfconscious interaction and unselfconscious cultures but more importantly the necessary differences and adaptations required in considering designing for goodness of fit with computation and interaction design in mind. This exercise also reveals future challenges with respect to unselfconscious interaction.

In unselfconscious interaction, resources are the interaction design artifacts that are ready at hand; found within the nearby ensembles of form and context. These computational artifacts have the qualities of resources designed into them (e.g. open-ended and lived-with) rather than being raw resources like the sod and grass in Alexander's unselfconscious cultures. One might consider open source, end-user programming or DIY electronic prototyping as modern day computational equivalents to working with raw materials. However, none of these practices manifest in an unselfconscious manner, in an everyday sense, due to the specialized skills required. In many respects, these practices are complementary to unselfconscious interaction but arise from replicating selfconscious practices of experts in amateur form rather than unselfconscious practices.

Adaptations in unselfconscious interaction are the dynamic of misfits, good fit and design with computation. Similar to Alexander, the misfit of a given aspect of an ensemble is motivation to fix the misfit or adapt it to achieve fit. However, only interaction design artifacts with the qualities of open-endedness—to support manipulation and change—and the lived with qualities—to allow for emergence of equilibrium—will participate within the dynamic of misfits and good fit. In contrast to raw materials, interaction design artifacts, as both designed and computational artifacts, hold an advantage in that they can serve as intentional catalysts. In unselfconscious interaction, there is a role for designers to shape the form and computation of artifacts to not only become enjoined in ensembles but to actively engage in supporting goodness of fit. Like we see in the Discovery Driven Prototypes, the Indoor Weather Stations and the table-non-table, the design of the form and computation purposely mobilized both curious engagements and unconscious intersections by mediating alien or defamiliarizing qualities. In this respect, unselfconscious interaction is active whereas unselfconscious cultures are passive with respect to adaptation.

Ensembles in unselfconscious interaction are virtually the same in unselfconscious cultures. Interaction design artifacts contribute to goodness of fit not individually but within an ecology of forms and context, an ensemble. In order for interaction design artifacts to participate in unselfconscious interactions, it is necessary but not sufficient to become part of an ensemble. Without enjoining an ensemble the artifact is essentially rejected or abandoned with no potential to contribute to goodness of fit.

Time plays a similar role in unselfconscious interaction; it is the crucial condition by which equilibrium of fit occurs. Similar to unselfconscious cultures, without time the ensembles of forms will not create cumulative progress and improvement. However, the active role of interaction design artifacts affects the incremental dynamic of achieving goodness of fit by accelerating the pace of increments or inducing creative leaps between increments in ways unselfconscious cultures were not capable[1]. Whereas active adaptation may accelerate the change within an ensemble, the current limitations of computation and design, limit our understanding of the potential of a generational time scale of unselfconscious cultures in unselfconscious interaction.

Anonymity is an essential feature of unselfconscious interaction as in unselfconscious cultures. However, anonymity is more constrained within unselfconscious interaction. It speaks to the anonymous shaping of interaction design artifacts that is creative in the sense of achieving goodness of fit. As we discussed with adaptation, there is a role for a designer, a selfconscious one that is intentful and reflective, drawing upon abstracted knowledge and specialized skills. While selfconscious, a designer who designs for unselfconscious interaction is not a traditional designer. He or she makes significant space within their making for the realization of the artifact's purpose and engagement through the anonymous creativity and participation in ensembles. The designer embraces what Don Ihde refers to as the designer fallacy (Ihde, 2008) (see Section 2.2). An unselfconscious interaction designer deeply understands the agency of a design is distributed among other artifacts, contexts and anonymous creators. Moreover, the significant difference is that to design for unselfconscious interaction is to design for the gap between designer, anonymous maker and ensembles such that it is bridged through the relations and intersections that the artifact supports and creates.

[1] Alexander believed that in unselfconscious cultures creative knowledge came in the form of traditions that were passed on from generation to generation. This was a weakness that dismantled most unselfconscious cultures since they were unable to keep up with the pace of change in materials, technologies and skills in modern time (Alexander, 1964).

7. CONCLUSION

Our contribution in this article is our definition and description of a new conceptual construct for interaction: unselfconscious interaction. We were motivated by the idea of exploring a construct that allows for computational artifacts to have a role in achieving goodness of fit.

Through the careful selection and analysis of three concept artifacts: the Indoor Weather Stations by Gaver *et al.* (2013), the Discovery-Driven Prototypes by Lim *et al.* (2013) and our own table-non-table and the notions of goodness of fit and unselfconscious culture by Alexander (1964), we developed the construct of unselfconscious interaction. We presented unselfconscious interaction as a form of interaction with computational artifacts that over time, and through ongoing incremental intersections, opens to subjective and subtle improvements in the relationships between artifacts, environments and people. We have argued that the motivation behind our construct, goodness of fit needs to be supported by the two design qualities of open-ended and lived-with. Unselfconscious interaction is then a combination of those qualities, along with the tensions that exist between them, balancing between active and passive as well as between familiar and alien.

We discussed how the role for interaction design is to become part of an ensemble of forms and context and to act as a catalyst that animates ongoing incremental engagements. To achieve this, interaction design artifacts are purposely designed with non-existent or weak use goals. We called this high-level design strategy purposeful purposelessness.

In addition to developing the conceptual construct of unselfconscious interaction, we elaborated on the notion of construct within concept-driven interaction design research (Stolterman and Wiberg, 2010). Moreover, in our view constructs are not bounded by the practical goal of improving artifacts, design practices or use situations, but rather aim at

contributing to our understanding of the relationships between artifacts, people and the world.

In conclusion, our hope is that unselfconscious interaction offers a useful lens that leads interaction designers to emphasize design qualities that enable goodness of fit in interaction design artifacts rather than a sole focus on improving use situations.

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Chapter 5.

Autobiographical design project: Living in a prototype

In this chapter, I report on an ongoing autobiographical design project of converting a cargo van into a camper van. After 23 months into the project, I published a paper called “Living in a Prototype: A Reconfigured Space” (Desjardins & Wakkary, 2016) at CHI 2016, which I present in this chapter. This paper was co-authored with Ron Wakkary and received an honorable mention award at CHI 2016. The original goal of the paper was to provide an in-depth look at how people design and make in a space they live in—in this case: in a camper van. The motivation of the paper was to offer a critical perspective that could challenge researchers interested in the IoT to rethink the ways in which they design interactive technologies. In line with the trajectory from ubiquitous computing, pervasive computing, and smart homes, the Internet of Things proposes to transform everyday settings by adding computation to everyday objects so that they can be identified, communicate, sense and act on the physical world to support people’s daily activities. While the IoT suggests reconfiguring everyday settings, not much research has been conducted on how people will, in return, reconfigure an IoT setting around and for themselves. By offering a detailed description of how people engage in the design and making of a space like a camper van, this chapter describes the experience of designing and making in a lived-in space.

In this dissertation, chapter 5 provides the closest illustration of the concept of design-in-living. However, I note that at the time of writing the paper, I focused on the qualities of making and living in such as space and had not articulated the concept of design-in-living yet. In this dissertation, this article addresses the question: *What is the first-person experience of designing and making a lived-in space?*

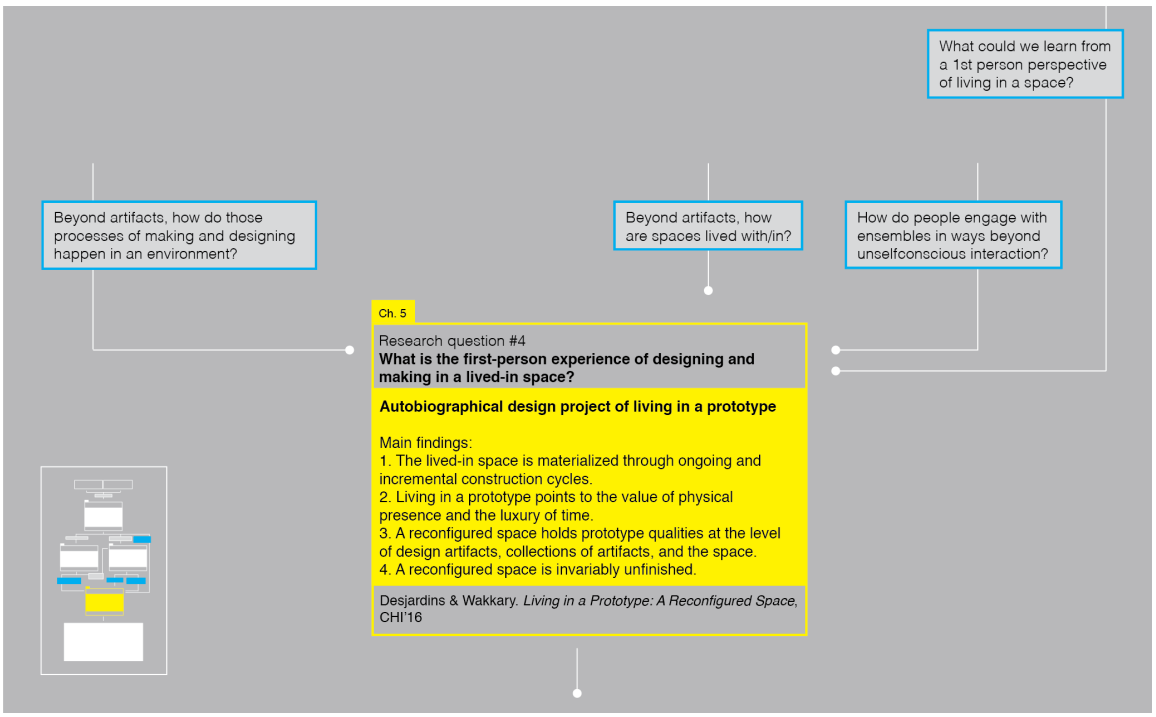

Figure 6. Chapter 5 research questions and findings (excerpt from Figure 1)

In this paper I use a single case of autobiographical design (the conversion of a cargo van into a camper van I conducted with my partner Léandre Bérubé LeBrun) to describe the experience of designing and making in this reconfigured space (see Figure 6). The article describes this experience through a collection of six qualities of 'living in a prototype'. The term 'prototype' is used in this article to underscore how a reconfigured space is an ongoing project and how each act of design can be seen as a sketch or a prototype for what future builds could or will be.

The six qualities of living in a prototype are:

1. Reciprocal Shaping
2. Intimate Knowledge and Intimate Frustration
3. Renewed Novelty
4. Ownership and Change
5. Care and Trust
6. Growing Uniqueness

Those qualities describe the experience of designing, making, and living in a reconfigured space. More importantly, they start to describe the space itself, as the outcome of the processes of designing and making. A central quality of the space is that it is constructed through cycles of changes, providing ongoing and incremental improvements to the space. This quality echoes the findings from design-in-use, as well as chapters 3 and 4, however, it brings the focus to how a *space* rather than *artifacts* are part of those ongoing changes.

In addition, the three key ideas addressed in the discussion of this paper allow me to more specifically define the concept of design-in-living.

The first point discusses the value of physical presence in the prototype as well as the long temporal scale (or the luxury of time present in this project). While time had been discussed previously as a criterion for design-in-use (Wakkary & Maestri, 2007) and for unselfconscious interaction (chapter 4), in this article I refine this description of time by adding the qualifier of *cycles*. In this project, I saw how maker/users alternated between cycles of making and cycles of living. This allowed them to live with the different additions they made to the reconfigured space and to fully live the implications of their design decisions. Design-in-living builds on this observation. In addition, physical presence within the space is a novel point that had not been previously addressed in HCI literature on the reconfiguration of spaces. While I hinted at this quality in chapter 3, it is in the discussion of this paper that this point was firstly uncovered, a point that is also central to the discussion of design-in-living.

The second point in the discussion addresses the idea that a reconfigured space holds prototype qualities and that different elements of that space may have reached different levels of refinement. For example, in the van project, the bench-table-bed unit was well-built, finished and polished whereas the kitchen unit was still a quick appropriation from a large surface store shelving unit, an appropriation that served as a sketch for what a future kitchen cabinet could be. The possibility to sketch and prototype within the van—and to live with those 'manifestation of design ideas' (Lim, Stolterman, & Tenenberg, 2008) at different levels of finish—echoes some findings from chapter 3, where different competences and materials were chosen based on the motivation of the

non-expert designers. I revisit the idea that different levels of finish (6.1.7) alongside different levels of expertise (6.1.5) are consciously chosen for each element of reconfigured spaces in chapter 6.

Thirdly, as a way to critically reflect on current IoT and home automation systems, this project serves as an example to champion unfinished spaces. It highlights ongoing, piecemeal, incremental and long-term builds. A question arises: how will interactive artifacts or pervasive technologies fit in those long-term processes? This observation reiterates once more what was described in everyday design and in unselfconscious interaction: the HCI and interaction design communities need strategies to design interactive artifacts so that they take an active part in the practices of making in our everyday settings.

Lastly, this chapter also holds a methodological contribution: the use of autobiographical design in HCI research. While this method has been used before in HCI (as reported by Neustaedter and Sengers (2012)), it is still widely underutilized. In chapter 2, one of the outcomes from the critical literature review on HCI research on the home was the suggestion to use first-person research methods to investigate personal, intimate, and long-term phenomena. How people engage in acts of design and making in a space they live in is an exemplary case that benefited from autobiographical design methods. While I do not discuss the implications of using this methodology in this paper, I present a reflection on methodology in the discussion of this dissertation, in (6.4).

There are four insights from this article that were useful in articulating design-in-living. Those insights are:

- The lived-in space is materialized through ongoing and incremental construction cycles.
- Living in a prototype points to the value of physical presence and the luxury of time.
- A reconfigured space holds prototype qualities at the level of design artifacts, collections of artifacts, and the space.
- A reconfigured space is invariably unfinished.

While in the previous chapters (2 to 4) the findings from one study generally led to more questions weaving a path between the articles of this cumulative thesis, chapter 5 differs as it mostly helped concretize and synthesize what design-in-living is.

The first insight refers to the outcome of design-in-living: a space that is constantly redefined and reconstructed (6.1.1). Moreover, this quality also points to the cyclical nature of designing and making in a space, where it is possible to go from intense building phases (where living is mostly impossible), to small fixes while living. This idea of cycle is presented in 6.1.5.

The second insight highlights the conditions for design-in-living to happen: the need for time and for physically being in that space. This is articulated in more details in 6.1.3.

The third insight acknowledges the prototype quality of artifacts, ensembles and spaces. This suggests that artifacts, furniture, collections, and the space itself can serve as resources for further design acts. The same artifact or area of the space can be redesigned, fixed, or adapted multiple times to reach a desired degree of fit. I discuss artifacts and surroundings as resources for design actions in 6.1.6.

The last insight underscores the fact that a lived-in space is never finished, that changes (small or large) will always continue to happen. The value of the unfinishedness of a space is presented in 6.1.7.

The fact that I have not presented questions stemming from this article does not imply that there is no future work to be done (because there is, see 7.3), but rather that with this paper I was able to answer enough questions from the previous chapters to confidently articulate design-in-living as an answer to the main research question of this dissertation: How do people design and make a space they live in?

Living In A Prototype: A Reconfigured Space

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ABSTRACT
In this paper, we present a twenty-three months autobiographical design project of converting a Mercedes Sprinter van into a camper van. This project allows us to investigate the complexities and nuances of a case where people engage in a process of making, transforming and adapting a space they live in. This example opens a radically different and productive context for revisiting concepts that are currently at the center of human-computer interaction (HCI) research: ubiquitous computing, home automation, smart homes, and the Internet of Things. We offer six qualities characterizing the evolving relationship between the makers and the lived-in environment: the van. We conclude with a discussion on the two themes of living *in* a reconfigured home and prototype qualities in a reconfigured space, and a critical reflection around the theme of the invariably unfinished home.

Author Keywords
Autobiographical design; Maker; making; lived-with; DIY; everyday design; IoT; Smart home.

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

INTRODUCTION
We present a long-term autobiographical design project of converting a Mercedes Sprinter van into a camper van. Over the past twenty-three months, we have reconfigured the space in a cargo van to allow activities like cooking, eating, sleeping and entertaining during their biking and skiing trips. In this paper, we present this project as a way to examine further and critically reflect on how people imagine, design, make, and repair an environment they live in. The core goal of this paper is to interpret insights from this project in the context of future research in HCI on the design of technologies for the home, particularly smart homes and the Internet of Things (IoT).

