

DESIGNING FOR THE SECOND-HAND USE OF CONSUMER GOODS

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ABSTRACT

In this paper, we present results from a research through design inquiry into the design space of second-hand use of consumer goods and their potential for creating more sustainable and less consumerism-oriented lifestyles. These results are presented in the form of an annotated portfolio that is comprised of early conceptual and material explorations along with the final material artefact, Radius – an internet connected tangible artefact that helps make decisions to buy or sell second-hand consumer goods easier to take. By analytically and critically articulating observations and reflections from the constructed portfolio, we expand the existing understanding of this design space along with explicating the knowledge latent within our process. Our reflections offer new directions and insight for future research and design along with making a theoretical contribution to the discourse on knowledge outcomes from research through design in HCI.

KEYWORDS

Sustainable HCI; consumer goods; second-hand use; prototyping; design space; annotated portfolios.

1. INTRODUCTION

The unsustainable environmental impact of the high rate of consumption and disposal of consumer goods like clothes and electronics, amongst others, has received a lot of interdisciplinary research interest (see (Van Hinte, 1997; Verbeek and Kockelkoren, 1998; Vezzoli and Manzini, 2008)) and is a growing area of concern within HCI (Blevis, 2007; Kuijer et al., 2008; Odom et al., 2009; Pierce and Paulos, 2011). Many disposed consumer goods are not at the end of their functional lifespan and end up getting discarded prematurely often due to disuse and/or dis-interest in repair or the availability of a newer and ‘better’ alternative (Manzini and Vezzoli, 2003; Pierce and Paulos, 2011).

In the light of these challenges, wider adoption of used or second-hand goods has been suggested as a promising solution that can potentially reduce the demand for new, or first-hand goods (Bowser et al., 2015; Pierce and Paulos, 2011). However, while the practices of second-hand use have existed for quite some time in the form of physical thrift stores, antique stores and more recently web and mobile platforms, people still tend to have hesitations when it comes to their adoption as an alternative to first-hand marketplaces (Pierce and Paulos, 2011). Further, within recent sustainable HCI discourse, the practices, value and potential of re-use and repair have been getting significant attention (Kuijer et al., 2008; Pierce et al., 2008; Wakkary et al., 2008). However, when it comes to second-hand use of consumer goods, barring a few technology specific explorations (like (Gegenbauer and Huang, 2012; Huh et al., 2010a)), designerly explorations and articulations of the design space itself have been limited. Considering the promising potential latent within the area of second-hand use of consumer goods we argue that there is a need for articulating more exploratory outcomes that go beyond commercially available web and mobile solutions, such as those from conceptual, speculative, fictional and reflective design approaches (Auger, 2013; Gaver and Martin, 2000; Sengers et al., 2005). These outcomes can serve as exemplars that can enable us to better understand and critically engage with this area as a rich design space. The importance of such articulations was noted even in early discussions on sustainable HCI by Blevis (Blevis, 2007) who suggested that:

“Design methods for dealing with the complexity of SID would do well to include those common in other design disciplines, such as design critiques, design case studies, and reflective practices (see Cross (2001),

Fallman (2003), and Schön (1984)), at least in addition to general models of process as enumerated in HCI texts.”

In this paper, we present explorations conducted within the design space of the second-hand use of consumer goods that lead to Radius (Figure 1), a tangible internet connected interactive artefact that explicitly communicates the demand and supply of consumer goods within local and reachable second-hand marketplaces — an aspect that is largely left implicit within web and mobile based applications. Radius as an artefact represents a critique and speculation on a dominant design paradigm within the design space (Bardzell and Bardzell, 2013) and explicitly emphasizes awareness and discovery of use/disuse and availability while designing for second-hand use of consumer goods. Further, we supplement our discussion of Radius as an artefact with a reflective and analytical articulation of the early exploratory phases of the design process as a means of explicating the knowledge latent within our process and furthering the understanding of this design space. Specifically, we highlight the value of intermediate artefacts that are created during the design process as a means of exploration, representation and ‘reflection in action’ (Schon, 1984).