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This project relates to previous research investigating how people live with design artifacts (digital or not) in everyday settings and how they creatively appropriate, remake, or modify them through ongoing practices. Ethnography and ethnomethodology works by Tolmie et al. [29], Crabtree et al. [10], Swan et al. [25], and Taylor and Swan [27] show how families organize, communicate, and coordinate their everyday lives through and with the help of a variety of artifacts and media in the home as part of their routines. Specifically, work by Wakkary et al. [32,34] has looked at how those artifact and system transformations are part of ongoing design processes and build on incremental engagements with artifacts and the surroundings. With design-in-use, everyday designers are able to adapt their artifacts and systems to the daily pressures of use and family members' individual needs [34]. Use is a strong motor for changes to occur, and the accessibility to resources and materials in the surroundings makes it possible for those changes to happen dynamically. While, at times, those changes can be tacit and unselfconscious [32], at other times home dwellers are aware of the value of those changes and intentionally plan and test out design variations for a specific need [34]. Our van conversion project is an example where the maker is aware of the design process and this project is a particularly rich example for how making, using, and living over time are inevitably linked.

The van conversion project offers a radically novel and productive context to explore questions regarding ongoing developments along the trajectory of research leading from ubiquitous computing [1] towards smart home research [14] and the IoT in the home [5]. As an extension of visions of ubiquitous computing [6], the IoT promises to reconfigure our everyday environments by sensing the world around us and providing connectivity to and between things, buildings, the city and beyond, our social network, and our own body [5]. Building on and extending ideas that emerged from ubiquitous and pervasive computing, the IoT also imagines how computation will continue to shift away from the desktop to becoming part of and disappear into the physical environment we inhabit, from graspable things to using architectural surfaces as active surfaces for computation [1]. As we describe later, the van conversion project is a unique example for how people can reconfigure a whole environment, its furniture, and its artifacts; *and live in it*. This project allows us to understand how all aspects of a reconfiguration are connected, and provides a strong starting point for reflecting on the current trajectory of the integration of technologies in the home.

For those who are advocates of IoT, there are still challenges for a widespread adoption. For instance, De Roeck et al. state: "in order for the IoT to really take off, end-users need to participate in the creation process on a larger scale. They need to have the power and control over the creation and use of applications for smart environments." [20:170]. As computing becomes more entangled with the things we live with and the places we dwell in, it also has the challenge of becoming highly unique, personal, and multifaceted to fit each of our lives. Proposed solutions include end-user development [28] and a do-it-yourself (DIY) approach [20] to allow users to take control over how, when and why they will integrate IoT 'things' in their lives.

Both end-user development and DIY are approaches that see people as being creators and designers instead of consumers or users [35]. The van conversion project offers a deep look into a DIY approach where people have become creators and makers. With this single case of autobiographical design, we are able to dive into details of how a complete environment is designed and made, and how the makers have lived with this space for almost two years. Although the camper van is not primarily a technological environment, nor an IoT project, it has the benefit of being easily customizable and transformable, and existing accessible tools and materials can seamlessly be used in the van conversion. The design conception and the physical transformations in the van could not have attained the same level of richness, fluidity, and detail compared to an existing technological environment or IoT system. This is mostly due to the nascent state of such systems, which currently do not sufficiently support off the shelf customization, adaptation, and transformation. We turn to the van conversion project as an illustration of a space that already encourages maker/user[1] practices as a way to investigate the complex, personal and evolving relationship that exists between the maker/user and the designed artifact or environment. This project opens a critical and reflective space for examining domestic technologies. In particular it can bring into focus qualities that may be overlooked in a more technocentric view of technology in the home. Our goal in this paper is to expand and provide details for future IoT for the home from both autobiographical researcher and maker/user perspectives.

In this paper we investigate making in an everyday context, particularly how makers live with the things they make over time. In this manner, we not only look at how one object is created or transformed, but also how it relates to other objects in the environment. Specifically, we ask the questions: *What can we learn from the evolving relationship between the maker/user and the designed lived in environment?* and *What critical perspective does the van conversion project offer on the current trajectory of the integration of technology in the home?*

Our contribution to the human-computer interaction (HCI) community is two-fold. Firstly, we offer a description of six qualities of the relationship between the user/maker and the lived-in environment. This has specific implications for future research and design in the area of the IoT and computing environments like smart homes. Our second contribution is presented in our discussion: a reflection on the current trajectories of technologies in the home under three themes: living *in* a reconfigured home, prototype qualities in a reconfigured space, and the invariably unfinished nature of the home.

BACKGROUND

Before we present the van conversion project, we provide an overview of previous HCI related research that has investigated how everyday people and makers reconfigure their own spaces and environments. The ways in which people have engaged in those transformations range from being mundane, tacit, and unremarkable to being at the center of DIY and maker practices.

Everyday reconfigurations of the home

HCI and interaction design research has been interested in understanding people's routines and organization strategies in their most intimate space: the home (e.g. [10,19,25,27,29]). In those studies, researchers often found unique and personal practices where people reconfigure the space around them, including the artifacts within it, to fit their family's needs and activities. An important insight from these studies is that the systems created by families are often only intelligible to themselves and are so well integrated into routines that they often become invisible or unremarkable [29]. The study of everyday design [34] investigates the incremental and ongoing processes of living with design artifacts in the home, and particularly how people may creatively and resourcefully adapt or transform them to better fit their everyday routines and needs. The work on everyday design highlights that systems in the home are often heterogeneous, unique, dynamic, and personalized. This echoes findings by Taylor and Swan [27] who also bring attention to the lived experiences in the home and the material properties of artifacts in households. Collectively, this work emphasizes how design and making are ongoing processes that are part of everyday routines, how the material aspect of those practices are central to their working, and how everyone can be a designer and maker.

The study of mundane and tacit design coincides with the description of unselfconscious cultures described by architect Christopher Alexander [3]. In unselfconscious cultures, design and architecture are not professions, but rather something that is performed by everyone, following the traditions of family and ancestors. In those cultures,

[1] Throughout the paper, we use the term maker/user to refer to the people who simultaneously design and build a new artifact, system, or environment by creatively and resourcefully using materials and tools; and live with the designed artifact, system, or environment over long periods of time.

design is an integral part of everyday life, where small fixes and changes are performed in an ongoing manner as a way to reach a better design (or a goodness of fit between what is designed and the context). In [32], Wakkary et al. revisit characteristics of unselfconscious cultures and present the conceptual construct of unselfconscious interaction, a form of interaction that enables ongoing and incremental engagements with an everyday setting, leading to goodness of fit. A supporting notion to the construct is the quality of *lived-with*: the idea that it takes time for those interactions to emerge and take place, and that it is through co-inhabiting with artifacts that home dwellers can eventually see them as resources for further design action.

The analysis we present in this paper builds on this previous research. While the major design acts in the van conversion project are not tacit, unselfconscious, or mundane (they are rather in the realm of DIY practices, as we describe in the next section), some qualities of ongoing design processes and the long-term relationship between the maker and the environment as described here are central to what we have observed in the van.

Do-it-yourself reconfigurations of the home

Do-it-yourself (DIY) enthusiasts and makers share the common practices of designing, appropriating, and transforming existing products to better fit their own needs, lifestyle, or aesthetic tastes. Makers have been of interest to HCI for the alternative and critique to mass production and consumerism of personal technologies they provide (e.g. [2]). In addition, the study of makers has provoked deep reflections on the ways they expand both the definition of the user [35] and the definition of the designer [33]. In this paper, we refer to maker/users: a term that invites the reader to consider a user to be simultaneously using and making (or remaking) an artifact or a space, hence combining the two actions into a unique identity.

More specifically, studies of maker and DIY cultures push the boundaries of our understanding of the relationship between people and design artifacts and technologies by foregrounding themes such as identity, empowerment, creativity, and resourcefulness. In the past years, the HCI community has been studying maker individuals and communities to gain insight about how to create interactive technologies that better support their design and making practices (e.g. [15,17,21,26,36]) as well as to gain inspiration for designing future personal technologies. While DIY and maker ideologies aspire to inclusion and technology democratization [26], we wish to highlight the distinction between the types of reconfigurations that 'everyone' can do in the everyday (as presented in the section above) and more involved reconfigurations performed by makers or DIY enthusiasts [4,30], as illustrated in our van conversion project.

True to its origins in home improvement [24], DIY has been investigated in the context of smart home and home automation, and more recently as an approach to IoT in the home. In those contexts, DIY is not only about the reconfiguration of artifacts, but also spaces and environments. Dautriche et al. [11] champion the idea of bringing end-user development to smart home systems. In this way, they argue that people will have more control and will be able to create and adjust the system to their own needs. Commercially available systems like Twine [38] and Ninjablocks [39] are DIY kits that allow people to install sensors and actuators around their house and to program rules to activate them. Woo and Lim [37] have studied how people use these DIY kits for home automation in a three-week deployment study. They describe the usage cycle as follows: "*initial installation*, *motivation*, *implementation*, *use-through-routine*, *routinization*, and *removal*" [37:783]. In addition to DIY kits, we see in Casa Jasmina [40], a project by Arduino, an example of a house designed to be open source, connected, and part of the IoT. With this project, the team hopes to see how people can live within a space that encourages the making of artifacts that will become part of the home. These recent examples show that there is interest in incorporating a DIY approach to smart homes and other environments.

Through this brief literature review of HCI research on everyday and DIY reconfigurations of home, we have highlighted how people actively, sometimes tacitly, engage in the adaptation and transformation of their own artifacts and dwellings over time. This research foregrounds the role people have in shaping their environment to better fit their identities and needs. However, as Verbeek [31], a philosopher of technology, has articulated: those artifacts and technologies also have an impact and a role in mediating between people and their actions in the world. In this paper, we are interested in understanding the qualities of this two-way, co-shaping relationship between what is being made and the maker/users.

OUR STUDY

Our goal with this paper is to investigate what it is like to live in a reconfigured space for the maker/user. More specifically, we want to understand what are the qualities of the relationship between the maker/user and the design artifact that is built and lived in.

We want to note here that while this paper is a collaborative effort with multiple authors, Desjardins and Wakkary, the latter author did not participate in the van conversion. Further, Bérubé Lebrun, Desjardins' partner, participated in the van conversion and autobiographical design but is not an author or researcher in this paper. Despite these multiple and different contributions, we decided to use the authorial voice "we" to refer to both authors and participants. We feel justified in this approach since the first author, whose contributions we rely on the most in this paper, is both author and autobiographical design participant. This allows us to adhere to our methodological commitment to autobiographical design research (see Methodology) in which we report in the first-person perspective (in our case

in the plural form), and acknowledges the fluidity of insights that occur during the experience of the autobiographical design by participants and on further reflection by participants and researchers.

The Van conversion project

This study reports on the first twenty-three months of building and living in the converted van. This is a project the first author Desjardins and her partner Bérubé LeBrun started alongside their day time jobs: Desjardins is an interaction design researcher trained in industrial design and Bérubé Lebrun is a landscape architect with eight years of professional experience and woodworking skills. The maker/users in this case have had extensive design training, which distinguishes them from non-expert designers.

We bought a Sprinter van in October 2013 with the intention of converting it into a camper van for camping and ski trips. The van was new with nothing else in it other than the driver and passenger seats. The walls were not finished; they were the bare metal sheets. The back of the van represented a space of approximately 6 feet wide by 10 feet long by 6 feet tall. The complete van conversion was planned over five years with different stages such as adding a complete kitchen unit, electricity, water, solar panels, etc. Each stage includes breaks that allow us to live in the van and go skiing, mountain biking, or camping; however small changes, additions, and repairs are ongoing, even while traveling with the van. To date, the van has been through four major building stages: insulating the walls, creating a back platform for storage, finishing the walls with cedar tongue-and-groove panels, and building a unit that serves as benches and a table that converts to a bed (see figure 1).

The van conversion autobiographical design project potentially offers deep insights into how a maker/user builds and lives in a delimited environment. We chose this case because we were able to follow each step as it occurred, from buying the van to the most recent build and trip. In addition, the van offers a circumscribed area where all the transformations and living occur. This enclosed, contained environment accentuates characteristics of living in a prototype over time. Although the van conversion project may share similarities to home improvement or home renovation projects, we note that a home is rarely renovated as a whole while people live in it. Finally, the van also allowed us to observe not only aesthetic transformations, but also functional and technical adaptations, such as the storage platform, the installation of a new radio and speakers, and reflections on the electrical system of the van. We reiterate here that we believe the van is a useful case to study as a way to understand the deeply personal and rich practice of maker/users in environments.

Methodology

The conversion of this van was never intended to be research; it was meant to be the process before we were ready to hit the road and travel, camp, ski, and bike. However, this project offers a rare opportunity to take an in-depth look at how people live with (and in) the things they make. It allows us to extract many of the sensibilities and nuances of the intertwined processes of making and living, and to identify qualities of the relationship that exists between the maker and the thing that is made. As the project moved forward, it became clear that it was revealing and illustrating issues and matters of concern that were relevant to HCI research. Hence, we use an autobiographical design approach to present those insights in this paper.

Autobiographical design is defined as "design research drawing on extensive, genuine usage by those creating or building the system" [18:514]. Neustaedter and Sengers [18] argue that successful autobiographical design needs to fulfill a genuine need, the system needs to be lived with over a long period of time, and the designer needs to be the user of the system. All those criteria are fulfilled with the van conversion project. Neustaedter and Sengers' study shows that this type of design research can support fast

Figure 1. Building steps: From top left: the empty van; step 1 – wall insulation; step 2 – back storage platform; step 3 – wall finishing with cedar panels; step 4: benches-table-bed unit in a) table position, b) bed position.

tinkering, requires and tests real systems beyond concepts, can provide detailed and experiential understanding of the system, and reveals the big effects of a system. Interestingly, in our view, the autobiographical designer is by definition a maker/user as well, because he or she embodies both the making aspect as well as the living with aspect of the maker/user.

Autobiographical design offers a lot of potential for studying complex, long-term, personal situations, such as the practices of maker/users in lived environments [12]. In addition, it allows us to gain insights into the making and design aspect of the van conversion, as well as the iterative experience of living with it over time.

Data collection

As Neustaedter and Sengers state, record keeping and data collection are unusual in autobiographical design [18], since projects are often not seen as research projects while they are being made or used. The van project conversion is an exception. We had an extensive process for gathering data about the fabrication of the van, the different steps of making, and about living in the van as well. The data gathered was not aimed at generating a research account, but rather to create documentation about the design process to share with other DIY enthusiasts and the community invested in converting campervans. The data gathered included:

- Tutorials on the Instructables web platform for each important fabrication stage. Tutorials were created for the wall insulation, the construction of a storage platform, the finishing of the walls with cedar panels, the construction of benches and a table that convert into a bed, and the making of cushions for the benches and bed.[2] The tutorials have received between 33,000 and 178,000 views to date.
- The Instructables tutorials required photos of each step in the making, including tools and materials. Those photos also show the finished product at each step.
- Within the Instructables tutorials were also added timelapse videos[3] of each day of building. Photos were taken every 30 seconds and then assembled to make short videos. There are a total of 17 videos to date.
- The Instructables tutorials also hold a record of readers' comments and questions, and the authors' answers (total of 169 comments and replies to date). Questions often led to reflections on design decisions and current living practices in the van.
- Short diary logs that record the dates, places, and important events of the trips made in the van.
- Photos of the van's interior while on trips, focusing on different activities like cooking, eating, playing games, sleeping, and getting ready for outdoor activities.
- Blog post of some of the trips on the site www.go-van.com as travel reports.

Data analysis

The data was organized by creating a thematic analysis that grouped data points following how they characterized and qualified the relationship between the maker/user and the environment of the van. Themes such as intimacy, shaping the maker, dialogue, arguing, taking care of, getting to know you, knowing you too much, dreaming up a future, pride, and timing were developed. In a second analysis iteration, those themes were revisited and some were combined into six qualities of living in a prototype, as presented in the following section.

QUALITIES OF LIVING IN A PROTOTYPE

In this section, we describe qualities, or characteristics, of living in a prototype. These qualities emerged during the process of making/using but concretized in later reflections and analysis of the experience and data. Those qualities describe the intimate relationship that has taken shape between the maker/users and the prototype, or in this case, between Desjardins and Bérubé Lebrun and the van as it is being converted.

Reciprocal shaping

In a long-term personal project, we have observed that not only the project changes over time, but we change as well. We call this quality of the relationship between the maker/users and the environment: *reciprocal shaping*. This is not far from the idea of reflective conversation, first theorized by Schön [22], but goes beyond the observation that materials may have a say in how they are formed and shaped. In the case of the van project, we have noticed that by living in the van as it is constructed, we have changed our expectations for what a van is (or should be), and our predicted or expected needs.

Firstly, we observed how our bodies (dimensions and flexibility) dramatically influenced how things were designed in the van. For example, when shopping for the van and doing a road test, we stopped the van and lay on the floor in different positions to imagine how the bed could be positioned. Later in the process, we also followed our personal bodily dimensions to balance the height and depth of the benches and table on the back platform. Decisions were made based on physical comfort, and it is important to note that in this case comfort was defined accordingly to the only two users who would live in this van.

Simultaneously, as we made decisions about how to build the van, the van itself gave hints and suggestions for how to build the next steps. By slowly designing and adding

[2] http://www.instructables.com/id/How-to-insulate-a-camper-van/
http://www.instructables.com/id/Storage-platform-for-the-back-of-your-Sprinter-van/
http://www.instructables.com/id/Cedar-paneling-for-van-interior/
http://www.instructables.com/id/Bed-Table-and-Benches-for-camper-van-All-in-one/
http://www.instructables.com/id/How-to-sew-cushions-for-a-camper-van/

[3] https://vimeo.com/album/2607513

Figure 2. Evolution of the furniture.

different parts to the environment we were living in, the time allowed for reflections on our needs. We started this project with expectations and ideas of what a converted van was and how it resembled a small recreational vehicle (RV). For example, for both of us, it was clear that the van would eventually need electricity through a secondary electric system to support lighting and a fridge. However, as a convenient solution while waiting for the time and resources to install an electrical system, we developed alternative strategies to support our electric needs such as small portable solar panels, rechargeable batteries, and a camping cooler for the food. After almost two years of living with the 'alternative' system, we realized that electricity (in the form we had envisioned) might not be necessary anymore. The realization that having less than expected might work better for us occurred only because we lived in the van over a long period of time, in a manner we had not imagined. The luxury of having time to deeply know our needs influenced greatly how the rest of the van was built.

Intimate knowledge and intimate frustration

The quality of *intimate knowledge and intimate frustration* refers to the deep personal connection we have with the van. It is a strong relationship and a profound understanding for how things are in the van. For example, when driving, we can hear different sounds like creaking and rattling depending on how things are positioned in the van. However these sounds vary with the temperature and the weather (heat and humidity make wood and metal expand and shrink at different rates). After twenty-three months of building, living, and driving in the van, we have learned where these noises come from, and we now know how to make them stop by rearranging objects in some cases.

However, with intimacy can also come frustration. As much as we know where the sounds come from when driving the van, there are some noises we know cannot be changed, since they are related to how the van was built, particularly how different sections are connected together (such as the storage platform and where it touches the cedar panel walls). Since the project follows a trial and error process, we are able to adjust the next steps in building to reduce noises, however for some noises it is impossible to go back and make adjustments now. In a way, the earlier builds served as prototypes for future builds where we were able to adjust the technique based on previous mistakes, and to share it with others through our Instructables tutorial:

"*Also, **more importantly**, we left at least a 1/4 inch between the benches and the walls. From our previous experience with the platform and the cedar walls, if things are too close together but not attached together, there is so much creaking and rubbing noises when we drive that it can drive us crazy! For the same reason, we also added small felt auto-adhesive pads between the side benches and the back bench, to prevent them from being too close together.*"[4]

The intimate frustration is accentuated when we share our concerns with others who do not have the same intimate knowledge of the van. For example, after the first winter, the side door started to make more creaking noises when driving. These noises were quite specific, but they were happening at the same time as other noises were produced from the platform touching the cedar panel walls. We brought the van back to the van dealership to have the door checked. After two test runs, the mechanics still concluded that the noise was only coming from the wood platform and walls that were added. It was impossible to show or communicate the noise that we had heard.

Intimacy is also about developing routines for camping in the van that are gained over time. For example, knowledge for how to pack the van or knowledge for how to be most efficient when cooking comes from multiple days of living in the van. These are hard things to share with others who have not lived in the van, even if explained in words or with demonstrations. For example, on a weekend trip, one of our friends from out of town shared the van with us. Although we managed to do everything we needed to accomplish, things needed to be verbalized and explained with patience. This revealed the deep intimacy that is shared only between us and the van, something that is often invisible to the eyes of others.

Renewed novelty

The quality of *renewed novelty* describes the sensation of novelty experienced whenever a change is made in the van. This is a similar feeling to getting accustomed to a new piece of furniture in a home or the freshly painted walls of a room in a different color.

[4] http://www.instructables.com/id/Bed-Table-and-Benches-for-camper-van-All-in-one/

Renewed novelty was felt the strongest after making important changes to the van, such as adding the storage platform, finishing the walls, and adding the benches and table (see figure 2). In such cases, we had worked for a very long time on the making of each step before trying the results out. This meant that for two or three weekends in a row, we had been focusing on the making rather than the living in the prototype. Once a step was concluded, a palpable excitement was felt as we planned a weekend trip to try it out. Each first time living in the van again was also a rediscovery of the van itself, or perhaps it was a different version or iteration of the van.

Moreover, we noted that this sensation of renewed novelty was not only experienced with large changes, but also with small subtle additions to the van. The intimate knowledge of the van, as described earlier, is deeply tacit and any small change has an important effect on how we felt about the van. For example, in January 2015, more than one year after starting the conversion, we installed two hooks on the ceiling on the van to allow for hanging a light and its wire. Even though lights had been used and positioned in various places in the van previously, this slight change created a new feeling, one that was more homey, and that expressed how much more settled we were in the van at this point. That small change also transformed how other activities were performed, such as cooking, eating and hanging out.

After each incremental improvement, in addition to the feeling of accomplishment, we also found ourselves dreaming about the next building stages almost as soon as we tried current versions of the van. This imaginative process was catalyzed and supported by the now existing newly added pieces to the van. Instead of envisioning multiple steps ahead, the current version of the van offered a strong anchor to explore possibilities of future design and builds. This finding echoes recent literature on prototypes that argue that the value of the prototypes lies in how it manifests a design idea [16].

Ownership and change

One of the main qualities of our relationship to the van is ownership. Ownership influences how we manage and deal with changes in the van over time. Contrary to most research artifacts deployed in field studies, the van is something that we own. Knowing that the van cannot be returned to the store after its transformation provides a sense of freedom, while also adding more responsibilities. For instance, ownership has an important influence on the choice of the materials, the quality of the materials, the attention to the craftsmanship and detail that is put into making the different changes in the van. As we were making decisions about what material to use to finish the walls, we knew that this was going to be a main feature and would be value-added to the van. Even though tongue-and-groove cedar panels were a good choice for durability, sustainability and style, they were not an easy choice in terms of installation or price. We needed to drill into the metal frame of the van to install wood studs before nailing the cedar panels into place. Regardless, we were thoughtful when planning how we would install the cedar panels, made a small set of test pieces, and then spent over 25 hours installing the panels.

As owners, we also made decisions about how permanently or temporarily certain elements should be installed in the van. A balance between how committed we are about a change, the ease to install and uninstall, and the time and monetary resources has to be found before a change is made in the van. For example, with the cedar paneling, even though the installation was complicated and time consuming, the final result is intended to stay for the life of the van. The motivation to have beautiful and well-made walls was strong enough to encourage us to put the effort and time into crafting them purposefully and to think through all of the fabrication details.

Yet, in some cases, temporary solutions needed to be installed in the van to support important activities. For instance, a simple kitchen unit was necessary since the first trips to be able to prepare meals in the van when it is too cold or rainy outside. Before putting the time and effort into building a kitchen unit fully furnished with stove, fridge and sink, we wanted a temporary solution that would give us time to live in the van before making any decisions. We bought a pre-made simple kitchen unit (with 3 shelves and a counter top) from a large retail store (see figure 3). We simply used c-clamps and attached the unit's posts to the wall and floor with screws. This simple solution works well as a temporary solution, but also as a 'sketch' for what we could build when they create the 'real' kitchen unit.

In terms of ownership and the various versions of elements in the van, the van is not a traditional prototype, one that stands as a representation of something to be made in the future. Some decisions lead to permanent installations, which, in turn, influence how future elements are designed. At the same time, it seems also evident to 'prototype' within the van, to try elements of the future design, as exemplified by the kitchen unit. We return to the question of sketching and prototyping in the discussion section.

Figure 3. Kitchen unit as a temporary solution. (Left) as it was firstly installed, and (right) after the walls were finished.

Care and trust

The qualities of *care and trust* in the relationship between the prototype and the maker/users are strong underlying ties that take time to grow. Care included maintenance of the van, such as changing summer tires to winter tires, changing burned lights, and retouching the paint of the hood for rock chips. In this sense, we see maintenance as part of how we care for the van, similarly to how Gaver attended rapidly to a repair he needed to do on the Video Window [13] (another example of autobiographical design). Care was also about how we treat the van on the road, for example by being very cautious on backcountry roads that can be rocky, steep and snowy. When taking a challenging route, we felt proud when the van was able to transport them without any problems. By constantly driving the van, a sense of trust developed, the trust that the van can 'take it' and that it is possible to explore with it further and faster.

Trust also developed in and about ourselves. We learned how to secure and attach things to the van, how to build things in the most efficient and safe ways. Since this project is the first one both of us have ever done of this type, we needed to build trust in ourselves and with each other that we had the proper skills to transform the van the way we wanted. The first time we drilled in the van walls to install studs to support the cedar panels, it was a stressful moment, but we eventually realized that our technique was working and we could move along with the process. This trust in our own skills also relates back to the quality of *ownership and change* since the care for the van goes hand in hand with the sense of responsibility present with ownership. Care was also demonstrated when we wanted to make important changes to the van but did not believe we had the proper skills, such as cutting metal to add windows to the doors or a fan to the ceiling. In such cases, we hired professional help specialized in camper conversions to do the job. This is an example where the care for the van was strong enough to push us to seek external help.

Trust in our own skills was also assessed when writing the tutorials online. We were aware that we are amateurs and wanted to make sure readers of the tutorials did not take us for professionals. This is illustrated in the disclaimer that we added at the beginning of each tutorial:

Figure 4. Laser cut paper deer head and watercolor of the cabin that inspired the van conversion project.

"*DISCLAIMER: This is the first van conversion we are doing, so this is certainly a process of trial and error! We tried to describe at every step the reasons why we made the material choices we made, so hopefully you can see that we used common sense to design this process. I am an industrial designer and design researcher and my boyfriend is a landscape architect with some knowledge in wood working. We see this project as an experiment and as a wonderful place to try out some ideas about design, materials and fabrication.*"[5]

Growing uniqueness

The quality of *growing uniqueness* highlights how, as the prototype becomes more and more unique to the maker/users, it also becomes less and less suitable for any other users. The ongoing process of living and making in the van, augmented by the quality of *reciprocal shaping*, has led to a nuanced and detailed understanding of how to build for usability and functionality in the van. Similar to what has been observed in everyday design [34], systems used in the van are often only intelligible and make sense fully to its inhabitants. For example, every object has its own place in the storage bins and areas. These positions have been developed over time, based on space, size, but also on how noisy things are when driving, and when and how or when each thing has to be used in the van.

In addition to finely adjusted functionality, we are also designing for our own aesthetic taste, influenced by places we have lived in before, places we have visited, and our own preferences. In the case of the van, we had rented a small blue A-Frame cabin for 2 winters before buying the van. This A-frame was our ideal of what a cabin in the woods should be: cozy, filled with wood and with the smell of cedar. Our experience in that cabin, along with the memories it carries, was the inspiration for many decisions in the van, including the warm materials like cedar panel walls, the plaid curtains and cushions, as well as the wooden table. For example, this is how we presented the cedar panel step in the Instructables tutorial:

"*We love skiing. We love mountain life. We love the feel of rustic cabins. We love the smell of cedar. We wanted a real cabin on wheels. This means there was only one material we wanted to use for the walls and ceiling of the van: CEDAR PANELS!*"[6]

In addition, decorative elements such as a paper laser cut deer head and a watercolor painting of the initial blue A-frame cabin were added to the walls (figure 4). Although these elements can be visually appreciated by others, their real significance is only felt by us.

Six qualities of living in a prototype

The six qualities described above are unique to this autobiographical design project and were rarely pointed at

[5] http://www.instructables.com/id/How-to-insulate-a-camper-van/

[6] http://www.instructables.com/id/Cedar-paneling-for-van-interior/

in previous literature on smart homes or the IoT for the home. For us, this gap indicates an opportunity for future research in HCI, where researchers can use these qualities as lenses to orient their designs. The six qualities as a group highlight themes such as designing for and supporting household uniqueness, enhancing a sense of self and at the same time a sense of responsibility towards the space, and finally acknowledging how small and subtle changes in the space can have important and big impacts on the ways of living in the space. In addition, those six qualities speak to the maker/user *in a space* rather than *with* artifacts in isolation. The findings of this paper make clear the kind of qualities such a relation can have and this contributes to a reframing of discussions in the trajectory of the design of technology in the home, from ubicomp, to smart environments, to IoT, as we will outline below.

DISCUSSION

In this section, we use the six qualities of the relationship between the maker/user and the lived in environment to reflect on how the van project can support and move forward the research fields of IoT and smart home. With this discussion, we answer our first research question: *What can we learn from the evolving relationship between the maker/user and the designed lived in environment?* We present our reflection under the two themes of living *in* a reconfigured space and championing the prototype qualities of a reconfigured space.

While we see the potential and promise of IoT, the simple, slow, and piecemeal design process of the van can also trigger more critical reflections on the current trajectory of the design of technologies for the home. With these reflections, we address our second research question: *What critical perspective does the van conversion project offer on the current trajectory of the integration of technology in the home?* Our critical reflective view is articulated under the theme of the invariably unfinished nature of the home.

Living *in* a reconfigured home

Our understanding of the complex relations and connections existing between things and the environment of the van offers a constructive anchor to reflect on the evolving visions along the trajectory from ubicomp, to smart home design and IoT. We bring specific attention to the physical immersion in the space and the long-term engagement within the space.

Physical immersion

Living in a prototype means to be surrounded by the project, to be physically immersed in the thing that is being designed and built. This particularity transforms the maker/user's perspective by providing constant cues, no matter where he or she is looking, for what could be improved, changed, redesigned, or crafted in a better fashion. This sensation that everything could be changed is supported by the ability to control, conceive and build all aspects of the lived in environment. For instance, in the van we aimed at creating an overarching aesthetic, across the ensemble of different elements added. Similarly, functional relations between things are also central to living and building the prototype, with a particular focus on how things work together and how to prevent interference between things (e.g. the creaking noises in the van).

The current IoT discourse aims to connect things to things but often neglects to account for the broader lived-in environment where those things are situated. The immersive physical experience of living in the van suggests that while interaction designers certainly design the relation between computational things, they should also pay particular attention to their relation to the environment and other systems and non-computational things already in place.

Temporality

In addition, we see implications in terms of temporality and the long-term making, using and living cycles in the van. This particularly long design process (the van conversion project was planned over a five-year designing and building process) diverges importantly from the fast pace user-centered design model that is commonly used and reported on in HCI research. The scale of time allows for a different relationship to the project and for a rich co-shaping between the van and the maker/users to emerge.

As we described in the *reciprocal shaping* quality, the capacity to have time to live with multiple versions of the van before making decisions about next building stages is a luxury that is rare in the practice of design. By living with the prototype, and by reevaluating our needs, we, as the maker/users, are able to know exactly what we want to build, find the proper materials and tools, and then build it in unique self-determined ways. The time spent in the prototype also enables us, the maker/users, to become accustomed to it and to grow and nurture intimacy as versions of the van accumulate and change through incremental adaptations and reflections. It is the temporal aspect of living in a prototype that creates the relationship for the sensibility on what changes to make in the van. It is precisely this constant back and forth between living and making over time that makes the maker/user such an expert in designing a space for him or herself.