Our approach reflects recent discussions within HCI related to the use of design practice and outcomes as means of inquiry and a way to generate new knowledge, generally referred to as Research through Design (RtD) (Zimmerman et al., 2007). RtD has received a lot of attention in HCI (Basballe and Halskov, 2012; Gaver, 2012; Höök and Löwgren, 2012; Zimmerman et al., 2007); in particular the means and forms of articulating the knowledge it generates (Bardzell et al., 2015; Bowers, 2012; Höök and Löwgren, 2012). It has been argued that knowledge outcomes from the results of RtD allow for “a range of topical, procedural, pragmatic and conceptual insights to be articulated” (Gaver, 2012). While, from the outset, designerly processes often do not have an explicitly clear structure or a linear model (Godin, 2006), they do have a disciplinary rigor and modes of navigating complexity inherent to design problems (Buchanan, 1992; Stolterman, 2008). Studies on designerly ways of thinking highlight that a critical form of navigating this complexity is through different forms of material and conceptual exploration (e.g. sketching, mapping, prototyping) conducted frequently throughout the design process (Cross, 2001; Schon, 1984). In our view, these intermediates or partially explored concepts and exploratory material undertakings play an essential role in the transformation of the initial intent into the final material outcome by opening an exploratory design space of material possibilities and conceptually informing and guiding the process. Moreover, intermediates serve as important knowledge outcomes from a RtD process in that they are representative of “partial ideas, that is elements of potential design solutions, that can be appropriated by designers and researchers and used in the creation of new instances” (Höök and Löwgren, 2012). Therefore, by explicitly articulating their conceptual and material nature, we can better understand the progression and evolution of the design process along with ‘partial ideas’ and ‘potential design solutions’ that frame the design space explored.



Figure 1: Radius

The central aim of our paper is to highlight the outcome and intermediate design proposals that were explored as a part of our RtD process and therefore, we limit our focus and discussion to our own reflections and concerns and how they evolved through hands on material engagement with the design process. Consequently, we do not discuss or present findings from the prototypes of our process in use or other forms of formal user studies. A range of prior research particularly relating to RtD in HCI has highlighted the value and importance of such articulations as a way of elaborating and expanding existing understandings of the design space (Backlund et al., 2007; Gaver and Martin, 2000; Neustaedter and Sengers, 2012).

The contribution of this paper is twofold. First, we present the material outcome and exploratory design proposals developed as a part of a research through design process and outline their guiding conceptual motivations and material considerations as a way of expanding and furthering the understanding of the design space relating to the second-hand use of consumer goods. Second, by building on prior research and presenting a methodology for analytically reflecting on and articulating the importance of intermediate explorations of the design process in constructing new understandings of the design space, we contribute to the larger theoretical discourse related to knowledge outcomes from RtD in HCI.

We start by outlining our conceptual background and methodological grounding and argumentation. Next, to develop our articulation and analysis of the design space, we use Gaver and Bower's (Gaver and Bowers, 2012) approach of using textual 'annotations' juxtaposed onto images of material outcomes from a design process as a means of highlighting "features of interest" within the process. We present an annotated portfolio of a chronological set of low fidelity, unfinished intermediates, leading up to the final material outcome created as our response to the question: how to scaffold and catalyze the prolonged lifecycle of durable goods in everyday life. A temporal analysis of the portfolio reveals traces of reflections from explorations of interim artefacts in the final material outcome. The final material outcome, Radius, is a simple internet connected device that plays on the formal characteristics of an internet connected button but alters the behavior and interactions from 'seamless purchase' to 'seamless visibility' of similar second-hand goods available in the geographic vicinity. Thus, the desirability of the second-hand item may facilitate a transition to finding the next owner. We conclude with highlighting possible exploratory dimensions within the design space along with critical reflections on the potential of reframing intermediate explorations as knowledge outcomes from research through design in HCI.