The long term and slow incremental process of living and making in the van suggests that time can allow for a deeper relationship to form with the reconfigured space. This is an interesting reflection that proposes that future IoT development should also support a longer temporal scale and allow for maker/users to engage and re-engage over time with the artifacts and systems created.

Prototype qualities in a reconfigured space

Throughout this paper, we have referred to the van as a space, an environment, and as a prototype. Even though the van is not a 'prototype' in the common definition of the term (it is not a version of another van that might exist in the future [8]), we have observed many similarities to

qualities of prototypes and prototyping activities that allow us to rethink future developments in IoT for the home.

Firstly, the van, at every stage of the construction, is a manifestation of a design idea [16]. We saw that through its presence and existence, the van dramatically influences how we made and used it, as illustrated by the quality of *ownership and change*. However, the van is not a single artifact, it is a combination of a space, furniture, and artifacts, and each designed thing in the van can attain different levels of refinement, between roughly sketched ideas to polished details. This combination is rich in contrast and can also serve as a point of friction to spark new ideas, new iterations, and future designs in the designed environment. The van conversion project is a productive example of how prototypes (or sections of prototypes) can serve as filters [16] to focus on specific design elements of a larger project that can be iterated on, manipulated, widely explored and even polished, while still ignoring other unfinished details in the space.

Secondly, even though the van might not be a prototype in the traditional sense of the term, it is interesting to consider how prototyping or sketching activities occurred in the van. Examples include the pre-manufactured kitchen unit as a simple, cheap, and straightforward way to prototype a future kitchen, the quick and dirty enactments for our sleep positions in the van and an improvised solution for curtains while on trips as the start of a series of improvements. Through these examples, we noted how the level of craftsmanship varied depending on how 'sketched' an element was or not. Hence, when we knew an element would be changed eventually, we spent less time, energy, and care in giving it a high level of finish.

Our reflection on prototype qualities in the van conversion project reiterate the identity of maker/users, an identity that embraces roles beyond use and customization, to create a substantial role for an evolving design process within the space. We see an opportunity for future IoT research to support better prototyping activities with connected artifacts and spaces.

The invariably unfinished home

Our critical reflection on the current trajectory of the integration of technology in the home centers on the idea of unfinishedness: the notion that a lived in space (or parts of that space) might never attain a high level of finish. Similar to the common understanding that home improvements are never finished, we saw in the van conversion project a clear illustration of how it is part of the nature of living in a reconfigured space to want to continuously change and incrementally adapt to everyday living practices. This echoes the findings in early studies of home life (e.g. [9,25,27,34]). The notion of unfinishedness allows us to start to paint a new picture for what IoT systems and artifacts might be in the future that challenges current visions. By accepting unfinishedness, this new picture welcomes and creates space for the maker/user who has agency in the creation of the unique space of his or her home.

As we presented in the last section, the van project allows us to think about the reconfiguration of the home to include various ongoing stages of prototyping. It also showed how the prototyped and unfinished sections of the van became part of the everyday and how we, as maker/users, became familiar to the various levels of finish in the van. At the same time, this ability to grow accustomed to the prototype could eclipse unfinished details, missing parts, and even inconvenient parts of the design. Through exposing unfinished elements and by embracing an unfinished aesthetic in the van, we as the maker/users set the scene to allow for a unique and deeper relationship with the space to emerge. Similarly to how unfinished design can invite more creativity on the part of end-users (as suggested in [23]), we can imagine how championing unfinished smart homes and IoT systems can support better maker/user practices. Overall, this suggests a more piecemeal, long-term, and incremental pace for introducing and implementing various elements of the IoT in home dwellers' spaces.

CONCLUSION

By building on the autobiographical design project of converting a van into a camper van, we presented six qualities of the maker/user's relationship with a lived in prototype. This work deepens our understanding of maker/user practices in general, but more importantly sheds light on how maker/users reconfigure their dwellings. We see this work to be in line with broader ongoing initiatives in the HCI community to move beyond designing for usability and efficiency and towards leveraging and enabling the creativity that people might have with regards to their own practices of 'making home'.

Our reflection grounded in the van conversion project led to the two points of living in a reconfigured home and the prototype qualities in a reconfigured space. With this discussion, we see in our work a contrasting vision to smart home design and IoT developments with regards to the ways in which people (or rather maker/users) reconfigure their homes. As a final thought, we meditate on Bell and Dourish's [7] proposition that past visions of ubicomp and smart homes might not have materialized the way the HCI field has collectively imagined, and that future technologies for the home might never look or feel like those visions. Instead, for new visions and inspiration, we might need to turn to today's unfinished, sketched, simple, and rich instances of how people reconfigure their everyday environments around the complexities and nuances of everyday life.

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Chapter 6.

Design-in-living: Articulation and reflections

In this chapter, I present in detail the concept of design-in-living, based on the analysis of the findings from chapters 2 to 5. In brief, design-in-living describes how creative and resourceful everyday designers engage in multiple ways of designing by combining unconscious design acts, ad hoc design, and planned design activities in order to construct their space. Design-in-living occurs while living in a particular space over time. Design acts are motivated by fit within and between artifacts, ensembles, and the space. As a result, the space is constantly and incrementally built, leading to an invariably unfinished space, constituted of artifacts reaching different levels of finish from sketched to highly polished.

Design-in-living is described through seven qualities in 6.1. In 6.2, I discuss how design-in-living relates to the concepts of everyday design, design-in-use and unselfconscious interaction. In addition, in 6.3 I share reflections on HCI and interaction design in relation to the complexities of connectedness in IoT, the layers of change in ubicomp environments, and unfinishedness in interactive artifacts.. I conclude the chapter with methodological reflections (6.4) and limitations of my doctoral work (6.5).

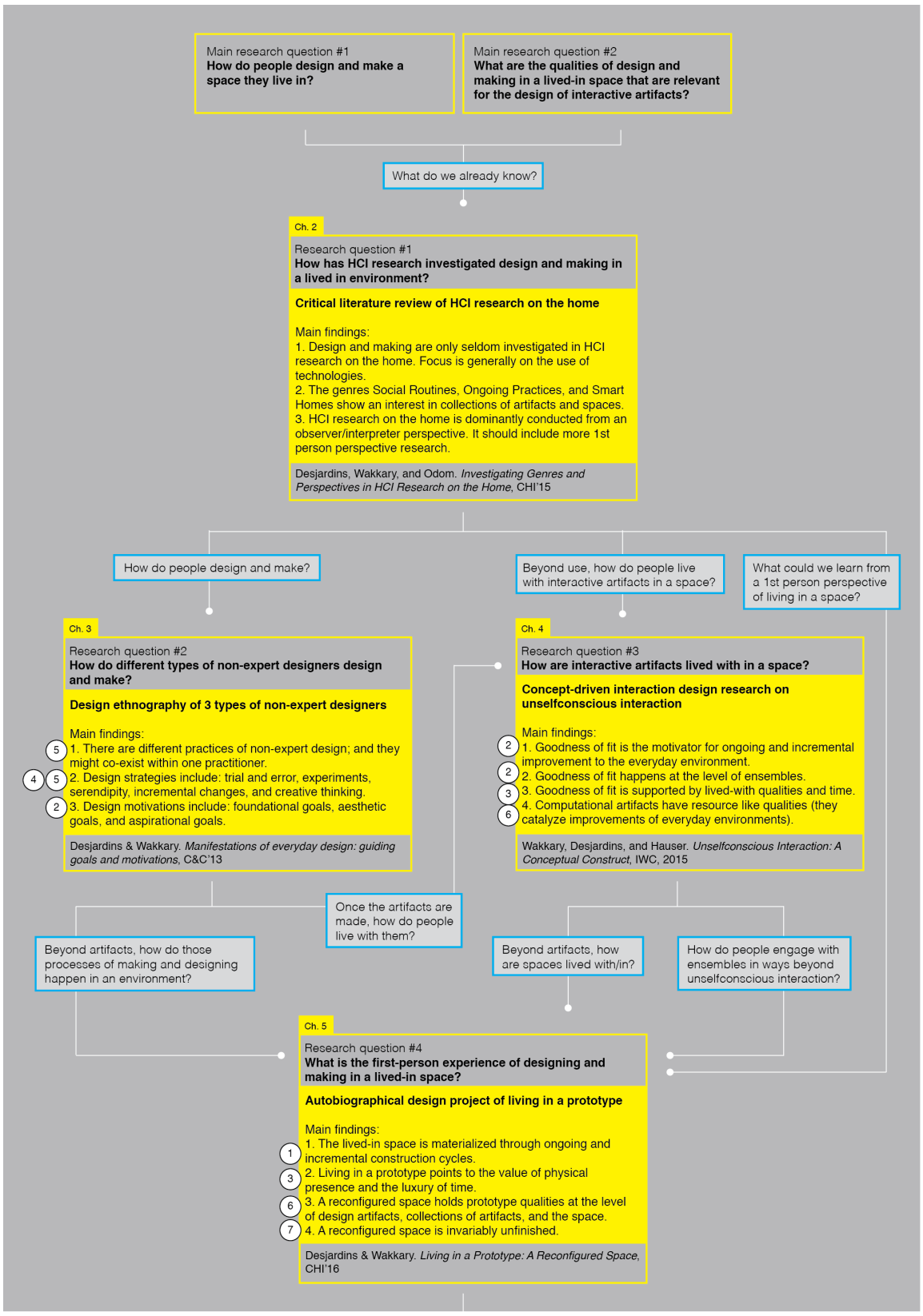
6.1. Design-in-living

The concept of design-in-living was developed through the post-hoc analysis I conducted once I put together the four articles from chapters 2 to 5. This concept is my answer to the first main research question: *How do people design and make a space they live in?* As I foregrounded in the introduction (chapter 1), the concept of design-in-living is an extension of—and a shift from—the concept of design-in-use, originally

presented by Wakkary et al. (Wakkary & Maestri, 2007; Wakkary & Tanenbaum, 2009). Design-in-use described how everyday designers adapt and appropriate common artifacts in their surroundings. A shift from design-in-use to design-in-living allows making the important shift from a focus on discrete elements to a more holistic understanding of the space. An understanding of how people make and design their space will have implications on how we (the HCI community) study and design IoT systems and smart environments (see 6.3).

Before describing design-in-living, I present a short note on the term everyday designer. In chapters 2 to 5, the reader encountered a variety of terms from people and users (chapter 2), to everyday designer, non-expert designers, amateurs, and hobbyists (chapter 3), to people, owners, and participants (chapter 4), and finally to maker/users (chapter 5). While each chapter had its own rhetoric for the choice of terminology, in this chapter I choose to come back to the term everyday designer to discuss design-in-living. This will ensure continuity with design-in-use and will further refine the complexities of the term itself. While the focus of design activities in design-in-use and design-in-living differs in scale, in both cases everyday designers share common motivations and qualities (see 6.1.2 and 6.1.4). In the following sections, by describing design-in-living alongside design-in-use, I will highlight the commonalities and differences between the two, enriching our understanding of design-in-living.

My process for developing the concept of design-in-living is illustrated in Figure 7. In that figure, I represent how each chapter answers a research question. In addition, the findings to those research questions helped articulate the next research questions, leading to the following chapters. The findings from each chapter were helpful in two ways: introducing new research questions, and starting to frame design-in-living. The findings around design-in-living were then organized in terms of outcome, motivation, conditions, qualities of the everyday designer, design strategy, quality of artifacts and space, and level of finish. The specification of those points allowed for a stronger comparison to the concept of design-in-use. Figure 7, contrarily to Figure 1 (in chapter 1), also ties back the elements of design-in-living to where they originate in the dissertation. In the diagram, I use circled numbers to make those connections.


Main research question #1
How do people design and make a space they live in?
Main research question #2
What are the qualities of design and making in a lived-in space that are relevant for the design of interactive artifacts?
What do we already know?
Ch. 2
Research question #1
How has HCI research investigated design and making in a lived in environment?
Critical literature review of HCI research on the home
Main findings:
1. Design and making are only seldom investigated in HCI research on the home. Focus is generally on the use of technologies.
2. The genres Social Routines, Ongoing Practices, and Smart Homes show an interest in collections of artifacts and spaces.
3. HCI research on the home is dominantly conducted from an observer/interpreter perspective. It should include more 1st person perspective research.
Desjardins, Wakkary, and Odom. Investigating Genres and Perspectives in HCI Research on the Home, CHI'15
How do people design and make?
Beyond use, how do people live with interactive artifacts in a space?
What could we learn from a 1st person perspective of living in a space?
Ch. 3
Research question #2
How do different types of non-expert designers design and make?
Design ethnography of 3 types of non-expert designers
Main findings:
5 1. There are different practices of non-expert design; and they might co-exist within one practitioner.
4 5 2. Design strategies include: trial and error, experiments, serendipity, incremental changes, and creative thinking.
2 3. Design motivations include: foundational goals, aesthetic goals, and aspirational goals.
Desjardins & Wakkary. Manifestations of everyday design: guiding goals and motivations, C&C'13
Ch. 4
Research question #3
How are interactive artifacts lived with in a space?
Concept-driven interaction design research on unselfconscious interaction
Main findings:
2 1. Goodness of fit is the motivator for ongoing and incremental improvement to the everyday environment.
2 2. Goodness of fit happens at the level of ensembles.
3 3. Goodness of fit is supported by lived-with qualities and time.
6 4. Computational artifacts have resource like qualities (they catalyze improvements of everyday environments).
Wakkary, Desjardins, and Hauser. Unselfconscious Interaction: A Conceptual Construct, IWC, 2015
Once the artifacts are made, how do people live with them?
Beyond artifacts, how do those processes of making and designing happen in an environment?
Beyond artifacts, how are spaces lived with/in?
How do people engage with ensembles in ways beyond unselfconscious interaction?
Ch. 5
Research question #4
What is the first-person experience of designing and making in a lived-in space?
Autobiographical design project of living in a prototype
Main findings:
1 1. The lived-in space is materialized through ongoing and incremental construction cycles.
3 2. Living in a prototype points to the value of physical presence and the luxury of time.
6 3. A reconfigured space holds prototype qualities at the level of design artifacts, collections of artifacts, and the space.
7 4. A reconfigured space is invariably unfinished.
Desjardins & Wakkary. Living in a Prototype: A Reconfigured Space, CHI'16

Design-in-living

1	**Outcome:**	Design-in-living materializes through the ongoing and incremental making and adaptations of the space and ensembles within that space. Design-in-living may also materialize through artifact and routines.	
2	**Motivation:**	Design acts respond to the catalytic pressures of everyday life. Design acts are motivated by goodness of fit within and between artifacts, ensembles, and the space.	
3	**Conditions:**	Design-in-living occurs while living in a particular space over time.	
4	**Qualities of the person:**	Everyday designers are creative and resourceful.	
5	**Design strategy:**	Everyday designers design through appropriation and adaption of everyday artifacts and the space. Everyday designers engage in multiple ways of designing by combining unconscious design acts, ad hoc design, and planned design activities.	
6	**Qualities of artifacts and space:**	The designed space and design artifacts are understood as resources for further design acts.	
7	**Level of finish:**	The space is invariably unfinished; the level of finish on artifacts ranges from sketched to highly polished.	

Figure 7. Design-in-living: Overview of research questions and findings

In the following sections, I discuss point by point the characteristics of design-in-living and examine how they depart (or not) from design-in-use.

6.1.1. Outcomes: The making of a whole space

I start the articulation of design-in-living by addressing the outcomes of this design practice. Outcomes are a way to describe how the changes provoked by design acts materialize and where they might be situated. In design-in-living, outcomes include adaptations of the whole environment as well as changes in routines.