2. SECOND-HAND USE OF CONSUMER GOODS

Our research and design process was informed by prior sustainable HCI research relating to the practices and design implications of second-hand consumption. Building on earlier research in sustainable resource consumption practices within HCI and other related research fields like material cultures and design philosophy, Pierce and Paulos (Pierce and Paulos, 2011) develop an understanding of the consumption of "durable material goods in terms of the acquisition, possession, dispossession and reacquisition of a particular material object." They emphasize the importance of distinguishing between the motivations and practices of first-hand consumption (which relate to not-previously-acquired/possessed consumer goods) and second-hand use (which relate to the reacquisition and transference of possession and use). They describe these differences in terms of the work, effort and time involved with second-hand transactions which is supplemented by the inherent value of the experience and satisfaction of reacquisition, even though the actual interface and interaction design of first and second-hand marketplaces has become increasingly similar. Through our design concepts, we also explore trust related dimensions of reacquisition practices which have also been highlighted by Pierce and Paulos (ibid.), amongst others (Bowser et al., 2015; de Jode et al., 2012), suggesting that users need to have *faith* in the quality and reliability of second-hand things they seek to purchase. Odom et al. (Odom et al., 2009) describe how the material qualities, perceived durability and meaningfulness of objects help determine if they get preserved or discarded. We explore their suggestions on employing these factors to identify completely different reuse contexts for objects that go beyond their intended function. Huh et. al (Huh et al., 2010b) develop Odom et. al's work further in their study of the reuse of old or partially functional PDAs as music players and GPS devices. The potential of designing for second-hand use is also emphasized by Blevis (Blevis, 2007), who suggests promoting renewal and reuse as a "first-order design requirement for sustainability". In subsequent work, specifically relating to sustainable fashion, Pan et al. (Pan et al., 2015) point to the importance of the situated practices of the local community in informing reuse and sustainable design.

In the following section, we outline our methodology for analytically reflecting on our exploration of the design space relating to the second-hand use of durable goods along with articulating the progression of conceptual motivations and material considerations within the design process.

3. METHODOLOGY

'Thinking through making' has been widely discussed as a critical part of designerly processes (Cross, 2001; Schon, 1984) and HCI design is no exception. Quite commonly in the design process, beyond sketching and paper based representations of the design ephemera, when an idea seems to lead towards a possible solution, richer material explorations are routinely carried out for deeper engagement with the design space. In the material trajectory of a design process, starting with a design intent and ending with the final material outcome, a chain of alternative and exploratory intermediate explorations is typically created and abandoned along the way. This is a crucial part of navigating the 'messy situations' presented by the design process and are used as a means of reflection, filtering and evaluation and progressing iteratively in the design process (Lim et al., 2008a). While many of these tangible directional outcomes could end up being labelled as rejects or failures, they are significant contributors to 'reflection on action' (Schön, 1984) and consequently to research through design. As such, rather than rejects, they offer insights as to why a certain line of inquiry is abandoned along with existing as potential seeds for alternate explorations within the design space.

However, the designer's concerns, judgements and intent are not directly accessible from the designed artefact itself, in particular when one considers digital objects (Mazé and Redström, 2005). Gaver and Bowers (Gaver and Bowers, 2012) propose the use of textual 'annotations' as a means of identifying and articulating facets that are "indexically connected to artefacts while connoting features of broader interest" (Jarvis et al., 2012). Pierce has referred to this hybrid form of knowledge outcome as 'concept-things' which he argues are "nexuses of verbally articulated concepts and designerly articulated material things" (Pierce, 2014). We propose that a temporal analysis of the annotated (interim and final) material artefacts of a design process can lead to the construction of such a 'concept-thing' hybrid which reveals the evolving nature of designerly understanding, judgements and situational responses at a given point in the design process along with collectively presenting a holistic picture of the design space encountered.

3.1 An artefactual framing

Many researchers have highlighted that the outcomes of a design process exist as material embodiments of design decisions (Gaver, 2012; Pierce, 2014). Ingold (Ingold, 2013) has also discussed conceptually similar themes framed collectively as the 'art of inquiry'. It refers to designers' and craftsmen's material engagement throughout their process. Ingold underlines this engagement as an essential influence in widening perception of the context and deepening the inquiry. As a part of his larger discussion, he also introduces a related concept of '*casual connections*', which refers to the traces of the tacit artefactual evolution of designerly thinking throughout the process and emphasizes that this is an important part of the process. We build on this understanding of casual connections and extend it to interim material artefacts, which we call intermediates, resulting from the early phases of explorations in the design process. With our work, we reflect analytically on explorations of intermediates within the context of prolonging the life of consumer goods. By considering all the intermediate explorations from a design process collectively, we argue that it is possible to highlight and demonstrate how design considerations shaped early on in the process carry forward into the metaphor, form and/or interactions of the final material outcome and to reframe such explorations as the drivers and evidence of material divergence and consequently conceptual convergence in a design process.

From a research through design standpoint, intermediates are also important as a means of evidencing the design dimensions that were explored in the design space which inform the conceptual motivations and material considerations of the particular and specific material outcome (Stolterman, 2008) of the design process. Therefore, we argue, they serve as important anchors for grounding rich accounts (Gaver, 2012) describing the design process and making them more transparent (without making them appear clinical and structured).

The value of prototyping, and specifically low fidelity (low-fi) prototyping, as a process and outcome of a design practice is certainly well established. In fact, prototyping, both as a conceptual approach and as a tool has been widely addressed in both HCI research and interaction design. Gerber et. al. (Gerber and Carroll, 2012) represent prototyping, especially low-fidelity prototyping as a widely-accepted way of reducing uncertainty and increasing knowledge. Pierce (Pierce, 2014) categorizes it as a means to "communicate and develop abstract concepts or theories". Lim et al. (Lim et al., 2008b) have proposed the anatomy of prototypes consisting of filtering dimensions which correspond to representational aspects of a prototype and manifestation dimensions which refer to its material or realized dimensions. However, it is not the general practice of low fidelity prototyping that we would like to highlight in this work, but rather the outcomes of

exploratory and experimental making and their individual and collective implications on the design process and their value as seeds for future exploratory work.

Intermediates represent explorations that move beyond conceptual sketches and into a more material form. However, the nature of material engagement and representations can vary widely based on the domain and process influencing the nature of explorations. Therefore, we suggest that intermediates should not be identified based on their physical characteristics but their exploratory potential and their ability to provide insights into critical junctures of conceptual and/or material progression in the design process. As we demonstrate through an annotated portfolio of explorations in the following section, intermediates are representative of optimistic possibilities that were explored within a design process making them an important source of articulating potential themes, well formulated reflections, well understood mistakes and concrete evidences of the casual connections implicit within a particular design process.

4. ANNOTATED PORTFOLIO OF DESIGN EXPLORATIONS

Besides Radius, the final material outcome of our research through design process, we highlight four intermediate outcomes, each of which represents a distinct dimension within our larger inquiry into the design possibilities of the second-hand use of durable goods. These intermediates are outcomes from four iterative cycles of concept development and material explorations. They were developed as semi-finished low-fidelity prototypes and were critiqued in collaboration with HCI researchers. While distinct in their conceptual and material form, they are also snapshots of our process in time, related by an evolution in intent, constraints and judgements. Thus, the final material outcome, besides being theoretically and conceptually informed by prior research and design work also carries forward elements of the conceptual, material or aesthetic learning from each intermediate proposal. We briefly introduce them with a short textual description and an *annotated* image highlighting our design and research motivations, material considerations and the artefact's functions. Lastly, we present our observations relating to the casual connections between them and the larger design space that they help outline.

4.1 Intermediate 1: Honest me

'Honest Me' is a radio that displays information about its own well-being, lifespan and perceived price, in addition to its usual radio function (see Figure 2a).

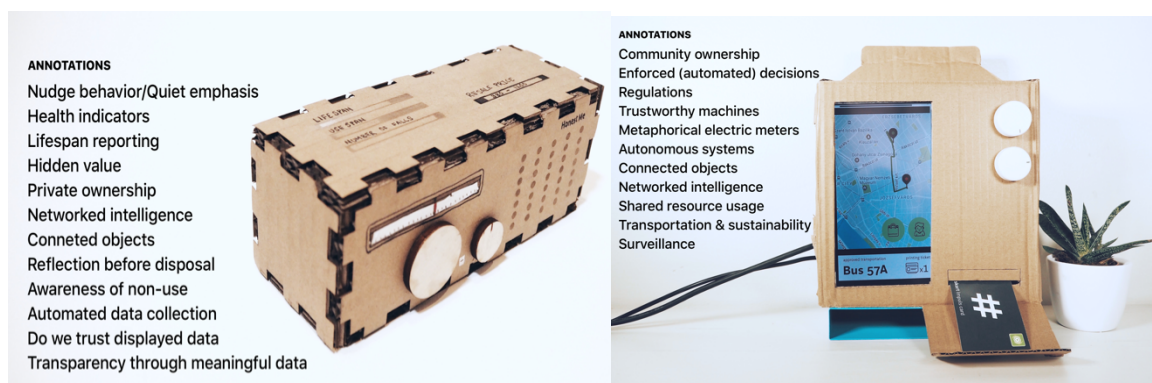


Figure 2: a) Honest Me b) Connected Conveyance

The concept evaluates and expresses the fluctuation in the value of the artefact as it ages, and the effects on its price in the second-hand market. The inquiry here was intended to explore to what extent is it possible, or whether it is even desirable, to design everyday objects with this kind of 'honesty'. For a potential buyer of second-hand goods, it is often difficult to look at electronic devices and know how well they were treated by their owners, how much use they had, or what is their general life expectancy (Pierce and Paulos, 2011). The concept builds on enabling devices to provide this information themselves. While engaging in the low fidelity