In design-in-use the emphasis is on the ongoing and incremental adaptation and appropriation of artifacts as ad hoc fixes, and, sometimes, on the creation of new routines around those artifacts. In design-in-living, instead of focusing on adaptations of unique or discrete elements, everyday designers are concerned with transforming whole environments. The main outcomes of design-in-living are the ongoing and incremental changes in a space. The example of the van conversion project adequately illustrates how, through multiple incremental stages of design and making, the everyday designers built and fixed the space they lived in. The space is seen as a unit; however it is constituted of a variety of interconnected elements: the volume of the space, the finish on the walls and ceiling, the furniture, the everyday artifacts, and the decorative elements. The way these elements are organized and fit with the space had a critical

impact in transforming the space itself: including its functionality, its meaning, and its aesthetic feel. Therefore, in design-in-living, everyday designers are not only adapting a space, they are considering a variety of elements of various scale and balancing a goodness of fit between them (as I will describe in 6.1.2). The complexity of the outcome in design-in-living is increased by the necessity to consider relationships between all the elements of that space.

Design-in-living is described as an ongoing and incremental process. This affirms that the outcome itself is temporary, or transitional. The incremental quality suggests that multiple versions of an artifact, system or space might exist in sequence, and that with each version the design decisions are more and more refined. For instance, the lighting system in the van was subjected to a variety of iterations before reaching its current state, which likely is not its last one. I return to this reflection when I describe the 'invariably unfinished' nature of spaces in design-in-living in section 6.1.7.

The making of the space does not only rely on the physical adaptations of the space. It also requires everyday designers' routines to evolve. Similarly to design-in-use, in design-in-living changes are ongoing, hence everyday designers need to quickly adapt and revisit their routines in the space. For example, the various versions of prototyped ensembles in the van led us, the everyday designers, to learn multiple ways of cooking, setting up the bed, managing electricity, or managing rattling noises when driving. The space gains as much meaning from the material transformations as from the newly associated activities and routines.

The shift from discrete artifacts to whole environments (as described above) directs and guides an important part of the articulation of design-in-living, as I will show in the following sections.

6.1.2. Fit as motivation

While in the previous section (6.1.1) I outlined the outcomes of design-in-living, in this section I articulate the motivations that push people to take part in those design practices. There are two main motivations: responding to catalytic pressures of everyday life, and reaching goodness of fit. I outline both below.

Firstly, design-in-living and design-in-use share the motivation to respond to the dynamic and unpredictable nature of everyday life. In design-in-use, the everyday designer aims at finding improvised solutions to the situations that emerge in daily routines. For instance, in chapter 3 I shared the example of a participant using her wallet as a flat surface to write down a note (p. 51). Examples from the van conversion project include using the driver's seat armrest as a hook for a garbage bag and using the holes in the metal frame of the van to hang glasses at night (Figure 8).

Figure 8. Garbage bag on armrest and glasses in metal frame

Secondly, the shift of emphasis from discrete artifacts to a whole space also influences the design motivations that animate everyday designers. In design-in-living, everyday designers are concerned with the relations between artifacts, ensembles, and spaces, and how they fit together, or how they might reach goodness of fit.

As presented in chapter 4, in describing unselfconscious cultures, Alexander (1964) argues that goodness of fit is reached by constantly addressing and fixing *misfits* (the things that are not quite right) at the level of the *ensemble*, not at the level of the artifact itself. Although it might be a singular artifact that is modified or designed, its appropriateness can only be judged in relation to the other artifacts or spaces around it.

The van conversion project further exemplifies the importance of the relationships between artifacts, furniture, ensembles, and the space itself as a motivation to design. When designing and making a complete environment, a lot of effort is put towards how elements will work together, exist next to each other, interact, and behave during different activities. The goal to reach goodness of fit between those elements is present at the functional and aesthetic levels. For example, the small felt pads added in the bench design were necessary for the sections of the furniture to co-exist and prevent unwanted noises (p.93) (see Figure 9). Similarly, the routines we have established for how cutlery, bowls, cups and plates need to be organized to prevent rattling noises when driving were developed specifically to reach the proper fit between the designed space, the furniture and the artifacts that are within those furniture elements. Aesthetically, very much like making design decisions in a home, we knew that each choice of material (the cedar for the walls, the plaid for the cushions and curtains) would reflect our aesthetic sensibility and that together those decisions would lead (hopefully) to a harmonious ensemble, as described in the quality of 'Growing uniqueness' (p.95).

Figure 9. Felt pads to prevent unwanted noises

Goodness of fit, in the way Alexander describes it and in how we present it in unselfconscious interaction (chapter 4), is reached by incrementally, tacitly and almost unknowingly fixing misfits around artifacts or spaces. In design-in-living, as illustrated by the van conversion project, I add a layer of complexity by describing how large design

actions, oftentimes aware and planned (e.g. the addition of the bench-table-bed unit), are also performed to strive towards goodness of fit. Hence, in design-in-living, goodness of fit is reached through a combination of the ongoing fixes of misfits and the discrete events of large transformations of the space. In section 6.1.5, I come back to this idea of a multiplicity of design strategies.

6.1.3. Condition: Living in a particular space over time

In addition to needing a specific motivation for people to engage in design-in-living, there are two conditions necessary for design-in-living to take place: time and a particular place. While time is a central part of design-in-use, the place specificity is something unique to design-in-living.

The condition of time is qualified by 1) time for design qualities to emerge, 2) time of reflection after design actions, and 3) temporal cycles of making and living. Firstly, time was described as a condition for design qualities to emerge in design-in-use in the original studies of everyday design (Wakkary & Maestri, 2007; Wakkary & Tanenbaum, 2009). The findings in chapters 3, 4 and 5 concur with this idea and show that time is also a necessary condition in design-in-living. Time allows for familiarization and experimentation that lead to the ongoing and incremental improvements to the everyday setting. For example, remember how it took a week of living with the table-non-table for its owners to realize it was moving, or how it took multiple days for owners of the indoor weather stations to find them an appropriate place to live (see chapter 4).

Secondly, in explicit creative acts such as with the practices of design of hobbyist jewellers and steampunk enthusiasts, I also observed the use of time as a way to confirm design decisions and to familiarize oneself with a materialized design idea. For example, hobbyist jewellers often left their pieces on their desks, untouched, for a few days before the last assembly stage to make sure they were satisfied with the final combination. By leaving the pieces on their desks, they were able to walk in front of them at different times of the day, offering many opportunities for reflection and adjustments.

Thirdly, design-in-living includes those conditions of time but adds a different sense of time, as illustrated by the van conversion project. Time is divided into different cycles: cycles of design and building, and cycles of living in the prototyped space itself. By having the possibility to go back and forth between making and living, the everyday designers gain a stronger understanding of what they might want in the next builds, and they also gain a much better understanding of the impact of their previous design decisions. In the quality of 'Reciprocal shaping' (p.92), I describe how previous decisions changed our future visions of the van. For example, by living in the van without electricity for over two years, we found ways of lighting (USB lights with rechargeable batteries) and keeping our perishable food cold (a cooler with ice). Although we expected to need electricity, the possibility of having a 'cycle' of living without it demonstrated that electricity might not be necessary for our usage of the van.

In addition to having time, in chapter 5 I propose that design qualities also emerge when the everyday designer lives within the space he or she is designing and making. The process of design-in-living is a process of constructing meaning at a specific location and of positioning design elements as a way to create the space that is the most appropriate to its everyday designers. This process can only happen within the unique scale and physicality of that space.

The success of design-in-living relies on the possibility for everyday designers to be within the space over time. Design qualities emerge because everyday designers are surrounded by their work-in-progress. By physically experiencing the space, at all the stages of the build, they are able to assess goodness of fit between the elements that are already present. Moreover, while being in that space, there is literally 'nowhere else to look', encouraging the everyday designers to consciously and unconsciously continue to assess the current version of the space and imagine what it could become.

In summary, design-in-living requires the everyday designers to experience their space over time and from within it. This position for the designer is rare in traditional professional design practices, but proved to support creativity and the emergence of design qualities in design-in-living. While in this dissertation I only address the impact of time and space as conditions for design-in-living, other contextual elements will surely

impact how (and if) everyday designers engage in design-in-living. Examples might include how temporary or permanent their living situation is, the climate they live in, their economic status, their proximity to tools and resources, their education, and more. Future research will be required to investigate the impact of these factors.

6.1.4. Creative and resourceful

Throughout this dissertation, the subjects of my investigations have been people who engage in practices of making and designing. Different levels of expertise and skills were shown. However, in all cases, people could be described as creative and resourceful. These qualities have also been described in the original studies of everyday design and in design-in-use (Wakkary & Maestri, 2007; Wakkary & Tanenbaum, 2009). While the qualities of being creative and resourceful expand far beyond design-in-living, they are the qualities that distinguish the 'everyday designer' from a passive home dweller who would not take part in modifying and adapting his or her space.

In design-in-living, creativity and resourcefulness manifest in different ways that are particularly related to the lived-in space. Similarly to design-in-use, creativity is present in the practical ways everyday designers are able to see different artifacts and appropriate them for their own purposes. Creativity is present in the subtle and often unknowing ways people make adjustments to their environments. What is particular in the case of design-in-living is how creative thinking together with a strong sense of observation allows everyday designers to pinpoint what element of an ensemble or within the space needs to change to gain better fit between the elements.

While some design acts in design-in-living are tacit and improvised, some are following a more precise goal and are planned ahead, and this showcases creativity differently. In fact, in design-in-living everyday designers use their creativity in a conceptual way: to develop a unique and personal idea for what their space should be. This vision allows them to tailor their conscious design decisions towards an idea they have for that space. Moreover, in the spirit of design-in-living, they are able to adjust and modify this vision depending on their experiences in the space, leading to a more unique place (see the quality of Growing uniqueness, p.95). For example, in the van conversion

project, we had a vision of what the kitchen unit should be. We had imagined what this kitchen would be based on our experience cooking at home and on previous camping trips, and from inspirational examples online. Our vision included a propane stove, a battery powered fridge (connected to solar panels), wood cabinets, and wood drawers. After living in the space for almost three years, we have realized that this vision is no longer appropriate in relation to our building skills and our current access to tools for making the cabinets. As a result, we have creatively reimagined what a more simple kitchen unit could be, one that still fits the style of the van, but that fits our skills better.

In addition to creativity, resourcefulness is also present in a unique way in design-in-living. When designing in a space, everyday designers are aware of the different elements that construct their space. By remembering what elements are part of the space, the everyday designer can source these different artifacts for different purposes in the space. This is exemplified well by how steampunk enthusiasts had large collections of materials as a way to have materials ready at hand (p.54). In the same way, a lived-in space can contain similar collections of artifacts, ready to act as resources for design (6.1.6).

Finally, in design-in-living, creativity and resourcefulness are augmented by the ability everyday designers have to combine and juggle different competences and skills. For example, in the van conversion project, we were able to combine our abilities for 3d modeling, woodworking, and sewing. The combination of those skills opened a range of creative possibilities that guided and oriented our design decisions.

6.1.5. Multiple ways of designing

In this section, I examine the strategies used by everyday designers to perform design-in-living. As a general observation, design-in-living does not describe one unique practice, but rather it is a collection of design and making practices. More importantly, everyday designers combine and alternate between practices of design to fit the situation they are in.

To start, design-in-use and design-in-living share a main design strategy: the strategy of designing through the appropriation and adaptation of everyday artifacts and

surroundings. This design strategy stems directly from the main qualities of being creative and resourceful (as described in 6.1.4); this leads to the ability to envisage the potential for reusing everyday artifacts or to imagine new functionalities for the surroundings. For example, in chapter 3 I described how everyday designers could see the railing as a place to hang clothes to dry or how they used a phonebook as a reminder to stretch calves after running. Other examples are how a hobbyist jeweller reused a pasta-maker to roll Fimo dough for jewelry making, or how a steampunk enthusiast painted a plastic basketball pump to make a fake piston for a costume. In chapter 4, creativity arose in action, in the ways people used artifacts in a variety of ways. For example, participants used the discovery-driven prototypes to keep a husband awake when driving or to massage someone's back (Lim et al., 2013).

Figure 10. The kitchen unit, the bed-bench-table unit, and the hooks

In addition to the strategy of designing through appropriation and adaptation, in design-in-living, I observed how a variety of other design strategies emerge. In chapter 5, I described how we engaged in different cycles of imagining, designing, making, and living in our prototype. What was not articulated in the original paper was the ability or the need to switch between multiple forms of design practices throughout the van conversion project. Below, I highlight how the different 'flavors' of design and making were central to the van conversion project and how they showcase different types and levels of expertise.

Consider the examples of the sketched kitchen unit (p.94), the polished, thoughtful and refined bench-table-bed unit (p.93), and the hooks added to hang lamps (p.94) (see Figure 10). Each of these changes in the van is a design act, however the types of planning and the required expertise in each case are dramatically different. As a ready-made item, the kitchen unit simply required enough imagination to see the unit as a kitchen unit and to screw it to the wall. As described in chapter 5 (p.97), we understood this design act as a prototyping phase to investigate how we might design a more personalized version later. The hooks only needed to be screwed in at the right position in the ceiling. In contrast, the bench-table-bed unit required much more thought into what was desired. Its design evolved through various paper sketches, a 3d model in SketchUp, another 3d model in Rhino, a full scale testing session with milk crates in the van for ergonomics, and a multiple day build to bring to life the design vision. The contrasting example of small ad hoc changes (the hooks), with appropriations of existing elements for prototyping purposes (e.g., the kitchen unit), and full 'from scratch' builds (the bench-table-bed unit) showcase the differences in the know-how necessary for each design. What is noteworthy is how we were able to access the competences necessary in relation to our goals. Small ad hoc changes do not require tools; only the use of a hand suffices. Rapid prototyping and sketching in the space required ready-made elements and some connectors (screws in the case of the kitchen unit). Major changes, conversely, necessitate multiple tools, including a table saw, a nail gun, a drill, and varnish, and the skills to use them. In each case, we deployed the essential tools and competences for the task, but not more. The examples presented in the previous paragraph illustrate adequately how everyday designers are able to combine and fluidly

move between acts of unconscious design, ad hoc design, and planned design in order to create a unique but coherent space to live in. In addition, the van conversion project also demonstrated that some design activities are too far from the everyday designers' competences and they might decide to outsource this design step. For example, in the van conversion project, instead of trying to cut the metal panels of the van exterior to install windows and an aeration vent ourselves, we hired professionals who had the expertise to do such work. This decision was based on the risk involved in trying this ourselves and the potential cost (in time and money) of a mistake. While in some cases, the challenge of learning something new was intriguing and inviting (such as learning how to install cedar paneling, or how to replace the radio in the van), in other cases, the risks were too high in our perspective.

In summary, the closeness in which living, designing, and making occurs in design-in-living invites a fluid dance between different ways of designing, including unconscious design acts, ad hoc designs, and planned design activities.

6.1.6. Spaces and artifacts as design resources

In design-in-use, design artifacts are understood to be resources for further design acts by everyday designers who can appropriate them to respond to events that arise in their everyday lives, as described in 6.1.4. Examples include how a chair, a piano bench, and the top of a fridge are used as flat surfaces on which to rest other artifacts (chapter 3). The materiality, actuality and proximity of those artifacts are often what allow everyday designers to see them as possible starting points for design actions.

In design-in-living, everyday designers see the lived-in space and the artifacts within that space as resources for further design acts. For example, the varied appropriation of the van space, as described in section 6.1.2, shows how while living in the van we were able to see cues around us to fit our needs. In design-in-living, appropriation of mass-produced artifacts is present, however, the multiple cycles of designing and making also allow for everyday designers to see their own designs as resources for future design acts. Past design actions, now materialized in the space, can

be seen as a prototyping starting point for future designs. For example, in the van conversion project, the storage platform built the first year then served as a new reference when designing the bench-table-bed unit. The actuality of the completed platform offered rigid constraints to start designing from, such as the footprint for the unit and a reference point for height. In addition, by having the platform present, it was then possible to physically prototype the size of the bench unit (using our current living room couch (see Figure 11).

Figure 11. Living room couch as prototyping material

To summarize, in design-in-living, everyday designers see design artifacts in addition to their own creations as resources for future design acts.

6.1.7. The space is invariably unfinished

In design-in-use and in design-in-living, it was observed that changes are ongoing and incremental (6.1.1). In design-in-living, I add that this creates invariably unfinished lived-in spaces. The example of the van project illustrates this idea very well as revealed in the section 'The invariably unfinished home' (p. 97). In addition, the van conversion project shows how this unfinished status of the lived-in space does not prevent the everyday designers from using it or living in it. In fact, this unfinishedness is an accepted quality of the space, one that supports creativity and design actions. For instance, as I described in 6.1.6, our own designs served, at times, as a catalyst to propel next design iterations.

The unfinished nature of the space is also recognized through the different levels of finish of artifacts within the space. For example, the unresolved idea of a kitchen unit co-exists with the well finished and polished cedar panelling for the walls.

Living in a space that is being designed and built has the contradictory effects of provoking and supporting creativity as described above, and simultaneously offering a blinding effect on the aspects that still needed some work. The combination of physically living in a space with the long temporal scale allows the everyday designers to forget or eclipse the aspects of the build that are unfinished, require adjustment, or need repair. This quality is necessary to allow everyday designers to enjoy living in that space and not constantly be concerned or worried with design ideas and plans.

6.2. Design-in-living: Relationships to other concepts in this dissertation

Throughout the dissertation, I have used the terms of 'everyday design', 'design-in-use', 'design-in-living', and 'unselfconscious interaction'. The nature of the cumulative format thesis led to the introduction of these terms dispersedly throughout the previous chapters, often without acknowledging the existence of the other concepts. These four terms represent concepts that are interrelated and I take the time in this section to describe the relationships that link them.

I begin by describing the relations between everyday design, design-in-use, and design-in-living, as illustrated in Figure 12 (I will come back to unselfconscious interaction further below). Everyday design is the term that Wakkary and Maestri (2007) proposed in their paper presenting the original ethnographic studies of families in their homes. With this new term, the authors describe a type of design practice, one performed by home dwellers (see 1.5.3 for the relationship between the practice of everyday design and professional design practices). Within everyday design, in the 2007 and 2009 papers (Wakkary & Maestri, 2007; Wakkary & Tanenbaum, 2009), Wakkary and colleagues use the concept of design-in-use as a way to describe the processes and design actions that happen in everyday design. The relationship between everyday design and design-in-use is one where design-in-use is part of everyday design. More

specifically, design-in-use describes the opportunistic appropriations of artifacts in everyday life and how those appropriations can sometimes be at the core of new routines and systems in the home. The focus is on the appropriated artifacts and the immediate systems or routines around them—keeping a narrow perspective on the use and the design of the artifact itself.

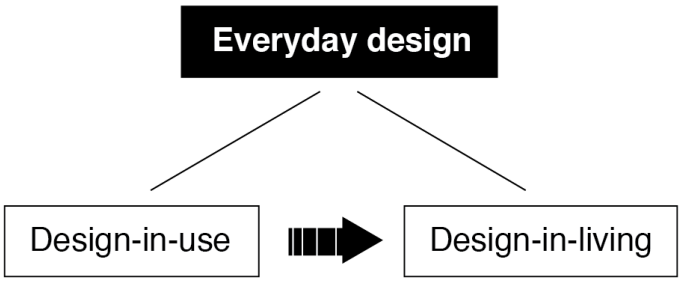


Figure 12. Relationships between everyday design, design-in-use, and design-in-living.

Like design-in-use, design-in-living is also part of everyday design (as shown in Figure 12). However, the arrow between design-in-use and design-in-living illustrates how design-in-living grows from and extends design-in-use, while still being part of everyday design. Design-in-living expands beyond the appropriated artifacts (and their associated systems and routines) to focus on the ongoing improvements of the whole space. In design-in-living, the attention is on the reciprocal shaping between the everyday designers, the space and the elements within that space that happen over long periods of living with.

Everyday design—together with design-in-use and design-in-living—articulates a specific *design practice*. In comparison, unselfconscious interaction describes the *experience of living with* interactive artifacts over long periods of time. This experience includes engagements, intersections and interactions with artifacts; and some of those engagements lead to the rearrangements of the artifact in the environment in some ways that are similarly described in everyday design. However, the conceptual construct of unselfconscious interaction was built on the analysis of three sets of artifacts: the table-non-table, the indoor weather stations (Gaver et al., 2013) and the discovery-driven

prototypes (Lim et al., 2013). Each set was designed based on a theoretical concept, respectively: the concept of everyday design, ludic design, and discovery and openness. Hence, unselfconscious interaction goes beyond everyday design to include other theoretical concepts that articulate the relationships between users and artifacts.

6.3. Reflection for HCI and Interaction Design Research

The work presented in chapters 2 to 5 as well as the articulation of design-in-living (6.1) present a detailed portrait of how people design and make a space they live in. This portrait challenges certain assumptions that are often present in current HCI and interaction design research on the design of interactive artifacts in the home. In the next sections, I present reflections concerning connectedness and the value of unfinishedness. These reflections advance the current discourse in HCI and interaction design research surrounding interactive technologies in the home, IoT and DIY. Those reflections, when taken together, form the answer to my second research question: *What are the qualities of design and making in a lived-in space that are relevant for the design of interactive artifacts?*

6.3.1. The intricacies of connectedness

The concept of design-in-living highlights the relations between things, ensembles and a space as an important characteristic to support ongoing changes and adaptations in that space (6.1.1). Goodness of fit between elements is an ideal powerful enough to incite everyday designers to make changes to their environment (6.1.2). These observations from design-in-living resonate strongly with one of the main assumptions of ubiquitous computing and particularly with the IoT: environments will become fully connected and synchronized through the integration of small electronics (including sensors, network connectivity, software and actuators) in everyday things and furniture. In addition, the IoT relies on the connections between those artifacts and between the artifacts and a larger networked infrastructure to fully function. Design-in-living further refines how HCI researchers might understand the complexities of connections in the IoT. Below, I describe three types of connections: 1) connections

between digital and non-digital artifacts; 2) connections amongst digital artifacts, and 3) the invisible and digital dimension of connections.

Firstly, I underline what the IoT often ignores: connected artifacts will exist in a space where non-connected (and non-digital) things will also exist. As design-in-living illustrated above: connections will take place and ensembles will form between all sorts of things in the space, regardless of their level of computation. From a computational standpoint, this affirmation generates new possibilities and challenges for HCI research. Designers will need to consider in what ways computational artifacts act with or upon non-computational ones. There are possibilities in how connected artifacts could report on non-connected ones through video, photo or audio feeds. In addition, connected artifacts could also act on, move, or transform non-digital artifacts. These ideas assume an autonomous life and ecology of artifacts within the house and are still very abstract. However, current home technologies already apply those ideas. Imagine how current alarm systems already have 'eyes' to detect if a window or a door is open. This is an example for how a technological system is connected to a non-digital aspect of the space and can act (turn the alarm on or not) based on the data gathered about non-computational events that happen in the home. These reflections open a new area for research where varied and potentially unbalanced relations start to exist between artifacts. In the context of designing IoT artifacts and systems, the HCI community could investigate further how the contrast between non-connected and connected artifacts could trigger more or less design actions by everyday designers. Further research should focus on the value perceived by everyday designers in connecting digital and non-digital elements in the home.

From a physical and material standpoint, connections between digital and non-digital artifacts in a lived-in space engender a different discussion thread. Fit, in a lived-in space, also comes from the materials of the artifacts included in that space. Digital and connected artifacts as well as non-digital artifacts should be able to relate to each other at the level of materials, shapes, textures, colors, scale, and form—the same way everyday artifacts in a home are combined and co-exist. Furthermore, direct connections can be imagined in the physical realm as well, to support design-in-living. Physical connectors could be clips, buttons, Velcro, glue, tape, hooks, strings, tie wraps, etc.

Further research could investigate the new types of connections in the computational world that these connections in the physical realm would bring. Woo and Lim (2015) argued that temporary connectors could support more experimentations with DIY sensors and actuators in the home. More broadly, I believe these physical connections could lead to different types of digital views and understandings of the home as well.

Secondly, I discuss connectedness between digital things. The discourse of IoT assumes that each object will be able to connect directly to the cloud as well as any other artifact in the world. This offers an infinite number of possible connections. Aside from the technical challenges this presents, I question the value of having connections to everything and propose a more focused approach. Design-in-living highlights the importance of goodness of fit between artifacts. Goodness of fit will likely be achieved more easily between artifacts that should have a closer relationship. For example, Crabtree and Tolmie (2016) describe 'methodical assemblages of things' based on how we use a variety of artifacts in concert with each other for certain activities (e.g., waking up in the morning or making dinner). Building on their work, it will be necessary to study how proximity (in purpose) can be designed for. Reflections regarding proximity will also rely on a sensibility to the temporal scale and timing by which assemblage form and deform. For instance, assemblages are not the same depending on the time of the day, the day of the week or the season in which artifacts are used and lived with.

Lastly, I address how other forms of computation in the home can also become part of the processes of design-in-living and potentially connect with physical interactive artifacts within the home. Currently, services like electricity, water, cable, and connection to the Internet are often hidden 'in the walls' of a home and manifest themselves only through the commodities they provide: the lights turn on when flicking the switch, a website is accessible via a tablet, the phone rings, etc. More and more, new services will be digital (or offered via the Internet) and will still be invisible to the home dwellers. Examples include conversational agents (Cassell, 2000) who are able to speak to inhabitants to find solutions to their needs the same way Siri[7] is accessible through iPhones or Amazon's Alexa that can engage in a verbal exchange through the Amazon

[7] http://www.apple.com/ca/ios/siri/

Echo[8]. In both cases, the main functionality of the system is not in the physical artifact but in the intelligence of the system and in the ways it can use language to exchange with home dwellers. Those systems are highly complex and they are remotely located away from the home. This poses new considerations for the everyday designer. He or she will be able to experience the system through the service it provides, but it is unclear how the system itself will be able to become part of design-in-living practices. This is an interesting challenge for interaction designers and design researchers: data (invisible, shapeless, scaleless) and connections between data points will be a material as important as the physical materials in design-in-living. It will be interesting to see how design-in-living processes can develop around services and data since this will offer contrast to the more physical and visual qualities of the examples presented in this dissertation.

In the paragraphs above, I have outlined the computational and physical ways artifacts can connect to each other in a lived-in space. The diversity and range of possible connections highlight the complex and intricate considerations necessary to the design of interactive artifacts that could fit design-in-living practices.

6.3.2. Celebrating change and unfinishedness

Apart from rare exceptions (e.g. (Woodruff et al., 2008)), the image often projected in studies of smart homes, ubiquitous computing environments, and the IoT is a snapshot in time. It ignores the evolving and transitional nature of spaces and even more the unfinished nature of spaces. I propose to shift this assumption by asking the question: how would interaction designers design IoT artifacts or ubicomp spaces if the starting point were the quality of unfinishedness? Below, I discuss scales of change and manifestations of unfinishedness.

I start this reflection with discussing the different scales of change. I turn to work by Stewart Brand (1995) to expand on this reflection. In his book ‘How Buildings Learn: What Happens After They’re Built’ (Brand, 1995), Brand describes six layers of change

[8] https://www.amazon.com/Amazon-Echo-Bluetooth-Speaker-with-WiFi-Alexa/dp/B00X4WHP5E

that constitute how buildings evolve over the years. Those layers include site, structure, skin, services, space plan, and stuff. Each layer manifests on a different scale of time. For instance, the stuff (everyday objects, furniture, etc.) in people's homes change on an ongoing basis whereas services like electrical wiring or communication wiring might change only once every 20 to 30 years. Each scale of time allows its own understanding for what is finished or unfinished in the home. Things that take longer to change might be considered to be more 'finished' while home dwellers are using them (since they are more stable), whereas things that have a shorter change cycle might feel more open and unfinished.

Scales of change were observed in design-in-living where more important changes that require planning happen during dedicated cycles of building, whereas the ongoing adjustments of the environment through artifacts happen in an ad hoc manner on a daily basis. As I described in 6.3.1, interactive and connected artifacts hold both a physical presence and a computational existence (often in the cloud or throughout a system). In this case, changes are attached both to their physical presence in the space (and are considered to be able to evolve rapidly like other 'stuff'), and to a larger infrastructure which does not change as rapidly (at the layer of services). This paradox poses an interesting challenge for everyday designers in choosing the elements of the system that can be part of their ongoing appropriations and designs and in balancing the different scales of change that might happen beyond their control (e.g. a software update by the service provider). More importantly, this is also a challenge for interaction designers who might be interested in designing to support change, in which case they have to decide what scale of change they might want to address.

The second point in this section is related specifically to unfinishedness. Intentional unfinishedness and incompleteness were discussed in previous HCI literature as strategies to encourage users to find their own meaning for an interactive system or artifact (e.g. (Gaver et al., 2003; Sengers & Gaver, 2006; Seok et al., 2014)). For example, in chapter 4 we propose the strategy of purposeful purposelessness as a way to design with non-existent or weak use goals. This strategy is meant to leave open the use of an interaction design artifact to let people use it for their self-determined goals. Another example is how Seok et al. (2014) defined non-finito products as "intentionally

unfinished products, fostering new creations by end-users in their actual instances of usage for their personal user experiences" (p. 695). This work is inspirational; however it tackles discrete artifacts and does not speculate on how unfinished collections of artifacts or space would support creativity for everyday designers. In the following paragraphs I discuss concerns related to how to design for unfinished spaces.

Discussing how to design for unfinishedness necessitates addressing the different scales within the space: the artifact, ensembles, and the space. First, I discuss what elements of an interactive artifact itself can be left unfinished. Interactive and connected artifacts hold a variety of aspects that can each be left at different states of finishedness: their behaviour, their materials, the data they collect and generate, and their form. Differences will emerge from the decisions surrounding what is left unfinished. For example, an IoT artifact with a highly finished form but underdetermined data collection structure will differ from an IoT artifact that has a strict behaviour but materials that hold strong prototype qualities (malleability, flexibility, etc.). We will need further research to investigate what combinations of levels of unfinishedness (between those elements) are powerful in supporting design-in-living.

Designing unfinishedness within collections or ensembles of artifacts can also mean to design *in between* the artifacts. In the context of the interactive artifacts in the home, this might mean that we need to consider how we design in between systems or networks. Interoperability is concerned with allowing systems to work with other systems from a technical perspective. However, my discussion is grounded in design-in-living, which is focused on the everyday designer's active role in how connections between systems happen. If interoperability is possible, connections will be in the hands of the everyday designer, who, at home, will be able to potentially mix and match artifacts (and their behaviors) to become part of the ongoing and incremental changes that happen within the space. It will be important for interaction designers to acknowledge that there are aspects of their designs (such as how they connect to other designs) that will, by default, be left unfinished, and that these aspects might require additional attention to support design-in-living practices.

In the paragraphs above, I have articulated how the constant changes of the space, and the resulting unfinishedness of the space, become design qualities that can orient future reflections about how to design to support design-in-living practices with interactive artifacts and spaces.

6.4. Methodological reflections

In this section, I report on a reflection on the various methodological choices I made in this dissertation. The nature of the cumulative format allows showcasing various studies, each using its own method for gathering and analyzing data. This also allowed me, as the researcher, to take different epistemological commitments in each study, supporting an exploration of the topic from different perspectives. For instance, amongst the research genres uncovered in chapter 2, in the dissertation I visited the genres of research of 'ongoing domestic practices' (chapter 3), 'the home as testing grounds' (chapter 4), 'the home as a site for interpretation' (chapter 4), and 'a first-person view of the home' (chapter 5). This variety supported different data gathering methods including interviews, participant observation, video walkthroughs, relayed photos and notes taken by participants, and autoethnographic diaries and photos. Combining the data from all those sources helped to triangulate findings and supported the development and articulation of the concept of design-in-living.

The possibility of juxtaposing different epistemological commitments and of positioning myself as a researcher and a designer in different ways was valuable for making sense of design-in-living. For instance, my role shifted between the third-person observer (chapters 3 and 4), the relayed informant (chapter 4), the author interpreter (chapter 2, 4 and 5), and the experimenter (chapter 5). Shifting perspectives throughout this long-term research project supported an exploration of different facets of the phenomenon I was studying. Interestingly, the cumulative format of this dissertation also assists the reader along a methodological journey, potentially leading to a more nuanced understanding of design-in-living. With this reflection, I encourage HCI and interaction researchers to be aware of the positions they take as researchers and to value the diversity of positions they can take with regards to their projects and research questions.