prototyping of this concept, we focused on relevant parameters that could be made explicit in devices, like ‘usage’, ‘lifespan’, ‘bumps and bruises’ etc. and the relevance of these for the second-hand buying and selling. The annotated image (Figure 2a) highlights the motivations driving this design concept like “transparency through meaningful data”, “awareness of non-use”, “nudge behavior” along with material and functional dimensions like “networked intelligence”, “connected objects”, “lifespan reporting” and “automated data collection”.

4.2 Intermediate 2: Connected Conveyance

Taking the increasingly ubiquitous nature of algorithmic decision making in everyday lives, from suggestive email responses to predictive policing, as a point of departure, this intermediate explored a scenario where consumer goods from cars to toasters could be controlled by an autonomous sharing system. Working with the analogy of electricity meters installed in our houses, we prototyped an object for implementing a connected and autonomously controlled transportation system (Figure 2b). This system uses location data, use data on various devices, time of the day, weather and so on and, and cumulatively considers all private and public transportation options available to its users, indirectly intervening with the use of one’s privately-owned vehicles. Through this design concept, we were exploring conceptual dimensions of “trustworthy machines”, “enforced decisions”, “community ownership”, “surveillance” while expanding material concerns like “networked intelligence” and “connected objects” with “autonomous systems”. Finally, although vehicles were used in our example, this inquiry easily extends to a larger range of devices, e.g. laundry machines, coffee makers and so on.

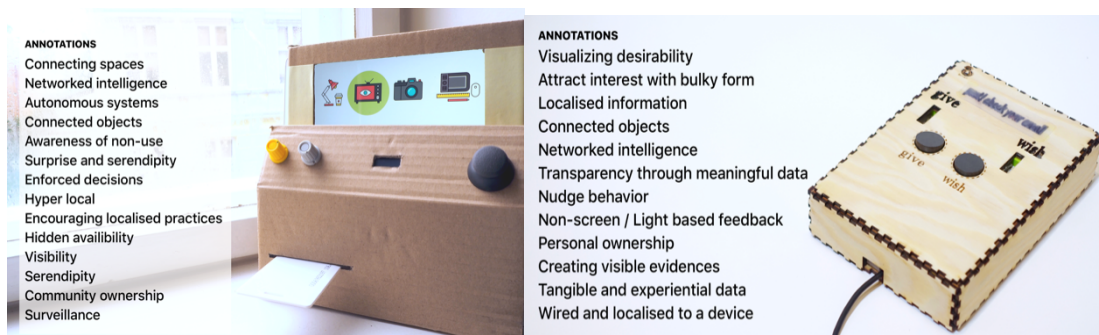


Figure 3: a) Slot Machine b) Buybit

4.3 Intermediate 3: The slot machine

The third exploration took the form of a ‘slot machine’ and attempted to situate the exchange of second-hand goods away from direct transactions between people (Figure 3a). Instead, it creates a space to experience and engage in the social practice of exchanging second-hand goods by localizing them within a neighborhood and automating the drop-off and pickup. This contrasts with the current state where this process requires logistical maneuvering by negotiating with others and then executing the exchange. Consequently, with time, unused items get stored away from sight, in attics, garage, basement, storage bins etc. in people’s houses and neighborhoods. Using the metaphor of chance or horoscope reading, we designed a slot machine that monitors the use of devices and connects people with a common and automated repository of disused but functioning devices in their locality. Users can enter the amount they can offer and select device categories and the machine presents a random selection of devices available to choose from. With this design concept, the material dimensions of our explorations like “networked intelligence”, “connected objects”, “autonomous systems” solidified further while our conceptual motivations represented both an amalgamation of existing themes like “enforced decisions”, “community ownership”, “surveillance”, “awareness of non-use” and an expansion with additional themes like “serendipity” and “encouraging localized practices”.