The second aspect I address in this methodological discussion relates to the value of using autobiographical design in HCI, or more broadly, the importance of first-person research in HCI. In the research presented in chapter 5, my goal was to investigate the personal, complex, and intricate first-person experience of designing and making a lived-in space. The first-person perspective, combined with the longitudinal format of this study, allowed me to acquire the rich and nuanced data required. By engaging in first-person research in chapter 5, I was also putting into action some methodological and epistemological propositions I had made in chapter 2, based on my critical literature review of HCI research on the home.

Through this process, I noticed how I was bearing multiple roles that were not always easily compatible: maker/user, design researcher, family member, lover, homemaker, co-designer, co-author, ethnographer and data gatherer. The combination of some roles were not always fluid. For example, as a data gatherer and a maker, I had to switch back and forth between building and taking photos. This often broke the rhythm of building established between my partner and me and sometimes led to tensions or frustrations. As a second example, there are challenges in reporting on a project that was designed and built by two individuals, but where only one is a researcher and author. It became even more complex when I was writing the article with Wakkary, who was not a part of the van conversion project, but who was present to analyze the data and articulate ideas with me. This led to much iteration in the writing around how we would refer to *us the authors* (Desjardins and Wakkary) vs *us the maker/users* (Desjardins and Bérubé Lebrun). As noted in chapter 5, in order to stay true to our methodological commitment and to present this first-person experience in a personal way, we decided to use the authorial 'we' throughout the paper, letting the context bring clarity on whose voice was used. Finally, as an autoethnographer and ethnographer, I had an interesting role in how I referred to my partner in this paper. Instead of specifically reporting his lived experience as a maker/user in his own voice, in the ethnographic tradition, I combined my experience with his into a report on the maker/user team.

Beyond the challenges presented above, by fluidly interchanging these roles, I was able to understand the van conversion project with more depth, more definition and

more details. In addition to investigating the potential for appropriation in interactive and ubiquitous computing environments, I see how first-person research could be useful in personal or sensitive areas and topics such as health concerns, family life, and interpersonal relation. Finally, this dissertation also provides a detailed example of how autobiographical design can be combined with other HCI research methods.

6.5. Limitations of this research

The ways in which I decided to conduct research in this doctoral work uncovered interesting opportunities (as described in 6.3), but it also resulted in limitations of the findings. In this section, I present five limitations of this work.

Firstly, qualitative research and design research have the inherent limitation of being hard to generalize and to reproduce. This stems from the very nature of this kind of work: it aims at describing in great details and depth a few unique examples. Richness of data and uniqueness of the cases allow for an in-depth understanding of the phenomenon studied, however it is challenging to see how the findings would be applicable beyond the cases described. Autobiographical design, similarly, is also hard to generalize and reproduce, due to the very personal nature of the method. In addition, the method itself usually does not allow for an outsider's perspective, as Neustaedter and Sengers (2012) noted. In the case I presented in chapter 5, however, I conducted the analysis of the data together with Wakkary, allowing for an outsider perspective to help direct the organization of the findings.

Another limitation of this work comes from the structure of the thesis itself. While all the core chapters of the dissertation (chapters 2 to 5) supported the development of design-in-living, chapter 5 is the only one that presents a concrete example of a design-in-living process. In future research, it would be valuable to collect and describe more examples that illustrate design-in-living, in order to present a range of lived-in spaces (see 7.3.1).

A third limitation of this work relates to the choice and diversity of participants in my studies. The work presented in chapters 3 and 5 of this dissertation refers to

participants who are fortunate enough to enjoy the practices of making and designing. Hobbyist jewelers, steampunk enthusiasts, and my partner and I in the van conversion project could all be considered privileged to have time, money, and support to embark on design projects in large part for the pleasure it provides us. It is important to acknowledge that these examples cannot represent all people who make and design. However, I also want to highlight how the practices of families (chapter 3) and of the owners of the artifacts in chapter 4 were not motivated by the pleasure of making, but by the catalytic pressures of everyday living, something everyone experiences, in their own way. Future work should showcase examples from participants coming from a variety of backgrounds, ethnicities, genders, ages and social classes.

Fourthly, design-in-living is a phenomenon that happens over years, if not decades, of living in a space. Because of the practicalities of conducting research during doctoral studies, it proved hard to study first-hand how that practice evolves over very long periods of time (decades or more), something that autoethnography suggests as being beneficial (Ellis, Adams, & Bochner, 2010). However, in the context of HCI and interaction design research, to have had the opportunity to study the van conversion project for almost three years is already much longer than many previously conducted studies. It would be highly interesting, however, to find ways to study how spaces evolve over 20, 50 or 100 years (see 7.3.5).

Lastly, while this dissertation is aimed at informing how the HCI community designs and thinks about interactive artifacts and spaces, the majority of the examples offered in this dissertation are non-computational (with the exception of the table-non-table, the Indoor Weather Stations, and the Discovery-Driven Prototypes presented in chapter 4). These non-computational examples were strong and rich enough to support the development of the concept of design-in-living, however it would be beneficial, in future research, to add new examples of computational spaces that also illustrate design-in-living. These new examples will likely refine and add more nuance to the way I describe design-in-living in this dissertation.

6.6. Conclusion

In this chapter, I have presented the concept of design-in-living. I have described the concept through seven characteristics: outcomes, motivation, conditions, qualities of the everyday designer, design strategies, quality of artifacts and the space, and level of finish. Using the findings from chapter 2 to 5, and expanding on the concept of design-in-use, I was able to articulate how people design and make a space they live in. While the process of weaving the four articles together was not always straightforward, the cumulative format of this dissertation allowed me to clarify the links between chapters 2 to 5 and to show how the four different studies lead to the articulation of design-in-living.

In addition, at a higher level, I have also reflected on the broader implications of this work for interaction design and HCI, particularly offering new perspectives on connectedness, layers of change, unfinishedness, and the qualities of creativity and resourcefulness. I have shared some reflections on the methods I used throughout my work, with an emphasis on autobiographical design, and described the limitations of my work.

Chapter 7.

Concluding remarks and future work

In this last chapter, I offer my concluding remarks and reflections on the work I have conducted in this dissertation. The cumulative format of this dissertation has supported a deepening of my reflections regarding each of the articles presented in chapters 2 to 5. The possibility of taking a step back from each of the articles allowed me to articulate the concept of design-in-living as an answer to my first main research question: *How do people design and make a space they live in?* In addition, I was also able to present a discussion of the implications of design-in-living for interaction design and HCI research focused on IoT and ubiquitous computing environments. This allowed me to answer my second main research question: *What are the qualities of design and making in a lived-in space that are relevant for the design of interactive artifacts?* In the first section of this chapter (7.1), I present a synthesized answer to both main research questions.

In addition, in 7.2 I articulate the four contributions this work makes to the HCI and interaction design research communities.

Finally, in light of the findings of this dissertation, I offer five areas for future work in interaction design and HCI research in 7.3. These areas are: 1) in-depth qualitative studies of alternative ways of living to inspire design, 2) qualitative studies with a focus on gender and domesticity in relation to design-in-living, 3) a generative approach to creating IoT artifacts and spaces for design-in-living, 4) a material perspective to design-in-living, and 5) imagining ways to conduct long long-term studies of design-in-living.

7.1. Revisiting the research questions

At the beginning of the dissertation, I presented my two goals. I explained that my first goal was to investigate how people design and make in a space in which they live. While HCI has investigated how non-expert designers make artifacts, how they design and make a lived-in space was still underexplored. My second goal was to find a way to articulate and make relevant those findings to inform the design of interactive artifacts, particularly in the context of IoT and ubiquitous computing environments. These two goals became my main research questions. Below I offer a synthesized version of my answers, in light of what I uncovered through chapters 1 to 6.

7.1.1. How do people design and make a space they live in?

The first main research question I asked in this doctoral work was: *How do people design and make a space they live in?*

In chapter 6, I described design-in-living in terms of outcome, motivation, conditions, qualities of the everyday designers, design strategies, quality of artifacts and space, and level of finish. I have shown how in order to understand how people design and make a space they live in, it was crucial to shift away from studying artifacts in isolation, but instead to explore ensembles of artifacts and the relation between those ensembles and the space. This shift adds a layer of nuance and complexity to a lived-in space: it becomes the site of a multiplicity of activities, for usually more than one everyday designer, and involves an evolving configuration of artifacts, furniture and space. Hence, the outcome of design-in-living is the ongoing and incremental adjustments to the space itself as well as the artifacts within that space.

Moreover, this shift offered a new perspective for understanding the motivations everyday designers might have in making their ongoing design actions. A first motivation was to react to the ever-changing everyday events. This resulted in ad hoc, sometimes unconscious, design actions that were performed in an ongoing manner. But a second motivation—stemming directly from a shift towards looking at the whole environment—is the goal of achieving goodness of fit between elements and the space itself. Goodness

of fit was a strategy for everyday designers to tackle the complexity of their space, their artifacts and their activities.

In return, this goal of goodness of fit directs the multiple design strategies used by everyday designers. Strategies can include the ad hoc improvised design acts and unconscious design actions described above; but also include planned and elaborate design endeavours. What is particularly remarkable in design-in-living is the ability of everyday designers to alternate between those strategies, depending on the situation and the design need. For each strategy, everyday designers are able to deploy (and even learn) the appropriate design or making skills and competences.

In addition to a variety of design strategies, design-in-living relies on two conditions to happen: the need for time and the need for everyday designers to be inside the space they are designing and making. With time, and by being physically surrounded by a space, everyday designers can start to creatively and resourcefully see the space around them, the artifacts within that space, and their own manifested design ideas as resources for future design acts. Through an iterative process, everyday designers build on what they have already built, adjusting to what they have learned from their previous designs and builds.

Finally, design-in-living illustrates how a space holds the quality of being invariably unfinished. By acknowledging and internalizing this quality of the space, everyday designers are able to continuously make changes to their space. More importantly, they are also able to accept living in an unfinished space, one that combines elements that are refined and well tuned together with elements that are early prototypes for what future versions could be.

7.1.2. What are the qualities of design and making in a lived-in space that are relevant for the design of interactive artifacts?

The second main research question was: *What are the qualities of design and making in a lived-in space that are relevant for the design of interactive artifacts?* In section 6.3, I offer two areas of reflection for interaction design and HCI research: a focus on connectedness and a celebration of change and unfinishedness.

Firstly, I show how design-in-living can guide a new reflection on how interactive artifacts connect to each other, to the space, and to other non-interactive artifacts. Design-in-living emphasizes the importance of goodness of fit between artifacts, ensembles and the lived-in space. In 6.3.1, I discuss how connected interactive artifacts need to be connected in a computational way (the common IoT perspective), but they also need to connect (and fit) in a physical and material way. In addition, I highlight the importance of acknowledging how those computationally connected artifacts will also connect to non-digital artifacts within the space.

Secondly, I describe how HCI and interaction design also need to consider how those connections evolve over time. In design-in-living, time is crucial to let the ongoing and incremental adaptations occur. In 6.3.2, I articulate the challenges in having different scales of time for artifacts, structures, and the space itself. This generates interesting new research questions regarding how everyday designers manage their changes together with changes from the larger infrastructures supporting IoT artifacts. In addition, I reflect on how unfinishedness is a quality underexplored at the level of spaces such as ubiquitous environments or IoT spaces. I propose to investigate which aspects of IoT artifacts could be left at different levels of finishedness. I also highlight how the space in between the artifacts could be the locus of unfinishedness.

7.2. Contributions of this work

This dissertation presents two levels of contributions to the HCI and interaction design communities. Firstly, chapters 2 to 5 have their own contributions as individual articles previously published. Secondly, when combined, these articles and my post hoc analysis provide a second layer of contributions. In the next paragraphs, I present the contributions of each individual article.

Chapter 2 offered a critical review of HCI literature about the design of technologies for the home. This paper presented an analysis that resulted in seven genres of HCI research on the home, five epistemological commitments, as well as two proposed complementary research approaches for future research. This chapter

presents a critical view of the state of research in the field today and opens radically new opportunities for future work.

Chapter 3 portrayed three groups of non-expert designers and their making and design practices. The contribution of this article lies in the in-depth and rich description, as well as the articulation of three types of goals that motivate non-expert design practices: foundational goals, aesthetic goals, and aspirational goals.

Chapter 4 articulated the conceptual construct of unselfconscious interaction. Through unselfconscious interaction, this article theorizes how interaction design artifacts can become part of the ongoing and incremental improvements that people make to their surroundings. In addition, this article makes a methodological contribution by extending concept-driven interaction design research (Stolterman & Wiberg, 2010).

Chapter 5 reported on an autobiographical design project of converting a cargo van into a camper van. This project contributed six qualities of living in a space that is reconfigured in an ongoing way in order to inspire a new perspective when designing interactive artifacts for IoT or smart environments.

In addition to the individual contributions each article (chapters 2 to 5) makes to the HCI and interaction design research communities, the collection in itself—together with the articulation of design-in-living—offers four central contributions.

The first contribution is descriptive. Together, the studies presented in chapters 3 to 5 provide detailed and rich examples of how people design and make artifacts within a space and how they reconfigure the space itself. As a collection, chapters 3 to 5 describe how everyday people, hobbyists, and DIY enthusiasts engage in a variety of design activities ranging from unaware, ad hoc and ongoing acts to planned design steps executed with focus and precision. The qualitative methodology used allowed for nuanced, detailed, and fine-grained illustrations for what it could mean to design and make in a reconfigured space. These descriptions fill a gap in current HCI and interaction design research by providing new knowledge on non-expert design practices in lived-in spaces.

The second contribution is conceptual. In chapter 6, I outlined the concept of design-in-living and detailed its seven main characteristics. Departing from design-in-use, design-in-living shifts from a focus on artifacts to a focus on the space itself and the ensembles of artifacts within that space. This conceptual shift allows noticing different design strategy, a new motivation for design acts (the aim to reach goodness of fit), and a new quality of the space: its invariable unfinishedness. The concept of design-in-living proposes an alternative and new perspective for imagining interactive artifacts in lived-in spaces for future HCI and interaction design research.

The third contribution of this work is the reflective and critical avenues I propose as a result of the articulation of design-in-living. Those reflections aim at shifting assumptions about the design of connections in IoT, the different scales and times of change in ubiquitous computing environment, the value of unfinishedness, and the qualities of creativity and resourcefulness in design-in-living. Those reflections are important for HCI and interaction design research as they can push the boundaries of how we, as a community, research and design for the future of interactive artifacts for lived-in spaces.

Finally, the fourth contribution is methodological. My work provides an example of using a variety of methodologies in design research to answer a main research question. In addition, this dissertation provided an example of autobiographical design in HCI. Autobiographical design has been investigated as a methodology for HCI (Neustaedter & Sengers, 2012), however it remains an underutilized method. By providing a successful example of autobiographical design, this dissertation makes a step forward in pushing our research community to explore different perspectives when conducting research, particularly first-person research.

7.3. What's next?

This research has contributed an important step towards understanding and articulating how everyday designers design and make a space they live in. While this provides an important contribution to the HCI and interaction design research communities, one of the most exciting things to do at this stage is imagine how this work

can be the starting point for future research. In the next sections I outline five opportunities for future work.

7.3.1. Studies of alternative ways of living

I mentioned in the limitations of this work (6.5) that this dissertation only provided a single in-depth example of design-in-living via the van conversion project. While this example was enough to develop the concept of design-in-living, it would be highly interesting to study and document other processes of design-in-living. Practices around the world will likely differ, including variations of, for example, tools, skills, and aesthetic choices. This could already serve as an inspirational starting point to rethinking how the design of IoT artifacts or ubiquitous computing would make sense and be appropriated by people from different economic status, in different climates, who have different access to resources, or who live a sedentary or nomadic way of life.

In addition, the study of the van conversion project offered an entry point to investigating how people live in homes that are not a stereotypical North American single family detached house. Across the world people are finding a variety of ways to live—or to shift their living practices. Changes can occur because of the climate change crisis, for sustainability and ethical reasons, or for monetary reasons in expensive housing markets in large cities. Across the globe, there are various trends in shifting assumptions about what it means to live in a home. Often, these new ways of living don't have predetermined rules or formats, leaving more space for everyday designers to reconfigure and imagine the space they live in.