4.4 Intermediate 4: Buybit

Buybit was the fourth intermediate exploration and is conceptually the closest to the final material outcome of our design process (Figure 3b). It is designed as an internet connected object belonging to a household, connected to different second-hand marketplaces within a local neighborhood. Two light based indicators highlight the demand (wish) and supply (give) of everyday objects like lamps and toasters in second-hand marketplaces. In addition, two buttons, give and wish allow the user to immediately put an object up for sale (give) or indicate their interest in purchasing it (wish). The behavioral attributes of the device built on the ‘nudge’ like behavior of “Honest me” and therefore were designed as ‘polite suggestions’ and an ‘informed advice’. It uses non-intrusive interactions and aims to create small moments of reflection about the possession and dispossession of things. Buybit was designed as an external device that could be attached to all sorts of goods, enable suggestive, light based interactions, and catalyze second-hand reuse practices. A semi-functional prototype was built using the littleBits prototyping platform (Littlebits, 2017). Material considerations and conceptual motivations such as “connected objects”, “networked intelligence”, “transparency through meaningful data”, “nudge behavior” carry forward from earlier design concepts along with additional considerations like “localized information”, “tangible and experiential data”, “attracting interest with a bulky form” get added in this iteration.



Figure 4: a) Radius b) Annotations of intermediates help trace casual connections of conceptual motivations, material considerations and functional aspects in the final material outcome, Radius

4.5 Final material outcome: Radius

Radius is the final material outcome of the project (Figure 4a). It is a simple internet connected device that plays on the formal characteristics of an internet connected button but alters the behavior and interactions from ‘one-click purchase’ to ‘one-click visibility’ of similar unused second-hand goods available in the geographic vicinity. It uses the metaphor of tags on new devices which rather than glorifying product attributes, exposes its demand and supply in the second-hand market as a way of motivating consumers consider selling goods they do not use anymore and buying pre-owned goods when they consider making a new purchase. The form of the artefact was intentionally kept portable and wireless to allow for mobility and on the go usage for example in situations where people could use the device in stores to compare second-hand demand and supply and prices with those of new goods. A semi functional prototype was built using a particle internet board (“Particle Photon Series wifi development kits and connectivity modules,.” n.d.), RFID sensor and a rechargeable Li-Po battery embedded in a custom 3D printed enclosure. This iteration was intended for further formal and alternate material explorations, but ended up pushing the ‘Buybit’ concept further both in form and conceptually. For example, its size and shape made it more portable. Portability greatly increased its effectiveness and utility, making it readily available while also eliminating the need for multiple ‘Buybits’ in a household. Sound was added as an additional mode of interaction and in combination with light, the artefact could now communicate different data points such as condition, demand and proximity.

4.6 Observations

Assimilating the explorations and outcome of the Radius project in the form of a portfolio allows us to temporally and relationally analyze the material progression of the design process. This analysis helps trace

the casual connections and highlight the flow and flux of the design decisions and judgements taken by the team by visually highlighting similar themes of enquiry that were explored further in each concept and iteration even when the artefacts are conceptually and materially different. At the same time, the evolving, generative and emergent form of both research and design intent and domain understanding can also be evidenced. We present the main observations from the portfolio of outcomes of our design process below.

4.6.1 Temporal evolution and casual connections

Each intermediate outcome was discussed and critiqued in the light of our larger research inquiry: if a product like this existed, would it be desirable and would it scaffold and catalyze the extension of the lifespan of consumer goods? Asking these questions showed that the 'Connected conveyance' was too far removed from our initial intent by being overly reliant on automation and machine intelligence. While 'Honest Me' was promising, the nature of metrics represented would need to vary widely between different devices and contexts. Therefore, wider application of the concept became a key thematic area to be addressed in the next iteration which lead to 'the slot machine' prototype. As an outcome, the 'Slot machine' seemed to offer a promising solution that integrated design considerations like artefact non-use, condition and connectivity with the thematic areas of suggestive interactions that are generalizable across consumer goods. However, upon reflecting and critiquing the artefact, our implicit reliance on machine intelligence, decision making and automation in this case became evident, positioning it as an example of enforced decision making. Thus, we decided to move away from community driven or owned artefacts as an area of exploration and added personal spaces and ownership as the key contextual area for future explorations. Focusing on personal spaces and ownership, we decided to go back to design considerations explored in the 'Honest me' concept. At this point, we started to note a key underlying theme relating to 'creating visibility of data points' and 'transparency in communication' as a conceptual undertones and parallels between 'Honest me' and 'the slot machine'. At this stage, 'Buybit' and later 'Radius' emerged as conceptual extensions that scaffold reflection and engagement with second-hand use through visibility of metrics such as demand and supply, closest distance and health.