For instance, the tiny home movement shows how people see value in down-sizing their often very large houses to live in small houses (250 square feet to 1000 square feet) (Kahn, 2012). The current fascination for wooden cabins away from cities embody the desire for simpler living, often disconnected and away from the technological world (Klein, Leckart, & Kalina, 2015). Similarly, with the possibility to work online from anywhere, many people decide to live a mobile life in RVs or vans (Zafiroglu & Chang, 2007). Another example are travelers who, for work, need to be away from home more than half of their time. They experience living in hotel rooms as much as

they experience home, leading to yet another way to understand how people dwell (Petersen et al., 2010). These examples are only a few amongst many ways of living, and each has associated practices of design-in-living. Studies of how people dwell in those spaces can provide a strong contrasting vision to current views of the North American detached family home often designed for in IoT projects.

Furthermore, design-in-living can also be examined through the lens of those who design by necessity rather than for pleasure or for a sense of accomplishment. Examples include tent cities created by homeless populations (Heben, 2014) and people living in their cars because it is their last resort. Those situations would certainly show a different manifestation of the characteristics of design-in-living. It would be highly interesting to study how those practices differ and extend the view of design-in-living presented in this dissertation.

Together, studies of different alternative ways of living in a variety of contexts can start to paint a more nuanced portrait of design-in-living. In turn, this would also allow a more delicate and precise starting point for generating design propositions for smart artifacts or environments—or potentially offering reasons for not designing at all in certain situations.

7.3.2. Gender and domesticity in design-in-living

In this dissertation, I set my goal to study how everyday designers design and make a space they live in. My attention was on the motivations and strategies of their design practices, as well as the qualities of the space created. To keep focus, I purposefully did not address questions of gender and domesticity in my work, as I mentioned in 1.8. However, I believe that to paint a truthful and complete picture of how design-in-living manifests, it is necessary to include a discussion on gender, domesticity and design in lived-in spaces.

Much work has been conducted in gender studies, anthropology, and sociology, for example, to describe and analyze the relationship between the material reality of the home and the underlying gendered roles for women and men in the home (e.g. (Gillis, Hollows, & Blackwell Echo, 2009; Hayden, 1982; Pink, 2004). As a simple example,

Evan Haynes put together a digital exhibit (Haynes, n.d.) that showcases new technologies for the home throughout the twentieth century, how they were advertised, and how women are represented. Through those advertisements of future kitchens, it is possible to see the ideals of living and ideals of womanhood at the time. Artifacts are not neutral in how they implicitly convey and dictate gendered roles and power relationships. A potential future research question is: When artifacts or a space are transformed through the process of design-in-living, how are gendered roles represented?

As an example, I can speak to my experience with the van conversion project. This, of course, does not intend to be an answer to this question; however, it aims at showing the nuances and complexities of such a question. Because of my education (through my parents and through industrial design undergraduate education), power tools and the processes of making didn't have a gender for me. During the project, it was natural for me to move fluidly between the radial saw and the sewing machine for instance. Similarly, having camped since a young age, splitting wood to make a fire was for me as simple (and satisfying) as cooking to make dinner. Moreover, I share my experience of design-in-living with my partner who, very much like me, doesn't see tools to be gendered, but associated with experience, skill, and training. This is a very personal position and I realize that it is a privileged one. In design-in-living, a lot of power lies in the hands of the everyday designer designing and making the space. He or she has the control over what is built, the scale and proportions each element takes, whose needs are fulfilled, and whose taste is met. Future research could investigate this question: In a world where skills and craftsmanship are not considered equal between genders, what does this say about where the power lies?

The points made above evolved from my experience in the van. Much more work is necessary to study power and gender in design-in-living, and even more work is needed to inform the design of interactive artifacts based on those new reflections.

7.3.3. Generative work: Research through design

The concept of design-in-living was developed at the conceptual level, based on empirical data in chapter 6. A logical next step for research will be to experiment with the

concept of design-in-living as a starting point for design. The generative method of research through design (Gaver, 2012; Zimmerman et al., 2007) would allow design researchers to explore the challenges and opportunities of designing for design-in-living by directly engaging in the process of designing interactive artifacts. In research through design, designers generate knowledge at the level of the ultimate particular. By designing an interactive artifact (or a space), the designer is making a multitude of decisions that lead to a unique configuration of design elements. The result offers an exemplar for what a specific concept could be. In the case of design-in-living, designers could, for example, choose one characteristic of the concept as the main goal of their design process. The design outcome would then help articulate that characteristic further as well as provoke reflections on how to design with this characteristic in mind.

Furthermore, once design-in-living design artifacts are created and materialized in the world, they can be deployed in participants' lived-in spaces. Through observations and interviews with participants, it will be possible to study how people use those newly designed artifacts and, more importantly, if they are able to design with them and to adapt them to their ongoing processes of making.

For example, in HCI, researchers have shown inspiring examples of how to conduct research through design to investigate research questions with discrete artifacts (e.g. (Gaver et al., 2015; Gaver et al., 2013; Helmes et al., 2011; Y. Lim et al., 2013; Odom et al., 2014)). In the spirit of design-in-living, I suggest that future research should scale the idea of research through design at the level of a space. It would be fascinating to explore how a space could be designed (both by professional designers and everyday designers) with considerations of design-in-living and IoT.

A current example that tackles IoT, DIY and open-source electronics at the level of a space is Casa Jasmina[9] (a project by Arduino in Torino, Italy). With this project, the team (which includes Bruce Sterling and Massimo Branzi) aims at experimenting with the design of connected things in a house by creating artifacts, placing them in the house and having people live with them for different periods of time (through a bed and

[9] http://casajasmina.arduino.cc/

breakfast structure). While this project still reserves most of the design tasks for professional designers, it is possible to imagine a similar structure where the everyday designers have enough time within the house to also start making and designing. The Casa Jasmina project proposes a space that is at the same time a house, a gallery, a bed and breakfast, and a lab. Departing dramatically from the living labs for smart homes (see chapter 2), this dynamic arrangement of the space allows for multiple experiments to emerge over time. I think this is a promising area for future work in research through design.

7.3.4. Material perspective

A material perspective of design-in-living would help bring a balanced view of the relationship between people and design artifacts within a reconfigured space (as proposed in chapter 2). In chapter 5, the quality of 'reciprocal shaping' makes it clear that there is an ongoing reciprocity causing changes and adaptations both in the lived-in space and in the everyday designers. However, in design, the focus is generally on the human activities, needs, desires, ergonomics, and values; leading to an asymmetry between the spheres of humans and non-humans (Bogost, 2012; Harman, 2010; Latour, 2007)). In an IoT space—where artifacts can have their own identity, communicate, sense and act—it is of particular interest to readjust this asymmetry in order to investigate the ways artifacts and humans co-exist and evolve together in that space. Those objects will engage in different lives within the space (other than the ones humans experience or witness) and these alternative trajectories can suggest and generate new ideas or avenues for the design of future interactive artifacts.

For example, researchers have started to examine lived-in spaces through the 'eyes' of everyday mundane artifacts. Giaccardi et al. (2016) present a thing ethnography of a kettle, a cup and a fridge. In their work, the authors placed a small logging camera on these artifacts to take pictures based on reactions to five sensors (accelerometer, color sensor, magnetometer, thermometer, and PIR proximity sensor). The collected images revealed new relationships between artifacts in the home, relationships that were mostly unknown to the owners or the researchers. Their work offered new considerations regarding how objects in the home move or not, and how

they can create time or fill in time. These new perspectives allow us to better understand the role of artifacts in the space and can serve as inspiration for new ideas in the design of interactive technologies.

The example presented above shows a short thing ethnography of how mundane objects exist in a space. To extend our understanding of design-in-living and to nourish a generative design process, it would be highly interesting to use a similar methodology to follow how artifacts are transformed, built and adapted.

7.3.5. Long long-term studies

In chapter 2, both complementary perspectives (the material perspective and the first-person view of the home) were proposing to change HCI research's current scale of time in future research. I proposed that there is a lot to gain from much longer studies than what is currently conducted in the field of HCI. This proposition stemmed from reflections on the scale of time when discussing how people live in spaces, over years, decades, and even how houses can outlive human lives by centuries.

The van conversion project (chapter 5) has been ongoing for almost three years now. The findings from chapter 5 were in depth and detailed, but I wonder what additional findings I would encounter if I studied this project for the next 15 or 20 years. Certainly, this would offer the possibility to see how the initial observations I made in chapters 5 and 6 stay relevant, change and evolve. But in addition, I believe that observing a project for that long would also give the opportunity to investigate complementary questions to the first main research question of this work. For example, it would allow me to look at gender and domesticity issues in my own autobiographical design project.

Following the process of design and making over that many years would certainly open reflections around methods for conducting such research (in autobiographical design, but also beyond). This opens new questions for HCI research, such as: In what ways can we study the processes of making and design that are already taking place in a space? A first option would be to conduct studies in retrospect. Another question could be: can we study processes that have been documented and that allow revisiting

multiple years of making? An example of this strategy is Odom's study of the platform FutureMe (Odom, 2015) where the goal of the study was to investigate long term uses of slow technologies. In this study, the participants had been using this platform for about seven years, some for over a decade.

Another option would be to develop a method that can start data collection now so that in 10, 30 or 50 years future researchers can use this data. This is a much more speculative process since it is hard to imagine how the research questions of today will be relevant in that many years. It also opens interesting questions about ethics, since data might be used after participants' deaths, or by a researcher other than the one creating the study structure in the first place. In both options, researchers' creativity and imagination will be necessary to establish the appropriate research questions and tools to investigate design-in-living over long periods of time.

7.4. Final remarks: Blurring the lines

The process of writing this dissertation has allowed me to refine my understanding of artifacts (digital or not) and to sharpen my position in relation to how we, as humans, live with them—including how we use, change, and make them. As a whole, this work provided more clarity and new articulations for concepts that were previously not represented in the HCI and interaction design research community. Hopefully those articulations can serve as the starting point for inspiring, nuanced, and novel future interaction design research.

In addition to clarity and synthesis, my reflections in this doctoral work have also pushed me to embrace the blurry lines that exist with regards to my roles as a design researcher as well as with regards to the distinctions between computational artifacts and physical artifacts. Throughout the different chapters of this dissertation I have taken different roles: alternating between design researcher, design ethnographer, professionally trained designer, and DIY enthusiast, amongst others. I perform those roles in my professional and personal lives; yet they constitute me as a person—and as a researcher. Together, they have allowed me to analyze and understand the projects I embarked on and to arrive at the concept of design-in-living. Noticing and

acknowledging those roles were important in my process and I hope that this can inspire other design researchers to reflect on their own roles as well. I am looking forward to seeing how I continue to develop as a designer, researcher, and DIY enthusiasts as I pursue my career in HCI and interaction design research.

While many of the examples presented in this dissertation are from non-computational artifacts, my aim was to discuss the design of interactive technologies. For me, as technological progress continues to advance, this distinction between digital and non-digital will become more and more blurry, almost to the point of disappearing. As someone with an industrial design and interaction design training, this is very exciting! I am curious to see what the future holds when we truly combine the qualities of computation with the qualities of form and materiality. I hope that this intersection will lead to creative and honest design-in-living processes for everyday designers. Moreover, I hope that these new blurry lines will inspire the HCI and interaction design communities to continue investigating alternatives to the ways we produce and consume interactive artifacts.

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Appendix A

In appendix A, I describe in detail my role for each publication that composes this cumulative format dissertation.

Chapter 2 – Desjardins, A., Wakkary, R., & Odom, W. (2015). Investigating Genres and Perspectives in HCI Research on the Home. In *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems* (pp. 3073–3082). New York, NY, USA: ACM.

Origin:

This paper is based on my doctoral annotated bibliography.

Study work:

- In the Fall 2013 and Spring 2014 I conducted a review of literature on the topic of technology in the home.
- I read over 121 works in HCI research on the home. For each work I wrote a summary and annotation. The list of 121 works was drafted by me, but refined and agreed upon together with my senior supervisor Ron Wakkary.
- Beyond the annotated bibliography, I conducted a further analysis focusing on the methodology used in each paper, the questions the researchers were asking, and the object of their study.
- I categorized this data in an excel sheet.
- I created a first set of Genres of research on the home
- I discussed this set with Ron Wakkary and Will Odom, my co-authors for the CHI 2015 paper.
- We refined the genres.
- We discussed the epistemological commitments

Writing:

- I wrote the first full draft of the paper
- The three co-authors (Desjardins, Wakkary, Odom) then went through various rounds of editing to create the final version of the paper.
- I completed a final pass on the paper before submission and made final edits for the camera-ready version of the paper.

Chapter 3 – Desjardins, A., & Wakkary, R. (2013). Manifestations of everyday design: guiding goals and motivations. In *Proceedings of the 9th ACM Conference on Creativity & Cognition* (pp. 253–262). New York, NY, USA: ACM.

Origin:

This paper is based on my master's thesis, published at SIAT, SFU in Summer 2012.

Study work:

- To conduct the thesis work, I framed the research, selected three cases, and created a case study protocol. I collected first hand the data for the cases of hobbyist jewellers and steampunk enthusiasts. I did a secondary data analysis for the case of the families.
- I analyzed the data based on my case study protocol.
- I provided answers to my research questions.
- I discussed the findings with Ron Wakkary and this allowed me to refine the discussion points.

Writing:

- Once the thesis was defended, submitted, and accepted at the SFU library, I adapted the multiple case study from the thesis for an ACM C&C publication. This required significant remodelling of the text, particularly to reduce the number of words to fit the ACM C&C requirements.
- Using sections from the master's, I wrote a full first draft of the C&C article. Below are the similarities and differences between the Master thesis and the C&C article.
- The framing was re-written and is different in the C&C paper.
- The lit review reuses some parts from the thesis, but reorganizes the info and cuts down quite a bit to fit in a 10 page paper.

- The research approach is the same (the methodology has not changed), but it is reduced to fit the paper. I mention in both places that I use Shove's articulation of practice theory, but it is much less present in the C&C paper than the MA thesis
- The findings are using all examples that were part of the MA thesis. The main difference is that the findings are reorganized to talk about 'strategies' for their practices of everyday design rather than separating the findings by goal, outcome, materials, tools, competences, sharing, etc.
- The discussion and conclusion are almost completely new. The conceptualization of foundational, aesthetic, and aspirational goals is new and was not part of the MA.
- The two co-authors (Desjardins and Wakkary) then went through various rounds of editing to create the final version of the paper.
- I completed a final pass on the paper before submission and made final edits for the camera-ready version of the paper.

***Chapter 4* – Wakkary, R., Desjardins, A., & Hauser, S. (2015). Unselfconscious Interaction: A Conceptual Construct. *Interacting with Computers*, iwv018.**

Origin:

This journal article emerged from the collaborative work I did with Ron Wakkary and Sabrina Hauser.

Study work:

- As a team, the three co-authors (Wakkary, Desjardins, Hauser) discussed and selected the three cases that served to develop the conceptual construct of unselfconscious interaction
- As a team, the co-authors analyzed the three cases and discussed the qualities of each case.
- As a team, the co-authors articulated the conceptual construct of unselfconscious interaction.

Writing:

- The co-authors split the writing of sections for the article in approximately three equal amounts.
- Each section was read and revised by the two other co-authors.
- Once all the sections were ready, we put them together in one document.

- The three co-authors (Wakkary, Desjardins and Hauser) then went through various rounds of editing to create the final version of the paper.

Chapter 5 – Desjardins, A., & Wakkary, R. (2016). Living in a Prototype: A Reconfigured Space. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (in press, 12 pages). New York, NY, USA: ACM Press.

Origin:

This paper is based on the conversion of a cargo van into a camper van. I started this conversion project in 2013.

Study work:

- Since Fall 2013 until today, I have been designing, making and living in the camper van as an autobiographical design project in collaboration with Léandre Bérubé LeBrun.
- From Fall 2013 to Fall 2015, I collected data on the designing, making and living in this project (photo, video, notes)
- I analyzed the data and saw 6 qualities of living in a prototype emerge
- Based on discussion with my supervisor Ron Wakkary, I framed this project from the angle of designing interactive technologies for the Internet of Things (as an extension to home automation and ubicomp projects).

Writing:

- I wrote the first full draft of the paper
- The two co-authors (Desjardins and Wakkary) then went through various rounds of editing to create the final version of the paper.
- I completed a final pass on the paper before submission and made final edits for the camera-ready version of the paper.