4.6.2 Suggestive vs enforced interactions

Looking at the diversity and breadth of our explorations, we can observe that scaffolding and catalyzing the use of second-hand durable goods is a complex and contextually diverse design space. However, throughout our explorations, two distinct modes of interaction can be observed — suggestive/demonstrative and enforced/autonomous. The first exploration, 'Honest me', represented a suggestive mode of interaction while the second, 'Connected conveyance', represented an autonomous or enforced mode of interaction. While 'the slot machine' created opportunities for serendipitous encounters, the concept was thematically quite reminiscent of the provocative and enforced behaviors from the 'Connected conveyance' concept by giving away things that were disused. Finally, the later iterations of our process leading to 'Buybit' and later 'Radius', show an amalgamation of the suggestive interactions from 'Honest me' and creating opportunities for discovery and surprise from 'the slot machine' by making implicit data relating to second-hand goods explicit and readily available through a portable and personal device.

4.6.3 Material and conceptual considerations

Reflecting upon outcomes of both concepts and annotating their images, we could easily see that our material considerations were quite similar throughout the process. All the outcomes represent some form of connected and 'smart' objects that used (or in the case of cardboard prototypes, could use) technological materials like wireless transmitters, networked APIs and localized sensors and actuators. However, throughout the design process the team continuously explored possibilities and implications of finding a balance between themes of community vs personal ownership and suggestive vs enforced interactions as they related to second-hand reuse. Based on the nature of our conceptual engagement in each iteration, these materials were re-configured and composed to create distinct outcomes.

4.6.4 Summary: Annotating intermediate outcomes

From an analytical perspective, the annotations play a dual indexical and demonstrative role. While they do provide a specific contextual understanding of the artefact and connections to research areas of broader interest, in this case, they also demonstrate the designer's or design team's understanding and judgements at a specific point in the design process. Consequently, considered collectively as a portfolio, they highlight the evolution

of the team's understanding and response to the research domain and design brief - both by evidencing considerations and intent that were developed further and those that were left behind (see Figure 4b). We argue that this helps contextually and conceptually situate the final material outcome by underlining both what its research and design intentions and considerations are and what they aren't. In the case of our process, 'connected/always on/networked' interaction appears as a common theme that the team tried to utilize in formulating its response to catalyzing second-hand practices. Decision making (either human or autonomous) based on usually hidden/obfuscated data appears as another theme. However, in this case, the annotations highlight that the team deliberately moved away from autonomous or black boxed decision making and towards transparent and meaningful data as a form of catalyzing second-hand practices in the final material outcome. Hence, this underlines transparency, reflection and communicating meaningful data as the outcome's design and research intent and autonomy, obfuscation and provocation as intents that it does not stand for.

5. DISCUSSION

5.1 On the design space (of second-hand use)

Based on our reflections and observations from interim explorations, we present three potential design spaces for future exploration of second-hand use.

5.1.1 Visibility and transparency

As highlighted in prior research (Odom et al., 2009; Pierce and Paulos, 2011), the practices of second-hand use are distinctly different from those related to first-hand goods and marketplaces. Thus, designing for second-hand use could use such practices as a point of departure rather than borrowing design elements from first-hand marketplaces. Trust in people and durability of second-hand goods is one of the important factors that differentiates the first-hand and second-hand markets. While it is possible (and important) to speculatively and critically engage with existing notions of implicit trust in first-hand goods, easily visible and understandable information can also act as catalysts that can create feelings of confidence and trust, as described in (van der Velden and Culen, 2013). 'Honest me' makes information about the potential lifetime of a radio visible and allows for an easy estimate of its durability. These metrics are incorporated into the device itself and are driven by automated reporting on stressful experiences the item may have had, such as falls. This kind of transparency and visibility into the lifetime and nature of use of consumer goods can mitigate mistrust and lessen the subjective judgements and work needed to identify durable second-hand goods.

5.1.2 Serendipity and discovery

While designing for second-hand use, engagement and reflection could be created through scaffolding serendipitous encounters and discovery. Visibility can be a basis for designing scaffolds for serendipitous encounters, like those enabled by 'Radius' and 'the slot machine'. 'Radius' can help see the availability of a thing one might need or want but not expect to get close by, while 'the slot machine' displays disused but locally available items simply on turning the handle of the machine and transferring ownership, if the user's profile fits. Usually, the local availability and ubiquity of second-hand goods is often a factor that is not emphasized in the design of second-hand markets. However, unexpected things one never thought could be locally available (or affordable) may be found, tried and shared this way. Serendipitous discovery, i.e. finding interesting and valuable things unexpectedly could add additional values to the experience of second-hand interactions like being lucky, pleasure, surprise and/or happiness in addition to the satisfaction of reacquisition (Pierce and Paulos, 2011). Going beyond these feelings, such serendipitous discoveries could also trigger reflection over one's own needs and buying behaviors.

5.1.2 Ownership and use/disuse

Designing for second-hand use could question and suggest alternates to prevalent understandings of ownership and use/disuse. Design fiction (Blythe, 2014) and speculative design (Auger, 2013) are examples of potential approaches that can be adopted to suggest alternatives and propose potential futures. With 'connected conveyance' and 'the slot machine', we engaged with such an approach by imagining a world where the use

of transportation and ownership of consumer goods is appropriated through use and necessity. While the outcomes do not represent usable or useful results in a traditional sense, they help highlight underlying assumptions relating to the utility of owning goods that are disused (in the case of the slot machine) and often implicit decisions like choosing a car over public transport for commuting (in the case of connected conveyance).

5.2 On intermediates

5.2.1 As knowledge outcomes

Intermediates act as material evidences of a design process, and when read in conjunction with their design and research intention and the context of their manifestation (within the process), can reveal important insights about how and why a certain design outcome came to be. To be sure, they do not necessarily make the entire conceptual design space explicit but rather highlight the exploratory, iterative and often fragmented journey that was undertaken as a part of the design process. The annotated portfolio of intermediate explorations presents each exploration as a concept-thing hybrid and underlines them as important material and conceptual beacons that collectively offer traces of this journey for reflection and future exploration. Making and annotating intermediates, may be, in some sense compared to the research using grounded theory, where collecting data and taking careful field notes may be compared to making of intermediates, while the process of coding and categorizing compares to annotating and analyzing annotations.

5.2.2 As partial ideas

Identifying intermediate explorations and compiling them into a portfolio can sometimes be problematic. This is because documenting and presenting ‘unfinished’ and ‘failed’ explorations together with the final material outcome may be perceived as adding unwanted complexity and messiness to the documentation and dissemination process. However, as we have demonstrated, rather than adding complexity, such a narrative provides a much more grounded articulation of the final material outcome along with seeds for future explorations. Important qualities of intermediates are that they are experimental, allow a design researcher to pursue the main line of inquiry in different directions (highlighting the importance of divergent thinking, expressed through material explorations), serve as speculative objects enabling reflections through speculation on meaning, desirability and use. Moreover, what may have been perceived as an invalid or failed line of exploration in one case due to constraints or particularities of a brief, could become promising points of departure under a different research or design brief.

5.2.3 As artefacts for reflection and critique

We have also experienced this process to be quite effective as a means of critique and reflection even during the design process and the portfolio in such cases tends to become a living document and an active material that helps shape future directions in the design process. In such cases, annotations help shape the process as well as generate a richer set of knowledge outcomes. Besides their role as artefacts for reflection and evidencing, we also speculate about the potential of intermediate explorations as a means of inducing flux in the process by facilitating hands on engagement with multiple potential directions, keeping promising artefacts intentionally ‘unfinished’ while other dimensions of the design space are explored. For instance, the metaphor of polite suggestions and devices as active participants that we worked with in *Honest me*, was very influential for the final design of *Radius* since we were actively engaged in critiquing our interactions and behaviors against these metaphors. Going forward with alternate explorations through diverse exploratory forms and consciously articulating possible themes, interactions and learnings might help in actively informing and developing the design concept in unexpected and novel ways.

6. CONCLUSIONS

Building on prior work on second-hand interactions and sustainable HCI, we have presented *Radius*, an internet connected tangible artefact along with intermediate design concepts and explorations leading up to it as a means of expanding the understanding of the design space relating to the second-hand use of consumer goods. We

used annotated portfolios as a way of highlighting the exploratory potential within this design space along with developing an articulation of the ‘casual connections’, both material and immaterial, between the intermediates and the final material outcome. In our future work, we aim to explore the design spaces outlined along with furthering the understanding of the nature and relevance of this knowledge in HCI.

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